European NG112 Crossroads: Toward a New Emergency Communications Framework

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Different initiatives worldwide are addressing the need for specifying a stable IP-based next generation emergency communications framework. The authors provide a general overview of the different international approaches with special focus on the European perspective, where the NG112 architecture has been specified, and it has now entered the testing and evaluation phase.

ABSTRACT

Nowadays, citizens are getting used to new ways of agile communications supporting media-enriched and context-aware information. However, the adoption of these evolved technologies in emergency communications between citizens and public authorities faces a series of barriers, including the lack of harmonized and interoperable solutions. Different initiatives worldwide are addressing the need for specifying a stable IP-based next generation emergency communications framework. This article provides a general overview of the different international approaches with special focus on the European perspective, where the NG112 architecture has been specified, and it has now entered the testing and evaluation phase.

INTRODUCTION

It is estimated that approximately 320 million emergency calls are made every year in the European Union (EU). Among all the different numbers still available, more than 135 million [1] used the unified 112 one (note that some member states do not provide such statistics). At the same time, multimedia applications and voice over IP (VoIP)-based devices have become commonplace, and citizens use them to conveniently communicate, sending and receiving multi-modal information. Among several standardized and proprietary over-the-top (OTT) VoIP solutions available today, voice over LTE (VoLTE) seems to be playing a significant role in the near future, as predominant access to emergency services from fourth generation (4G) broadband mobile networks. In fact, more than 60 percent of emergency calls are already from mobile devices in the EU [2].

Unfortunately, for the time being, most European emergency service organizations (ESOs) can only be reached by voice and through the public switched telephony or mobile networks. Meanwhile, different kinds of text messaging and video and picture sharing apps have become more common communication means, and social networks have indeed become a new medium by themselves. Modern mobile phones from which an emergency call might be placed have the potential to transmit life saving location information simultaneously with the call.

As a result, the way citizens and emergency services interact is undergoing significant changes in terms of communication means and content. Similarly, the number of stakeholders involved in emergency communications and the technologies used for interacting among them has significantly increased, leading to a complex heterogeneous ecosystem. Nevertheless, the existing legacy emergency services infrastructure (circuit switched telephony for 112 telephone calls, not data) is not designed in a way that enables interaction with enhanced services, or current and future communications and operational requirements to be met.

In such a landscape, more rapidly changing than ever, ESOs are struggling to identify a consistent and longstanding set of solutions that would leverage their current legacy systems while keeping systems interoperable, scalable, and technically stable.

The concept of Next Generation 911/112 (NG911/NG112) has been identified as a potential answer to such demands, since it combines the definition of a set of international standards with the scalability and flexibility of IP connections. Several initiatives all over the world have been initiated for both defining and testing such a concept.

NG911/NG112 systems are designed to close the gap between the quickly evolving technologies (fixed and mobile IP-based communications) and the more conservative approaches required by the emergency communications industry (including public administrations). Such systems will then enable citizens to contact emergency services in different ways, using the same types of technologies as they use to communicate every day. They will also make it possible for public safety answering points (PSAPs) to receive more effective and richer information about emergencies of all magnitudes through a stable communications framework, which improves interoperability between emergency services. Consequently, response times and operational costs will be reduced, while effective response will increase significantly.

In this article we analyze the current status of next generation emergency communications with special focus on Europe, where the first European-wide industry-driven interoperability initiative was recently launched. This interoperability event was hosted by the European Telecommunications Standards Institute (ETSI) and takes NG112 archi-

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tecture as a basis for next generation emergency communications. NG112 was originally proposed by the European Emergency Number Association (EENA) a European NGO dedicated to promoting high-quality 112 emergency services, similar to the National Emergency Number Association (NENA) in the United States. Among all the different boards, it is especially the Next-Generation 112 Committee (NG112) that is working on designing the future of IP-based emergency services.

The article foresees the challenges and the role of the NG112 structure, identifying the border elements as key enablers of smooth evolution in a scenario where evolving access technologies and heterogeneous use cases are called to become key elements in the emergency ecosystem.

The structure of the article is as follows. The following section identifies the novel user requirements concerning emergency communications, highlighting the main work performed in different standards development organizations (SDOs). Then we give an overview of the most relevant approaches by different SDOs worldwide for defining the next generation emergency communications framework. Following that we summarize the NG112 architecture proposed by EENA and briefly describe the main functional nodes. Based on the outcomes of the first industry interoperability event, we then identify the current status concerning different types of access networks. Finally, we provide the conclusions to the article.

Evolving Requirements for Next Generation Communications between Citizens and PSAPs

User requirements in the design of a technology have always been of paramount importance in the deployment of emergency communications. Therefore, the identification of user requirements is the initial step prior to the technical definition of a system. In recent years, a wide number of international SDOs and research projects have performed surveys for obtaining user requirements for emergency communication systems.

The European Telecommunications Standards Institute (ETSI) Special Committee (SC) on Emergency Communications (EMTEL) has been specifically focused on emergency communications, including emergency call services, caller location enhanced emergency services, and public safety communication systems. As a result, the requirements between citizens and PSAPs and between PSAPs during emergency communications, at both the functional and operational levels, were collected in [3]. The EENA NG112 Technical Committee also conducted a series of surveys of different members of European emergency services regarding emergency services requirements. The outcomes of these surveys are publicly available in [4, 5]. Additionally, user requirements have also been taken into account in the definition of the Third Generation Partnership Project (3GPP) Non Voice Emergency Services (NOVES) characteristics [6]. More specifically, among other requirements, location information should be provided by users at call setup and instantly updated. NOVES services shall be free of charge, as any other emergency call, while emergency communications have to be prioritized over other communications. At the same time, in cases lacking 4G coverage, voice and location should always be available.

In recent years, a large number of "SOS" and "help" applications have been created. Almost all European emergency services have been contacted by developers who wanted to send data and establish a voice connection directly to 112 [7]. Different solutions have been built on heterogeneous technologies that are not generally interoperable. This may explain why some public authorities have already developed their own official applications that can only be used by citizens living in a certain geographic area and may not work properly if they are used outside the boundaries of a certain PSAP.

The use of standardized or industry-adopted technologies may help to overcome this heterogeneity in emergency apps and OTT VoIP services. Different technologies can be identified as prevailing candidate solutions, including the use of webRTC or the mobile industry supported Rich Communications Suite (RCS). However, none of the solutions have really gained the required wide support in the emergency communications world.

To add more complexity to the unified emergency communications playground, the use of crowd sourcing and social networks is becoming more and more frequent in emergency situations [8]. Public authorities are trying to get prepared to seamlessly include this kind of communication means, mainly based on private mobile applications, in their daily operations. However, the lack of a standardized architecture forces public authorities to integrate ad hoc solutions for the different technologies. Additionally, the proliferation of emergency-related online user groups and volunteers indicates the need for a harmonized media-enhanced communication framework between citizens and PSAPs. The Internet of Things (IoT) will soon add new players to the emergency communications ecosystem

eCall can well be considered the first major industry initiative in this sense. 3GPP introduced the requirement of identification of eCall in the support of emergency calls in 2007 and approved the in-band modem solution in 2009. On 28 April 2015, the European Parliament voted in favor of eCall regulation, which requires that all new cars be equipped with eCall technology from April 2018. eCall specifications have now been stable for several years, covering circuit-switched 112 eCall over 2G and 3G mobile networks. However, a more evolved version of eCall is already being defined, taking advantage of the IP-based 3G and 4G communication technologies.

In summary, public authorities and PSAP professionals are aware of the benefits that modern mobile technologies can provide to the emergency communications framework. However, there is a lack of a unified stable technological framework that eases the adoption of the heterogeneous sources of information, which would be undoubtedly valuable for emergency management operations. Most of the available approaches are based on ad hoc solutions, generally not interoperable among them and with current PSAPs.

User requirements in the design of a technology have always been of paramount importance in the deployment of emergency communications. Therefore, the identification of user requirements is the initial step prior to the technical definition of a system.

Public authorities will rely on a stable technological framework for incoming emergency communications. The different emergency communication details specific to the access technologies will be mapped to the ESInet protocol suite by the defined border controllers.

Standards for IP-Based Emergency Citizen-to-PSAP Communications

Concerning next generation citizen-to-authority emergency communications, several relevant standardization initiatives have been launched worldwide. In general, all the initiatives tend toward IP-based scenarios, with Session Initiation Protocol (SIP) as the key technology for communication signaling and control.

In the Internet Engineering Task Force (IETF), the Emergency Context Resolution with Internet Technologies (ECRIT) working group has been mostly working on SIP-based citizen-to-authority emergency communications. Since its creation in 2005, ECRIT has released a significant number of Internet Drafts and RFCs including the definition of the framework [9], the specification of the signaling protocol details [10], the specification of call routing by means of the emergency service routing proxy (ESRP) node, the inclusion of location capabilities (in cooperation with the GEOPRIV WG) within the call [11], routing by means of the location-to-service translation (LoST) protocol [12], and so on.

Concerning the 3GPP, public safety (individual to/from authority) communications include eCall, public warning systems (PWSs), multimedia priority service (MPS), and so on. Specifically, 3GPP TS 23.167 defines the architecture and procedures for establishment of citizen-to-PSAP emergency services in IMS since Release 7 (June 2006), by means of introducing a SIP session control node named the emergency call session control function (E-CSCF). Enhanced functionalities have been added through new releases; for example, LTE-specific support for IMS emergency services was introduced in Release 9, and enhanced emergency calling though WLAN is defined in Release 13. Additionally, 3GPP defines the architecture for location services (LCS) where the location resource function (LRF) is the network element responsible for providing user location information to other entities. More specifically, 3GPP TS 24.229 describes different methods to include location information in IMS signaling, while enhanced user location reporting (indoor and outdoor) is being defined in 3GPP Release 14. It must be stated that many of the IMS emergency protocol specifications are mainly based on IETF ECRIT's RFCs adapted to the IMS procedures.

In the scope of ETSI, the more relevant groups are EMTEL and lately the Technical Committee on Network Technologies (NTECH). While the former is more related to user requirements and general specification of the emergency calling context, the latter works on the specifications of the interfaces surrounding the network architecture and protocol details to support location in emergency calling. In general, ETSI originally adopted the 3GPP's specifications involving IMS emergency architecture, but is currently further working on specific requirements due to mandate M/493.

NENA, back in 2000, already detected the need to develop, expand, and improve emergency communications in North America. NENA has been working since 2006 on its own research and development initiative to promote NG911, defining the system architecture and a transition plan that comprises costs, responsibilities, schedule, and benefits derived from the deployment of a nationwide evolved emergency network. This NG911 standardized system permits the transmission of both voice and non-voice multimedia data from various devices: wired, wireless, VoIP, sensors, and so on. NG911 utilizes an IP-based network technology to connect different emergency agencies and citizens to a system capable of offering a wide range of emergency services and access to advanced data. The so-called Emergency Services IP Network (ESInet) comprises a broadband packet-switched core network. The Functional Interface Standards for NG911 (i3) comprise a set of standards that define the core IP functionality of the NG911 system based on standards from IETF and other organizations (e.g., SIP for session control). Some examples of the functional entities included in the NENA i3 architecture are: the location information server (LIS), providing the location of the endpoints; the emergency call routing function (ECRF), which is based on the location of the call, provides the information to contact the corresponding PSAP and ESRP; and a SIP proxy server that routes the calls using location and policy rules.

It is also worth mentioning the efforts being performed within the ATIS Next Generation Emergency Services Subcommittee (NGES) of the Emergency Services Interconnection Forum (ESIF), which is working on closing the gap between the NENA i3 architecture and the 3GPP IMS standards for emergency calling through commercial mobile broadband networks.

In Europe, the production of the Long-Term Definition Document (LTD) by EENA [13] was the first comprehensive attempt to describe the technicalities and potentialities of a structured approach. Due to the relevance of this initiative for the NG112 ecosystem in the EU, it is further analyzed in the following section.

Almost at the same time (May 2011), the European Commission (EC) sent the M/493 standardization mandate to the European standards organizations, referring in particular to Article 26 of the Universal Service Directive 2002/22/EC on emergency services and the single European emergency call number as amended by Directive 2009/136/EC. In early 2012 ETSI created a work item to address the M/493 requirements taken over by the ETSI project End-to-End Network Architectures (E2NA). ETSI published in 2015 the "Functional architecture to support European requirements on emergency caller location determination and transport" ES 203 178 [14], where the requirements and functional architecture are described. The stage 3 document, "Protocol specifications for emergency service caller location determination and transport," is currently being drafted by the Technical NTECH working group.

In summary, it can be observed that the major standardization efforts concerning next generation citizen-to-PSAP communications are based on IP-based networks and SIP communications, with different flavors and architectural specifications.

EENA NG112 Long Term Definition

The EENA NG112 committee released the first public version of the Next Generation 112 Long Term Definition document in 2012. To ensure global interoperability, EENA reused existing experiences from other regions. In particular, the work from NENA was adapted to European PSAPs. The current NG112 LTD document, released in 2013, defines a long-term architecture for European emergency services and remains voluntarily close to the NENA i3 standard.

The NG112 LTD document describes the end state that has been reached after migration from legacy circuit-switched telephony, and the legacy E112 system built to support it, to an all-IP-based telephony system with a corresponding IP-based emergency services IP network.

The high-level NG112 LTD architecture and main functional elements (FEs) are illustrated in Fig. 1. Comprehensive message flows explaining how the emergency calls arrive at the appropriate PSAP are collected in [13].

Various originating networks and heterogeneous devices are able to trigger emergency communication toward the PSAPs, which are inter-connected through the NG112 ESInet. The different access networks considered include OTT VoIP providers, IMS/VoLTE operators, enterprise networks using unified communications (UC), as well as legacy public switched telephone networks (PSTNs). The standardization of emergency calling through these access networks is outside the scope of the NG112 LTD document. The NG112 LTD document focuses on clearly specifying a limited subset of protocol headers, messages, and procedures to be considered within the ESInet. In that way, public authorities will rely on a stable technological framework for incoming emergency communications. The different emergency communication details specific to the access technologies will be mapped to the ESInet protocol suite by the defined border controllers.

The main FEs included in the NG112 architecture are:

- ESRP, which is the SIP entity that makes decisions about the call routing by using location information.
- ECRF, which is the FE that provides the PSAP address to route an emergency call.
- The border control function (BCF), which is actually in charge of adapting the incoming emergency calls from the different access networks to the ESInet requirements. Additionally, the BCF acts as a border controller in both the signaling and media planes.
- The legacy network gateway (LNG), which acts as a border controller for legacy PSTN networks, converting the emergency calls to SIP.
- The location information server (LIS), which provides the user location functions in the scope of the ESInet.

The specific details of all the FEs and protocols involved in the different interfaces are clearly described in the NG112 LTD document [13].

Providing a converged network for different access networks, the NG112 ESInet supports several variations of end-to-end emergency communications with a series of objectives that need to be supported to ensure interoperability.

Connectivity: The NG112 system shall cover basic connectivity between FEs at the network and application levels. The application level refers to signaling and media transport protocols in use. This feature may require protocol translation to

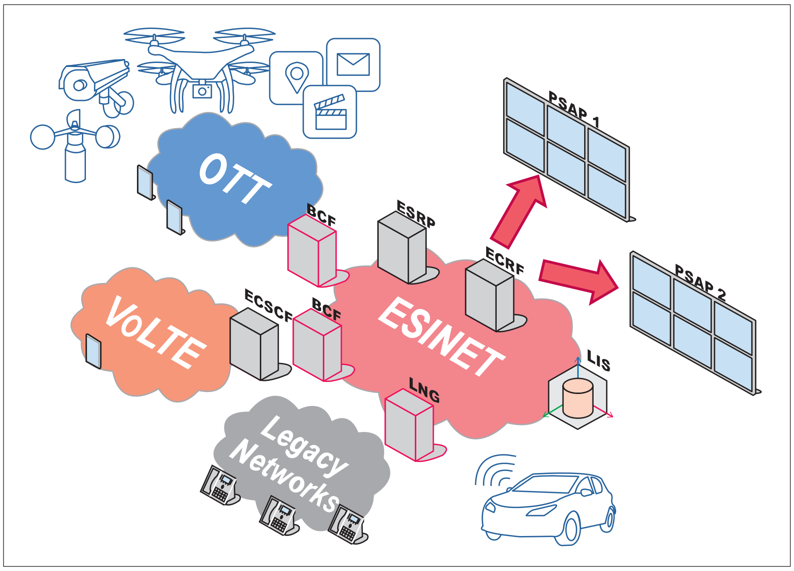

Figure 1. NG112 LTD high level architecture.

the ESInet SIP subset, including different security and privacy schemes.

Routing: The NG112 system shall cover variants of location-based emergency call routing. These include different methods to assess user location and how this information is delivered to emergency services. Location by value (LBV) and location by reference (LBR) are the two alternative ways supported for location conveyance. When required, the BCF shall adapt the incoming location information or include basic location information when not provided in the incoming emergency call.

Media: The NG112 system shall cover different media types in order to contact emergency services, including audio, video, text, messaging, and additional data. When needed, media transcoding shall be supported by the BCF.

Policy: The system shall cover variants of policy-based emergency call routing. A major strength of next generation emergency communication is advanced call routing features that allow retargeting emergency calls based on time of day, call volume, and queue or element state.

Quality: The NG112 system shall cover quality aspects with respect to emergency calling. These are, among others, successful call setup, call setup time, and media quality including the use of SIP preconditions.

Logging and Recording: The NG112 system shall cover logging and recording aspects with respect to emergency calling. These are, among others, successful media recording and event logging.

It must be noted that the scopes of the EENA NG112 and ETSI NTECH working groups are different. ETSI NTECH is focused on the standardization of a general solution for emergency caller location acquisition and transport, which is valid for heterogeneous deployment alternatives including current and next generation communications systems. While NENA and EENA architectures are based on the concept of a unified ESInet with a common SIP-based signaling suite, ETSI NTECH develops its solution taking into account the complex deployment context where each European

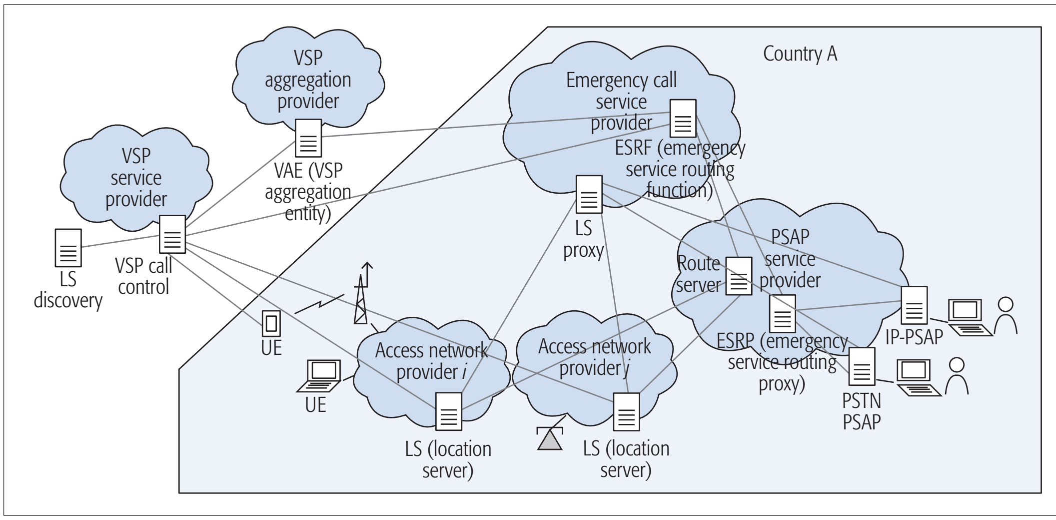

Figure 2. ETSI 203 178 architecture in response to M/493.

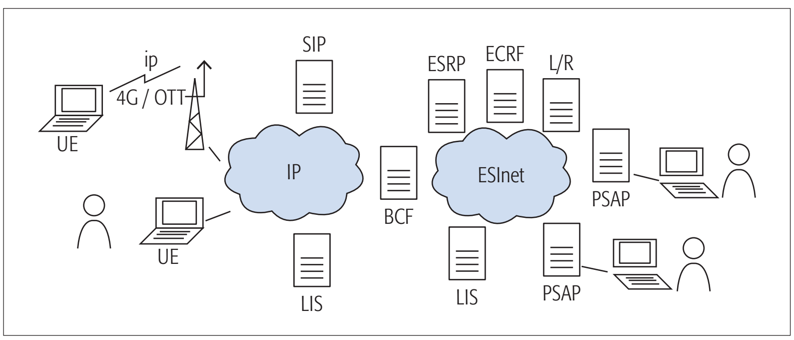

Figure 3. IP-based access to the NG112 ESInet.

PSAP may be served by one or more national network operators (Fig. 2). Due to national regulatory requirements, network-provided location information is used, and the voice service provider (VSP) gets the routing information from the location server (LS) based on a new extension to HTTP-enabled location delivery (HELD) [15].

European-Wide Interoperability Testing Initiative

In March 2016, ETSI and EENA co-organized the first emergency communications interoperability test in Europe, the first of a series of planned NG112 Emergency Services Plugtest events supported by the EC. Thirteen vendors participated in the tests, providing different FEs including different types of user equipments (UEs) and PSAPs, mobile apps, IP/IMS/UC/PSTN access networks and different ESInet elements such as BCF, LIS, ESRP, and ECRF. In addition to NG112 industry partners, seven external international observers attended the event in order to get first-hand experience from the current situation of the NG112 developments.

In order to validate the NG112 architecture and to evaluate the maturity of the different commercial solutions already available, a wide range of tests over different access networks were performed.

The main use cases and the preliminary outcomes from the first test event are provided in the following paragraphs.

IP-Based Access to the ESInet

This configuration is used for basic emergency call routing where calls originate from an IP network that connects to a PSAP, as shown in Fig. 3.

Any UE registers with the SIP Proxy, and the SIP Proxy forwards emergency calls to a configured BCF in the ESInet. This node comprises both signaling and media interfaces, and, as it remains in both the signaling and media path, events can be logged and media can be recorded.

These emergency calls are routed to the corresponding PSAP based on location information, which is retrieved from an LIS by either the UE or any capable ESInet FE. LTD references two different protocols to retrieve the location information from the LIS server: HELD or SIP using the presence event package. The location information is provided either by value or by reference. If LVB is provided, geodetic or civic location information is included in the call establishment signaling messages. When LVR is used, the reference added in the call establishment should be dereferenced in order to obtain the actual location information.

If the IP network does not include an LIS, the UE may be able to interface with the LIS deployed at the ESInet to provide location-related information.

However, the major issue confronted when accessing the ESInet from heterogeneous IP networks is the variety of IP/VoIP protocols used by different 112 applications which should be handled correctly by BCF. Currently, LTD defines the output of BCF toward the ESInet, but not all the different inputs.

Facing the lack of a harmonized European-wide approach for 112 applications, EENA promotes the clear definition of a Pan-European Mobile Emergency Application (PEMEA), which provides a functional architecture, and defines roles and responsibilities as well as data exchange formats and a general security model so that PSAPs can be sure of the veracity of the information being provided, and application users can be sure that information is not being misused. The additional caller information and the use of NG112 data formats foster the use of PEMEA toward the implementation of NG112 emergency services.

VoLTE-Based Access to the ESInet

This configuration is used for basic emergency call routing where calls originate from an IMS that connects to an ESInet, as shown in Fig. 4.

Any UE registers with the IMS (emergency bearer), and the IMS E-CSCF forwards emergency calls to a configured BCF, which acts as a border controller at signaling and media planes. The specific SIP messages and data formats included between the IMS E-CSCF and the ESInet BCF are not fully standardized, and they heavily depend on the security and trust associations between the two networks.

Location information is either provided by the IMS or retrieved from the LIS by any capable FE within the ESInet. The actual 3GPP standardized node for location conformance and PSAP selection is the LRF. Emergency calls are detected in the IMS network and forwarded to the E-CSCF node, which contacts the LRF to validate the location provided in the call establishment messages and to select the appropriate PSAP. However, it is not yet standardized in 3GPP how to forward emergency calls to non-IMS PSAPs. Another challenge to be faced is when location is provided by reference, since 3GPP has not defined how to access to LRF from external PSAPs (Le) if possible.

UC-Based Access to the ESInet

This configuration is used for basic emergency call routing where calls originate from a UC that connects to an ESInet, as shown in Fig. 5.

Any UE registers with the enterprise UC (soft switch), and the UC forwards emergency calls to a configured BCF. Again, the interface between the UC nodes and the ESInet BCF are not specified, and the BCF is required to understand the specific SIP flavor deployed in the enterprise to implement the signaling and media plane.

In this case, location information may or may not be provided by the UC nodes. Location information is either provided by the UC or retrieved from the LIS by any capable node within the ESInet.

PSTN-Based Access to the ESInet

This configuration is used for basic emergency call routing where emergency calls originate from a PSTN that connects via an LNG to an ESInet, as shown in Fig. 6.

Any UE-triggered circuit-switched emergency call terminates at the LNG, and the LNG is responsible for forwarding the call to a configured BCF based on SIP/IP communications. At the signaling and media planes, the LGN is split into a protocol interworking function (PIF) and a NG112 interwork function (NIF). Depending on the compliance of the NIF to the NG112 specifications, the role of the BCF may differ among different implementations.

Additionally, the LNG includes a location interwork function (LIF) that provides user location information to be included in the signaling plane messages or accessed by the ESInet nodes.

Conclusions

Mobile broadband technologies are quickly evolving, adding the possibility for end users to adopt enhanced multi-modal communications in their daily communications. However, the use of these novel multimedia capabilities is hardly incorporated into the overall management of emergency services due to the lack of standardized solutions. Public administrations generally require more solid communications frameworks with medium-/long-term stability.

In the last few years, different international standardization initiatives have been aimed at specifying a common playground for next generation emergency communications based on IP and SIP communications.

In Europe, the European Emergency Number Association released the NG112 Long Term Definition document, which is targeted to close the gap between the evolved needs of the end users and the public authorities in emergency management. The proposed NG112 architecture looks for the highest possible compatibility with international standards in order to foster interoperability between the involved players.

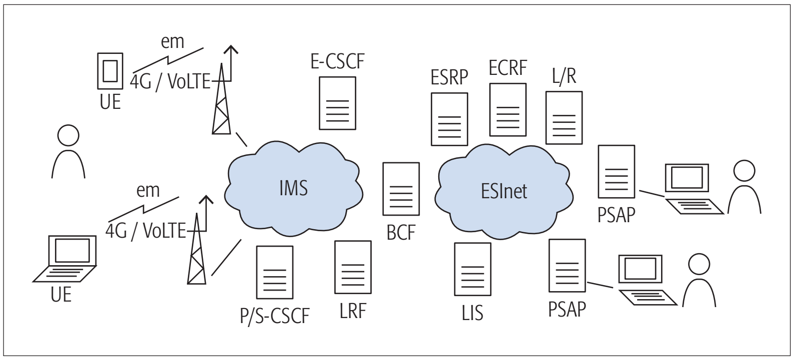

Figure 4. VoLTE-based access to the NG112 ESInet.

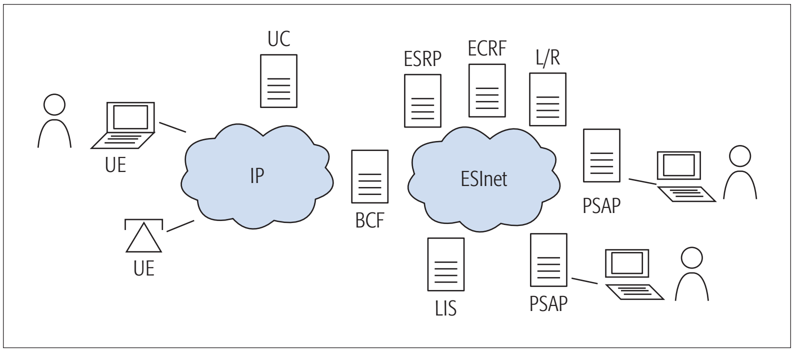

Figure 5. UC-based access to the NG112 ESInet.

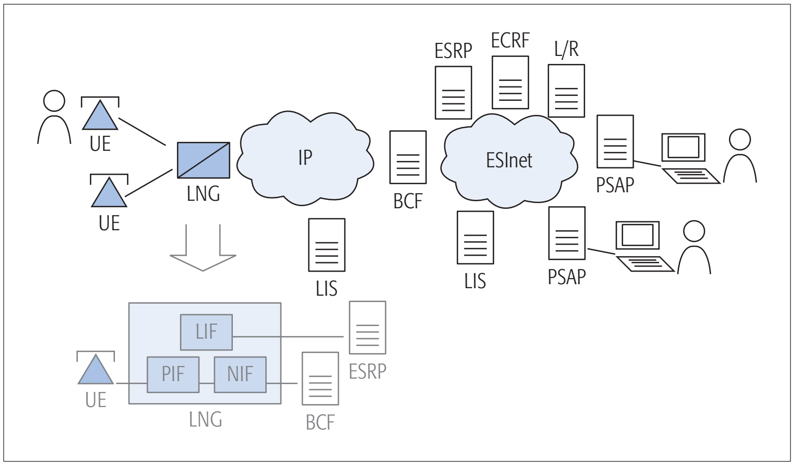

Figure 6. PSTN-based access to the NG112 ESInet.

The EENA NG112 LTD solution has now been passed to a first testing phase, where different interoperability events will be organized under the auspices of ETSI and with the support of the EC. As a result of these interoperability events, it is expected to validate the maturity of the architectural solution and the associated commercial products.

The EENA NG112 LTD solution has now passed to a first testing phase, where different interoperability events will be organized under the auspices of ETSI and with the support of the EC. As a result of these interoperability events, it is expected to validate the maturity of the architectural solution and the associated commercial products. Additionally, these events will provide valuable feedback to re-design and fine-tune the NG112 architecture.

As a step toward the adoption of the NG112 LTD document as a European-wide solution, and after the experimental validation of the proposal, it is expected that the document will be submitted for consideration as an ETSI standard. In this sense, the NG112 LTD solution needs to fulfill the specifications related to caller location procedures provided by the ETSI NTECH working group, with special focus on the ESInet-based deployment.

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Biographies

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Wolfgang Kampichler received his Ph.D. from the Vienna University of Technology in 2002. He currently contributes to standardization working groups in Public Safety and Air Traffic Management, and is a recognized expert on NG9-1-1/NG112 and a speaker at public and consumer events addressing topics related to VoIP and emergency services with Internet technology. He has also chaired and co-chaired the Planning Committee for NENA Industry Collaboration Events, and since 2014, he has also chaired the EENA Technical Committee.