Comparison of Architectures Supporting Emergency Services for VOIP Services

Kyesang Lee, *Member, KIMICS*

***Abstract*—Supporting emergency services (ES) for VOIP services in the Internet is a critical feature. It requires international standards since the VOIP services over the Internet has no national boundaries. Recently, standard development organizations such as the IETF, the IEEE 802 committee and the WiMAX Forum (WMF) have worked on this issue. In this paper, we review and compare ES architectures proposed by the IETF and the WMF, and summarize the IEEE 802's relevant activities.**

***Index Terms*— Emergency Services, IEEE 802, IETF, VOIP, WMF.**

I. INTRODUCTION

Recently, population using VOIP services has been growing fast. As of Nov. 2009, in Korea, over six million users subscribed to the VOIP services. People are expecting the same emergency service (ES) as PSTN's to be offered by the VOIP service providers (VSP)[1]. In U.S., providing the ES by the VSP is required by E911 regulations since 2005. In Korea, though not mandatory by law at this moment, the association of the VSPs offers 119 services voluntarily since the mid of 2008.

Provision of the ES has been traditionally a national matter. However, Internet services like VOIP does not confined to one country's boundary. Therefore, supporting the VOIP ES draws much interest from international standardization bodies. The IETF has worked on supporting multimedia ES in the Internet[2]. The IETF published a framework document and related protocols. These days, the Internet is accessed via various IEEE 802 networks such as 802.3 Ethernet, 802.11 WLAN and 802.16 WMAN. Supporting the ES in these 802 networks does not belong to the IETF's scope but to the IEEE 802's. Several working groups in the IEEE 802 have separately worked on the same issue. This year, a new working group was created to harmonize the works across the 802 level, and its work will complement the IETF work[3]. The WiMAX Forum (WMF) also has dealt with supporting the ES in mobile WiMAX networks. The WMF published a ES framework document and related protocols[4]. In this paper, we review and compare the IETF's and the WMF's architectures, and also summarize the IEEE 802's relevant activities.

Manuscript received September 2, 2010; revised September 15, 2010; accepted September 20, 2010.

Kyesang Lee is with the Department of Information and Communication Eng., Dong-eui University, Busan, 614-714, Korea (Email: ksl789@gmail.com)

II. IETF'S ES ARCHITECTURE FOR THE INTERNET

The IETF's ecrit WG[2] has established the ES architecture and related protocol standards. Fig. 1 shows network components described in the framework document[5] to support emergency calls from citizens to authorities. We follow the typical call establishment sequence to show how these components come into play.

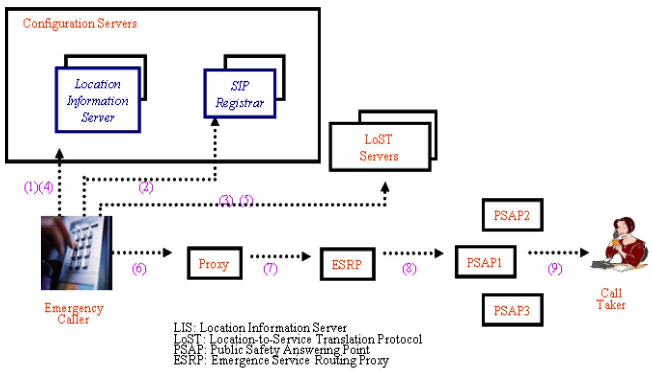

Fig. 1. Call components for supporting ES in the Internet

After booting, emergency caller's User Agent (UA) retrieve its location from the LIS (Location Information Server) via a location configuration protocol(1). The LIS belongs to either the IAP (Internet Access Provider) or the ISP (Internet Service Provider)[1]. The UA then registers itself with a SIP registrar(2). This will allow the PSAP to call back to caller after the completion of the emergency call. The UA contacts the LOST (Location to Service Translation) server to obtain local emergency dial string and the most appropriate PSAP-URI(3). The LOST server may be distributed over several providers. Some time later, the caller places an emergency call. The UA recognizes the dial. The UA updates its location(4) and PSAP-URI(5). The UA then creates and sends a SIP INVITE request message including an ES URN, caller's location and PSAP-URI to the outgoing SIP proxy(6). The SIP proxy and registrar belong to the VSP. The ES URN is included to indicate that this message is an emergency call request. The INVITE request is routed via outgoing SIP proxy to the ESRP (Emergency Services Routing Proxy) which is the first inbound SIP proxy of the emergency service domain(7). The request is then routed towards the PSAP designated by URI(8) and finally to the call taker(9). Call taker's UA returns OK response, along the reverse path, all the way back to the caller's UA.

In this IETF scenario, emergency call sessions established between the caller and the PSAP are assumed to comprise any multimedia media such as instant messaging and video as well as voice. PSAPs are assumed to be able to handle these Internet multimedia emergency calls natively.

Along with the architecture, the IETF published related protocols standards. However, these IETF works belong to the network layer and above. Emergency call handling at the data link layer has not been dealt with within the IETF. To complement this gap, IEEE 802 committee launched a new working group 802.23 in March 2010[3].

III. IEEE 802'S ES SUPPORT

Today, various IEEE 802[6] network technologies are widely used to allow Internet hosts to access its first router. The examples include 802.3 wired LAN, 802.11 wireless LAN and 802.16 wireless MAN. Commonly, packet frames traverse several networks of same or different 802 types before reaching the first router. Considering that the first router which corresponds to the point of network attachment may be far off from the host, there should be appropriate mechanisms to support ES over heterogeneous 802 networks. Functions of such ES mechanisms will be ES identification, location provision, call priority, callback information provision, and so on. To deal with this issue, a new working group 802.23 named as Emergency Services Working Group was formally formed when its PAR was approved in IEEE 802 in March 2010[3]. Prior to this new WG establishment, existing working groups such as 802.1, 802.11 and 802.16 had independently worked on their own solutions related with supporting the ES.

The IEEE 802.11 WG has raised the initial interests in the ES among IEEE 802 WGs. We will consider two aspects: ES access and providing location information. First, the aspect of ES access to 802.11 networks was dealt with by 802.11u[7]. The 11u standards allow access to the ES and include ES identification during network entry. Fig. 2 shows emergency network entry over 802.11 WLAN[8].

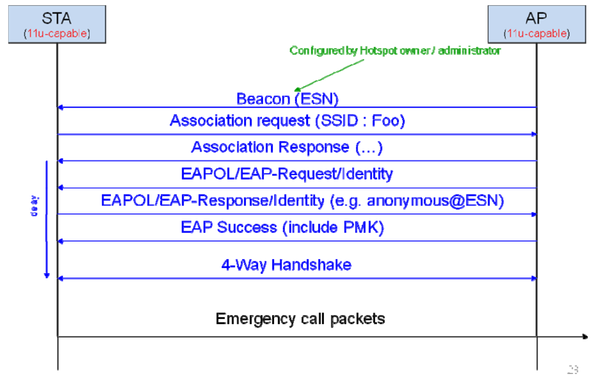

Fig. 2. IEEE 802.11u network entry for ES

The 802.11u covers the unauthenticated access case where user is not pre-authorized to access the network. This is a desirable service feature because emergency service should be a public service available to anyone. In the 11u scope, an admission control is assumed to be enforced. This may help implementing the prioritization of emergency call setup and possible service preemption. To indicate emergency call initiation, it is proposed that a new 'Expedited Bandwidth Request' element is used.

Second, the aspect of providing location information was dealt with within 802.11v[9]. The 11v was originally created for a wireless network management protocol since the SNMP is not appropriate in 802.11 wireless environments. A location service is one among 20 services which the 11v can provide. Procedures and L2 frames were defined for location services such as location configuration request/reply, location track notification and radio measurement request/report.

The IEEE 802.1ab group has developed the LLDP (Link Layer Discovery Protocol)[8]. LLDP supports network topology discovery and exchange of device configuration and capabilities. Later, LLDP was extended to LLDP-MED (Media Endpoint Discovery) to enhance features of the LLDP. The auto-discovery feature of LAN policies such as VLAN, L2 priority and Diffserv settings enable plug and play networking. Device location discovery feature allows creation of databases and can be utilized in supporting E911 in the case of VOIP services. LLDP-MED was formally approved and published as the ANSI/TIA standard in 2006.

The IEEE 802.16 working group has published 802.16-2009 document where EAP and TDOA were mentioned briefly. Recent work of 802.16m includes capabilities for location service. More importantly, the WMF published recent release 1.5 documents in 2009 which contain the ES support based on IEEE 802.16e. In the next section, we will describe the architecture supporting ES in mobile WiMAX networks proposed in the WMF's 1.5 release.

The newly formed working group 802.23 aims a single uniform standard for supporting the ES across 802, without regard to which 802 technologies are in use. The 802.23 WG will harmonize and provide a common interface to L3, so that all IP applications should not need to know which 802 MAC is currently used. This will be likely to be envisioned as a shim layer, a sublayer between MAC and upper layers. The 802.23 intends to provide what the IETF ecrit WG needs.

IV. WMF'S ES ARCHITECTURE FOR MOBILE WIMAX NETWORKS

WMF's Network Working Group has published architecture and related protocols for supporting ES in mobile WiMAX VOIP networks, as a part of release 1.5 document[4]. In this section, we briefly describe network reference model and emergency call establishment procedure.

A. Network Reference Model

Fig. 3 shows WMF's network reference model for supporting ES as in [4]. The figure depicts that WiMAX bearer network services are provided by the NAP (Network Access Provider) and the NSP (Network Service Provider), and also that VOIP services are provided over WiMAX by a VSP that can be either be part of an NSP or can be a separate entity. The WMF intentionally splits general aspects needed to support ES in WiMAX networks and specific aspects needed to support ES in particular VOIP technology into separate documents. Here, we summarize the general building blocks needed commonly in WiMAX networks without regard to specific VOIP technology as described in [4].

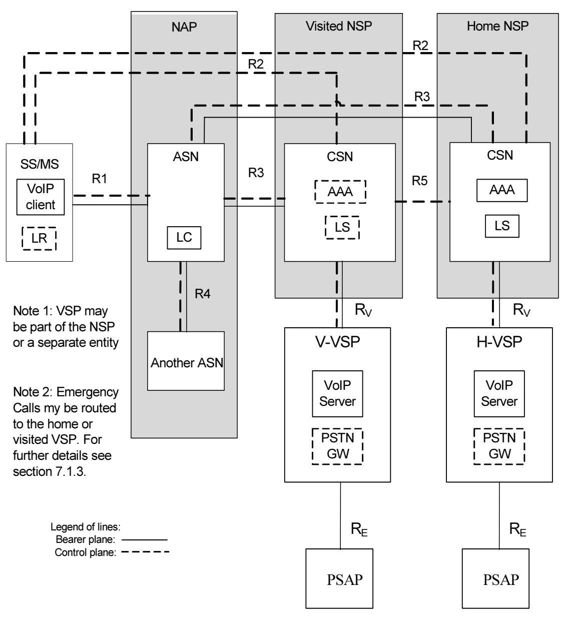

Fig. 3. Networks reference model for WiMAX based emergency services

The VOIP server may be ES enabled. If enabled, the VOIP server should support full ES capabilities and protocols to VOIP client. The architecture support communication between a VSP's VOIP server and the PSAP over both VOIP protocols or PSTN based voice. The PSTN gateway allows a connection to legacy PSAPs. The gateway is VOIP application specific. To cover the roaming cases, the figure includes visited NSP and VSP.

Before we examine the ES call establishment in the next subsection, we should note various building blocks related with location capabilities, since providing the location information of the mobile station (MS) is essential to support the ES. The location server (LS) in the CSN determines location information with the help of the location controller (LC) and the MS, and stores it. Later, location information is requested and used not only to route the ES call to the most appropriate PSAP but also to dispatch emergency vehicles from PSAPs. The LC in the ASN coordinates location measurements and report measurement data to the LS. The location requestor (LR) requests location information to the LS. The LR may be located in MS, in VSP or in PSAP though not shown explicitly in the figure. LR in MS, which is optional, obtains its location information from the LS and provides it to ES-enabled VOIP client which in turn relays it to the ES-enabled VOIP server. The VOIP server may use it to determine the responsible PSAP. Alternatively, the LR in the VOIP server may request the location information directly from the LS. The LR in PSAP requests the location information to the LS and use it to dispatch emergency vehicles to the site. The LR may be located in the normal LBS application and requests the location to the LS. However, this request should be differentiated from one originated in the emergency cases.

B. Emergency Call Establishment Procedure

Fig. 4 shows network entry procedure for supporting ES in WiMAX networks[4]. Here, we consider only the non-roaming case for simplicity. We also assume that the NSP acts as the VSP.

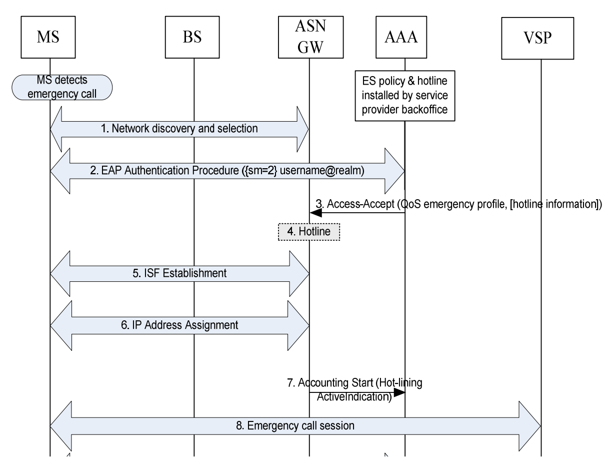

Fig. 4. WiMAX network entry for ES call

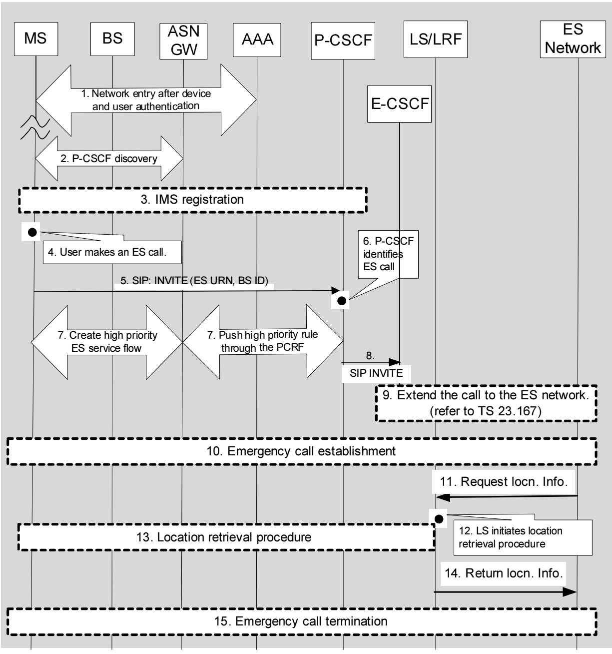

Fig. 5. IMS based ES call establishment procedure

The MS is assumed to be able to recognize emergency call and is not attached to the network initially before the ES call. On detecting emergency call, the MS tries to discover and select a WiMAX network(1). This is performed through a normal procedure. During the authentication procedure, the MS indicates that this is an emergency call by appending a particular network access identifier, {sm=2}(2).

The AAA server authorizes the ES call based on its policy and sends Access-Accept message containing QOS emergency profile and possibly hotline information(3). According to deployment options, a provisioned hotline may be used to allow the MS to be connected to the VSP(4). Based on the QOS profile, the ASN sets up an initial service flow for the MS(5). The IP address is then configured through either DHCP or MIP protocol(6). The ASN sends an accounting start message to the AAA(7). Now, the WiMAX network entry of the MS completes. Over the WiMAX network, the MS starts to establish an emergency call session to the VSP(8). Details of this step is dependent on the VOIP technology used in the VSP. For example, an ES procedure for the case of IMS-based VOIP is specified in the separate document[10].

Fig. 5 shows the IMS-based emergency session establishment procedure as in [10]. The MS enters a WiMAX network(1). This step corresponds to steps (1) ~ (7) of Fig. 4. First of all, the MS discovers the P-CSCF(2) and registers itself to the IMS registrar(3). When the user makes an ES call, a SIP INVITE message is created and sent to the P-CSCF(5). ES URN indicates that this is an ES call. The P-CSCF identifies the ES call(6) and relay this messge to the E-CSCF. The E-CSCF refers to the LRF with BS-ID and obtains the routing number. E-CSCF extends the call to the ES network. This completes the ES call setup to PSAP. Later, for dispatching emergency personnel, PSAP requests the MS's location information to the LS(11). The LS initiates location retrieval procedure and returns it to the PSAP(12~14).

V. CONCLUDING REMARKS

In this paper, we reviewed the IETF's and the WMF's architectures for supporting the ES. There are many similarities between them but also some differences can be found. Table 1 compares two architectures. The IETF work has been focused on the layer 3 and above, and will be complemented by the IEEE 802's new WG's work. In the mean time, the WMF developed the architecture and related protocols for supporting ES in WiMAX networks for VOIP.

TABLE I
COMPARISON OF ES ARCHITECTURES

	IETF	WMF
Layers	L3 and above	L2, L3 and above
Lower layer support	Across all 802 (802.23)	802.16 only
VOIP protocol	Mainly SIP	Mainly IMS
Location determination	LIS (or LCS)	LS, LC, LA
Mapping routing information	LOST	LRF
Retrieval of routing info	End point	E-CSCF
VSP outgoing proxy	Outgoing SIP proxy	P-CSCF, E-CSCF
Providers	ISP/IAP, ASP(VSP)	NAP/NSP, ASP(VSP)

ACKNOWLEDGMENT

This work was supported by Dong-eui University Grant (2010AA173).

REFERENCES

[1] H. Tschofenig, H. Schulzrinne, "Emergency Services Architecture Overview: Sharing Responsibilities," *draft-tschofenig-ecrit-architecture-overview-00.txt,* Jul. 2007
[2] IETF's ecrit WG Home Page [Online]. Available: http://datatracker.ietf.org/wg/ecrit/charter/
[3] IEEE 802.23 WG Home Page [Online]. Available: http://www.ieee802.org/23/
[4] WMF NWG, "WiMAX Forum Network Architecture - Architecture, Detailed Protocols and Procedures: Emergency Services Support," draft-T33-102-R015v02-C, 2009.4.
[5] B. Rosen, H. Schulzrinne, J. Polk, and A. Newton, "Framework for Emergency Calling using Internet Multimedia," *draft-ietf-ecrit-framework-10*, Jul. 2009.

[6] IEEE 802.23 WG Home Page [Online]. Available: http://www.ieee802.org/
[7] IEEE 802.11u TG Home Page [Online]. Available: http://www.ieee802.org/11/Reports/tgu_update.htm
[8] S. McCann and et. al., "Emergency Services for 802," [Online]. Available: http://www.ieee802.org/802_tutorials/07-March/
[9] IEEE 802.11v TG Home Page [Online]. Available: http://www.ieee802.org/11/Reports/tgv_update.htm
[10] WiMAX Forum, "Architecture, detailed Protocols and Procedures, IP Multimedia Subsystem (IMS) Interworking," T33-101-R015v02, Release 1.5. 2009.1.

Kyesang Lee was born in Seoul, Korea, in 1956. He received the BS and the MS degrees from the Seoul National University, Seoul, Korea, in 1979 and 1981, respectively. He received his PhD degree in EE Engineering from the KAIST, Daejeon, Korea, in 1997. His research interests include Internet protocols and their performances. He is currently with the Information and Communication Engineering Dept. of the Dong-eui University.