VoLTE IMS GSMA

Technology Reports

Overview of GSMA VoLTE Profile

It was agreed in the GSMA in February 2010 that voice services over LTE (VoLTE) shall use the IMS platform standardized by the 3GPP with a view to maximizing international interoperability. This article describes the background behind the adoption of VoLTE using IMS, the contents of the VoLTE profile which is a technical specification drafted by the GSMA for VoLTE implementation and, the technical details of IMS registration and voice call origination procedures which form the basics of VoLTE.

Core Network Development Department

Itsuma Tanaka

Takashi Koshimizu

1. Introduction

Since both LTE and Evolved Packet Core (EPC, which is a core network[*1] accommodating LTE) are All-IP networks for offering high-speed mobile broadband and multimedia services [1][2], it is inevitable that voice services provided over LTE — which is the subject of this article — adopt an IP-based system.

The GSM Association (GSMA), an industry organization, has conducted studies on Voice over LTE (VoLTE) using the IP Multimedia Subsystem (IMS)[*2] platform - IMS being a system standardized by the 3GPP for IP-based multimedia services - as a means to provide voice services over LTE, and a document called "VoLTE Profile" has been drawn up which specifies a set of minimum required functions [3].

This article describes the background to the creation of the VoLTE Profile, its specifications and the basic procedures VoLTE follows.

2. Background

When the specifications of LTE were first completed in 3GPP Release 8, there were several systems existing to provide conventional circuit switched voice and SMS services (that have been offered in 3G radio access) over LTE which does not have circuit switched domain[*3] Those included the 3GPP-standardized Circuit Switched Fallback (CSFB)[*4] [4], the IMS [5] and the non-internationally standardized Voice over LTE via Generic Access (VoLGA)[*5] [6].

Due to the existence of these multiple systems, there were strong concerns that unless service operators adopt the same system, there would be adverse impact on the service qualities including interoperability and international roaming. It was also feared that the adoption of different systems would not allow the equipment vendors to take advantage of scale so that equipment

*1 **Core network**: A network comprising switching equipment, subscriber information management equipment, etc. A mobile terminal communicates with the core network via a radio access network.

*2 **IMS**: A communication system to realize multimedia communications by consolidating communication services offered by circuit switching, using IP technologies such as SIP.

investments by the network operators would increase.

In order to solve these issues it was necessary for the industry to adopt a single system for voice, and the GSMA undertook from 2009 to 2010 to draft a service migration plan for VoLTE (**Figure 1**).

The VoLTE envisaged by the GSMA, while accepting systems using CSFB and VoLGA as transitional steps, sets out the system using IMS as the final goal, and agreement has been reached on aiming at this final goal.

Against such a background, the VoLTE Profile is the technical specifications drafted by the GSMA to implement VoLTE using IMS.

3. Overview of VoLTE Profile

3.1 Scope of VoLTE Profile Specifications

The VoLTE Profile, as shown in the "VoLTE network configuration" in **Figure 2**, specifies the minimum mandatory functional set out of the optional functions for the interface between the terminal and the core network (User-Network Interface (UNI)) in the IMS specified by the 3GPP. In particular, there are specifications each of the basic functions/optional services provided by the IMS, its voice media such as codec, and the various LTE/EPC capabilities.

The VoLTE Profile has been specified based on 3GPP Release 8 but, in addition, the functions standardized in Releases 9 and 10 have also been partly adopted.

It should be noted, however, that the specifications for the Network-Network Interface (NNI) — an interface relevant to roaming and interoperability — are outside the scope of the VoLTE Profile although they are being studied in other specifications.

3.2 Network Configuration and Basic Functions of VoLTE

As shown in fig. 2, VoLTE encompasses three areas: terminals, the LTE/EPC and the IMS. The LTE/EPC consists of five modules for mobility

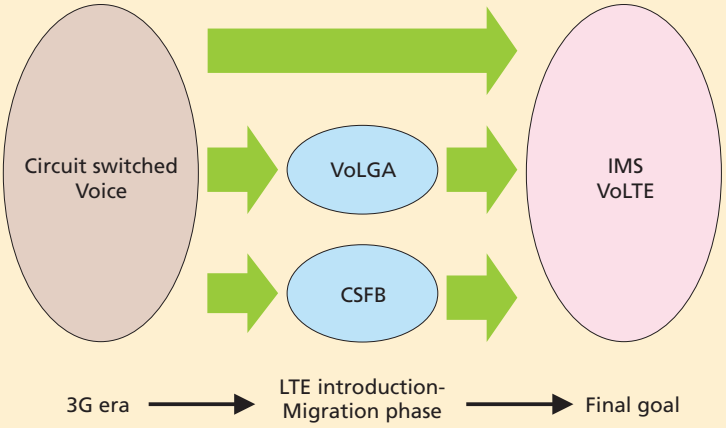

Figure 1 Voice service migration

*3 **Circuit switched domain**: A functional block of a network offering circuit switched services.
*4 **CSFB**: A function to enable voice services provided in the circuit switched domain by switching to W-CDMA or GSM systems when originating/terminating a voice call while camped on an LTE network.
*5 **VoLGA**: A technology to offer virtual circuit switched voice services by accommodating the LTE radio in circuit switched networks.

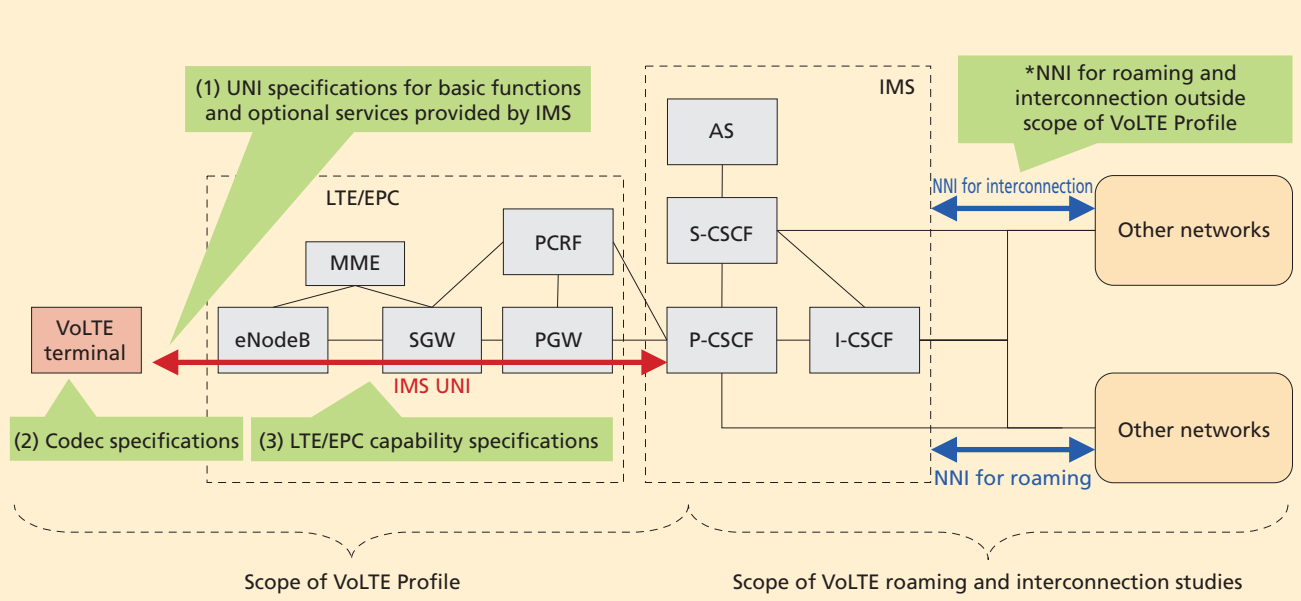

Figure 2 VoLTE network configuration

and the QoS control: the eNodeB[*6], the Mobility Management Entity (MME)[*7], the Serving Gateway (SGW)[*8], the Packet Data Network Gateway (PGW)[*9] and the Policy and Charging Rules Function (PCRF)[*10]. The IMS is comprised of four modules for voice session control[*11]: the Proxy Call/Session Control Function (P-CSCF)[*12], the Serving Call/Session Control Function (S-CSCF)[*13], the Interrogating Call/Session Control Function (I-CSCF)[*14] and the Application Server (AS).

Among the basic functions of the IMS, there are the IMS registration control for setting up transmission paths between the terminal and the IMS equipment, security functions for user authentication and the basic voice call origination/termination function. These functions are controlled by Session Initiation Protocol (SIP)[*15] and are described in detail in Chapter 4.

3.3 IMS Supplementary Services

Terminals and networks conforming to the VoLTE Profile must be equipped with the following three functions: call forwarding, caller ID presentation/restriction, call-waiting/holding and multi-party conference call provided by the IMS; operator determined barring control by network operators; and, SMS over IP, so as to inherit the supplementary services which have been provided in current circuit switched networks.

In enabling the users to start/stop supplementary services, Unstructured Supplementary Service Data (USSD)[*16] has been conventionally used between the terminal and the core network. Howerer, in VoLTE, XML Configuration Access Protocol (XCAP)[*17] defined by the Internet Engineering Task Force (IETF)[*18] and the 3GPP is used.

3.4 Voice Codec

Adaptive Multi-Rate Narrow Band (AMR-NB)[*19] that is used in the current

*6 **eNodeB**: A node accommodating base station and radio link control functions in the LTE radio access system.
*7 **MME**: A logical node accommodating the eNodeB and providing mobility management.
*8 **SGW**: A packet gateway in the camped-on network accommodating 3GPP access systems.
*9 **PGW**: A gateway serving as the interface with the IMS platform and performing IP address allocation, packet transfer to the SGW, etc.
*10 **PCRF**: A logical node for controlling user data QoS and charging.
*11 **Session control**: A function to manage end-to-end type IP communications by the network.
*12 **P-CSCF**: A server for relaying SIP (see*15) messages located at the interface point to the EPC. It not only relays SIP messages but also has the role of triggering QoS control in coordination with the EPC.
*13 **S-CSCF**: A SIP (see*15) server performing terminal session control and user authentication.
*14 **I-CSCF**: A SIP (see*15) gateway server that a remote network first connects to when interconnecting networks or roaming. It has the roles of identifying the S-CSCF and relaying messages.
*15 **SIP**: A standardized protocol in the IMS application services that performs session initiation, modification and termination necessary for exchanging voice, video, text, etc. among multiple clients.
*16 **USSD**: A protocol used when setting various parameters in circuit switched optional services.
*17 **XCAP**: A protocol used when setting various parameters in IMS optional services.

3G circuit switched voice services has been specified as the mandatory voice codec in VoLTE. In addition, AMR Wide Band (AMR-WB)[*20] voice codec having a better quality can also be used as an option. In transmitting the voice media, Real Time Protocol (RTP)[*21] and RTP Control Protocol (RTCP)[*22] are used over User Datagram Protocol (UDP)[*23]/IP.

When initiating a voice call, communicating terminals exchange capability information between each other and a common codec installed on both terminals is selected as the codec to be used.

Tone signaling using Dual-Tone Multiple Frequency (DTMF)[*24] is also specified as mandatory for the terminals and networks.

3.5 Capabilities Relevant to LTE/EPC

By connecting to an Access Point Name (APN)[*25] for VoLTE immediately after the power is switched on, a terminal is set up ready to originate/terminate a voice call at any moment. The APN for VoLTE uses a globally shared format and its bearer is completely separated from other data services such as the Internet.

One of the reasons why such a specification to separate the APN was agreed to is because it was considered necessary to enable emergency calls to the local emergency agencies via the camped-on network even when the terminal is roaming.

The LTE/EPC realizes a high level of voice quality in VoLTE by guaranteeing the necessary bandwidth for communication through an appropriate QoS control by the LTE/EPC layer.

In transmitting the SIP and XCAP signals, which are the control signals for VoLTE, a QoS specified exclusively for SIP is used (QCI[*26]=5), and in transmitting voice media, a QoS with guaranteed bandwidth and a minimum transmission delay is used (QCI=1).

Therefore, in the LTE/EPC, two bearers are required, one for the SIP signaling and another for the voice media.

4. Overview of VoLTE Basic Control

4.1 Procedures from Power Switch-on to IMS Registration

Figure 3 shows the control procedures from the moment of the VoLTE terminal's power is switched on until it reaches a status where voice communication becomes possible.

Before voice communication becomes possible, following two procedural steps need to be performed, namely LTE Attach[*27] and IMS registration.

As the first step, when the power is switched on (fig. 3(1)), the terminal sends an Attach request message to the MME (fig. 3(2)). A destination APN is not sent from the terminal at this moment.

The MME that has received the Attach request conducts location registration together with the Home Subscriber Server (HSS)[*28] (fig. 3 (3)), and downloads the subscriber profile[*29] containing the APN for VoLTE.

The MME decides the destination PGW based on the VoLTE APN information that has been obtained and makes a request to set up a bearer between the SGW and the PGW (fig. 3 (4)).

Within its bearer setup procedure, the PGW assigns a terminal IP address and at the same time identifies the address of the P-CSCF the terminal will be connecting to (fig. 3(5)). The PGW sets this address in the Protocol Configuration Option (PCO) — an information element used for direct communication between the PGW and the terminal — and passes it to the MME via the SGW (fig. 3 (6)). The MME sends to the terminal, by way of the Attach completion message, the PCO with the P-CSCF address, thereby completing the Attach procedure to the LTE/EPC (fig. 3 (7)).

As the next step, after the Attach procedure is finished, the terminal will

*18 **IETF**: A standardization organization that develops and promotes standards for Internet technology. Technical specifications formulated in this body are published as Request For Comment (RFCs).
*19 **AMR-NB**: One of the voice codecs used in, for example, telephony services.
*20 **AMR-WB**: A voice codec used in, for example, telephony services, having a better quality than that of AMR-NB.
*21 **RTP**: A protocol standardized by the IETF for delivering voice, video and other media in real time.
*22 **RTCP**: A communication protocol for tasks such as controlling transmission rates by exchanging information on data reception status between the device and streaming servers. Used in combination with RTP.
*23 **UDP**: An upper-layer protocol above IP, normally used in the Internet. Unlike in the case of TCP, functions such as confirmation of the establishment of communication between the server and the terminal or the re-transmission of dropped or lost data are omitted.
*24 **DTMF**: A method to send audio tones uniquely allocated to each button of a telephone set. Alternatively called tone-signals or push-tones.
*25 **APN**: The name of a network connection point used by users to connect to the network when performing data communication.
*26 **QCI**: QoS classes specified by the 3GPP for bearers in the LTE/EPC. There are values of 1 to 9, and the smaller the value is the more the bandwidth is guaranteed and the smaller the transmission delay.

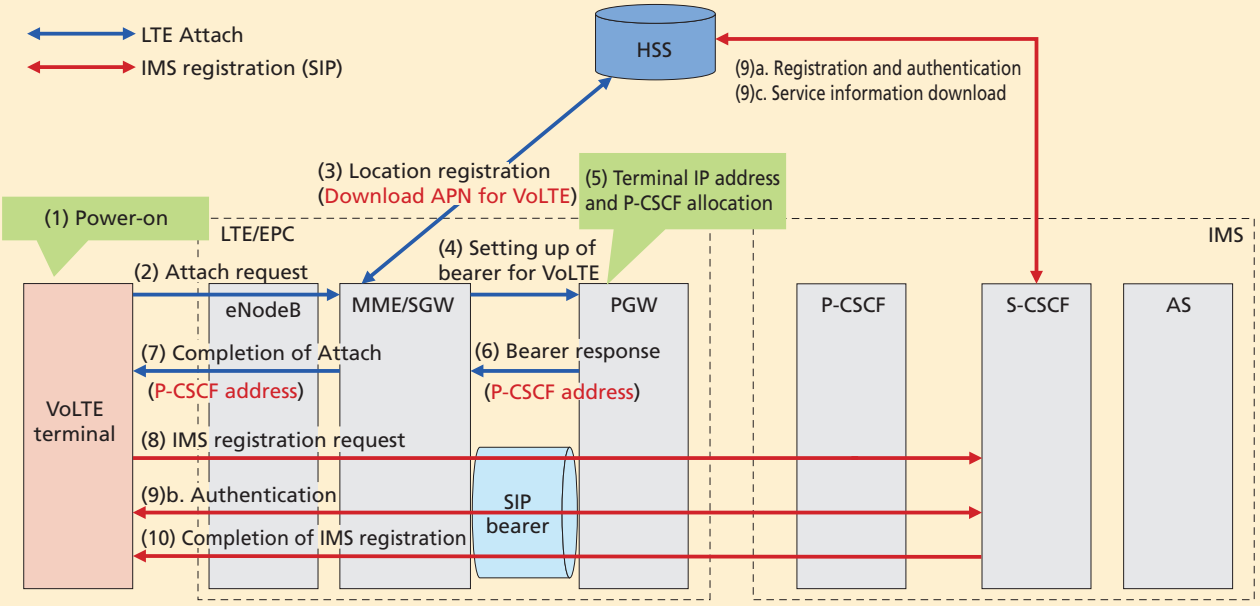

Figure 3 Control procedures from VoLTE terminal power switch-on to IMS registration

start the IMS registration process (fig. 3 (8)). In this process, the terminal must set the International Mobile Equipment Identifier (IMEI) for the identification of the terminal, and the IMS Communication Service Identifier (ICSI) value declaring an IMS voice service so that these pieces of information can be used for service control, charging and other purposes.

Furthermore, because LTE has high transmission efficiencies, it is specified that Signaling Compression (SigComp), a technology for compressing SIP signals, is not to be used.

When the IMS registration request arrives from the terminal via the P-CSCF, the S-CSCF performs registration procedures with the HSS (fig. 3 (9)a). At this point in time, the S-CSCF acquires the information necessary for user authentication and proceeds with the authentication procedure for the terminal (fig. 3 (9)b). After the authentication has succeeded, the S-CSCF downloads (fig. 3 (9)c) and stores the service control information of the user from the HSS. Then, the S-CSCF notifies the terminal that the registration is completed (fig. 3 (10)) thereby finishing the IMS registration process.

4.2 Voice Call Origination

Next, the origination of a VoLTE call is described by means of **Figure 4**. In the VoLTE profile, a scheme called the "precondition" is adopted whereby a session is established after bearers for the voice media for both originating and terminating directions are set up.

When the user initiates a voice call (fig. 4 (1)), the INVITE message sent by the terminal travels to the terminating terminal via the P-CSCF, the S-CSCF and the AS (fig. 4 (2)). The INVITE message is set with, for example, the identifiers of the originating/terminating terminals, the declaration for

*27 **Attach**: A procedure to register a terminal on the network when, for example, its power is switched on.
*28 **HSS**: The subscriber information database in 3GPP mobile communication networks. Manages authentication and location information.
*29 **Subscriber profile**: Information necessary for service management such as contract, user settings and camp-on.

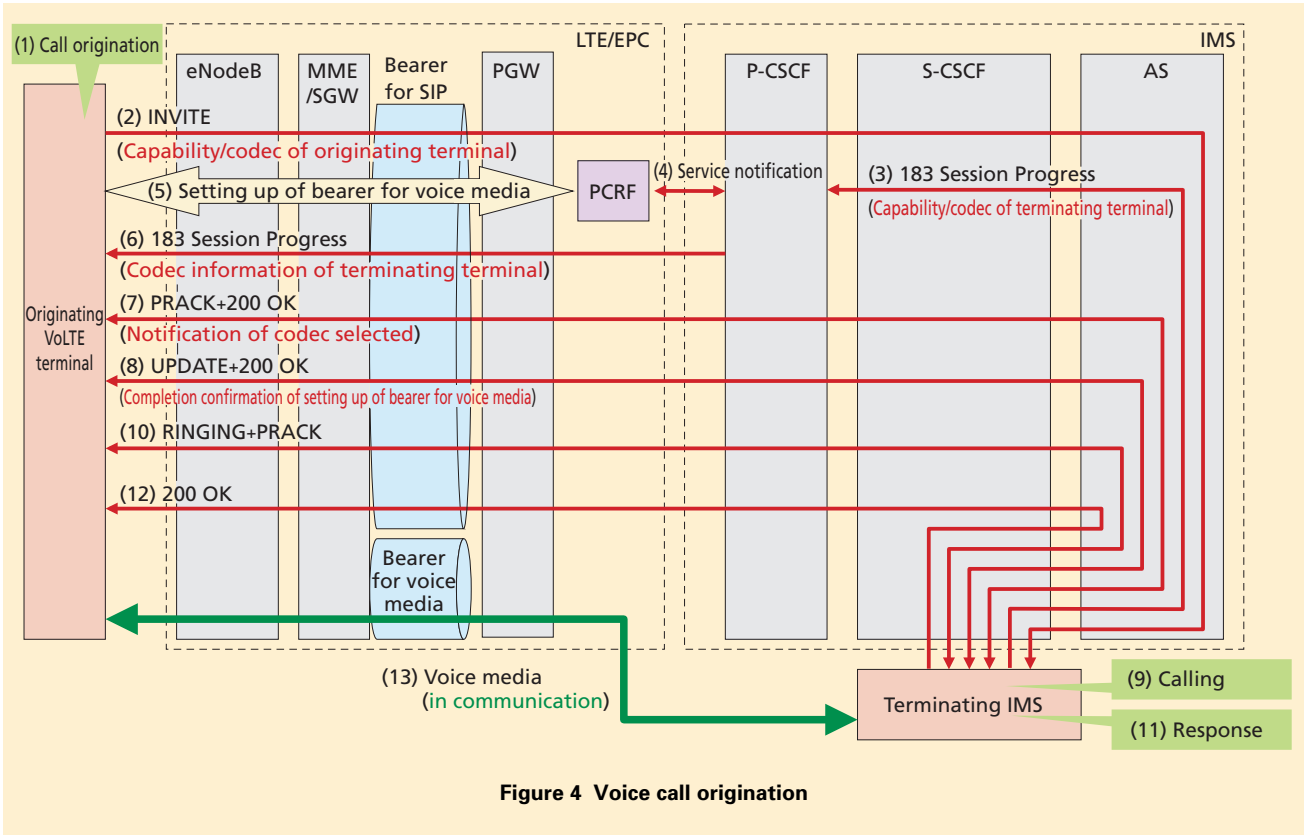

Figure 4 Voice call origination

using the "precondition," and the codec capability of the originating terminal.

The terminating network responds with a "183 Session Progress" message (fig. 4 (3)). The "183 Session Progress" message is set with information such as the codecs on the terminating terminal. When this is received by the P-CSCF, it commands the PCRF to set up a dedicated bearer for voice media (fig. 4 (4)). The PCRF, in coordination with other devices in the EPC such as the PGW and the SGW, sets up the bearer for the voice transmission with the appropriate QoS (fig. 4 (5)).

The P-CSCF at the same time sends a "183 Session Progress"message to the originating terminal. Upon receipt of the message (fig. 4 (6)), the originating terminal compares the capability of the terminating terminal with that of its own and determines the codec to be used. Then, the originating terminal notifies the terminating terminal using the PRACK message the codec that has been selected, and "200 OK" message is received from the terminating terminal (fig. 4 (7)).

Following this, when both terminals have confirmed the set up of the bearer for the voice transmission with the QoS based on the UPDATE message from the originating terminal and the "200 OK"message, which has been sent as the response to the UPDATE massage (fig. 4 (8)), the terminating terminal starts playing ringtones to notify the incoming call to the user (fig. 4 (9) (10)).

When the user on the terminating side responds (fig. 4 (11)), a "200 OK" message is received by the originating

terminal, and the session is established (fig. 4 (12)), thereby starting the actual voice communication (fig. 4 (12)).

5. Conclusion

This article has described the background to VoLTE using IMS specified by the GSMA and to the VoLTE Profile, network configuration, minimum mandatory functions and the basic VoLTE call control flow.

Now that the specification of the VoLTE Profile is completed (as of the summer of 2010) the GSMA is currently working on VoLTE international roaming and interoperability systems. NTT DOCOMO intends to actively contribute to these studies.

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