

Further Development of LTE/LTE-Advanced – LTE Release 10/11 Standardization Trends –

VoLTE Roaming and Interconnection Standard Technology

In 3GPP Release 11, the VoLTE roaming and interconnection architecture was standardized in cooperation with the GSMA Association. The new architecture is able to implement voice call charging in the same way as circuit-switched voice roaming and interconnection models by routing both C-Plane messages and voice data on the same path. This was not possible with the earlier VoLTE roaming and interconnection architecture.

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1. Introduction

Voice over LTE (VoLTE) is a technology for providing existing voice and SMS services on LTE, which does not have a circuit-switched domain^{*1}[1]. It is implemented using the IP Multimedia Subsystem (IMS)^{*2}, which is a standard 3GPP technology for IP-based multimedia services.

3GPP Release 11 (“Rel. 11”) specifies VoLTE roaming and interconnection architecture, created in collaboration with the GSM Association (GSMA)^{*3}.

Rel. 11 adds standardized necessary functions for implementing roaming and interconnection in a manner similar to existing circuit-switched voice on top

of the existing VoLTE roaming and interconnection architecture.

This article compares existing circuit-switched voice roaming and interconnection models with the earlier VoLTE roaming and interconnection models, describe issues that needed to be resolved by 3GPP and GSMA. Then it is described the new VoLTE roaming and interconnection architectures standardized to resolve these issues.

2. Existing Circuit-Switched Voice Roaming Model

Existing circuit-switched voice roaming and interconnection apply a charging model called “cascaded charging”[2]. This model is described below.

Figure 1 shows the circuit-switched voice interconnection model, with Subscriber (a), using Operator A, placing a call to Subscriber (b), who uses Operator B

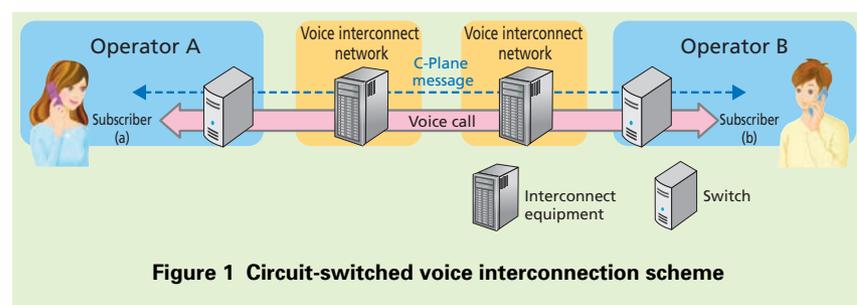


Figure 1 Circuit-switched voice interconnection scheme

B. There are also voice interconnect networks between the two operators.

Charging for voice communication uses information in the Control Plane (C-Plane) message, and parties are billed, in-turn, from the call receiver's operator (Operator B), to the voice interconnect network, and the caller's operator (Operator A).

An example of roaming with the circuit-switched roaming scheme is shown in **Figure 2**. In this model, Subscriber (a1) from Operator A has a roaming connection to Operator C in another country. In this case, for example, Subscriber (a1) then calls Subscriber (a2) from Operator A, or a subscriber on another operator. Between Operators A and C, there are two types of interconnect network, one for voice and one for signaling. Voice charging

in this case is done between operators and voice interconnect networks in order, as with voice interconnection. Combining these two cases yields the circuit-switched voice roaming and interconnection scheme as shown in **Figure 3**. In this case, Subscriber (a) from Operator A is roaming to Operator C, and Subscriber (b) from Operator B is roaming to Operator D.

Subscriber (a) pays for voice communication on the segment including Operators C and B, while Subscriber (b) pays for the receiving segment, between Operators B and D.

Calculation of charges for each operator and the voice interconnect network is done, as in the cases in Fig. 1 and 2, according to the information in the C-Plane messages used to set up the voice call, and the duration of the call.

3. Existing VoLTE Roaming Model

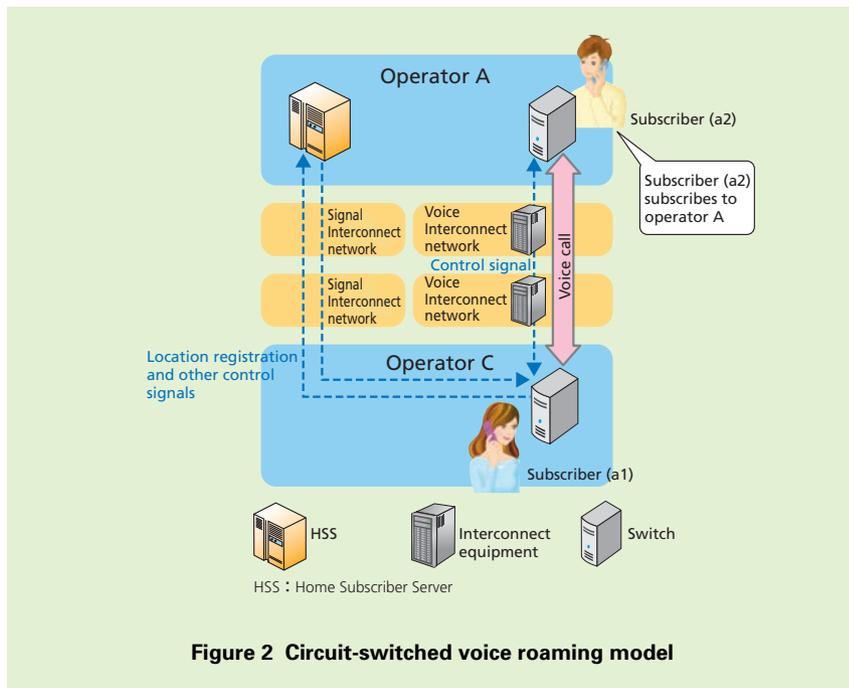
3.1 Overview of Existing VoLTE Roaming Model

VoLTE is based on IMS, which is an IP-based system implemented using the Session Initiation Protocol (SIP)^{*4} standardized by the Internet Engineering Task Force (IETF)^{*5}. IMS comprises SIP control equipment including Proxy Call/Session Control Function (P-CSCF)^{*6}, the Serving Call/Session Control Function (S-CSCF)^{*7} and the Application Server (AS)^{*8} [3].

The existing VoLTE roaming and interconnection model is shown in **Figure 4**. The P-CSCF is implemented by Operator C, but the S-CSCF and AS, which perform actual call control, are implemented by Operator A. There are also multiple IP eXchanges (IPX)^{*9} between the operators, which form the international IP interconnect network that transmits the SIP and voice data [4].

In circuit-switched networks, call control is achieved using switches belonging to the operator where the subscriber is located, but a major difference between this and VoLTE is that call control is achieved with SIP servers (S-CSCF, AS) on the home network (the subscriber's contracted operator).

Also, since VoLTE is an IP based system, there is no need for the C-Plane messages (SIP) to use the same route that the actual voice data uses, as was



*2 **IMS**: A communication system standardized by 3GPP for implementing multimedia services. IMS used IP and the SIP Internet telephony protocol to integrate the communication services of the fixed telephone and mobile communication networks.

*3 **GSMA**: An association that supports and manages activities of the mobile industry, such as formulating roaming rules. The largest mobile communications industry association in the world, with members in related businesses including mobile communications providers,

IPX operators, and terminal, equipment and software vendors.
*4 **SIP**: A call control protocol defined by the IETF and used for IP telephony with VoIP, among other applications.

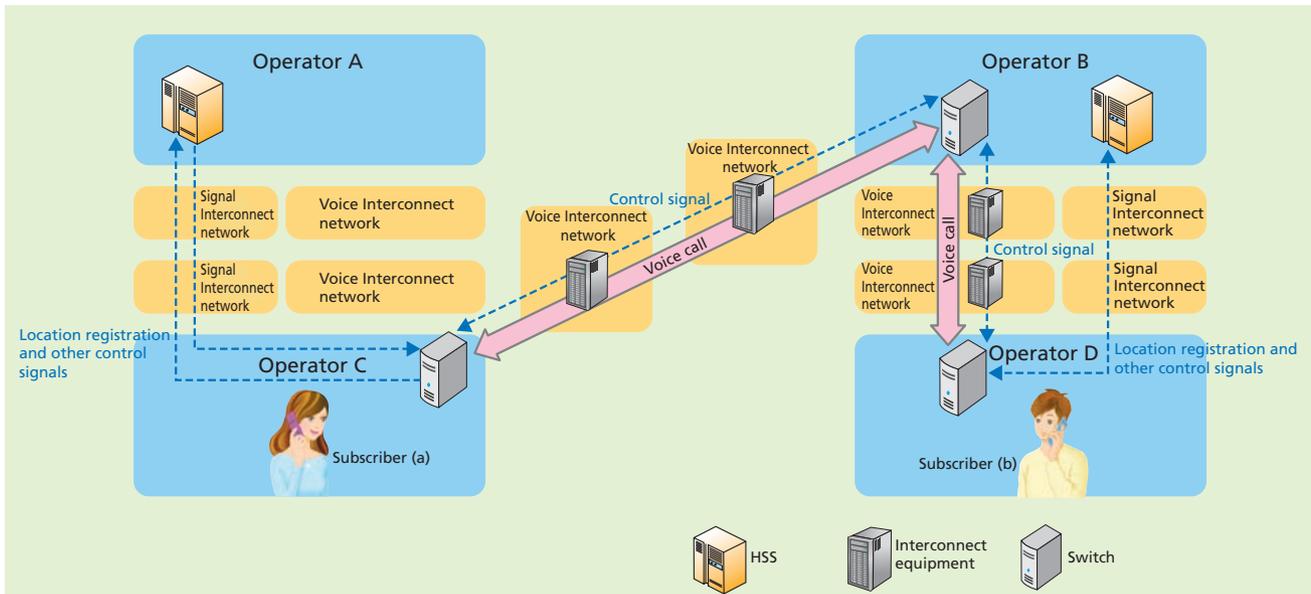


Figure 3 Circuit-switched voice roaming and interconnection model

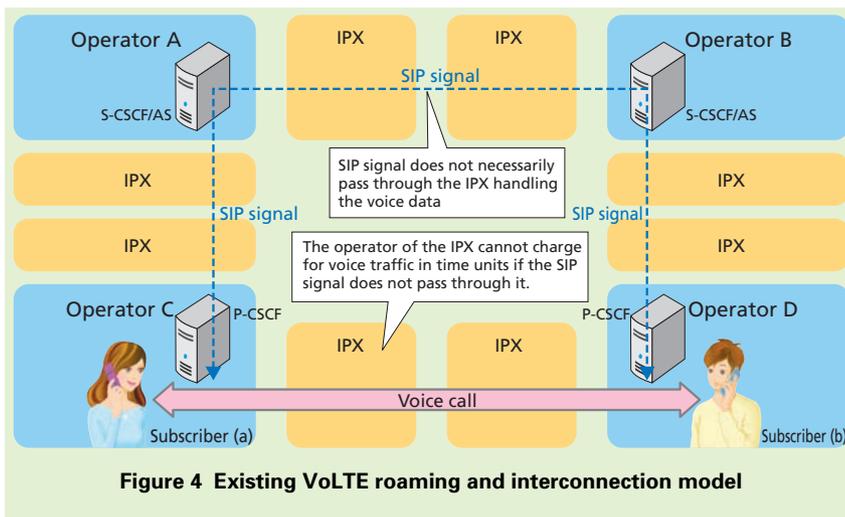


Figure 4 Existing VoLTE roaming and interconnection model

true for earlier schemes, and communication from Subscriber (a) to Subscriber (b) goes through IPX and can be routed directly, without needing to pass through the home network. With circuit-switched schemes, the actual voice data always uses the same route as the C-Plane messages.

3.2 Issues with Existing VoLTE Architecture

Existing VoLTE architecture allows for more efficient voice data routing, without requiring it to pass through the home network. However, from the perspective of IPX operators, since SIP signaling does not necessarily pass

through the same IPX, it is not possible to identify what users placed voice calls over what periods of time. Thus, IPX operators not carrying SIP signals are not able to charge for voice calls on a time basis.

VoLTE is positioned as an extension to existing voice services at the GSMA, and the GSMA has agreed that implementing existing voice charging, including IPX operators, is a business requirement [5]. Given this GSMA requirement, the 3GPP studied signaling and voice routing schemes that are equivalent to existing circuit switching in order to implement existing voice charging for VoLTE voice calls.

4. Rel. 11 VoLTE Roaming Model

For Rel. 11, a work item called

*5 IETF: A standardization organization that develops and promotes standards for Internet technology. The technology specifications formulated here are published as Request For Comment documents (RFCs).
*6 P-CSCF: A SIP relay server that performs the

roles of SIP transmission as well as linking with the LTE core network, and QoS control.
*7 S-CSCF: A SIP server that performs terminal session control and user authentication.
*8 AS: A server that executes an application to provide a service.

*9 IPX: An exchange network that has evolved from GRX and that provides QoS function.

“Roaming Architecture for Voice over IMS with Local Breakout” (RAVEL) was agreed upon and the architecture was studied within this framework.

A feature of the existing circuit-switched voice model was that voice data and control signals were routed on the same path, and RAVEL agreed on a model to emulate this for VoLTE as well.

Figure 5 shows a RAVEL VoLTE roaming and interconnection model and session setup procedures [3].

With this architecture, a new entity called the Transit & Routing Function (TRF) is introduced, which brings the SIP signals back from the network where the caller is currently connected (Operator C) to the home network performing call processing (Operator A), and provides an anchor^{*10} function that routes the voice data and SIP signals over the same path.

The calling process is described below.

- (1) When Subscriber (a) presses the Call button on the terminal, the terminal sends an INVITE^{*11} signal to the P-CSCF, which is a request to initiate a call.
- (2) The P-CSCF includes the associated TRF address to the INVITE.
- (3) The P-CSCF then forwards the INVITE to the S-CSCF/AS on the home network (Operator A). Here it specifies the route that the voice data must take.
- (4) The S-CSCF/AS performs voice call control.
- (5) The S-CSCF sets the Loopback Indicator in the INVITE and sends it to the specified TRF as a response.
- (6) Having received the INVITE from the S-CSCF, the TRF checks whether there is a Loopback Indicator. The Loopback Indicator is used by the TRF to distinguish INVITE signals for voice calls

passed from an S-CSCF from other INVITE signals.

- (7) Having determined that the INVITE was passed from an S-CSCF, the TRF uses SIP Uniform Resource Identifiers (SIP URIs)^{*12} and other destination information configured in the INVITE to decide the destination operator (Operator B) and the IPXs to use. The example in Fig. 5 shows IPXs, but existing voice interconnect networks can also be used as the interconnection network.
- (8) The INVITE is then transmitted to Subscriber (b) by ordinary VoLTE calling processes, completing VoLTE call configuration. In the call configuration process, Operator B configures the voice data route to be the same as that used for the SIP signaling. Note that the details of VoLTE call configuration were described in an earlier issue of this journal [1], so we omit them here.

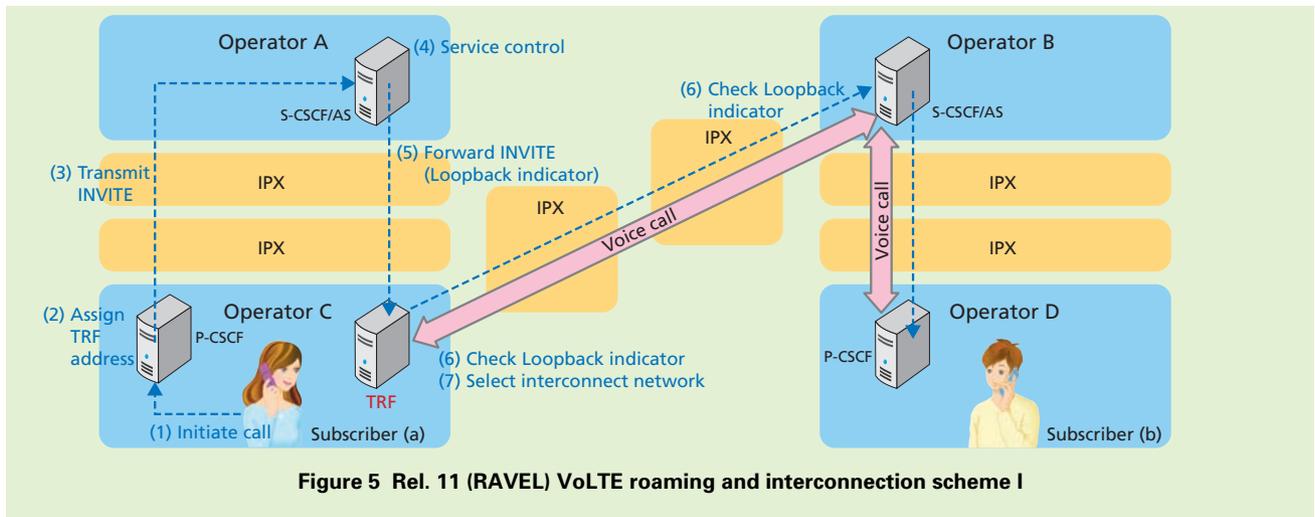


Figure 5 Rel. 11 (RAVEL) VoLTE roaming and interconnection scheme I

*10 **Anchor**: A logical node site for control-signal or user-bearer switching.

*11 **INVITE**: A SIP signal that requests a connection.

*12 **SIP URI**: The SIP addressing scheme used when making a telephone call via SIP protocol.

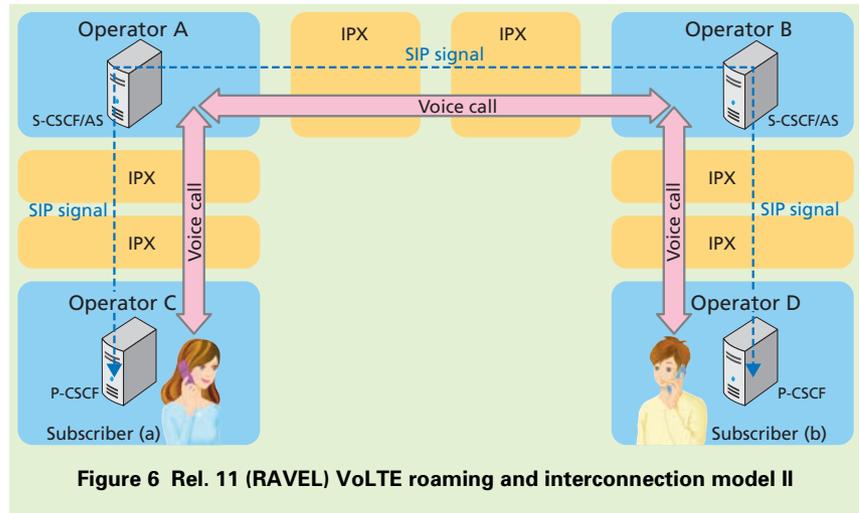
Using the above procedure, SIP signalling and voice data use the same path, and each operator and IPX provider can apply existing voice charging.

Applying the above techniques, a scheme that routes voice calls to Operator A first, and then interconnects with Operator B is also specified in Rel. 11 (Figure 6). This scheme is expected to be used for functions such as lawful intercept or to provide assistance to Subscriber (a).

5. Conclusion

This article has given background and described voice roaming and interconnection schemes specified in the VoLTE architecture in 3GPP Rel. 11.

VoLTE operators can use the three roaming and interconnection architectures described in Fig. 4 to 6 and specified in the 3GPP Rel.11 standard. It is not yet known which one of these models will ultimately become the de facto



standard. Selection of the model will be left to organizations such as the GSMA or the bilateral operator agreement.

NTT DOCOMO has contributed greatly to study of these architectures at both the 3GPP and the GSMA, as chairperson and in other roles. Looking forward, concrete operational guidelines based on the 3GPP specifications will be created at the GSMA, and NTT DOCOMO will continue to contribute proactively to this study.

REFERENCES

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