VoLTE eSRVCC VSRVCC

Technology Reports

Inter-domain Handover Technologies in LTE for Voice (VoLTE) and TV Phone

A data communication service called "Xi" (Crossy) has started in LTE. In the future, voice and TV phone services will also be provided in LTE by way of handset terminals. This article describes technologies for enabling smooth voice and TV phone inter-domain handover especially during the radio access network migration phase when LTE and 3G networks coexist and where both LTE and 3G radios/network domains will be involved. The article will also provide background on the standardization of these technologies.

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1. Introduction

This article describes the background and motives for developing Enhanced-SRVCC (eSRVCC: enhanced Single Radio Voice Call Continuity) and Video-SRVCC with their functions and capabilities.

NTT DOCOMO launched an LTE service in Japan in December 2010 under the name of "Xi." Xi at the moment mainly provides data communication using data-card type terminals but it is expected that handset-type LTE terminals will be available in the near future. Because LTE is a radio system geared towards packet communication, it is initially envisaged that voice communication using handset-type LTE terminals will be provided by means of circuit switching using Circuit Switched FallBack (CSFB)[*1] [1] and later by a technology called Voice over LTE (VoLTE)[*2] [2]. The LTE service area will be expanded gradually [3] so that when the VoLTE service is started, there will still be areas where LTE has not been rolled out (**Figure 1**). SRVCC [4] is the technology that will enable seamless voice communication between VoLTE and Circuit Switching (CS) in 3G in such a situation. eSRVCC is developed to facilitate the HandOver (HO) from VoLTE to 3G-CS between

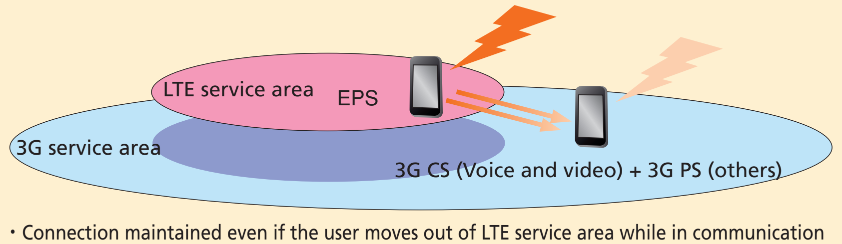

Figure 1 Roaming between radio service areas

*1 **CSFB**: A procedure for switching to a radio access system having a CS domain, when a terminal sends/receives a circuit switched communication such as voice while camped on an LTE network.

network domains or, in other words, to improve the performance of SRVCC.

In view of the fact that the expansion of the areas providing the LTE service will be gradual, when "TV phone[*3]" service is provided over LTE in the future, it is envisaged that continuity with the TV phone service provided over the current 3G network will also be required.

In this case the seamless switching of radio access from LTE to 3G as well as the switching of networks from Packet Switch (PS) to CS also become necessary. The scope of video-SRVCC (vSRVCC) studies include this kind of HO function for TV phone services over network domains.

This article describes implementation technologies for VoLTE, which will be followed by 1) SRVCC which is a voice HO technology for the handover of VoLTE to 3G-CS, 2) eSRVCC which is an enhanced version of SRVCC and 3) vSRVCC which enables similar HO for TV phone services. The article also covers standardization activities relating to these technologies in the 3GPP.

2. IMS/EPC Functional Coordination for Implementing VoLTE

Voice calls over LTE (VoLTE) cannot be made possible without the close functional coordination of the IP Multimedia Subsystem (IMS)[*4] and the Evolved Packet Core (EPC). **Figure 2** shows how this functional coordination is performed. Functions in the EPC network include the Mobile Management Entity (MME), the Serving GateWay (SGW), the Packet Data Network Gate-

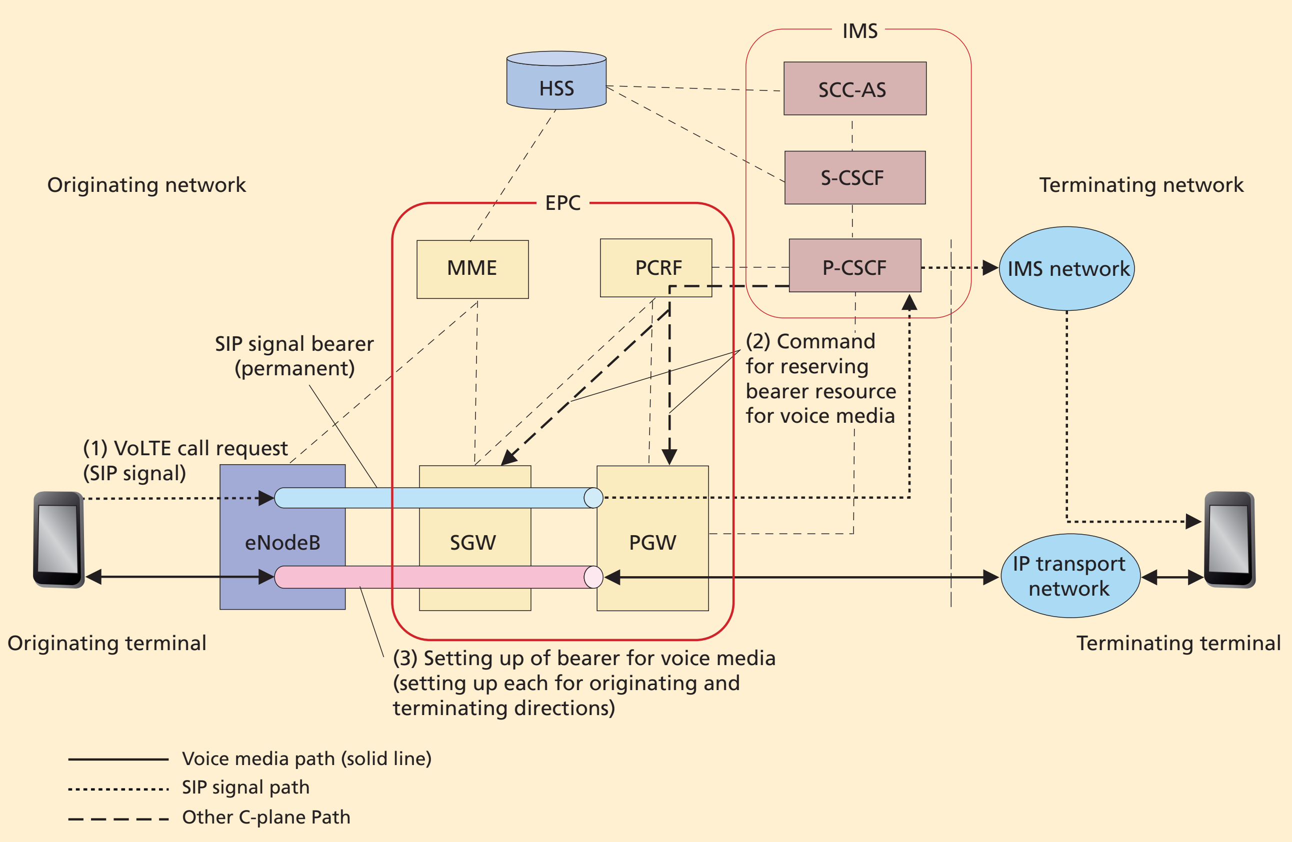

Figure 2 IMS/EPC functions and their coordination

*2 **VoLTE**: A function to provide voice services over LTE using packet switching technologies.

*3 **TV phone**: "TV phone" is a name of service in 3G. It may alternatively be called "videophone" and includes communications having both voice and video streams that are synchronized. This article uses the term "TV phone" throughout.

*4 **IMS**: A call control procedure that realizes multimedia communications by consolidating 3GPP standardized communication services offered over fixed and mobile networks through the use of SIP which is a protocol used on the Internet and in Internet phones.

Way (PGW) and the Policy and Charging Rules Function (PCRF) [5]. The MME is the module that controls the mobility of terminals and, for example, passes commands to the SGW and the eNodeB (i.e. the LTE base station) concerning route setting and modification of user data. The SGW is the packet switching entity in the visited network accommodating LTE and sends/receives user data to/from the PGW. The PGW is a gateway*5 connecting to outside networks and performs various functions such as issuing IP addresses to mobile terminals. The PCRF has the functions of setting the QoS*6 of the EPC bearer*7 path, policy control*8 and charging control. These necessary pieces of information are sent to the PGW and SGW to manage the setup of the required bearer paths [6].

The IMS conducts VoLTE call control via the bearer path set up through the functions of the EPC described above. The call control function of the IMS is comprised of the Proxy-Call Session Control Function (P-CSCF), the Serving-Call Session Control Function (S-CSCF), the Application Server (AS) and others [7]. In fig. 2, the Service Centralization and Continuity Application Server (SCC-AS) which provides the switching function between VoLTE and the circuit switching in SRVCC is shown as an example of an AS. In addition to these functions provided by the EPC and the IMS, the Home Subscription Server (HSS) manages subscriber information and provides service-related profiles*9 to the MME, the AS/S-CSCF and other modules.

2.1 VoLTE Provision Flow

Based on the functions introduced above, the functional coordination between the EPC and the IMS at the time of VoLTE call initiation will now be described using fig. 2. First, when the call originating terminal is connected to the EPC network, which is triggered by the switching on of power or by any other triggers, a Session Initiation Protocol (SIP)*10 control bearer path is allocated for signal controlling purposes and this bearer path for the SIP signal is maintained until detach*11. SIP is the call control scheme being used in the IMS. Next, when the call-originating terminal initiates a VoLTE call, the calling signal is sent over this signaling bearer path via the PGW to the P-CSCF which performs call control (fig. 2 (1)). The P-CSCF proceeds with the call processing together with the terminating IMS and requests the PCRF to reserve bearer path for voice signal coming from the call originating terminal. In response, and based for example on the media information obtained from the P-CSCF, the PCRF commands the PGW and the SGW to allocate actual bearer path resource for the voice media (fig. 2 (2)). As a result of the PGW and the SGW having set up the bearer path for the voice media, a transmission path guaranteeing the quality of the voice media is established between the mobile terminal and the PGW (fig. 2 (3)). Following this, control signals and voice data are transferred using these bearer paths that have been established for each signal.

3 SRVCC Functional and Operational Flow Overview

Figure 3 shows the functional configuration of SRVCC and its operational flow. For convenience sake, only those modules necessary to realize voice HO by SRVCC are shown in the figure. In addition to the functions already described, there are the Multimedia Switching Center (MSC)*12 and the Radio Network Controller (RNC)*13/NodeB which comprise the CS network. The former is a type of switching equipment and the latter controls the 3G radio. The figure illustrates the case where the calling terminal UE1 initiates a VoLTE voice call towards the called terminal UE2. Call control in the IMS is basically performed in the home network. In this figure, "visited network" refers to the network where UE1 has moved to, and, from where it is trying to originate a call, which is assumed to be different from its home network. First, the SIP [8] signaling is transmitted via the SIP signal bearer path between UE1 and the IMS in the home network, whereby the call processing is performed between UE1 and

*5 **Gateway**: A node function that performs protocol conversion, data relaying, etc.

*6 **QoS**: A quality specification over a network for the control of bandwidth usage, delay, discarding rate, etc.

*7 **Bearer**: A virtual packet transmission path set up between the SGW, eNodeB, UE, etc.

*8 **Policy control**: A technology for communication control such as QoS control, packet transfer enabled/disabled decision, etc. based on information about the network, user, etc.

*9 **Profile**: Basic information covering contract, user setting, camp-on, etc.

*10 **SIP**: A standardized protocol in IMS application services that performs the session initiation, modification and termination necessary for exchanging voice, video, text, etc.

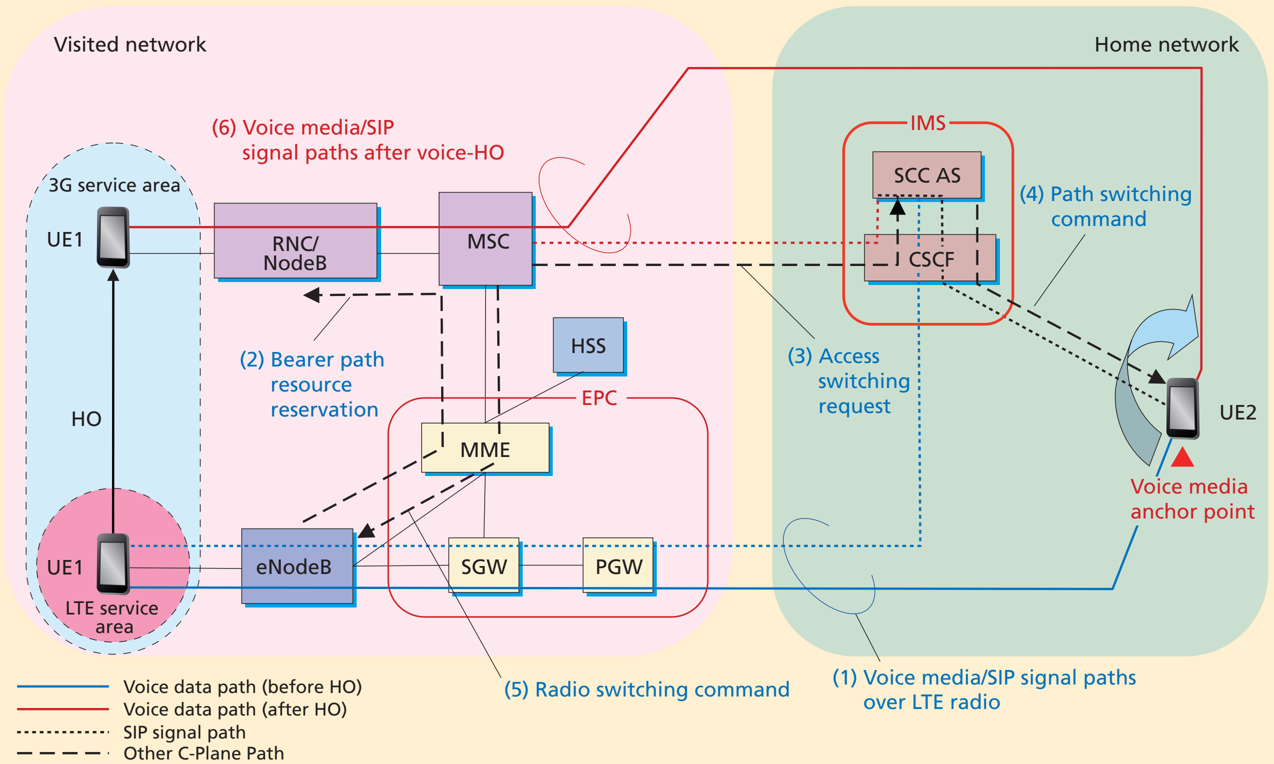

Figure 3 Overview of SRVCC functional configuration and operational flow

UE2 by means of the IMS. As a result of the call processing, a voice media bearer path is set up in the section links UE1–PGW–UE2 and the sending/receiving of voice data is started between UE1 and UE2 using this path (fig. 3(1)).

Next, when the eNodeB decides to switch the radio system from LTE to 3G after detecting the change in the radio access area resulting from the movement, etc. of the user, the eNodeB commands the initiation of the SRVCC processing. Specifically, the eNodeB sends a radio switching request signal to the MME, following which the MME requests the MSC to allocate resources on the CS side. Upon receipt of this request, the MSC proceeds with securing bearer path resources between itself and the RNC which is the radio control equipment on the 3G side (fig. 3(2)). After reserving the resources in the RNC, the MSC sends an access path switching request to the SCC-AS, i.e. the module controlling call processing in SRVCC, asking to transfer the voice call from LTE to 3G (fig. 3(3)). The SCC-AS, having received the request, instructs UE2 to change the route and to switch the destination of the voice media from the PGW to the MSC (fig. 3(4)). In parallel to the above, the MSC sends the MME a response to its request for allocating resources on the 3G side, and the MME commands the mobile terminal (UE1) via the eNodeB to switch to the 3G radio system (fig. 3(5)). After UE1 has switched to 3G, the transmission paths for the SIP signaling and the voice data are switched to those between the MSC and UE2, and the voice call is continued via the 3G paths by the MSC performing conversion between circuit and packet bearers (fig. 3(6)).

As described above, in SRVCC the preparation of the circuit bearer resources between the EPC and the CS network, and the access path switching of the voice call by the IMS are performed in parallel. The anchor point for

*11 **Detach**: A procedure, and the status thereof, covering the removal of the registration of a terminal from the network when, for example, its power is switched off.

*12 **MSC**: A node in the FOMA circuit switched network that performs call control, service control, etc. for providing mobile communication services.

*13 **RNC**: Radio Network Controller. A device defined by the 3GPP for WCDMA systems for performing radio circuit control and mobility control in the FOMA network.

switching the voice media is the terminal (UE2) and the anchor point for the SIP signaling path is the SCC-AS.

4 eSRVCC

4.1 eSRVCC Features and Operational Flow Overview

SRVCC follows the basic policy of IMS call control whereby the control is performed in the home network. As a consequence of this, especially in cases such as roaming, there used to be a issue because processing delays in communication path switching are increased due to the fact that call processing in the home network also becomes necessary even for HO taking place in the visited network. Therefore, an improvement was introduced into eSRVCC whereby the control of voice HO can be confined in the visited network in such a way that the visited network of the mobile terminal anchors[*14] the voice data and SIP signal paths at the time of the calling and receiving of VoLTE calls [9]. **Figure 4** shows the functional configuration and offers an overview of the operational flow of eSRVCC. In eSRVCC, new functional entities[*15] such as the Access Transfer Control Function (ATCF) and the Access Transfer Gate Way (ATGW) have been added in order to realize an anchoring inside of the visited network.

The function of the ATCF and ATGW is to anchor the SIP signal and the voice media in the visited network, respectively. The ATCF is set to relay the SIP signals beforehand within the IMS registration procedure that precedes the launch of eSRVCC. In addition, an ATCF identifier to identify the ATCF is sent to and maintained in the HSS and MME beforehand. In fig. 4, when the terminal launches a VoLTE call, the ATCF that relays the SIP signals allocates an ATGW depending on the media information, and immediately after that the voice media is anchored in the specified ATGW (fig. 4(1)). Then, when the eNodeB finds that, based on

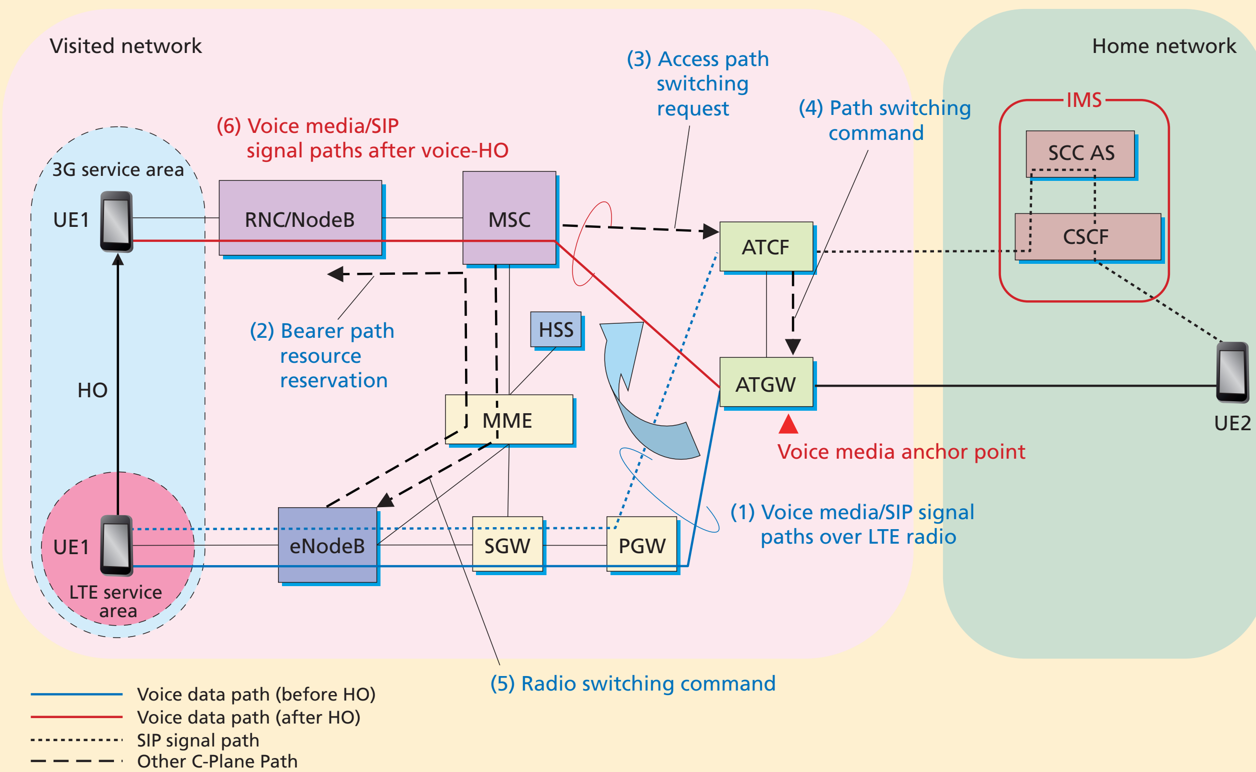

Figure 4 Overview of eSRVCC functional configuration and operational flow

*14 **Anchor**: The logical node point which will be the switching point for the control signals and user bearers.

*15 **Entity**: An element in the logical architecture that provides functions.

the radio information etc., it is necessary to switch the network used by UE1 from LTE to 3G, it requests to reserve the necessary bearer resources in the CS network (fig. 4(2)). After that, the MME informs the MSC via the CS resource request signal about the ATCF identifier that was stored at the time of the IMS registration process. In addition, after having reserved the CS bearer resources on the 3G side, the MSC requests the ATCF to switch the voice call concerned from LTE to CS (fig. 4(3)). After receiving this signal, the ATCF orders the ATGW to switch the sending/receiving destination of the voice media from the PGW to the MSC (fig. 4(4)) and in this way the path for the voice media is switched to the new route. Then, the MSC sends the MME a response to the request to reserve resources on 3G and the switching of the radio system used by UE1 is achieved by the MME commanding UE1 via the eNodeB to switch to the 3G radio system (fig. 4(5)) immediately upon receiving the response. In this way, the SRVCC issue concerning the delay in inter-domain HO when switching from VoLTE to 3G-CS, can be reduced by the ATGW in the visited network becoming the anchor for the media.

4.2 ATGW Application Conditions and Design Principles

Performance improvements in eSRVCC that has adopted the anchor scheme in the visited network have been described above. However, if the ATGW is to be allocated unconditionally there will be a waste of effort because there are cases where an ATGW essentially needs not be allocated. Therefore, in order to efficiently apply eSRVCC, elaboration is made to allocate an ATGW only when voice HO may be necessitated taking the following three conditions into consideration:

- SRVCC capability of the mobile terminal – conditions relating to the UE such as whether the UE has the SRVCC capability and whether this function is activated in its setting.
- Conditions relating to the subscriber – contractual conditions of the subscriber such as whether or not the subscriber is entitled to use voice service over LTE.
- Visited NW conditions – information enabling judgment regarding whether the UE is in the home network or in the visited network which allows improvements in operational flexibility such as applying an ATGW only in cases of roaming.

Next, in actually designing the information flow, the establishment of design principles for implementing the functions are indispensable and these will now be described. First, since the necessity of allocating an ATGW in eSRVCC of each call is judged by the mobile terminal's SRVCC capability, conditions of the subscriber and the visited NW conditions, the principle was established that these pieces of information should be uniquely gathered at the HSS. Next, it was decided to inform the ATCF of the capability of the UE before the initiation of any VoLTE call procedures so that an ATGW can be allocated depending on the SRVCC capability of the UE. In addition, because many of the eSRVCC functional procedures follow those of SRVCC, efforts were made to keep to the existing procedures and architecture as much as possible. Finally, by ensuring that it is not necessary to make any modification to the UE, it was made possible for a UE to make use of the eSRVCC described here in the case that it is SRVCC capable. Based on these design principles, the functions necessary for the allocation of the ATWG in eSRVCC and the operational flow involved will be presented below.

4.3 ATGW Allocation Function and Operational Flow

The ATGW allocation scheme and the operational flow involved are illustrated in **Figure 5**. Function 1 is performed within the EPC location registration procedure and Functions 2 and 3 are performed by the UE within the IMS registration procedure.

- Function 1: Notification to HSS of SRVCC capability of UE

When a UE tries to register its

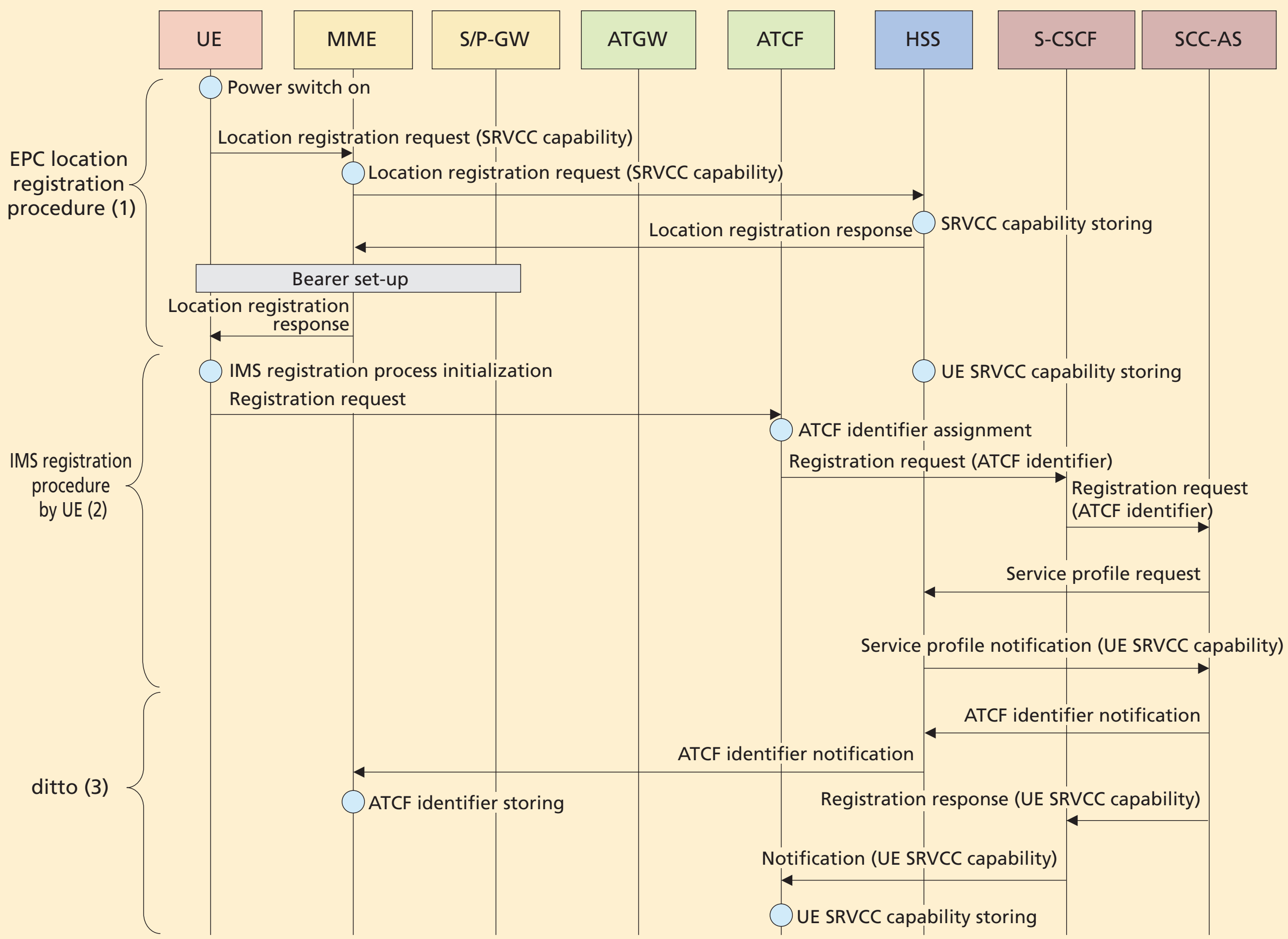

Figure 5 Overview of ATGW selection function and operational flow

location in the EPC after power activation or any other trigger, it transmits to the MME a location registration request and notifies its SRVCC capability. The MME will store the SRVCC capability information and if there is any change in the capability it will notify the HSS. The HSS will store the SRVCC capability information of the UE and executes tasks such as the eSRVCC application judgment and the notification of the SRVCC capability to the SCC-AS.

- Function 2: Notification to ATCF of SRVCC capability of UE

This is the function that notifies the ATCF about the SRVCC capability of the UE once the HSS has decided to apply eSRVCC based on the above application criteria. Operation-wise, first of all the UE transmits a location registration request signal towards the S-CSCF in the course of the IMS registration process. This signal travels though the ATCF and other equipment as configured in the setting of the visited network (N.B. the P-CSCF is omitted in the figure). Having received this signal the ATCF relays the request to the S-CSCF with its own ATCF identifier attached. The S-CSCF sends a registration request to the SCC-AS together with the ACTS identifier that had been received before so as to enable service in the SCC-AS. The SCC-AS transmits to the HSS a service profile request containing an inquiry about the SRVCC capability of the UE. If it finds that the UE is SRVCC capable by making reference to the UE's location registration processing in the EPC network, the HSS notifies this fact to the SCC-AS via the service profile notification. Notification by the HSS is made only when all the requirements for applying eSRVCC are met.

- Function 3: Notification of ATCF identification information to MME

  When the HSS makes the judgment to apply eSRVCC and when it receives the ATCF identifier from the SCC-AS, it notifies the MME to this effect. Operation-wise, the SCC-AS decides that it is instructed to apply eSRVCC when it receives the SRVCC capability via the service profile notification described in Function 2, and notifies the ATCF identifier to the HSS. If it finds that the identifier is different from the one it received before, the HSS notifies this fact to the MME. The SCC-HS on the other hand notifies the ATCF via the S-CSCF if there is any change in the SRVCC capability of the UE it receives from the HSS this time compared with the one it received before. The ACTF maintains this information and uses it to judge whether or not to allocate an ATGF when the UE is originating/terminating calls.

5 Overview of vSRVCC

In the case of eSRVCC, the target of the inter-domain HO was voice. vSRVCC is a network domain HO technology with its target expanded to include TV phone services.

The envisaged service scenario is that where the LTE network that a user is using to communicate with the TV phone switches, for reasons such as he or she is moving around or the radio communication conditions deteriorate, to the 3G network so that the communication can continue. It is expected that independent bearers for the voice and video streams will be allocated because there will be many codecs adopted and because a wide radio spectrum can be utilized. However, in the TV phone service over 3G, both voice and video are transmitted within the limited bearer bandwidth of 64 kbps. Therefore, it is assumed that the codecs used in the LTE network will not be the same as the ones used for 3G (i.e. 3G-H324M[*16]). Against such a background, vSRVCC has been developed taking into consideration the differences in the bearer configuration and the codecs when realizing HO between the LTE and 3G networks.

6 Functions Realizing vSRVCC

The functions that have been added to realize SRVCC for the TV phone service, in addition to those necessary for SRVCC for voice services, are presented using **Figure 6**. Functional flows will be described later using the figure showing the sequence.

(1) Function to notify the network that the UE is SRVCC capable for the TV phone service which is independent from the notification of the SRVCC capability of the UE for voice.

(2) Function to enable the MME to identify the TV phone communication which is a combination of voice and video, and also to separate its bearer from other bearers for PS communication. This function is necessary because even though the voice and video combined stream will be switched to the TV phone communication in the CS network, there may be separate PS communication which has to be switched to PS communication in the 3G network.

(3) Function enabling the MSC to know that the voice and video combined communication that it is about to request the SCC-AS to switch is the subject for invoking vSRVCC.

(4) Function for the MSC to request the RNC/NodeB for necessary radio resources[*17] for the TV phone service when it receives a vSRVCC request from the MME.

(5) Function to enable the UE to negotiate the codec to be used in the CS domain after the radio switching

*16 **3G-H324M**: A codec used in 3G FOMA network. An extension of the ITU H.324 Recommendation enabling its use in 3G cellular networks. Handles voice and video streams by means of 64 kbps bearers.

*17 **Radio resource**: Frequency bandwidth, transmission power, etc. that can be used by each user.

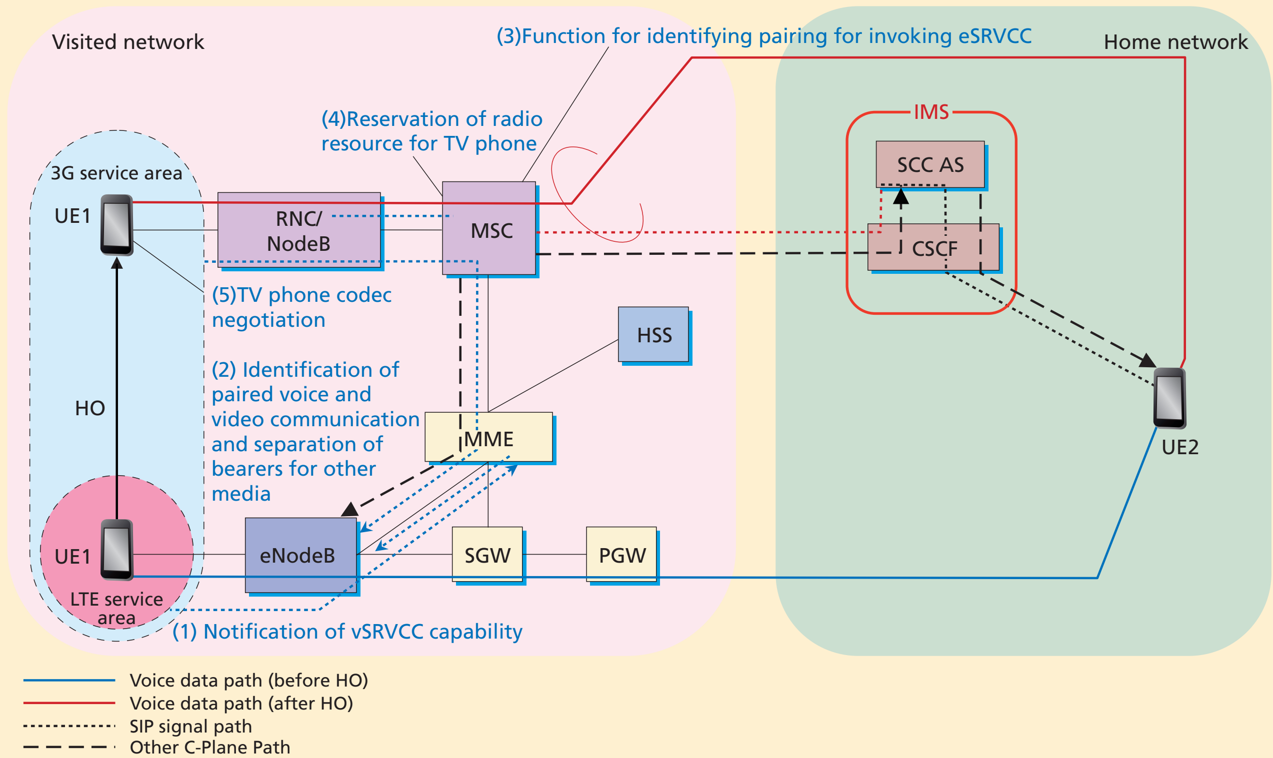

Figure 6 Overview of additional functions in vSRVCC

has been completed.

(6) Function enabling the PCRF to notify the MME, the SGW and the PWG at the time of establishing a TV phone call that the bearer that has been set up is for TV phone use and that it is subject to vSRVCC, together with an identifier indicating this. The PCRF in advance affixes to the bearers concerned an identifier indicating that they are subjects for vSRVCC in order to be able to identify the bearer for TV phone communication.

7 Overview of vSRVCC Operational Flow

A UE having the SRVCC capability notifies, at the time of attach[*18] procedure and the Tracking Area Update (TAU)[*19], its capability to the network by including it in the UE capability information element in the Non Access Stratum (NAS)[*20]. This vSRVCC capability is defined independently from the SRVCC capability for voice. The MME having the vSRVCC capability indicates this capability in the initial call setup request signal and if both the MME and the UE are vSRVCC capable, the MME will notify the eNodeB that vSRVCC can be offered. In the following figure, **Figure 7**, the operational flow of vSRVCC is illustrated focusing on major additions/changes to the sequence for SRVCC for voice.

When the eNodeB decides to switch the radio system based on the radio quality report from the UE (fig. 7 (1) and (2)), it sends an HO Request message for switching the radio system to the MME (fig. 7 (3)). The MME identifies the video and voice streams subject for vSRVCC using the QoS Class Identifier (QCI)[*21] and the vSRVCC indication, and separates these streams from the bearers of other data communication (fig. 7 (4)). The

*18 **Attach**: A procedure, and the status thereof, for registering a terminal on the network when, for example, its power is switched on.

*19 **TAU**: A procedure in LTE for updating location registration.

*20 **NAS**: The functional layer between the core network and the UE placed over the Access Stratum (AS).

*21 **QCI**: Parameters indicating priorities for QoS control of a mobile communication system. The priorities are classified in nine steps from 1 to 9.

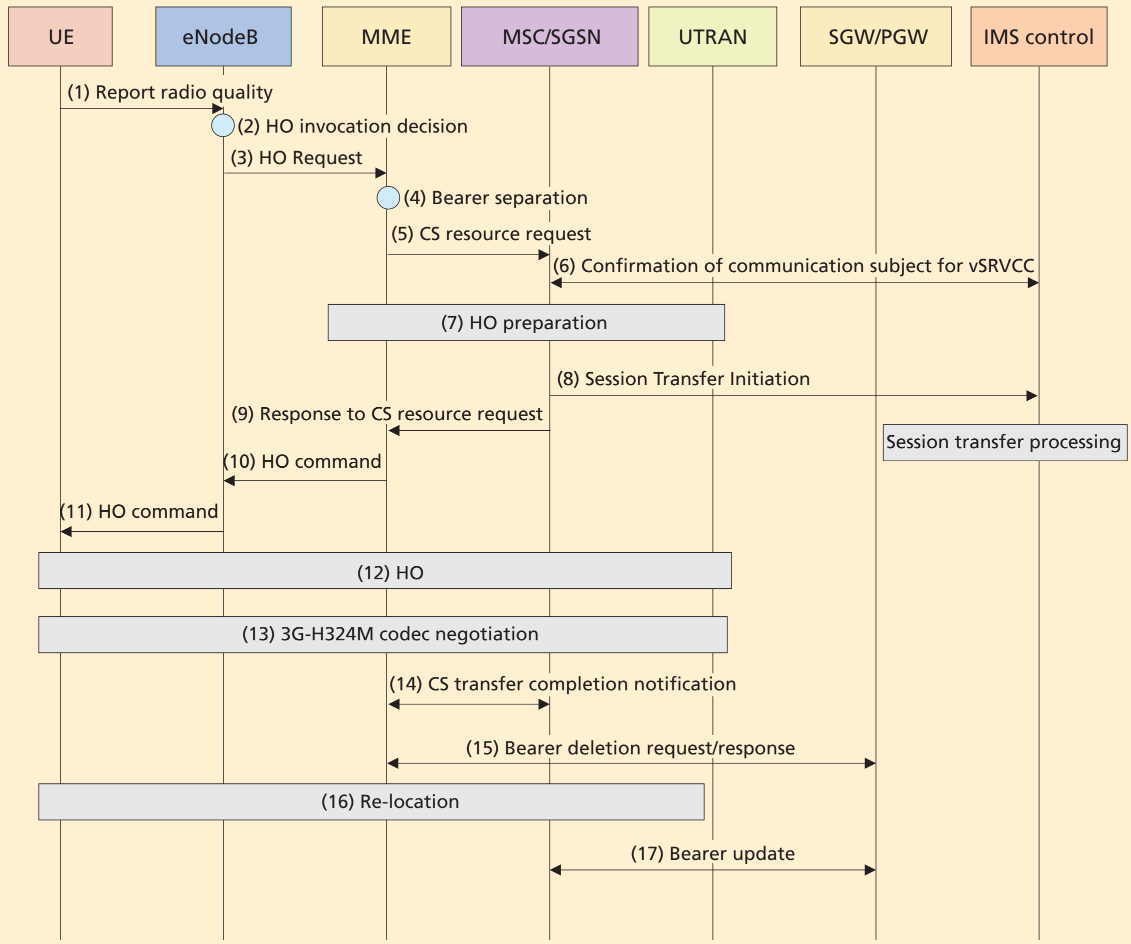

Figure 7 vSRVCC operation outline

former is subject for HO to CS and the latter is subject for HO to PS. The MME then requests the MSC for resources in the CS network so as to reserve resources on the 3G side (fig. 7 (5)). When the MSC recognizes that it is a request to switch the TV phone communication resulting from vSRVCC, it notifies the SCC-AS that the subject communication is a pair of voice and video and, in case there were more than one pair, notifies after confirmation, the latest pair that was established (fig. 7 (6)). Following that, the MSC reserves the CS bearer resource necessary for the TV phone between itself and RNC, and then requests the SCC-AS to switch the audiovisual call (fig. 7 (7) and (8)). The SCC-AS recognizes that the switching results from vSRVCC because the "Session Description Protocol (SDP)[*22] set" for video communication is contained in the call to be switched. The switching is then performed in the same way as in the case of SRVCC for voice (fig. 7 (9) to (12)). When the CS bearer on the 3G radio network is established between the UE and the MSC, the UE initiates the 3G-324M codec negotiation for the TV phone (fig. 7 (13)). Regarding the negotiation procedure, MONA[*23], which is a technology for shortening the negotiation time is recommended. By following the above procedures, audiovisual communication with the remote terminal using a path over the 3G radio system can be continued.

*22 **SDP**: A protocol to describe information, such as IP addresses, necessary for initiating sessions in the IMS. It is also used to describe session information relating to SIP which is a call control protocol.

*23 **MONA**: A procedure optimized for exchanging terminal capabilities of a multimedia terminal in a mobile communication system which is specified in ITU-T Recommendation H.324 Annex K.

8 Conclusion

This article explains an overview of eSRVCC and vSRVCC and describes the operational flows involved. It is expected that VoLTE capable handset-type terminals will be offered soon after the launch of the LTE service. eSRVCC will be an indispensable technology for smooth domain-HO for voice during the migration period when the LTE service areas and 3G service areas co-exist. In comparison to conventional SRVCC, eSRVCC achieves improvements in the domain-HO quality and shortening of switching time by equipping anchor functions (ATCF/ATGW) in the visited network. eSRVCC was designed to assign an ATGW after checking the three criteria, namely - UE capability in the home network, subscriber conditions and visited NW condition - so that the HSS can judge in advance whether or not to allocate the ATCF and the ATGW. Furthermore, it has been made possible to make use of this function simply by equipping the eSRVCC in the network by minimizing changes in the control signals of the EPC and the IMS thereby reducing the implementation impact on the UE so that a UE with the SRVCC capability can also use the eSRVCC.

vSRVCC which is the domain-HO enabling seamless switching of a TV phone communication from LTE to 3G access was also described. Because the TV phone service over LTE utilizes packet switching (PS domain) and that over 3G access uses circuit switching (CS domain), HO technologies between two domains are necessary. Information about the differing bearer configuration and codecs used respectively in LTE and 3G was also presented. Currently, the specifications of vSRVCC are progressing in Release 11 of 3GPP. It is anticipated that in the future studies will be conducted on the applications, etc. of eSRVCC including how to shorten the delay in the HO. NTT DOCOMO intends to contribute to the relevant activities taking consideration of the various scenarios and the functional requirements.

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