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VOICE AND VIDEO CALLING OVER LTE

A STEP TOWARDS FUTURE TELEPHONY

The GSMA IR.92 voice-over-LTE and GSMA IR.94 IMS conversational video specifications are the preferred industry choices for mass-market voice and video calling services over LTE, satisfying user expectations and providing the most advantageous solutions for operators. The specifications profile existing 3GPP IMS services, enhanced packet core and radio, and leverage telecom characteristics such as quality of service and global reach.

VOICE SERVICES IN MOBILE BROADBAND NETWORKS

Mobile broadband has created a world of opportunities and opened up new revenue streams for operators. Opportunities are often coupled with challenges, and mobile broadband tests the position of communication services, such as voice, which today accounts for around 70 percent of operators' annual revenue – about USD 650 billion – globally. The crucial question is how to take advantage of mobile broadband opportunities while at the same time maintaining and increasing revenue from communication services.

LTE networks can deliver mobile broadband and communication services with greater capacity and lower latency. However, as there is no circuit-switched voice domain in LTE, the mobile industry will adopt a globally interoperable IP-based voice, video-calling and messaging solution for LTE, which also enables development of new innovative multimedia services.

Some over-the-top (OTT) solutions, such as Skype and FaceTime, often come preinstalled on smartphones, and as these devices become much more widespread, the adoption of OTT solutions for video-calling services will also increase. These solutions are familiar to subscribers and have – until now – driven user expectations and shaped the market. However, a fully satisfactory user experience cannot be provided by OTT solutions, as there are no QoS measures in place, no handover mechanism to the circuit-switched network, no widespread interoperability of services between different OTT services and devices, and no guaranteed emergency support or security measures. Consequently, the adoption of OTT clients is directly dependent on mobile broadband coverage and the willingness of subscribers to use a service that lacks quality, security and flexibility.

With the industry aligned telecom solution, operators can now start commercial deployments of a telecom-grade, globally interoperable voice and video calling solution over LTE – even before LTE is fully deployed.

A GLOBALLY INTEROPERABLE SOLUTION

LTE and Evolved Packet Core (EPC) architectures do not include support for circuit switched voice and video calls. When starting to use LTE in phones, this limitation will have to be addressed. Over the past two years, two complementary tracks have emerged in the telecom industry: circuit-switched fallback (CSFB) and IMS/VoLTE. CSFB is suitable for use when the LTE coverage is spotty (typically in the early phases of LTE deployment), while IMS/VoLTE can be implemented when the coverage is better (typically in mature LTE networks).

IMS-BASED VOICE OVER LTE

The term voice-over-LTE (VoLTE) is used to describe the GSMA specification [1] for voice and Short Message Service (SMS) in LTE, which has its origins in the 3GPP IMS-based multimedia telephony (MMTel) solution. VoLTE has widespread backing in the telecoms industry – more than 40 key players declared their support for it at the 2010 GSMA Mobile World Congress in Barcelona and many more have done so since. Both GSM/WCDMA and CDMA operators are planning to deploy VoLTE based on IMS.

With MMTel, operators can evolve their voice and multimedia services, such as video calling – described in the GSMA specification for IMS conversational video [2]. MMTel can leverage the world's largest mobile user community (MSISDN), as well as traditional telecommunication principles such as guaranteed end-to-end QoS, support for emergency and regulatory services, global interoperability and mobility, as well as support for a user experience that meets the needs of the modern consumer. With the Ericsson MMTel, users can – for example – start a voice session, add and drop media such as video, and add callers.

VoLTE, together with video calling over LTE, will bring deployment of interoperable and high-quality voice and video services together, as well as facilitating the development of interconnect and international roaming agreements among LTE operators.

Operators deploying VoLTE can evolve their voice services into rich multimedia offerings, including HD voice, video calling and other multimedia services such as Rich Communication Suite (RCS), available anywhere on any device, combining mobility with service continuity. Leading operators are expected to launch voice and video calling over LTE in 2012.

CIRCUIT-SWITCHED FALLBACK

The standardized solution for providing voice services in early LTE deployment is CSFB – where no IMS voice service is available, or for roamers with no IMS roaming agreement.

When using CSFB, devices are directed to WCDMA/GSM to initiate or receive voice calls, and calls remain in the CS domain until completed. The NGMN recommends this solution as a minimum roaming requirement for LTE device manufacturers and LTE operators that support CS voice services over WCDMA/GSM. As CSFB provides support for voice and SMS, it is considered a first step in the evolution toward multimedia communication services, as well as a solution for handling roamers.

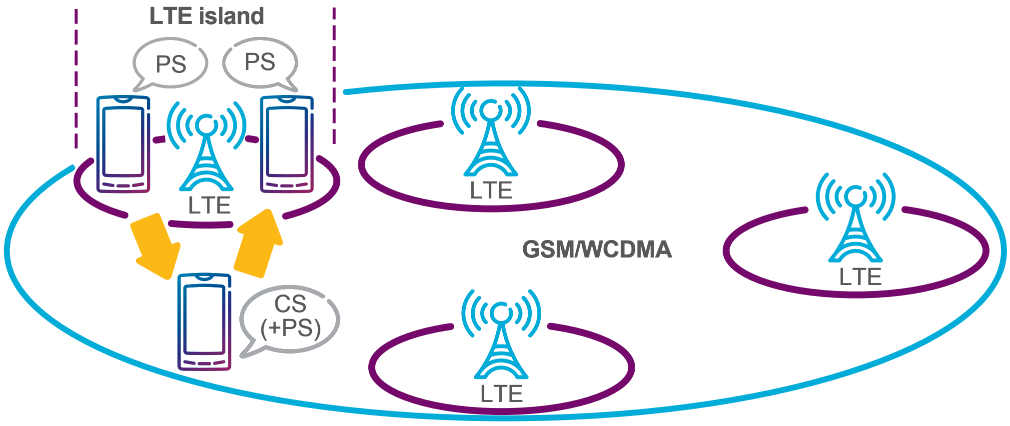

Figure 1: CS fallback.

HOW GSMA VOLTE WORKS

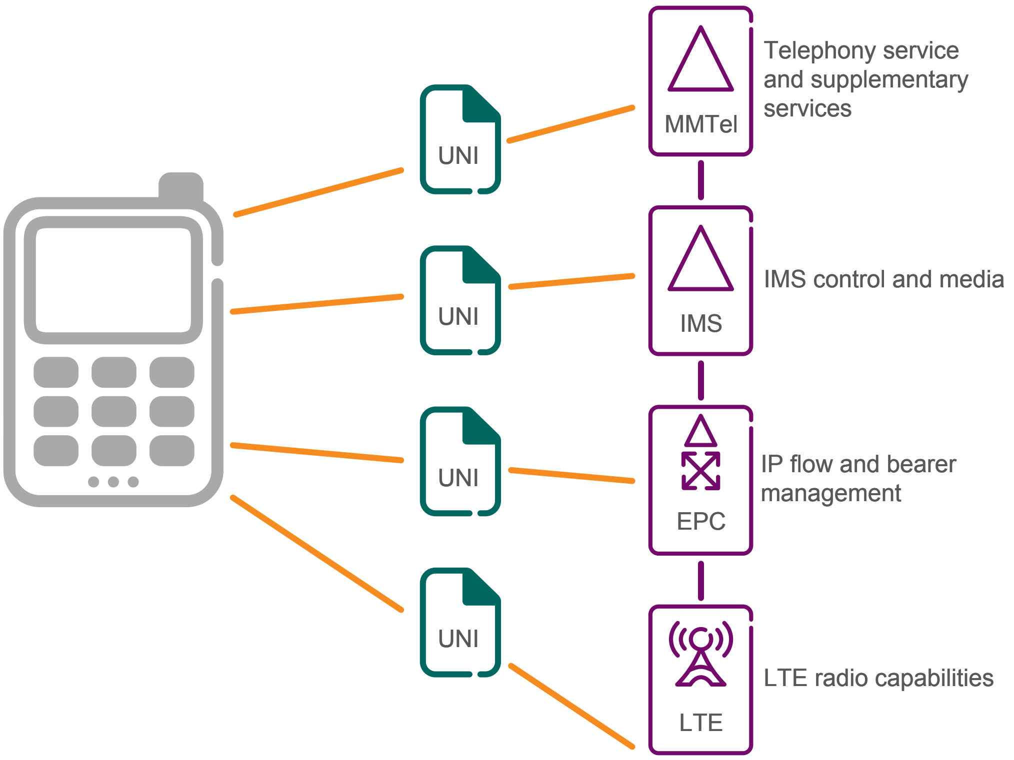

Figure 2: VoLTE interfaces across the User to Network Interface (UNI) between the device and network.

Although MMTel forms the basis of the VoLTE solution, EPC (with IP flow and bearer management) and LTE (with conversational radio bearers) are integral parts of it. Together, they secure interoperability on all interfaces between devices and networks.

The majority of interface requirements are based on 3GPP Release 8. There are a few exceptions to this, such as emergency voice calls over LTE and positioning services, which are defined on Release 9. In general, the requirements aim to set the minimal mandatory features for wireless devices and networks.

Figure 2 illustrates the importance of taking an end-to-end approach to implementation of voice over LTE, to ensure classic telecom principles such as excellent voice QoS (LTE), mobility management (EPC), reuse of MSISDN for global voice interoperability, and various types of regulatory and supplementary services (IMS and MMTel).

VOICE OVER LTE

VoLTE includes voice in full duplex, either in a one-to-one or one-to-many communication format. Figure 3 shows a simplified version of the VoLTE communication architecture.

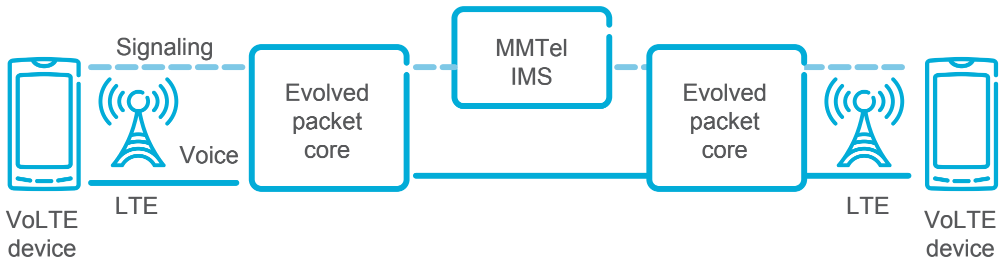

Figure 3: VoLTE end-to-end (simplified view).

GETTING CONNECTED

When a device is turned on, it attaches to the LTE/EPC network applying the IMS Access Point Name (APN) [3] to facilitate roaming and to retrieve an IMS domain reference as well as a signaling bearer to use for SIP signaling. The device then initiates the IMS domain-registration process with its MMTel identifier and optionally SMS-over-IP identifier. During this process the device will be checked for authentication and security.

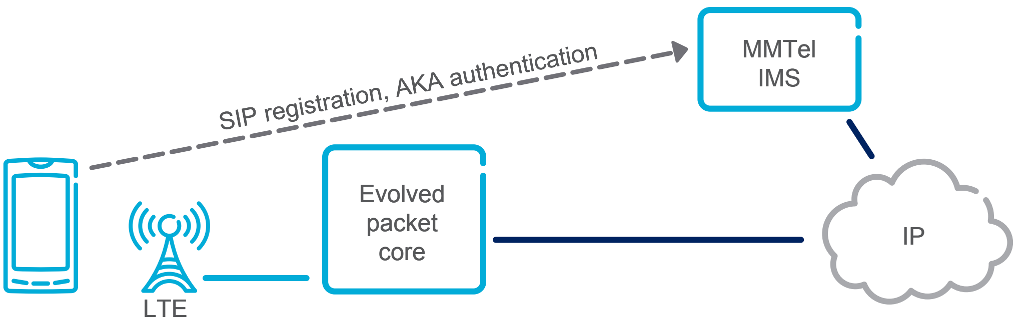

Figure 4: Registration and authentication with IMS domain across radio and EPC.

CALL AND MEDIA HANDLING

The INVITE signal contains a Session Description Protocol (SDP) that describes preferred media information such as which voice coding standard – Adaptive Multi-Rate Wideband (AMR-WB, used for HD voice) or Adaptive Multi-Rate Narrowband (AMR-NB) – IP addresses and ports to use. The IMS domain passes this information, via standardized interfaces, to the EPC's Policy and Charging Enforcement Function (PCEF), which in turn performs QoS and charging-rules analysis. A typical outcome of this analysis might be to establish a dedicated EPC and data radio bearer– with a guaranteed bit rate for VoIP media – and to zero-out any data volume charging on this bearer. Figure 5 illustrates SIP signaling and voice flow over a dedicated bearer.

The LTE radio network uses admission control to ensure that there are sufficient resources and capacity for the network-requested voice bearer. When the bearer has been established, the VoIP packets sent using Real-time Transport Protocol (RTP) are downsized using Robust Header Compression (RoHC) and transported using Radio Link Control (RLC) Unacknowledged Mode (UM) to minimize packet size and thus increase coverage and capacity. Discontinuous Reception (DRX) provides prolonged talk time and battery longevity. End-to-end voice latency is on par with, or even better than, 2G/3G CS.

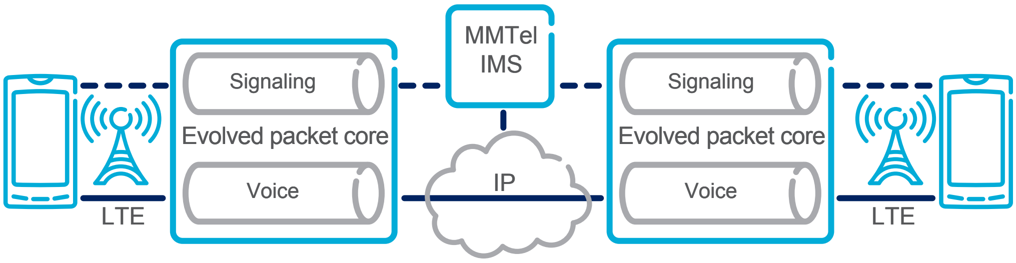

Figure 5: Signaling bearer and a dedicated bearer for voice

HANDOVER FROM LTE TO CIRCUIT-SWITCHED

In areas at the edge of LTE coverage, devices may find themselves with insufficient LTE radio coverage. To prevent a VoLTE call from being dropped in such cases, a handover mechanism allows the call to continue as a CS call. This process is enabled by the Single Radio Voice Call Continuity (SRVCC) mechanism.

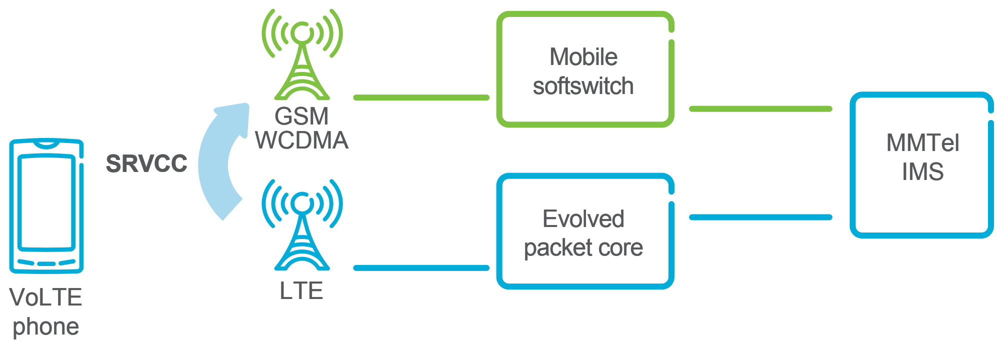

Figure 6: Handover from packet-switched voice to circuit-switched voice

Although the CS domain handles voice access after this handover, the SRVCC mechanism ensures that the IMS network remains in control for the duration of the call. This mechanism also caters for remote party voice streams to be sent to the media gateway function in the mobile softswitch and not the packet data network gateway function within the EPC, while the device is camping in CS access coverage.

ROAMING

The CS roaming model, which has been established for 20 years, has allowed inbound roamers to receive and make voice calls served by an MSC in the visited network which connect them to the destination and carry out regulatory services. The current business model enables the voice service revenue to be shared with the home operator.

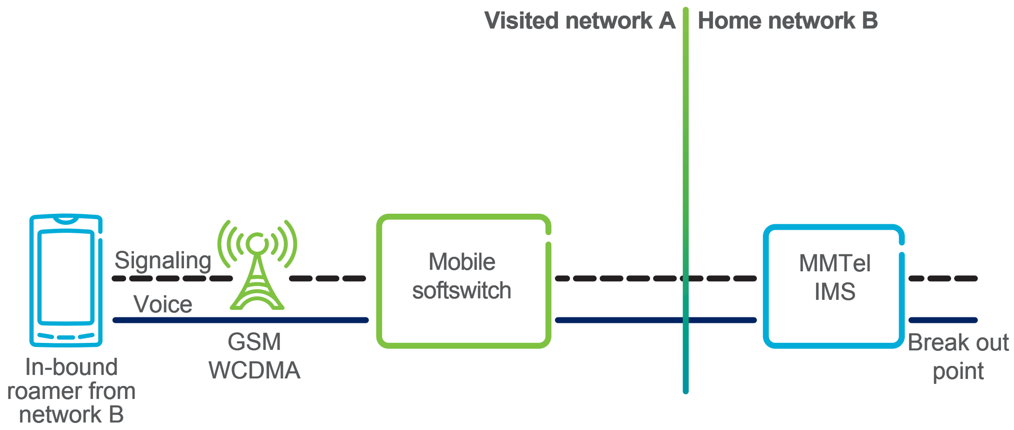

Figure 7: VoLTE roaming using CS roaming agreements.

In IMS user-oriented services are executed in the home network. This implies that the control of IMS services remains with the home operator and the MMTel application server serves the user from the home network also when roaming.

As a first step to support roaming, VoLTE operators can leverage existing CS roaming agreements and CAMEL until PS based IMS-roaming agreements are in place. Calls initiated by the inbound roamer are routed over a GSM or WCDMA access network, via the MSC in the visited network, to the IMS domain of the home network. The voice/video media breakout point and service control are within the home network – as illustrated in figure 7.

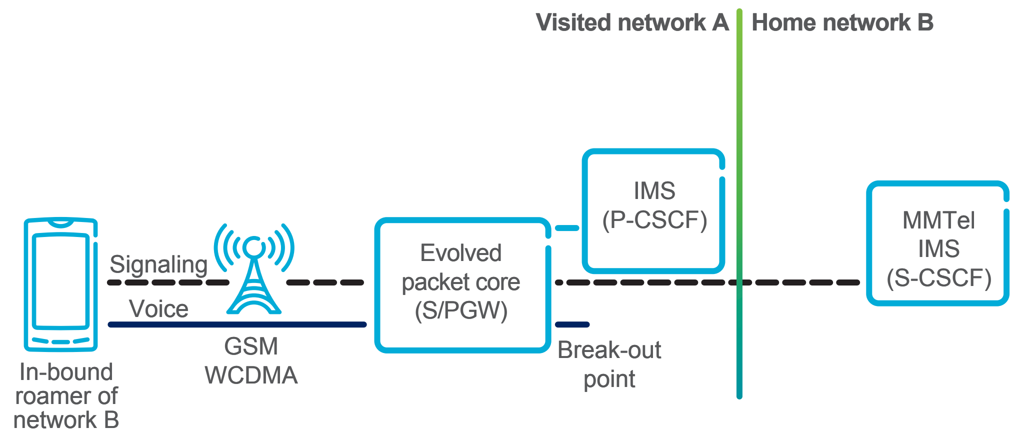

Figure 8: VoLTE roaming using IMS-roaming agreements

As a second step – when PS-based IMS-roaming agreements are in place – calls initiated by the inbound roamer are handled by the LTE/EPC access network with a local PDN-GW, via the P-CSCF in the IMS domain of the visited network, to the IMS domain of the home network. This architecture as illustrated in figure 8, enables IMS service awareness in the visited network, a foundation for visited network charging, revenue sharing and regulatory services: for example, Lawful Interception (LI) and non-UE detected emergency call. In this case the voice/video media breakout point can be within the visited network.

SUPPLEMENTARY SERVICES

VoLTE offers the most vital subset of the MMTel supplementary services, such as call-forwarding prevention, caller identification and mid-call services, such as call waiting, transferring and parking. Over a home-routed APN different from the IMS APN, the device signals subscriber-initiated settings to the network via the XML configuration access protocol (XCAP).

EMERGENCY CALLS

Most operators provide overlapping circuit-switched access network coverage for emergency calls. For operators without such coverage, the VoLTE profile includes an emergency VoIP over LTE solution based on 3GPP Release 9 to ensure compliance with international regulatory requirements.

TEXT MESSAGES

In 2010, 6.9 trillion text messages were sent globally and this figure is expected to break the eight trillion mark in 2011. This represents USD 127 billion in revenue for operators [4]. LTE [5] provides the same basic SMS features, such as concatenated SMS, delivery notification and configuration. However, the SMS delivery mechanism is somewhat different. A VoLTE device can send and receive text messages encapsulated within a SIP message. To receive a text message, the encapsulation process is invoked by an IP short-message-gateway in the IMS domain, and the gateway converts traditional Signaling System Number 7 (SS7) Mobile Application Part (MAP) signaling to IP/SIP.

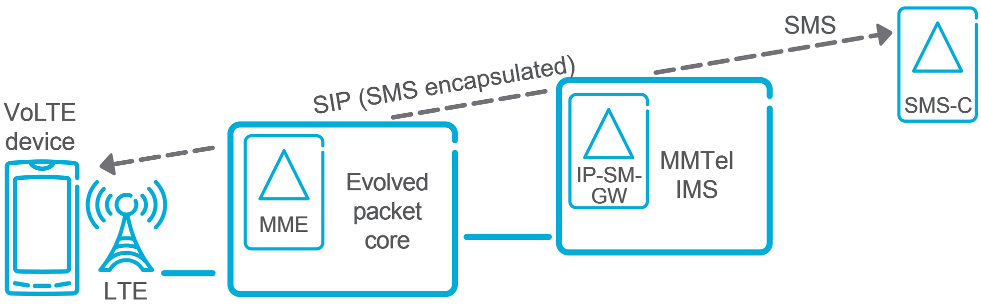

Figure 9: SMS over IP/IMS.

To ensure that text messages are routed via the gateway, the home location register (HLR) of the recipient needs an additional function to return a routable gateway address back to the SMS-C on receipt of an SMS-routing request.

When a VoLTE device sends a text message, it should perform the encapsulation. The gateway extracts the text message inside a SIP MESSAGE signal before passing it on to the SMS-C.

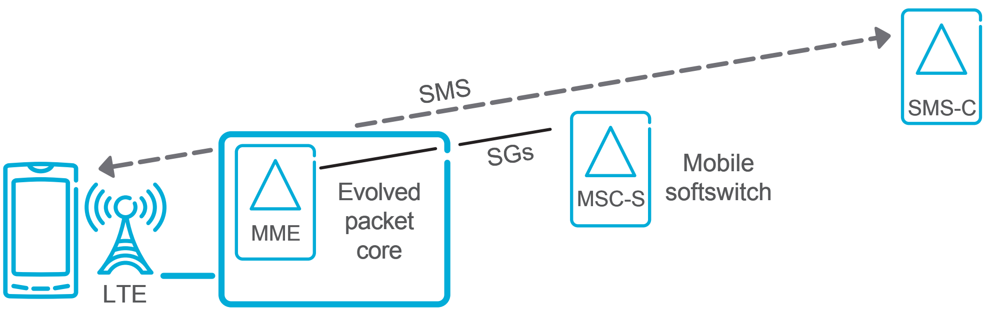

Figure 10: SMS over SGs.

However, if the VoLTE device is configured to not invoke SMS over IP networks [6], text messages can be sent and received over LTE without the need for any SIP encapsulation.

A received text message will reach the mobile switching center server (MSC-S) of the mobile softswitch system in the same way as it does today. The MSC-S will page the device via the SGs interface [7] with the Mobile Management Entity (MME) of the EPC system. Once a paging response is received, the MSC-S will pass the SMS on to the MME, which in turn tunnels it onto the device. Due to the support for SMS delivery and IP connectivity provided by LTE/EPC, MMS works seamlessly.

VIDEO CALLING OVER LTE

The GSMA specification for IMS conversational video [2] caters for video calls over LTE based on VoLTE with the addition of video capability, providing users with synchronized full-duplex voice and video streams. Users can make one-to-one or one-to-many video calls, switch to video at any point during a call, and drop video at any point to continue with just voice. During call establishment, all devices involved declare their video-availability statuses, and the results are displayed on all devices. Users can see immediately whether they can switch to video or not in order to ensure a predictable user experience.

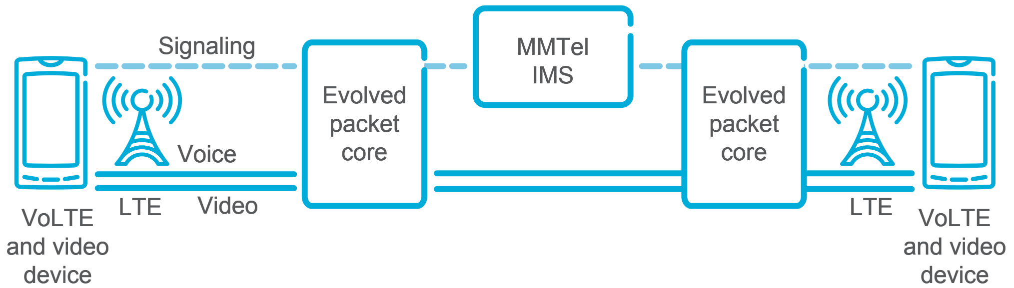

Figure 11: Video calling over LTE – an end-to-end communication view.

GETTING CONNECTED

A VoLTE and video-calling device performs the same network attach, IMS domain authentication and registration procedures as a VoLTE device, plus adding video capability information. The network can then use the video capability information to steer incoming video calls to a video-capable device.

USE CASE AND CALL HANDLING

A video call over LTE shares the same addressing and basic signaling rules as VoLTE. A VoLTE-and-video device can add a video component to an existing VoLTE call, and later drop the video component to return to a normal VoLTE call. The MMTel service and video capability information assist the IMS network and device in several tasks, including:

- Assigning the correct IMS domain MMTel application server for video-based supplementary services handling.
- Forking the invitation to a called device that has registered both a matching MMTel and video capabilitity.
- Assisting the receiving device in launching the correct client – its VoLTE-and-video application client.

The INVITE message contains video preference and capability information in the Accept-Contact and Contact headers, respectively, and an SDP body as VoLTE, but adding video media and using RTCP for both voice and video. As for a VoLTE call, the IMS domain passes this information to EPC for charging and policy analysis. Typically, the outcome of such analysis would be to establish one dedicated bearer for voice and another one for video.

Figure 12 illustrates the recommended flow for voice, video and signaling, over three separate bearers. When a VoLTE and video device is used to make or receive a normal VoLTE call, the device includes its video capability in the contact header. Each side can use this information to display to the user that the voice call can be upgraded to a video call.

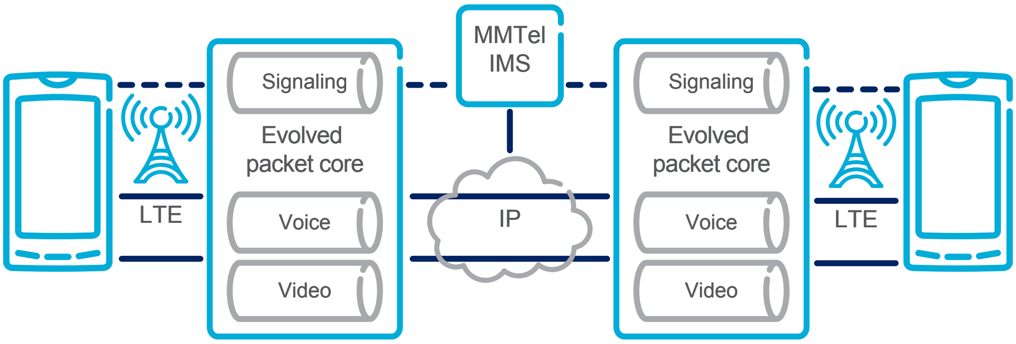

Figure 12: Three bearers – for signaling, voice and video.

If the user adds video to a VoLTE call, the device sends a SIP re-INVITE with the additional video media component. Devices in a video call must ensure lip-synchronization across the audio and video components. In addition, devices must support the Real-time Transport Control Protocol (RTCP) feedback messages, responding quickly to enforced changes in video bit rate and picture refresh such as when the video signal has been switched by a network videoconference system. Participants using video-capable devices are able to turn off video at any time during the call and continue with voice only. To do so, the device sends a SIP re-INVITE with audio media description and the video media description port set to zero. To reestablish video again, the device can send another SIP re-INVITE with the port number part of the video description set to the appropriate non-zero value.

To secure video interoperability, the well-established H.264 codec with constrained baseline profile (CBP) level 1.2 is the mandated codec for this purpose. This H.264 profile offers a video bit rate of 384kbps, providing high video quality.

Operators can use the LTE radio network admission control function to control video call usage of capacity and hardware resources, ensuring a balance for both voice and video.

VIDEOCONFERENCING

A VoLTE and video device can establish an ad-hoc multi party videoconference within the network and can also dial in to external videoconferences, because the supported RTCP feedback function provides the ability to sync the picture whenever the conference system switches video.

THE ROAD TO VOICE AND VIDEO CALLING OVER LTE

With GSMA in the driving seat and industry players aligned around VoLTE, the 3GPP standard track has become the preferred solution for voice over LTE. This includes support for both an interim solution that relies on falling back to CS as well as a solution that delivers voice and video natively over LTE. The steps to introduce voice and video calling into LTE networks can be implemented immediately after LTE deployment or with an interim solution.

The best approach for a given operator depends on initial LTE coverage and deployment strategy – operators with aggressive LTE deployment plans are likely to introduce VoLTE and video calling immediately, making it easier to evolve to richer multimedia services. These operators will also be able to support fixed mobile convergence scenarios earlier.

Operators starting with spotty LTE coverage will probably deploy CSFB as a first step to avoid excessive call handovers between the CS and LTE domains. Such operators would then bridge the gaps in the LTE coverage or complement their coverage with other packet-switched access technologies, thereby building a complete packet-based network for voice and video calling over LTE.

In short, operators may evolve to LTE communication through a phased approach or take more aggressive steps – as illustrated in Figure 13.

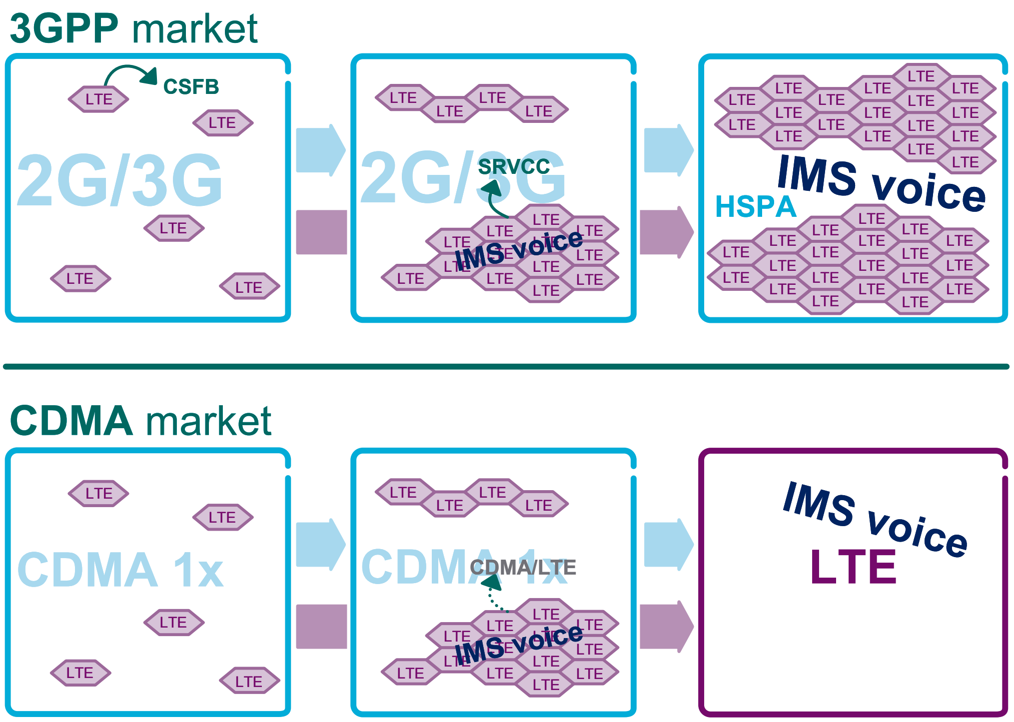

Figure 13: Different path choices for voice over LTE deployment.

CONCLUSION

With voice and video calling over LTE solutions based on established telecom standards with full industry support, operators can start launching commercial services immediately. Operators will be able to protect and develop their communication business and consumers will benefit from richer multimedia services, available from any device, anywhere, combining mobility with service continuity and global reach. As mobile broadband continues to expand, there is a great opportunity to build a whole new telecoms world with innovative communication services over IP networks, with real and lasting value for operators and consumers.

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GLOSSARY

3GPP	3rd Generation Partnership Project
AMR-NB	Adaptive Multi-Rate Narrowband
AMR-WB	Adaptive Multi-Rate Wideband
APN	Access Point Name
CAMEL	customized application for mobile networks enhanced logic
CBP	constrained base line profile
CS	circuit switched
CSFB	circuit-switched fallback
DRX	discontinuous reception
EPC	Evolved Packet Core
EPS	Evolved Packet System
GSM	Global System for Mobile Communications
GSMA	GSM Association
HLR	home location register
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LI	Lawful Interception
LTE	Long Term Evolution
MAP	Mobile Application Part
MME	Mobility Management Entity
MMS	Multimedia Messaging Service
MMTel	multimedia telephony
MSC-S	mobile switching center server
MSISDN	Mobile Subscriber Integrated Services Digital Network Number
NGMN	Next Generation Mobile Networks
OTT	over-the-top
P-CSCF	proxy call session control function
PCEF	policy and charging enforcement function
QoS	quality of service
RLC	Radio Link Control
RoHC	robust header compression
RTP	Real-time Transport Protocol
RTCP	Real-time Transport Control Protocol
S-CSCF	serving call session control function
SDP	session description protocol
SIP	Session Initiation Protocol
SMS	Short Message Service
SRVCC	Single Radio Voice Call Continuity
SS7	Signaling System Number 7
UE	user equipment
UM	Unacknowledged Mode
UNI	User to Network Interface
VoIP	voice-over-IP
VoLTE	voice-over-LTE
WCDMA	Wideband Code Division Multiple Access
XCAP	XML configuration access protocol
XML	extensible markup language

APPENDIX A

FACT BOX 1 – SMS OVER SGS

The UE registers with combined EPS/IMSI attach for "SMS-only." When an incoming SMS arrives to the MSC-S, the MSC-S will send a paging via SGs interface to the MME. The MME will page the UE only if it is in idle mode. Otherwise it will directly answer the MSC-S with a service request message.

Once the MSC-S receives the service request from MME, it will send the SMS via SGs interface to the MME, which will tunnel the short message to the UE.

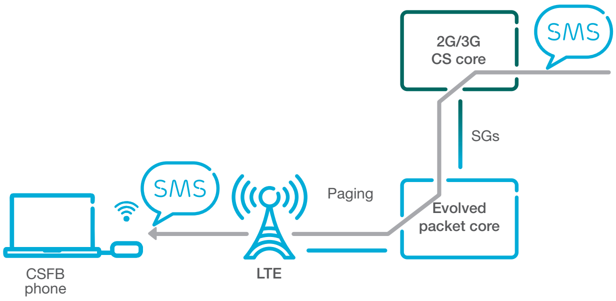

Figure A1: SMS over SGs

SMS over SGs is supported for CSFB capable terminals, without performing the fallback procedure.

FACT BOX 2 – CIRCUIT-SWITCHED FALLBACK

CS Fallback to another RAT for voice in LTE is specified in 3GPP 23.272. On a high level, this is how the CS Fallback solution works:

- When originating a voice call and when receiving a page for CS voice (via SGs interface), the UE is directed to WCDMA/GSM and the voice is sent over one of its access networks. The page response is then sent from the new RAT.
- The UE returns to LTE after call completion.

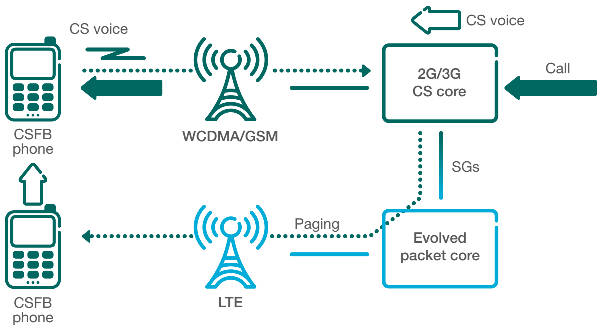

Figure A2: CS Fallback

CSFB can be done using different procedures, but with "Radio Resource Control (RRC) Connection Release with Redirect," it will be possible to introduce CSFB without any major updates to current GSM and WCDMA RAN systems.

If system information using Radio Information Management procedures is carried as specified in 3GPP R9, the enhanced CSFB procedure will in most cases only add a minor delay to the normal CS call setup time in current WCDMA/GSM systems.

FACT BOX 3 – VOICE OVER LTE

The voice over LTE solution is defined in the GSMA Permanent Reference Document (PRD) IR.92, based on the adopted One Voice profile (v 1.1.0) from the One Voice Industry Initiative.

Voice over LTE is therefore based on the existing 3GPP IMS MMTel standards for voice and SMS over LTE, specifying the minimum requirements to be fulfilled by network operators and terminal vendors in order to provide a high quality and interoperable voice over LTE service.

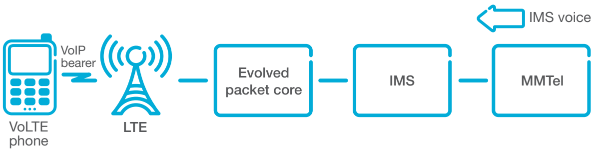

Figure A3: Voice over LTE

The basic scenario in the voice over LTE profile assumes full LTE coverage or LTE coverage complemented by another VoIP capable packet Switched technology, such as HSPA or 1xEVDO, including the following functionalities:

- QoS handling to guarantee a high quality MMTel service. Voice media is therefore mapped to Guaranteed Bit Rate (GBR) bearers, and SIP signaling is protected by mapping in to non-GBR dedicated bearers
- Mobility based on internal EPC/LTE procedures, which are transparent to the IMS/Application layers. If complementary Packet Switched technologies are used for coverage, IRAT PS Hand Over is also included
- Advanced radio features like LTE DRX mode for terminal battery saving and Robust Header Compression (RoCH) techniques to improve voice efficiency
- Self management of Supplementary Services via Web Portal or terminal browser (standard http based interfaces from 3GPP)
- GSM-alike subset of MMTel Supplementary services supporting smooth evolution towards the full multimedia capabilities

Complementary scenarios are also defined in the voice over LTE profile to cope with the cases where LTE coverage needs to be complemented with existing WCDMA/GSM CS coverage.

For these scenarios, the previously mentioned 3GPP CS co-existence mechanisms are included: IMS and SRVCC.

FACT BOX 4 – IMS CENTRALIZED SERVICES

ICS is specified in 3GPP 23.292. On high level, IMS Centralized Services provides communication services such that all services, and service control, are based on IMS mechanisms and enablers. It enables IMS services when using CS access for the media bearer, i.e., the CS core network is utilized to establish a circuit bearer for use as media for IMS sessions.

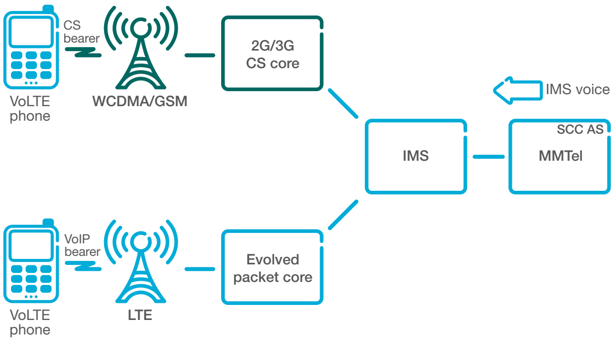

Figure A4: IMS Centralized Services

The main ICS functions for the voice over LTE solution are:

- The SCC AS, which provides functions specific to IMS Service Centralization and Continuity
- Enhancements to the MSC-S Server for ICS

And the three main ICS variants that can be utilized are:

- Access via unchanged MSC-S using Camel home routing
- ICS with Enhanced MSC-S i.e. MSC-S provides UNI to IMS acting as a SIP User Agent on behalf of the CS user
- ICS with enhanced terminals, i.e., service control signaling between terminal and IMS, via Gm interface or I2 interface (GSM without DTM)

FACT BOX 5 – SINGLE RADIO VOICE CALL CONTINUITY

SRVCC is specified in 3GPP TS 23.216. SRVCC allows IMS session continuity when the terminal is Single Radio, thus only one RAT can be active at a time. So when moving out from IMS Voice capable LTE coverage, SRVCC allows MMTel voice continuity via handover to 2G/3G CS.

It builds upon ICS, so it relies on the SCC AS to anchor the call and perform the call transfer between LTE and WCDMA/GSM CS access domains.

It also needs a new interface between the Evolved Packet Core and the CS Core, the Sv interface, so the MME can request the MSC-S to reserve the necessary WCDMA/GSM CS resources before handover execution.

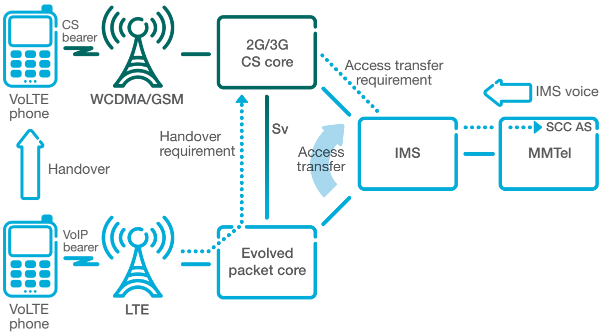

Figure A5: Single Radio Voice Call Continuity

FACT BOX 6 – IRAT PS HANDOVER

Specified in 3GPP TS 23.401, IRAT PS handover allows service continuity for all PS sessions between different 3GPP/3GPP2 PS accesses (e.g. LTE and HSPA) in a way that is transparent for the application.

Radio resources are reserved in the target network prior to handover, so interruption time is minimized. The user's IP address is maintained at the GGSN/PDN GW, and IP sessions are transferred to the target network depending on required bearer availability.

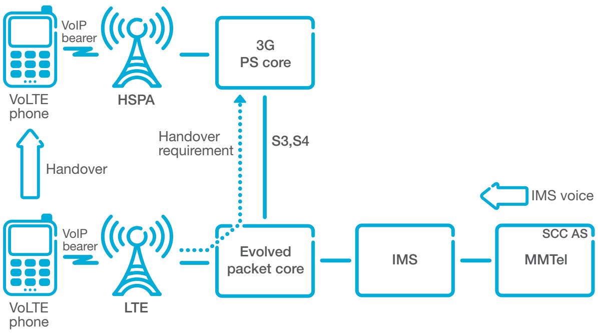

Figure A6: IRAT PS handover