VOICE OVER LTE: THE NEW MOBILE VOICE

INSPIRE NEW CONVERSATIONS WHILE STREAMLINING NETWORKS

STRATEGIC WHITE PAPER

4G LTE enables mobile operators to deliver a new conversation experience of enriched voice, enlivened video and intuitive messaging. VoLTE unlocks this experience, enabling 4G LTE's all-IP services for the mobile broadband consumer. VoLTE's infrastructure also leads directly to cloud communications and WebRTC's convergence of telecommunications and the web. Now is the time for you to begin your move to a new conversation experience that will captivate your subscribers and enable you to capitalize on your 4G LTE investment.

TABLE OF CONTENTS

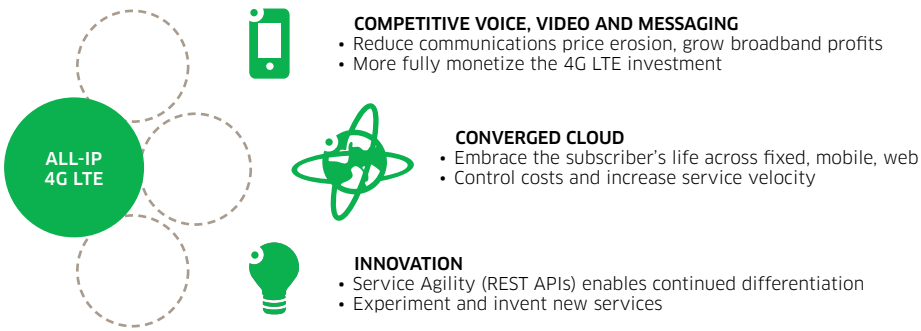
1. INTRODUCTION

Consumers' enthusiasm for mobile data services has driven operators to implement 4G Long Term Evolution (LTE) networks to better serve their subscribers with more capacity, higher bandwidth, reduced latency and improved pricing. Voice over LTE (VoLTE) is specifically designed for 4G LTE's all-IP network. This fact is vital because even as the operator's connectivity and content services increase over the coming years, and innovative competitors further alter the telecommunications industry, communication services remain a vital means by which operators create value in order to win and serve subscribers [12]. VoLTE is a key part of this equation because it unlocks all-IP communications in the 4G LTE network. With VoLTE, operators can:

- Bring customers on to the newest 4G LTE mobile network and deliver data simultaneously with crisp HD voice while efficiently offloading legacy infrastructure
- Create attractive communication services by blending mobile voice with video, converged IP messaging, the web and social networking
- Inspire more conversations by harmonizing today's fragmented communications that are stranded on different media

VoLTE operators have the most competitive freedom with the lowest risk, as shown in Figure 1. They can deliver the new mobile voice, add video and messaging, and converge with the web through Web Real Time Communications (WebRTC) [16]. They can partner with application providers by delivering the best user experience at the lowest cost per bit, and they can mainstream application developers' innovation into communication services. They can experiment with new communication features that enliven adjacent markets, such as the web, or rapidly customize features for strategic industries such as mobile healthcare. Regardless of where technology, regulation and competition take the industry in the coming years, VoLTE operators' investment enables them to act decisively.

Figure 1. Strategic value of VoLTE



2. THE NEW CONVERSATION EXPERIENCE

4G LTE operators need to rise above the data storm by delivering the best branded services. While consumers have happily adopted the latest gadgets and services, they now juggle conversations across disparate providers, devices and apps. Conversations are becoming complicated, and that stifles further innovation.

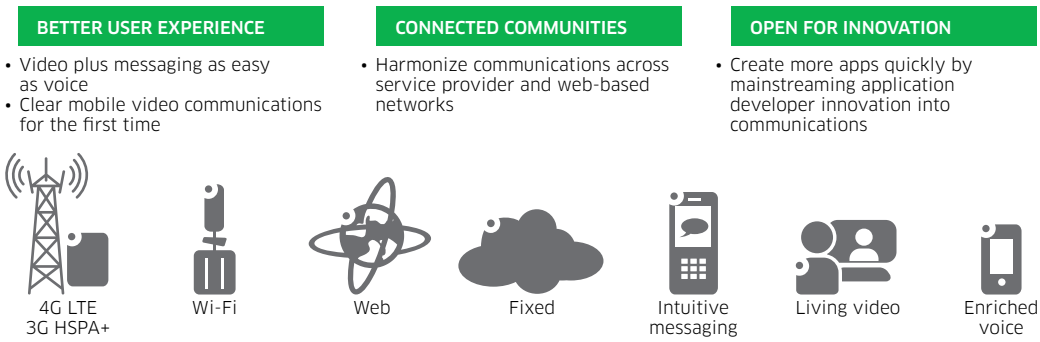
Video-calling is an example: Although people embrace it, video calls are beyond the reach of most people. You cannot just pick up your mobile device, wherever you are, for a video call that's as easy as voice.

With the Alcatel-Lucent New Conversation Experience (NCE) (shown in Figure 2 and discussed in the white paper *The New Conversation Experience: It's Time to Reinvent Communications* [6]), operators can deliver:

- A better user experience: Gained by making video and messaging as easy as voice. For the first time, mobile subscribers can enjoy video, voice and messaging using any combination of device, screen and network. We make it as easy and as trusted as voice is today.
- Connected communities: By harmonizing communications across telecom and web-based networks. Users can easily contact friends and family over social networks. And, through WebRTC, operators can extend their services to anyone with a web browser.
- Open for innovation: The solution has easy to use, open Application Programming Interfaces (APIs) to attract application developers with additional features that inspire and accelerate new conversation services and collaboration.

The Alcatel-Lucent 4G Consumer Communications solution [1] makes 4G LTE even more attractive for operators to deploy because with it they can captivate subscribers with a new conversation experience. It enables operators to capitalize on their 4G LTE access investment, reducing the erosion in communications pricing. The solution includes APIs for agile co-creation with partners in the LTE ecosystem. It also includes interworking the subscriber's services from 4G LTE to any broadband access, such as 3G HSPA + , WiFi, fixed and the web.

Figure 2. The value of the New Conversation Experience



3. VOICE FOR THE 4G LTE SUBSCRIBER

Only a couple of years ago, many people believed that legacy 2G/3G circuit voice was adequate for 4G LTE subscribers. Now VoLTE is a business necessity and it is being deployed in preparation for commercial service.

Service providers took a closer look at the competitive value of mobile voice and VoLTE's relationship to broader communications services' innovation. They realized that 4G LTE puts application providers in a stronger position to deliver communications services. Many operators are engaged in analysis, Requests for Proposal (RFPs) and trials of VoLTE technology. Verizon Wireless [15] and AT&T [10] are preparing to launch VoLTE.

VoLTE optimizes the spectral efficiency of mobile voice in 4G LTE networks. It does so through optimizations such as Robust Header Control ([RoHC], reducing bandwidth consumed), Semi-Persistent Scheduling ([SPS], reducing the control channels used) and Transmission Time Interval (TTI) bundling (boosting uplink coverage at the cell's edge).

In the near-term, VoLTE is not the only method by which all operators will initially launch voice service. However, it is the best method when measured by competitive enablement and business risk.

3.1 Voice options

The four primary methods of voice service for 4G LTE subscribers are:

3.1.1 Voice over LTE (VoLTE)

VoLTE is the all-IP method that tightly links the voice application to the LTE network to assure the best subscriber experience in terms of performance, reliability, interoperability and global roaming. This is the industry's preferred method, with several initial launches planned for 2012 and 2013, rapidly shifting to widespread usage by 2014.

3.1.2 Circuit switched fallback (CSFB)

This method is used for interim LTE voice service pending the operator's launch of VoLTE. As a 3GPP method, it ensures standards-based performance, reliability, interoperability and roaming. But CSFB is legacy 2G/3G circuit voice, typically narrowband (rarely HD audio), and does not enable all-IP services such as video calls or WebRTC. Originating a voice call or answering a terminating voice call (unless the call is rejected) forces the CSFB smartphone to fall back from 4G LTE to 2G GSM or 3G UMTS. Because 4G LTE smartphones are built to utilize only one radio at a time (the *single active radio* design which reduces size, battery consumption and cost), both the voice and the data service fall back simultaneously from 4G LTE to legacy service.

Focusing on the data service, the fallback to 3G HSPA+ might not be so bad, but fallback to 3G UMTS is certainly a competitive concern, and fallback to 2G GSM causes the data session to be suspended because no operator has deployed the Dual Transfer Mode technology that enables simultaneous voice and data in 2G GSM.

3.1.3 Simultaneous voice and LTE (SV-LTE)

Simultaneous Voice and LTE (SV-LTE) is implemented by some device manufacturers for CDMA operators. An SV-LTE smartphone actually has two simultaneously active radios. One radio provides CDMA 1xRTT for circuit voice, and a second radio provides 4G LTE for IP data. In this way, an SV-LTE handset equips the CDMA operator with the clear subscriber value of simultaneous legacy voice and 4G LTE data. (Without it, CDMA operators can use only voice or data, not both simultaneously, as can 3G UMTS and 4G VoLTE subscribers.) However, such a handset might be larger or heavier due to the need for two simultaneously used antennas plus a larger battery for the increased current drain, and therefore it might incur a higher acquisition cost.

3.1.4 Partnering with application and content providers

Application and Content Providers (ACPs) are sometimes referred to as over-the-top (OTT) providers. In this paper we refer to them as *application providers*. Rather than competing with all application providers, the mobile operator might partner with some for 4G LTE voice. This method would directly fuel the operator with the application developers' innovation, albeit with revenues shifting to the partner's coffers.

However, as a non-3GPP method, the mobile operator incurs custom development costs in order to make such an *over-the-top* VoIP in 4G LTE match the ecosystem benefits of VoLTE (smartphone supply, scaling, interoperability and roaming) and the performance aspects of VoLTE (spectral efficiency, quality of service and so on). Such a strategy directly incurs business risk should the partners' strategies diverge, causing the mobile operator to scramble to field a communications system.

While partnering can make sense for selected application innovation and new business models, the business risk to fundamental services such as mobile voice and all that the VoLTE infrastructure enables must be assessed.

4. VoLTE'S VALUE

Application providers have commercially launched very popular voice, video and messaging services that are shifting consumers' attention and usage. Skype has 700 million registered users, of which 170 million used the service at least once per month. [11] Apple® has sold countless iPhones®, iPads® and Macintosh computers, many of which are capable of FaceTime® video-calling.

The application providers' success stems from the fact that they are delivering services that people enjoy using and can use at a nearly-free price. Clearly, consumers are willing and eager to engage in new communications that are enabled by smart devices and broadband. It's time for the global public network to move beyond basic voice and texting. It's time for the global public network to deliver video-calling in mobile. For more information, please refer to the white paper, *Enliven conversations with video.* [2]

As the new mobile voice service, VoLTE provides better service, as shown in Table 1. VoLTE integrates voice with 4G LTE to ensure the critical reliability and quality of that voice service. VoLTE ensures subscribers continue to enjoy key mobile features such as global roaming, global interoperability and a global ecosystem of smartphones and tablets. VoLTE also enables new services beyond traditional mobile telephony. With VoLTE, smartphones and tablets remain in the 4G LTE network even during voice calls, allowing new services such as video-communications and converged IP messaging to be delivered.

Table 1. The value of VoLTE

		VoLTE	CSFB	APP PROVIDERS
	SUBSCRIBER'S SERVICE	NEW CONVERSATIONS	LEGACY VOICE & SMS	MANY SERVICES
Standards	End to End QoS	✓	✓	×
	Global interoperability, including regulatory	✓	✓	×
	Roam with local voice, not home-routed data	✓	✓	×
Multimedia	All-IP network enables video-comms, etc.	✓	×	✓
	4G LTE data simultaneous with voice	✓	×	✓
	Foundation for services innovation, WebRTC, etc.	✓	×	✓
Voice	Evolved voice: HD, new features, WebRTC, etc.	✓	×	✓
	Minimal voice call setup delay	✓	×	✓
	Graceful continuity to 2G/3G circuit voice	✓	✓	×

In the near-term, several operators use CSFB as an interim 4G LTE voice service prior to their deployment of VoLTE as the preferred method. Alcatel-Lucent already supports several mobile operators' commercially deployed CSFB service.

However, CSFB voice is a limited service. A voice call (originating or terminating) forces a fallback to legacy 2G or 3G service. This means that during voice calls the subscriber is limited to legacy circuit-switched (CS) voice, texting and slower 3G mobile data services — or the subscriber may lose mobile data service altogether during a fallback to 2G. Service providers who select CSFB as an interim phase should minimize time spent in that phase for the following reasons:

- Innovation is limited: New services that rely on all-IP networks cannot be implemented. These include video calling and WebRTC.
- Customer experience is compromised: During voice calls, CSFB subscribers actually lose their 4G LTE data service, falling back to 3G or 3G HSPA + rates or losing data service altogether during a fallback to 2G. Although HD voice is being increasingly deployed in 3G networks, it will be available less often than the new 4G LTE networks, which generally begin with the capability deployed throughout new devices and new network elements (such as conference bridges and gateways). And CSFB call setup time is greater than 4 seconds (approximately 1 second more than 3G call setup), and is noticeably longer than VoLTE's sub-second call setup time.
- Spending and risk increase: Service providers incur the financial burden, inefficiencies, business risk and technical challenges that come with operating, maintaining and growing two networks in parallel — 4G LTE and legacy 2G/3G networks. In the meantime, the application providers continue to win subscribers.

5. HOW DOES VoLTE WORK?

5.1 Introduction

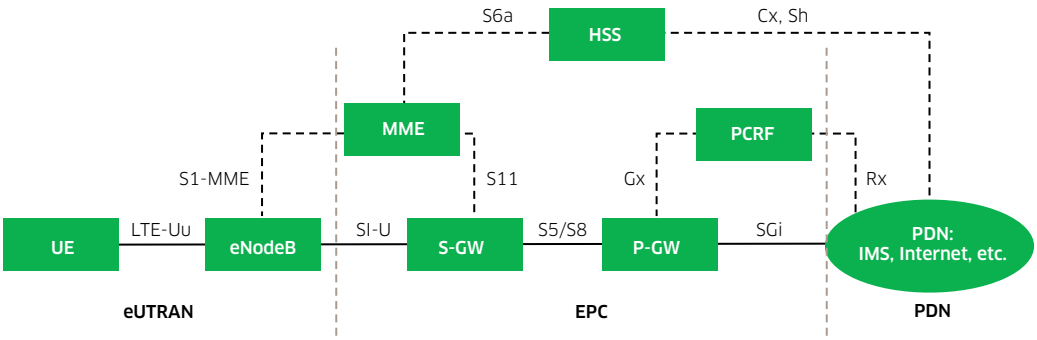
In contrast to the circuit-switched design of 2G and 3G networks, 4G LTE is designed as an all-IP network for the native support of packet services. It provides seamless IP connectivity between the subscriber's devices (user equipment [UE]) and the Packet Data Networks (PDNs), such as advanced communication services that are delivered through IP Multimedia Subsystem (IMS). 4G LTE provides this seamless IP connectivity while also providing improved spectral efficiency, higher bandwidth, reduced latency and Quality of Service (QoS).

The 4G LTE network is composed of the evolved universal terrestrial radio access network (eUTRAN) and the Evolved Packet Core (EPC). The 4G LTE network uses the concept of bearers to route IP traffic from the UE to the PDN. A bearer is an IP data session with a defined QoS. Aside from the default bearer that is established at the time of the UE's attachment to the 4G LTE network, the network sets up and releases bearers as required by an application. These additional bearers are called dedicated bearers, and two that particularly matter to the voice service are:

- SIP signaling: Established when the UE's client registers with the network
- VoLTE. Established during a VoLTE call

Figure 3 shows the overall architecture of the 4G LTE network. For more details, see the white paper *The LTE Network Architecture: A comprehensive tutorial.* [4]

Figure 3. 4G LTE network architecture



The functional elements of the 4G LTE network are:

- UE: The 4G LTE device used by the subscriber, such as a smartphone, tablet, laptop or machine-embedded service.
- Evolved Node B (eNodeB): A flat radio network architecture, unlike the layered method of 3G, which therefore simplifies the radio access network's operation.
- Serving Gateway (S-GW): All IP packets (signaling plus bearer) traverse the SGW, which is the local mobility anchor for bearers when the UE moves between different eNodeBs or hands over to legacy 2G or 3G network access.

- PDN Gateway (P-GW): It provides IP address management, QoS enforcement and flow-based charging according to the policy rules it receives from the Policy Control and Charging Rules Function (PCRF). It provides the mobility anchor point for non-3GPP technologies such as CDMA, WiMAX, WiFi and fixed broadband networks. The PGW also connects IP bearers to the PDNs.
- PDN: The PDN includes IP networks connected to the 4G LTE, such as for advanced communication services, content delivery networks and the Internet.
- Moblity Management Entity (MME): The MME processes the signaling between the UE and the core network. Its roles include bearer management (establishment, maintenance and release) and connection management (establishing the data connection between the UE and the network).
- PCRF: The PCRF is responsible for policy control decision-making and for controlling flow-based charging. It instructs the network about enforcement of QoS policies based on information it receives from the subscriber policy repository, typically in the Home Subscriber Server (HSS) or PDNs (such as VoLTE or video bearer identification sent to the PCRF through the Rx interface).
- HSS: The HSS contains the UEs' information, including QoS profiles, identification, authorization and provisioned services.

5.2 QoS and bearers

Typically multiple bearers are running on a UE at the same time, for example, covering the default bearer, streaming video, SIP signaling and an in-progress VoLTE call. Each of these services has different QoS requirements, and managing these as a group enables 4G LTE's graceful treatment of multiple simultaneous services.

Unlike 2G and 3G packet data services, which treat everything on a first-come, first-served basis, the 4G LTE bearer structure ensures that each service receives the QoS it needs to render a great subscriber experience, even when simultaneously using multiple applications. For example, too many missed bits in a streaming video (such as YouTube) causes flicker that is quickly noticed by the human eye but such streaming is safely buffered for a bit of time.

In contrast, a real-time voice session (such as VoLTE) can tolerate more missed bits because the ear does not notice it as quickly as the eye. However, the delay must be minimized to ensure the immediacy of human-to-human communication and to avoid the talk-over problem encountered on satellite calls or VoIP calls with excessively long jitter buffers.

For each bearer, the 4G LTE network assigns a QoS Class Identifier (QCI) level. Each QCI is characterized by resource type of guaranteed or non-guaranteed bit rate, priority during congestion, packet delay budget and a packet error loss rate. These QCIs determine how a bearer is handled all the way from the UE to the PDN, inclusive of radio resources and packet data flows. The standard QCIs (of 3GPP TS 23.203) are outlined in the Table 2.

Table 2. Standard QCI values

QCI	RESOURCE TYPE	PRIORITY	PACKET DELAY BUDGET	PACKET ERROR LOSS RATE	EXAMPLE SERVICES
1	GBR	2	100 ms	10^{-2}	Conversational voice
2	GBR	4	150 ms	10^{-3}	Conversational voice (live streaming)
3	GBR	3	50 ms	10^{-3}	Real time gaming
4	GBR	5	300 ms	10^{-6}	Non-conversational video (buffered streaming)
5	Non-GBR	1	100 ms	10^{-6}	IMS signalling
6	Non-GBR	6	300 ms	10^{-6}	Video (buffered streaming), TCP-based
7	Non-GBR	7	100 ms	10^{-3}	Voice, video (live streaming), interactive gaming
8	Non-GBR	8	300 ms	10^{-6}	Video (buffered streaming), TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
9	Non-GBR	9	300 ms	10^{-6}	

5.3 VoLTE overview

Aside from specialized aspects to interact with the 4G LTE network (for example, to ensure QoS or hand over voice calls from packet 4G LTE to circuit 2G/3G), the VoLTE application uses the same advanced communications network as found in fixed broadband VoIP, Rich Communications Suite (RCS, RCS enhanced [RCSe]), video communications and messaging applications. In this way, VoLTE immediately benefits from years of investment in commercial networks that have established its reliable performance, operations, scaling, economics and so on.

This reliability drives business benefits that are a key part of VoLTE's appeal, whether for CAPEX and OPEX controls or for the subscribers' service convergence across fixed, mobile and the web. To these advanced communications networks, the VoLTE application adds a few specialized functions:

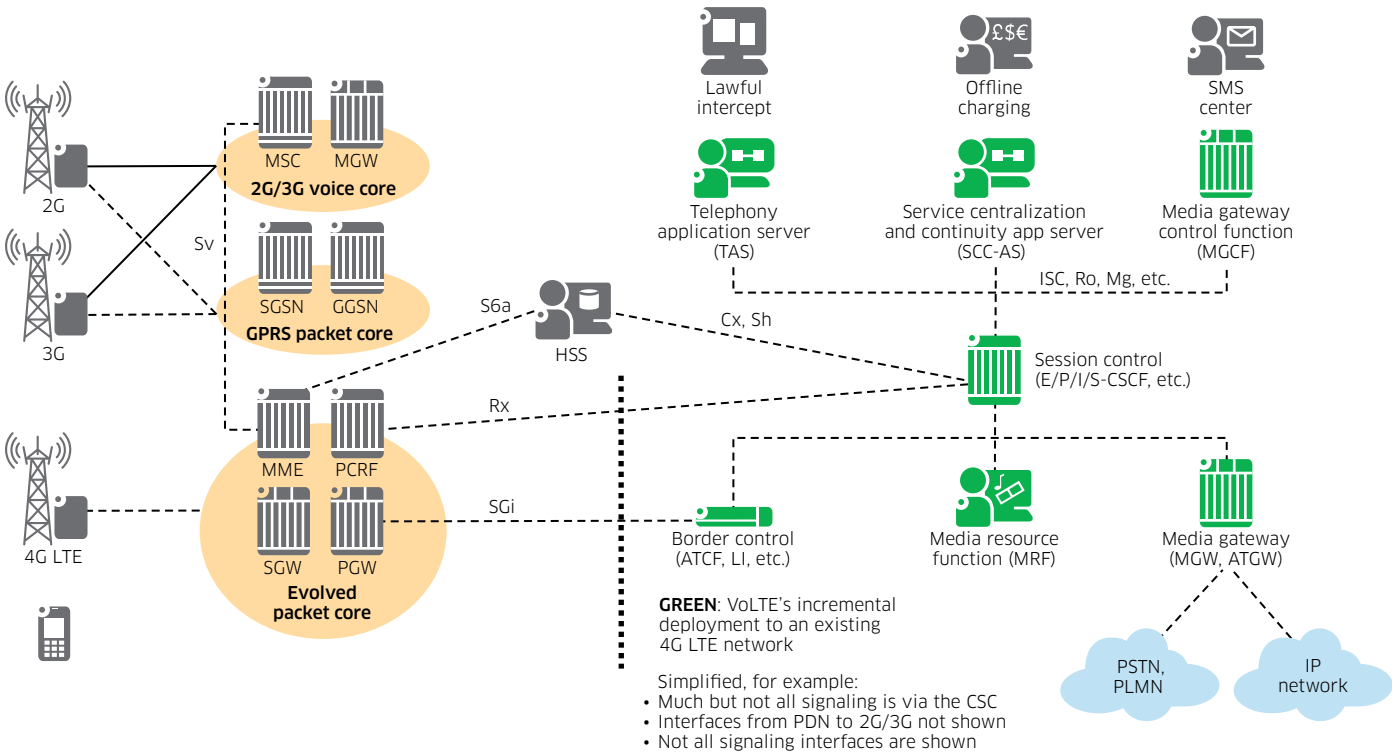
- QoS
- Graceful handover of in-progress voice calls from VoLTE (packet) to 2G/3G (circuit)
- Emergency calling (for example, a subscriber's call for help to police)
- Intelligent Network (IN) service migration
- Short message service (SMS) over IP
- IMS centralized services

The first four items are additional points of service differentiation for the VoLTE operator when compared to an application provider's mobile VoIP. Operators might use VoLTE's value to create partnerships with some application providers.

As part of the GSMA's VoLTE initiative [14], in PRD IR.92 [13], they have identified the minimum mandatory set of 3GPP standards that ensure a global VoLTE ecosystem. Such a global ecosystem is necessary to ensure that mobile voice telephony in 4G LTE achieves the performance, scale, interoperability, roaming and diverse supply of smartphones that was achieved in 2G/3G mobility.

Figure 4 provides the high-level network architecture for the VoLTE application.

Figure 4. VoLTE high-level network architecture



5.3.1 QoS

A hallmark of 4G LTE service is its multiple bearers and corresponding QoS levels, which enable a subscriber to use multiple applications simultaneously, as noted in the section *QoS and bearers*. VoLTE is such an application, and its QoS has been verified in lab and field trials in preparation for operators' commercial launch of VoLTE service.

When the subscriber originates or answers a voice call, a 4G LTE bearer with QCI = 1 is established. Mobile voice telephony is a critical service: subscribers expect and need reliable voice service. VoLTE's performance is a point of 4G LTE service differentiation that operators can provide better than can application providers' unoptimized voice (unless both the operator and the application developer invest in custom development of VoIP in 4G LTE). VoLTE's optimized voice bearer delivers on this need.

VoLTE ensures that the subscriber enjoys high-quality audio. VoLTE's QCI = 1 IP bearer is not encumbered by interference from other data applications contending for shared resources in the radio's connection, mobile backhaul from the cell site and so on. Such interference comes from concurrent applications on the subscriber's own device (such as browsing while talking) or from nearby subscribers who by mobility's design share the same radio and mobile backhaul resources.

Another effect of QCI = 1 is to use RoHC and SPS to efficiently match the rapid pacing of voice packets' creation and delivery.

The subscriber needs voice service throughout the cell. At the edge of the cell, the UE's voice application must have enough energy to reach the eNodeB without undue delay for retransmission of lost packets that would disrupt the voice call. VoLTE's techniques ensure that even at the edge of the cell, where distance and signal-levels are a concern, the voice service still functions. VoLTE techniques include RoHC and TTI bundling, which serve to boost the energy the UE can put into the voice bearer.

5.3.2 Graceful voice call handover

During the network's buildout, 4G LTE coverage is typically not ubiquitous for several years. And some 4G LTE networks operate at very high frequencies (such as 2.6 GHz) with line-of-sight characteristics. In either situation, the mobile subscriber is likely to move out of 4G LTE coverage during a live voice call. Subscribers need such calls to remain connected; otherwise, they will become upset at too-frequent dropped calls. This section provides an overview of such call handover. For a more in-depth description, see the white paper *Service Continuity for Today's VoLTE Subscribers* [9].

Intra-provider handover of a live voice call from 4G LTE VoIP (VoLTE) to 2G or 3G CS voice gives subscribers the confidence that their voice calls are preserved when moving out of 4G LTE coverage. This graceful voice call continuity is another point of 4G LTE service differentiation that operators provide better than the application providers' unoptimized voice (unless both the operator and the application provider invest in custom development of VoIP in 4G LTE).

4G LTE smartphones are built using the principle of a single active radio in order to reduce the smartphone's size, battery consumption and cost. Though the smartphones contain 4G LTE, 2G and 3G radios, only one is active at any given time. The VoLTE situation discussed here is different than a data handover because the subscriber is leaving 4G LTE coverage during a live VoLTE call, yet the live voice call must be gracefully handed over to 2G/3G CS voice.

This graceful call handover from 4G LTE's VoLTE to 2G/3G CS voice is accomplished through a technique referred to as Single Radio – Voice Call Continuity (SR-VCC), which is defined in 3GPP standards TS 23.216, TS 23.237 and TS 24.237. The voice interruption is very brief, less than 300 milliseconds, and is often not heard by the subscriber. Instead, what they may notice is that their 4G LTE's HD audio session reverted to today's typical 2G/3G narrowband CS voice or that their 4G LTE data service reverted to 3G.

For inter-continental roaming, an enhanced version, eSR-VCC, adds functions at the network's edge (Access Transfer Control Function [ATCF]) and Access Transfer Gateway [ATGW]) to ensure that the interruption in the voice service remains brief. This is accomplished by avoiding the longer distance's transport delays that would be encountered between the MSC and the home network. This process is defined in 3GPP standards TS 23.237, TR.856 and TS 24.237

As shown in Figure 4, the SR-VCC service works as follows:

1. During a live, in-progress VoLTE call, the subscriber's UE radio measurement reports to the eNodeB cause the eNodeB to trigger a handover to 2G or 3G.
2. The eNodeB instructs the MME what to do during the handover, including naming the target cell, and which services are to be handed over: only CS voice or both CS voice and PS data. Only live, stable voice calls are handed over, not calls that are on hold or in the process of being established.
3. The MME triggers the SR-VCC procedure with the 2G/3G MSC using the Sv interface. MSCs used in SR-VCC handovers must be upgraded with the Sv interface's software. The SR-VCC handovers can be focused onto a few MSCs, which reduces the number of upgraded MSCs. The MME selects the MSC based on the target cell ID provided by the eNodeB in its handover request to the MME.
4. The MSC prepares the handover, signals the target 2G/3G cell and initiates a session with the VoLTE network using the subscriber's identity, referred to as the Session Transfer Number – Single Radio (STN-SR). Under the direction of the Service Centralization and Continuity Application Server (SCC-AS), the VoLTE network switches the voice session from 4G LTE VoLTE to 2G/3G CS voice. After switching to 2G/3G CS voice, the MSC notifies the MME. The MME then instructs the UE to hand over from the 4G LTE eUTRAN to 2G/3G, which completes the handover.

5.3.3 Emergency calling

The subscriber's ability to safely make emergency calls for help to police, fire and ambulance is critical. Such calls must be reliable and consistently provide vital location information to the emergency agency so that help is quickly and accurately dispatched.

The calls must carry forward investments in techniques such as emergency auto callback in case of disconnection. The calls must also work in the midst of an emergency even if the subscriber moves out of 4G LTE coverage and the voice session is handed over to 2G/3G CS voice by SR-VCC. The confidence the VoLTE subscriber has to safely make emergency calls is another point of service differentiation for the VoLTE operator over the application provider.

Key network functions that provide VoLTE emergency calling include:

- Emergency-CSCF (E-CSCF): Interrogates the Location Routing Function (LRF) to determine the mobile subscriber's location and send the emergency call to the correct Public Safety Answering Point (PSAP).
- Emergency Access Transfer Function (EATF): Enhances the SCC application server to provide voice call continuity for emergency calls in the serving network and ensures that calls are not lost when a mobile device travels out of 4G LTE coverage area and into 2G/3G coverage.
- Removal of call-barring services in the HSS, so that emergency calls can be placed even while roaming.

5.3.4 IN service migration

Operators have invested years in their IN applications. In GSM/UMTS networks, these are often implemented as Customized Applications for Mobile Enhanced Logic (CAMEL) or Capability Set 1 (CS1) services, and are invoked by a query from the MSC towards an applications database. Example services include Prepaid, Toll Free/Free Phone, Number Portability, Charging, Call Limits, Home Zones and Virtual Private Networks (VPNs). Because of these applications' value, most operators prefer to migrate several of these IN services to VoLTE. This affords the VoLTE operator with the service differentiation of continuing popular services and ensuring that the subscriber's voice features are consistent in both 4G LTE and 2G/3G CS voice.

There are three common scenarios for IN service migration:

1. The specific IN service application supports both CAMEL for use in GSM/UMTS access and SIP for use in VoLTE access. The latter is sometimes referred to as next-generation IN (ngIN). Therefore, the application is always directly available.
2. The specific IN service application supports only CAMEL but the VoLTE operator has deployed the IP Multimedia – Service Switching Function (IM-SSF) to interwork between SIP and CAMEL signaling. Therefore, the application is also available from VoLTE through protocol interworking.
3. The specific charging application (such as for Prepaid) is accessible through CAMEL for GSM/UMTS access and also for online charging through the Diameter Ro interface for VoLTE access. Therefore, the Prepaid application is always directly available.

Not all operators will migrate their existing IN services from 2G/3G CS voice to VoLTE. Some wish to move to the more dynamic application creation environment enabled by Representational State Transfer (REST) APIs. REST APIs are enabled by Alcatel-Lucent for VoLTE networks and shrink the application creation time from months to weeks. Easy to use, REST APIs mainstream application developers' innovation into the operators' communication services.

For more information, see the white paper *IN Services Migration*. [3]

5.3.5 SMS over IP

SMS is included in the GSMA's VoLTE IR.92 specification because of the vital service it provides and its close relationship with voice.

There are two commonly encountered methods for providing SMS to 4G LTE subscribers: transporting SMS over a new interface from the MSC to the MME or upgrading the SMS application server to accommodate SIP.

Initial 4G LTE deployments that pre-dated CSFB and VoLTE required SMS for over-the-air activation, advice-of-charge, regular texting and so on. To avoid handovers to 2G/3G for every SMS that was sent or received, these initial 4G LTE deployments used a technique referred to as SMS over SGs, which had the beneficial effect of keeping the UE connected to 4G LTE instead of reverting to 2G/3G. The term SGs refers to an interface from the MSC to the MME that transported the SMS message between the existing SMS Center and the 4G LTE UE.

With the deployment of VoLTE and its advanced communications network, there is no need to perpetuate the consumption of 2G/3G MSC resources to provide SMS service through the SGs interface. Instead, the existing or new SMS Center is a SIP application server that provides SMS over IP. A business study of the operator's network would indicate which of three common techniques is best suited for providing SMS over IP:

1. Without upgrading the existing SMS Center, front-end it with a gateway that converts signaling between SIP and the SMS Center's SS7 MAP. Such a gateway is referred to as an IP-Multimedia SMS Gateway (IM-SM-GW).
2. Retrofit the existing SMS Center with a software upgrade so that it natively has a SIP interface.
3. Deploy a new SMS Center that natively includes a SIP interface.

5.3.6 IMS centralized services (3GPP ICS)

A key value of IMS is that of convergence. Consolidating networks and subscribers' services onto a common core creates economic savings and ubiquitous services. This is inherent in IMS networks. However, the industry explored enhancements that extend this convergence to legacy 2G and 3G CS voice services; collectively this extension is referred to as 3GPP IMS Centralized Services (3GPP ICS). The goal of 3GPP ICS is to ensure the subscriber's voice features are consistent in both 2G/3G's CS voice and 4G LTE's VoLTE.

After much analysis, the industry quietly converged on the realization that 3GPP ICS' value does not warrant investment. Aside from a modest assistance from the UE's client to take care of two features, the many popular voice features specified in GSMA PRD IR.92 (VoLTE specifications) are available in both 2G/3G CS voice and in 4G LTE VoLTE networks.

For more details, see the white paper *Service Consistency for Today's VoLTE Subscribers*. [8]

6. PATH TO VoLTE

Clearly, VoLTE is compelling and is being commercially deployed by first movers. So, what is it that triggers a specific operator's decision about when to begin their VoLTE deployment?

In our view, the decision is triggered by an operator's specific competitive situation and underlying 4G LTE's network readiness. The 4G LTE network's readiness is a gating factor. The VoLTE operator must have purchased 4G LTE spectrum that covers critical markets, and they must have deployed or have a firm plan to deploy 4G LTE's radios, mobile backhaul, packet core and so on. The VoLTE deployment is comparably small when compared to the rest of 4G LTE, yet it too must be done well in order to assure subscribers' service and win their business.

Examining the operator's specific competitive situation for communication services, the path to the new mobile voice encompasses a number of considerations, discussed in the following sections.

6.1 The New Conversation Experience

Today, technology drives our conversation experience. With 4G LTE, it's time to turn that around and let the user experience drive technology. With this approach, service providers can deliver a New Conversation Experience: one that encourages subscribers to use more services and spend more time on the network, and an experience that leverages network intelligence to deliver a user experience that application providers struggle to achieve. For more information about the New Conversation Experience, please see the article "Needed: A New Conversation Experience." [5] and the white paper *The New Conversation Experience: It's Time to Reinvent Communications*. [6].

6.2 Planning VoLTE's implementation

VoLTE is a serious engineering undertaking, which includes the following items that must be analyzed and for which specific plans must be created.

6.2.1 Voice call continuity

Most operators use SR-VCC or eSR-VCC. For more information on this topic, see the preceding section or refer to *Service Continuity for Today's VoLTE Subscribers* [9]

6.2.2 Device ecosystem

Smartphones, tablets, and other devices enable any 4G LTE service, including VoLTE. Thanks to VoLTE first-movers' preparations to commercially launch services in the near-term, these devices are being tested by Alcatel-Lucent, which prepares the way for subsequent operators' launches. Furthermore, by implementing VoLTE and its SIP client on the devices, these become a touch-point for innovation whereby video, messaging and further services are realized.

6.2.3 IN services

Most operators are planning or evaluating how to migrate their existing IN services from 2G/3G to 4G LTE. Some services are more critical, such as Prepaid. For more information on this topic, see the preceding section or refer to *IN Services Migration* [3]

6.2.4 Roaming between multiple operators' 4G LTE networks

A few early VoLTE operators have the breadth to launch home-network service without establishing 4G LTE roaming. Their subscribers use conventional 3G HSPA + services for the comparably rare situations when roaming to other operators' networks. Several VoLTE operators plan to use CSFB for the initial phase of 4G LTE network roaming and to transition to VoLTE-based roaming after standards, business agreements and interconnections are finalized. Most VoLTE operators are still planning their precise strategy using one of the preceding two methods or one of:

- *Interim home-routed method* (see Figure 5): This roaming method replicates the data-roaming method in 2G, 3G and 4G LTE, whereby the voice traffic is also routed to the home network. Its advantage is that it is based on a known, implemented architecture and is available from 3GPP R5. The drawback is that it does not follow current voice roaming practice where voice efficiently routes from the calling party's visited network to the called party's home network.
- Circuit switched copycat method (Figure 6): This roaming method uses Local Breakout (LBO) to expeditiously route the voice traffic and follows current voice roaming practices. It does not change the CS voice charging agreements between operators, which explains the name *circuit-switched copycat*. This method is championed by the GSMA and is part of 3GPP R11.

Figure 5. Interim home routed roaming method

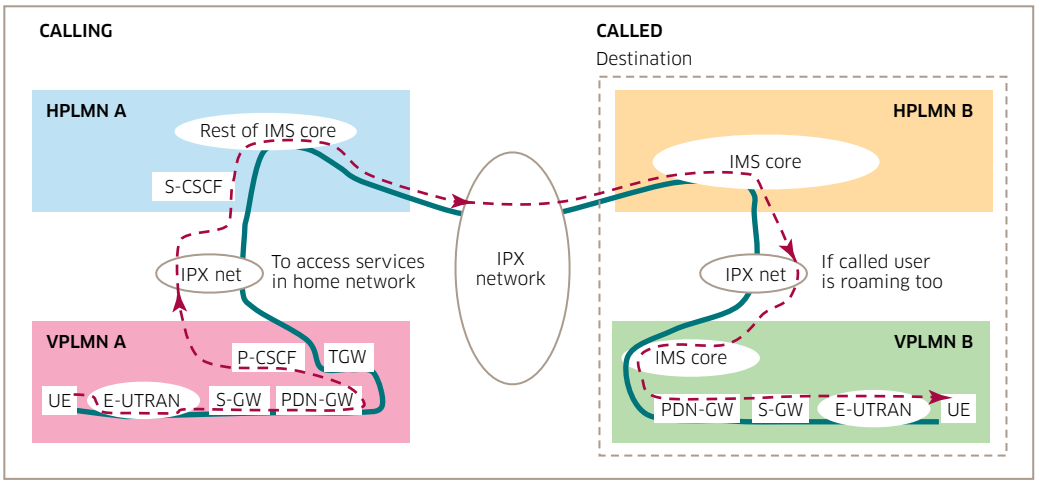
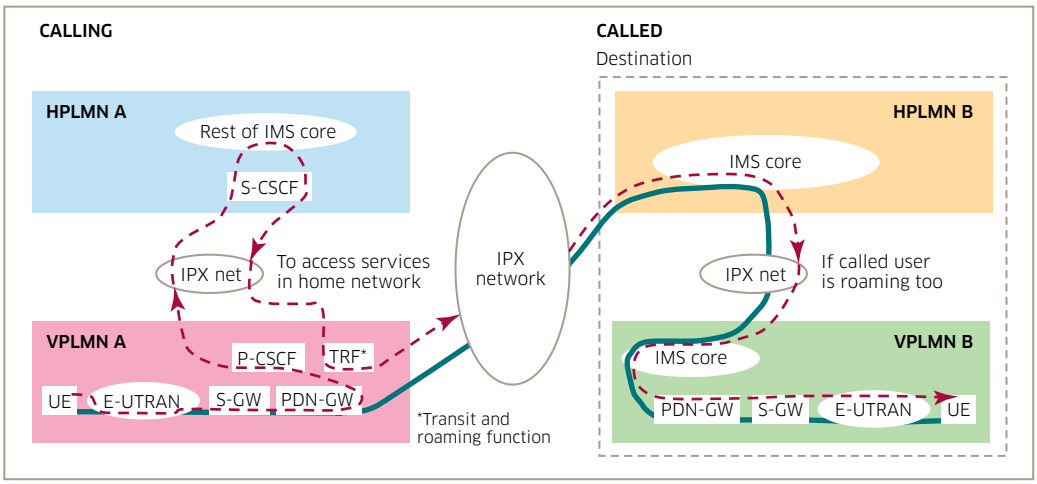


Figure 6. Circuit switched copycat roaming method



7. CONCLUSION

As operators plan VoLTE's deployment, they are taking care to ensure that the stringent metrics necessary for commercial mobile voice are guaranteed. VoLTE has tremendous value and de-risks an operator's business strategies by affording the most degrees of freedom, but it is a critical service that requires deep expertise to assure mobile voice that meets or beats 2G/3G's performance.

Today, operators of all sizes in all regions are engaged in VoLTE trials, evaluations and preparations. Some examples include Verizon Wireless, who has successfully placed VoLTE calls on their commercial network [15] and has shown the first public demonstration of VoLTE and video calling on a 4G LTE smartphone [7]. AT&T has announced they will launch VoLTE service in 2013 [10].

VoLTE is a serious engineering undertaking, and service providers need a partner who can help them follow a safe, profitable path. Operators have contracted Alcatel-Lucent for commercial service (including Verizon Wireless) and we have trials covering all regions of the world. We implement VoLTE as part of the 4G Consumer Communications solution [1]. This solution assures subscribers of global roaming, service interoperability and performance. Voice, video and messaging have the immediacy and quality that people rely on for conversational services.

VoLTE is the new mobile voice. Operators can use VoLTE to innovate and extend mobile voice beyond a traditional call. Voice can become a feature of other services, such as navigation, e-commerce, social networking, status updates and augmented reality applications. VoLTE lets operators create engaging services and converge services to the web through WebRTC.

VoLTE's time is now. Call us to begin your move.

8. ACRONYMS

2G	Second-generation wireless, such as GSM
3G	Third-generation wireless, such as UMTS/WCDMA
3GPP	Third Generation Partnership Project
4G	Fourth-generation wireless, such as LTE
API	Application Programming Interface
ATCF	Access Transfer Control Function
ATGW	Access Transfer Gateway
CAMEL	Customized Applications for Mobile Enhanced Logic
CDMA	Code Division Multiple Access
CS	Circuit-switched
CSFB	Circuit-switched fallback
eNodeB	evolved Node B
EPC	Evolved Packet Core
eSR-VCC	Enhanced Single Radio – Voice Call Continuity
eUTRAN	Evolved Universal Terrestrial Access Network
FTP	File Transfer Protocol
GBR	Guaranteed bit rate

GSM	Global System for Mobile communications
GSMA	GSM Association
HD	high definition
HSPA+	Evolved High-speed Packet Access
HSS	Home Subscriber Server
ICS	IMS Centralized Services
IMS	IP Multimedia Subsystem
IN	Intelligent Network
IP	Internet Protocol
IPX	IP exchange carrier
LTE	Long Term Evolution
MME	Mobility Management Entity
MSC	Mobile Switching Center
NCE	New Conversation Experience
OTT	over-the-top provider
P2P	peer-to peer
PCRF	Policy Control and Charging Rules Function
PDN	Packet Data Network
PGW	PDN Gateway
PRD	Permanent Reference Document
PS	packet-switched
QCI	QoS Class Identifier
QoS	Quality of Service
RCS	Rich Communications Suite
RCSe	Rich Communications Suite – enhanced
REST	Representational State Transfer
RFP	Request for Proposal
SGW	Serving Gateway
SIP	Session Initiation Protocol
SMS	Short Message Service
SR-VCC	Single Radio - Voice Call Continuity
SV-LTE	Simultaneous Voice and LTE
TCP	Transmission Control Protocol
UE	user equipment, such as a smartphone
UMTS	Universal Mobile Telecommunications System
VoIP	Voice over IP
VoLTE	Voice over Long Term Evolution
WebRTC	Web Real Time Communication

9. REFERENCES

[1] Alcatel-Lucent. 4G Consumer Communications solution, web page. www.alcatel-lucent.com/4g-consumer-communications

[2] Alcatel-Lucent, *Enliven Conversations With Video*, white paper, May 2012. www.alcatel-lucent.com/4g-consumer-communications

[3] Alcatel-Lucent. *IN Services Migration*, white paper. May 2012. www.alcatel-lucent.com/4g-consumer-communications

[4] Alcatel-Lucent. *The LTE Network Architecture: A comprehensive tutorial*, white paper. 2009. ID CPG0599090904. www.alcatel-lucent.com/4g-consumer-communications

[5] Alcatel-Lucent. "Needed: A New Conversation Experience", *Enriching Communications* magazine, Volume 5, Issue 3. http://www2.alcatel-lucent.com/enrich/en/v5i3/needed-a-new-conversation-experience/

[6] Alcatel-Lucent. "The New Conversation Experience: It's Time to Reinvent Communications", web page article. http://www.alcatel-lucent.com/ims-communications/inspire-new-conversations.html

[7] Verizon Wireless, VoLTE demonstration. http://www.youtube.com/watch?v = LXWD6swghrs

[8] Alcatel-Lucent. *Service Consistency for Today's VoLTE Subscribers*. 2011, M201110952 www.alcatel-lucent.com/4g-consumer-communications

[9] Alcatel-Lucent. *Service Continuity for Today's VoLTE subscribers*, white paper. May 2012. www.alcatel-lucent.com/4g-consumer-communications

[10] Fierce Broadband Wireless. AT&T's Rinne details LTE plans: VoLTE in 2013, web site announcement. Oct. 20, 2010. http://www.fiercebroadbandwireless.com/story/ts-rinne-details-lte-plans-volte-2013-will-use-aws-and-700-mhz/2010-10-20

[11] Gartner Inc. "Microsoft Skype Purchase to Drive Consumer and Social Efforts." May 27, 2011.

[12] Gartner Inc, "User Service Analysis: Consumer Services and Mobile Applications, Worldwide, 2011." ID number G002122213. May 3, 2011.

[13] GSMA Permanent Reference Document IR.92. http://www.gsma.com/documents/ir-92-5-0-ims-profile-for-voice-and-sms/21661

[14] GSMA VoLTE website. http://www.gsma.com/volte/

[15] Verizon Wireless. Verizon Wireless Announces World's First Successful Voice Over LTE Call On A Commercial LTE Network, press release. Feb. 9, 2011. http://news.vzw.com/news/2011/02/pr2011-02-09f.html

[16] WebRTC web site. http://www.webrtc.org

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