VoLTE: Mobile Voice Goes Packet-Based

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EXECUTIVE SUMMARY

No longer just a lab exercise, voice-over-LTE (VoLTE) is now being aggressively rolled out into live network trials, with mass deployment expected to start within the year. Fueled by the explosive growth of 4G long-term evolution (LTE) data traffic, the drive for reduced operating costs, and the promise of new competitive services, VoLTE nonetheless presents significant challenges to mobile network operators (MNOs), both in terms of achieving their business objectives and meeting the reliability and quality expectations of existing 2G/3G circuit-switch voice subscribers.

This white paper explains the multiple technologies that underlie successful VoLTE service rollouts, the associated challenges facing MNOs, and best current practices that enable MNOs to mitigate risks while maximizing the benefits of VoLTE—both for themselves and their subscribers.

INTRODUCTION TO VoLTE

What's Driving the Move to VoLTE?

Mobile Data Explosion

Mobile data services are growing at a compound annual growth rate (CAGR) of 66%, which means that in three years time, mobile bandwidth usage will have increased fivefold.

Today, mobile voice bandwidth currently stands at less than 0.3% of traffic, and as such is not significant enough to be represented in charts such as the one below, which illustrates global mobile bandwidth usage.

However, mobile subscribers still depend on high-quality voice services, much as service providers still depend on voice for revenue. So, what's driving the move to VoLTE? Why not stick with good ol' reliable circuit-switched (CS) voice?

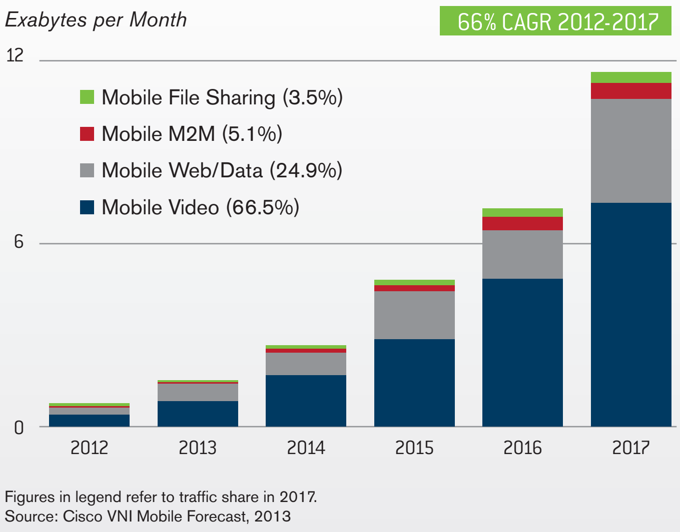

Figure 1. Mobile Data Usage Growth.

Cost Reduction

Cost reduction is one of the most important factors driving MNOs to adopt VoLTE; it's simply much cheaper to operate one packet-switched (PS) domain for data and voice than to operate two separate PS and CS domains.

Because MNOs need to keep re-investing in PS data technology to stay abreast of the mobile data tidal wave, it makes sense for them to focus their resources in this area. By investing in VoLTE technology, MNOs will be able to progressively displace their existing legacy CS voice access and core network infrastructure.

Reclaim Voice Spectrum

However, it's not just CS-access and core-network cost savings that are moving VoLTE forward. There are also the beneficial effects of LTE spectral efficiency. LTE is three to ten times more efficient at transferring bits per second per hertz and per cell sector than 2G or 3G radio technologies. Once 2G/3G spectrum is no longer needed for CS voice, it can be reallocated for LTE data services. In addition, VoLTE technology enables MNOs to bring voice services along in the changeover.

Because mobile data networks are data hungry, this extra spectral efficiency translates into significant cost savings.

Enable New Services

MNOs are also increasingly threatened by over-the-top (OTT) vendor services, and can't afford to sit still and watch their service revenue erode to the benefit of competitors who aren't burdened with managing a complex mobile service delivery network. However, VoLTE deployment is a critical stepping stone to offering competitive, new all-Internet-protocol (IP) services.

For example, most MNOs plan to roll out both high-definition (HD) voice and mobile video calling and videoconferencing as part of their VoLTE deployment, perhaps as a premium service option. HD voice and video calling requires much more bandwidth than traditional 2G/3G CS voice, and as such, is greatly facilitated by the move to high-bandwidth PS data networking.

However, it doesn't stop there. Once the VoLTE, HD voice and video infrastructure is in place, it's an easy step to the rich communications suite (RCS) of services, which in turn brings with it integrated social presence, shared directories, instant messaging (IM) and chat, live-session video and file sharing, and much more. None of these advanced services is possible when voice sessions force switchback to the CS network, as is necessary for 2G/3G CS voice.

Common IMS Service Delivery

Finally, VoLTE and associated video-calling services depend on the IP multimedia subsystem (IMS) multimedia telephony (MMTel) architecture for service delivery and service management. IMS is covered in more depth below, but in summary, it allows MNOs to deliver new RCS services, and also breaks the coupling between switching and service management layers. This in turn allows MNOs to centralize service delivery into a very small number of core IMS sites, thus streamlining and unifying service management.

Of course, IMS could be deployed without VoLTE. But, the reality is that most MNOs only plan to roll out IMS in conjunction with a compelling service driver. Thus, VoLTE deployment creates the need for IMS, and IMS provides even more opportunities for streamlining and cost savings.

VoLTE Basics

Traditional CS Voice and PS Data

In traditional 2G and 3G networks, voice is delivered over dedicated, fixed bandwidth channels to the user equipment (UE). Mobile data is transferred to and from the Internet using interleaved RAN timeslots via general packet radio service (GPRS) or enhanced data rates for global evolution (EDGE) access.

This arrangement is great for voice, because it guarantees fixed bandwidth for digital voice channels. However, it's not so good for data, because data bandwidth needs to burst up and down as upload and download demand rises and falls.

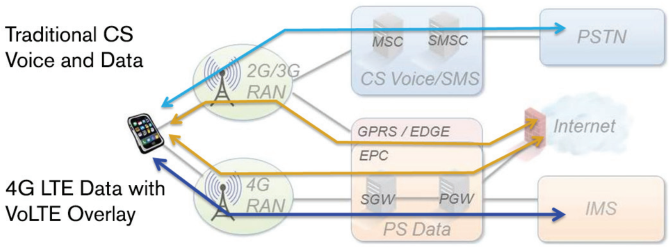

Figure 2. Traditional CS Voice and VoLTE Overlay.

LTE and Voice

With the advent of LTE, high-bandwidth, bursty data is optimized for the user, typically providing 40 Mbit/s or more of downlink bandwidth. However, LTE is defined as an all-digital, all-IP data network, so by definition, voice is expected to ride over the IP network along with the rest of the mobile data.

Essentially then, VoLTE is simply voice-over-Internet protocol (VoIP), but there are special considerations that apply to VoLTE versus other forms of VoIP.

Figure 3. LTE Bearer Quality Classes.

For example, VoLTE has explicit authentication and confidentiality requirements (using AKA authentication and IPsec encryption) that must be followed. Also, as previously mentioned, VoLTE standards mandate the use of IMS for service delivery. VoLTE also requires that different quality classes be assigned to signaling, voice and video media.

Finally, high-quality VoLTE support effectively requires IMS single radio voice call continuity (SRVCC). All of these topics are discussed in more detail in the following sections.

VoLTE NETWORKS IN DETAIL

IP Multimedia Subsystem (IMS)

IMS Basics

As previously mentioned, VoLTE service delivery requires that IMS be deployed in the mobile core. IMS is certainly not new, but it's fair to say that up to now, IMS deployments have largely been in fixed networks. Essentially, IMS breaks down session, call and service control into central, interoperable components.

For example, the call state control functions (CSCFs) provide call control, whereas the application servers (AS) provide service control.

Two key AS functions for VoLTE are MMTel (i.e., voice and video calling, and short message service (SMS) over IP features) and SRVCC, which is responsible for maintaining calls across inter-radio access technology (IRAT) handovers (which will be expanded on later).

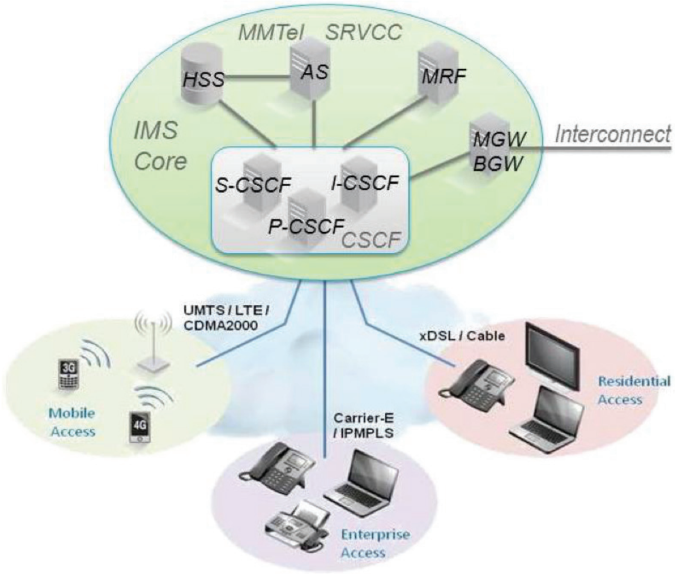

Figure 4. IP Multimedia Subsystem (IMS) Architecture.

IMS Benefits

In addition to multimedia telephony, there are multiple other benefits that come with IMS. The first of these is centralized service management, in which just a few AS servers are able to control service logic for the entire network.

Service delivery is also centralized, which means that only a few IMS core sites are required. This in turn translates to easier management and cost savings. IMS standards also enable interoperability of key components, which means that MNOs can pick and choose the best-of-breed offerings from among various vendors.

Also, owing to its built-in access-independent architecture, IMS is able to provide identical service profiles to subscribers, regardless of how they access the network. For example, a subscriber can specify a common set of call forwarding rules and numbers that work seamlessly between their mobile, business and residential services.

Finally, since IMS is dominated by server-based software, it lends itself very nicely to network virtualization techniques such as software-defined networks (SDNs) and network function virtualization (NFV).

LTE Dedicated Bearers and Quality Classes

LTE Bearers Overview

As mentioned, VoLTE standards specify quality-controlled dedicated bearers for different data-flow types. The table below summarizes the different dedicated bearer quality classes that are standardized, each assigned to a different quality class identifier (QCI).

Broadly speaking, the QCI classes are broken into guaranteed bit rates (GBRs), which have bandwidth reservation characteristics, and non-GBRs, which don't have such characteristics (and are therefore considered more unpredictable and bursty).

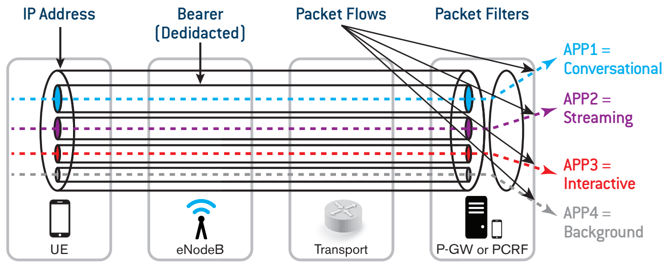

Figure 5. LTE Dedicated Bearers.

For example, VoLTE and IMS signaling is assigned QCI=5, which calls for non-GBR and moderately low packet delay, but extremely low probability of packet loss. It is also assigned the highest priority in accordance with the basic management principle that the controller needs to take precedence over what is being controlled.

VoLTE conversational voice bearers are assigned QCI=1, which calls for GBR and moderately low delay, but higher tolerance for packet loss (because voice media packets have better and speedier packet-loss concealment methods than signaling control messages). Conversational video has similar characteristics to voice, but is assigned lower priority (most subscribers place more importance on good voice quality than video quality), and lower packet loss objectives, given that video quality is much more susceptible to packet loss than voice.

Network Implementation

Needless to say, managing competing priorities to meet these packet delivery objectives is critical, but challenging. In practice, achieving QCI quality objectives depends on proper assignment of dedicated bearers to underlying transport infrastructure.

At the lowest level, dedicated bearer flows use standard Ethernet/IP DiffServ code point (DSCP) mechanisms to prioritize packet transport along the entire UE-to-core and core-to-UE delivery path. In addition, eNodeB to serving gateway (SGW) to PGW GTP-U tunnel policy enforcement and packet prioritization mechanisms are used to ensure that only traffic that meets requirements is admitted.

It is thus imperative that MNOs accurately tune Ethernet/IP switch-router DSCP policies with SGW/PGW traffic forwarding policies based on QCI, and properly assign VoLTE signaling and media to correct QCI classes. Otherwise, heavy bit-rate yet lower-class traffic such as Internet and streaming video can trash lower-bandwidth VoLTE call control and voice quality. The United States Department of Commerce (DOC) document entitled "LTE Priority, Preemption & QoS" [4] provides an excellent discussion and strategies for managing competing LTE dedicated bearer flows.

QCI	Resource Type	Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	GBR	2	100 ms	10^{-2}	Conversational Video
2		4	150 ms	10^{-3}	Conversational Video
3		3	50 ms	10^{-3}	Real-Time Gaming
4		5	300 ms	10^{-6}	Non-Conversational Video
5	Non-GBR	1	100 ms	10^{-6}	IMS Signaling
6		6	300 ms	10^{-6}	Video, Buffered Streaming
7		7	100 ms	10^{-3}	Voice, Video Live Streaming
8		8	300 ms	10^{-6}	Video, Buffered Streaming
9		9			

Figure 6. LTE Quality Class Identifiers (QCI).

Circuit-Switched Fallback (CSFB)

LTE Rollouts Today

Most MNOs have either already rolled out LTE service, or are actively equipping their network for LTE. However, very few MNOs (and, as of this writing, no tier-one operators) have rolled out the IP-based voice services mandated by the LTE all-IP architecture.

Instead, LTE is mostly used at present to deliver high-bandwidth mobile Internet data service, whereas voice is still carried over the traditional CS voice network. Apart from deployment of dual-radio UEs (an initiative that is now essentially defunct owing to severe UE size and weight penalties), delivering data on LTE and voice on traditional CS infrastructure requires switching between the LTE RAN and 2G/3G RAN every time the user wants to make a voice call.

CSFB is the standard method for achieving this switchover.

So, How Does CSFB Work?

Let's say a mobile user is browsing the Internet over LTE when a voice call comes in. Because in this case the MNO is only supporting CS voice, the call is delivered to the CS network mobile switching center (MSC) server.

The MSC server checks the status of the UE to which the call is to be delivered and validates that the UE is currently attached to the LTE network. The MSC server then sends a page message to the UE via the LTE/EPC network indicating that a call has come in, instructing it to switch (hand over) radio control to the 2G/3G CS voice network where the call can be picked up.

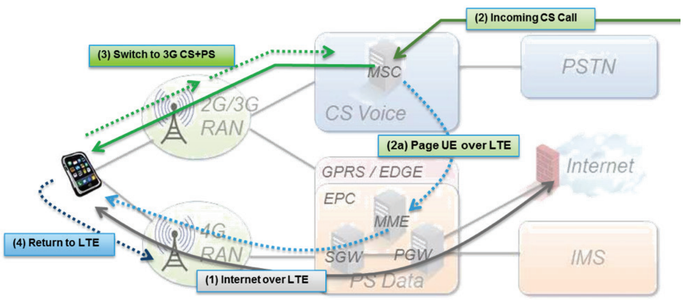

Figure 7. Circuit-Switched Fallback.

Once that is accomplished, the call is completed using traditional CS signaling and voice bearer circuits.

CSFB Drawbacks

Although comparatively easy to implement, there are multiple drawbacks to the CSFB approach. One particularly unfortunate drawback is that detaching from the 4G RAN and attaching to the 2G or 3G RAN takes the PS data connections along with it. As such, PS-data connection bandwidth is either severely downgraded to 2G/3G data bandwidths (at best)—or more likely, dropped completely (which is more typical).

Even more troublesome is the fact that voice call setup is delayed by an additional one to three or more seconds on top of already long mobile call setup times, due to the need to switch RANs on every call. This could easily be very negatively perceived by subscribers.

Finally, inter-RAT handovers are inherently more risky, because radio coverage and bearer availability on LTE and 2G/3G services may not be comparable at every location. Because a lot of the new RAN investment is going into LTE, it s not uncommon for LTE coverage to be superior to 2G/3G coverage. This leads to a much higher probability of dropped calls when UEs attempt to switch over to send and receive voice calls.

The solution to all of these drawbacks is SRVCC.

SRVCC

True VoLTE Rollout

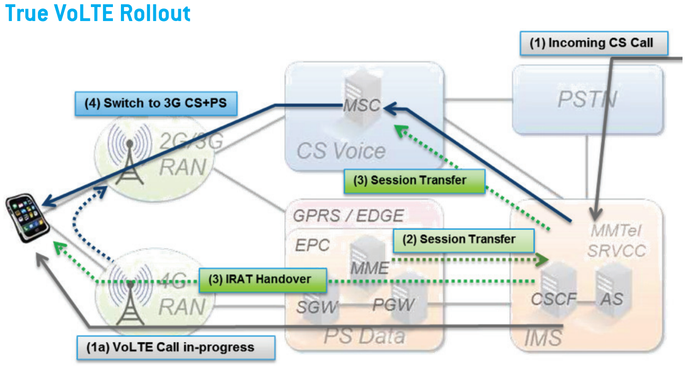

Figure 8. Single Radio Voice Call Continuity (SRVCC).

True VoLTE service effectively requires SRVCC, as this functionality allows voice calls to be delivered as VoLTE calls if LTE coverage is available where the UE is located. SRVCC also enables the call to be delivered via legacy 2G/3G voice if LTE coverage is not available. Furthermore, SRVCC provides for voice call handover between LTE and 2G/3G voice if there is radio coverage while a call is in progress.

And, as the name SRVCC implies, all of these functions are performed with only a single radio function on the UE, thus avoiding the size and weight drawbacks of dual-radio handsets.

So, How Does SRVCC Work?

First and foremost, voice calls are now made and received over the LTE PS data network; that is, as long as the UE remains attached to the LTE RAN. However, if 4G LTE service becomes unavailable, SRVCC functions will attempt to switch the call to the 2G or 3G CS voice network (if available) while it is still in progress.

Once call switchover is accomplished, the voice portion of the call is assigned to a CS voice circuit, but the video portion of the call (if present) is lost. The same thing happens to LTE PS data as CSFB—the data connections are either lost or downgraded to 2G/3G bandwidth levels. Thus, voice service would be preserved as a priority if LTE coverage were to degrade at the expense of more advanced voice and data services.

SRVCC switchover of voice calls is relatively fast: less than 0.3 seconds on a well-managed network. This is in part due to the fact that session transfer and IRAT handover occur in parallel, and in part due to the IMS core maintaining control over the call throughout the entire process.

Once LTE coverage is again available, the call is handed back to the 4G LTE RAN, and the previous voice, video and data session is resumed. Note that SRVCC handovers and handbacks can occur any number of times during a voice call session.

SRVCC Advantages

Because all calls are now on the high-bandwidth LTE/EPC network, call setup performance is much faster than tradition CS calls (about 0.5 seconds versus 4 seconds).

More importantly, voice calls can now be made at any time while other messaging and data sessions are running, and without disrupting any work the mobile subscriber has in progress. In addition, voice calls are now able to take advantage of higher bandwidth media allowing both high-definition (HD) voice and video calling on the same voice session.

Finally, if LTE coverage degrades during the voice call, or the UE subscriber is roaming where no LTE coverage exists, voice service is preserved as a priority by switching over to available 2G/3G voice as a backup. Thus, all of the CSFB functions continue to be available, but work at much higher performance levels thanks to the IMS directed architecture.

VOICE HANDLING ASPECTS

High Definition (HD) Voice

VoLTE Wideband Codecs

Traditional telephony uses so-called narrow-band (NB) codecs such as adaptive multi-rate (AMR-NB), which limit audio channel bandwidth to 300 – 3400 Hz. Narrowband is fine for speech intelligibility, but subscribers now expect more when buying high-bandwidth LTE service.

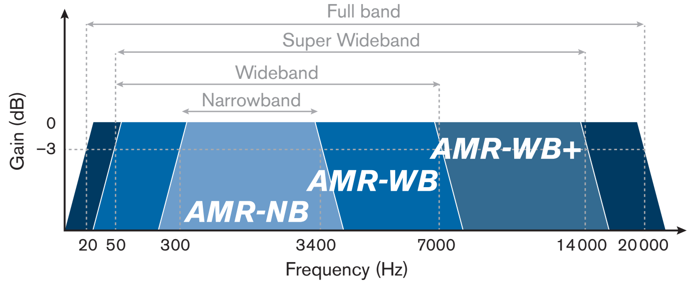

Figure 9. VoLTE HD Voice Codecs.

Consequently, most MNOs are planning to roll out VoLTE using so-called wideband (WB) or super-wideband codecs like AMR-WB or AMR-WB+. The much wider audio channel bandwidth provides mobile users with an incredible impression of "presence" when conversing with others, as if they were together in the same room. End-to-end voice latency is also reduced, simply by virtue of the higher bits/second transfer rates afforded by LTE.

However, superior fidelity also brings with it the annoying noticeability of any environmental noise on the speaker's end, including background street noise and even personal movements.

Background Noise Suppression

Due to the HD-voice background noise problem, most VoLTE-ready handsets are now equipped with built-in background noise suppressors. Typically, background noise suppressors use a second UE microphone that measures and interprets background noise independently of the speaker's voice, which is picked up by the primary UE microphone. The background noise signals can then be dynamically removed from the primary audio channel, thus leaving only the speaker's HD voice. Indeed, noise suppressors work essentially the same way as noise cancelling headphones.

With the combination of VoLTE, HD voice and noise suppression, all of the advantages of high-fidelity audio can be provided on mobile voice service without any of the drawbacks. Noise suppression technology is now so good that HD voice calls can even be made in crowded rooms full of talking people, and on streets filled with noisy traffic.

GSMA Branding Program

The global system for mobile communications (GSM) Association (GSMA) manages a branding program for HD voice, and sets the minimum requirements applicable for use of the HD voice brand by MNOs and handset vendors. In addition to wideband codecs, background noise suppression is also required for HD voice branding.

Although not strictly required for operation of a VoLTE service, all implementations of VoLTE will effectively be based on HD voice branding going forward. However, note that HD voice is not limited to VoLTE–it can be and is used on fixed-line voice services, as well as other mobile technologies (e.g., HSPA+).

Transcoding and Echo Control

Voice Echo

The question is, will echo be as big a problem on VoLTE calling as it was on fixed VoIP when it was rolled out? The simple answer is yes, it does have the potential to be a problem; however, technology is already in place to deal with it.

If present, the following two conditions will cause callers to experience unacceptable levels of echo on calls: (1) a far-end echo return source, and (2) significant round-trip audio transmission latency (greater than 100 milliseconds). The harsh truth is that these preconditions for echo problems already exist within the context of today's 2G/3G mobile voice calling, given that mobile end-to-end audio delays are already excessively long.

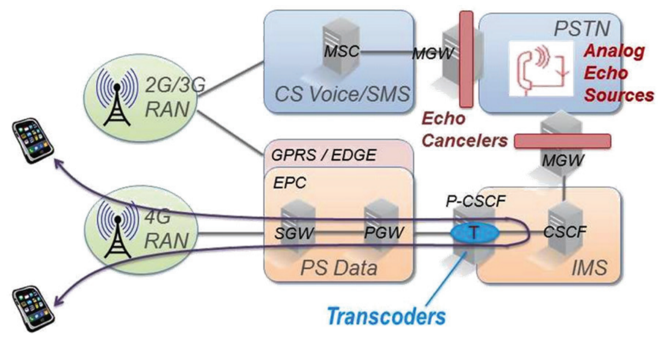

Figure 10. VoLTE Transcoding and Echo Control.

However, mobile-device echo return standards are so tight that at preset, no significant echo return exists from mobile UEs. Also, intervening mobile voice channels are all-digital, and therefore no echo return exists along the voice path either. As such, the long audio-channel latencies present on mobile-to-mobile calls are only an annoyance in terms of conversation turnaround time, but virtually never result in an echo problem.

Unfortunately, the same cannot be said for public switched telephone networks (PSTNs), for which terminal standards are much less stringent. In addition, terminating analog circuits in which hybrid devices may be present can cause impedance-mismatch echo returns.

It is thus essential for mobile-to-PSTN media gateways (MGWs) to have echo cancellers available (either built-in, or accessible in-line). Most MNOs already have such echo cancellers deployed, in which case no additional functionality is needed. However, if existing echo cancellers cannot be easily redeployed into the new IMS core network, a new echo-cancellation solution may be required.

Voice Transcoding

VoLTE-to-VoLTE calls that are on the same MNO network will most likely involve the same codec type (e.g., AMR-WB to AMR-WB), in which case audio transcoding is not required. This results in so-called transcoder-free operation.

However, VoLTE calls to other CS voice terminals (e.g., the PSTN or 3G mobile terminal) will require audio transcoding. Also, even if the same type of codec (for instance, AMR-WB) is being use at both ends of the mobile call, different data rates may be in use. If this is the case, transrating must be performed.

Audio transcoding and transrating for VoLTE is typically performed at the proxy CSCF (P-CSCF) or border gateway (BGW) boundary, e.g., in session border controllers (SBCs). As is the case for echo cancellers, the transcoder function is either built-in, or accessible as a separate in-line device. However deployed, transcoding has the potential for some level of audio distortion, and for this reason, careful measurement of transcoder quality is advisable.

VoLTE SECURITY

LTE Security Gateways

LTE Security Threats

Now, let's take a look at LTE security and its relation to VoLTE. High-bandwidth all-IP LTE networks are susceptible to similar security threats as other IP networks, including denial of service (DoS) attacks, information tampering and unauthorized eavesdropping (see the summary of threats in the table below).

Threats	Description
Destruction	Destruction of information and/or network resources; denial of service (DoS).
Corruption	Unauthorized tampering with an asset.
Removal	Theft, removal or loss of information and other resources.
Interception	Unauthorized access to an asset (eavesdropping).
Interruption	Network becomes unavailable or unusables.

Figure 11. LTE IP Network Security Threats.

Even though MNOs' IP core may be considered to be trustworthy, the increasingly distributed and diverse access and aggregation networks are much more of a concern. The problem is compounded by the advent of small cells, which are mushrooming in far less secure areas.

NGMN Recommendations

The Next Generation Mobile Networks (NGMN) Alliance recommends that security gateways (SeGWs) be deployed across any access and aggregation network segments that are considered untrustworthy. Reasons for this lack of trust include cases where the MNO either (1) doesn't control the physical security of all network elements, or (2) doesn't manage all the communication path segments (see "Security in LTE Backhauling" [8] for more details).

The NGMN recommends that SeGW functionality be deployed between eNodeBs (to cover LTE X2 interface traffic) and from eNodeB to EPC (to cover LTE S1 interface traffic). SeGWs work by creating IPsec ESP security associations (i.e., tunnels) between end points, thus providing both integrity checking and encryption on all IP packets. In this way, IPsec defeats tampering and interception, and also makes it easy to filter DoS traffic.

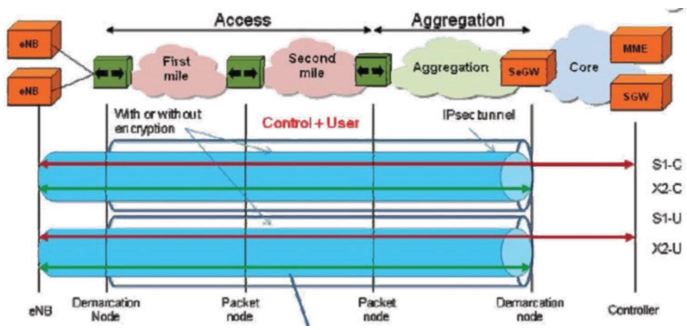

Figure 12. LTE Security Gateways.

Note: SeGWs only protect the traffic from the eNodeB to the EPC. Also, note that SeGWs are not VoLTE-specific, i.e., they are designed to protect all IP traffic where deployed.

VoLTE IPsec and AKA Authentication

VoLTE Security

GSMA IR.92 (IMS Profile for Voice and SMS) [9] applies to VoLTE and also requires that IPsec be used to protect at least all VoLTE IMS signaling from the UE to the IMS core (see the figure below). IPsec encryption of VoLTE voice and video media is optional, but will also be commonly used.

To accomplish this, IPsec ESP security associations (SAs) are established immediately when the UE registers for IMS services, and remain in place for all subsequent IMS service transactions until the UE deregisters. As such, IPsec encryption not only protects VoLTE calls, but also SMS/multimedia messaging service (MMS) messaging, IM and CHAT sessions, file and video sharing, and all other IMS-based RCS services as well.

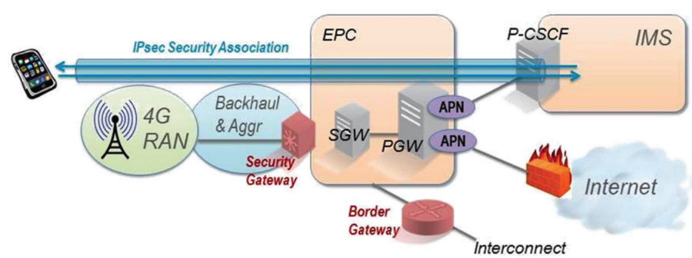

Figure 13. VoLTE IPsec Security Associations.

Because UE-to-IMS traffic is also carried over SeGWs, the question may arise as to why IPsec is needed at both levels, i.e., at UE to IMS, and also at eNodeB to EPC SeGW. There are several reasons, including: (a) SeGW may only be deployed at a subset of access and aggregation networks; (b) SeGWs only protect a subset of the UE-to-IMS communications path; (c) SeGWs' main job is to protect the EPC from malicious access traffic, including DoS attacks; and (d) a UE-to-IMS security association is needed to authenticate the UE device to the IMS core, and the IMS core to the UE.

VoLTE Security Setup

In order to setup the needed VoLTE IPsec SAs, IR.92 specifies that the authentication and key agreement (AKA) protocol be used to validate UE and IMS core authenticity, and also to manage the exchange of IPsec cypher information.

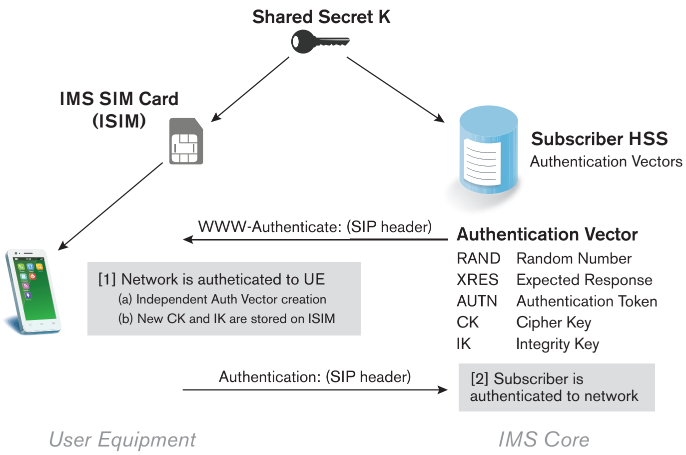

Figure 14. VoLTE IPsec AKA Authentication.

AKA works via secure access to a shared secret key. This shared key originates from the MNO's authentication center, and is made accessible both to the IMS core via the trusted home subscriber server (HSS), and the UE via a tamper-proof IMS SIM (ISIM) card.

AKA not only ensures that authenticated UEs can register with the IMS core, but also that UEs are registered with an authentic IMS service provider.

Once the security association is established, IPsec ESP integrity checking and encryption is used on all VoLTE and IMS transactions to prevent unauthorized tampering and eavesdropping.

IMS security comes at the price of additional management overhead, as well as additional processing capacity to cipher and decipher messaging. Nonetheless, all MNOs that are currently trial testing VoLTE are also deploying AKA IPsec.

ADDRESSING VoLTE CHALLENGES

VoLTE Network Challenges

As the above discussion has highlighted, there many technologies, issues and challenges associated with rolling out a new VoLTE service, including the following:

- **Service availability** can be impacted by IPsec AKA complexity, in addition to issues managing new network element capacity–especially all of the new elements in the IMS core. Generally speaking, the HSS in particular has a lot more work to do for VoLTE and IMS services, and is therefore a prime capacity-management concern.

- **Dropped calls** could easily reach unacceptable levels arising from SRVCC-based inter-RAT handovers, in addition to roaming and interconnect management.

- **Unacceptable latency** is also a concern, because IMS signaling dialogues are far more complicated than traditional CS voice.

- **Transport impairments** can occur, for instance excess packet loss and jitter caused by improper CoS-controlled bearer management between transport elements such as switches, routers, SGW and PGWs.

- **Voice impairments** caused by heavy video and data traffic, in addition to analog impairments such as noise, transcoding distortion and echo.

Fortunately, there are ways to minimize the incidence of these potential issues, and limit any damage they might cause.

VoLTE Lab Performance Assessment

VoLTE performance measurement is absolutely critical, and must start in the lab prior to VoLTE rollout, and also during each network upgrade cycle. It is imperative to validate that each network element procedure is functioning perfectly, both in isolation (with functional simulators filling in for the surrounding network), and in real-network combinations.

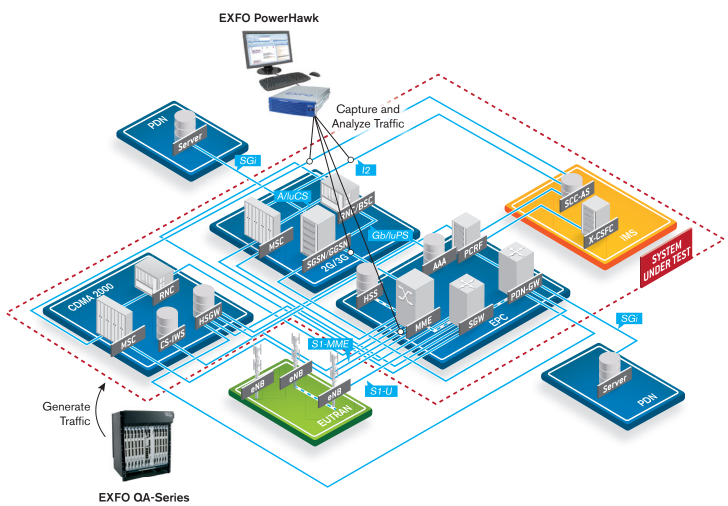

Figure 15. VoLTE Lab Performance Assessment.

Network-element behavior correctness must not only be validated under normal conditions, but also as follows:

- In corner cases
- Under error conditions
- Under the heaviest of traffic-loading conditions (this point is especially important)

And, not only must VoLTE signaling procedures be validated, but so must associated voice and video media quality–and once again, both at the time of initial service deployment, and during every network upgrade cycle.

EXFO has several product offerings to assist MNOs with these VoLTE service challenges, as follows:

- **EXFO Quality Assurer (QA) Series**–For mobile services functional test and load generation

- **EXFO PowerHawk Pro**–For LTE and mobile IP traffic capture and analysis.

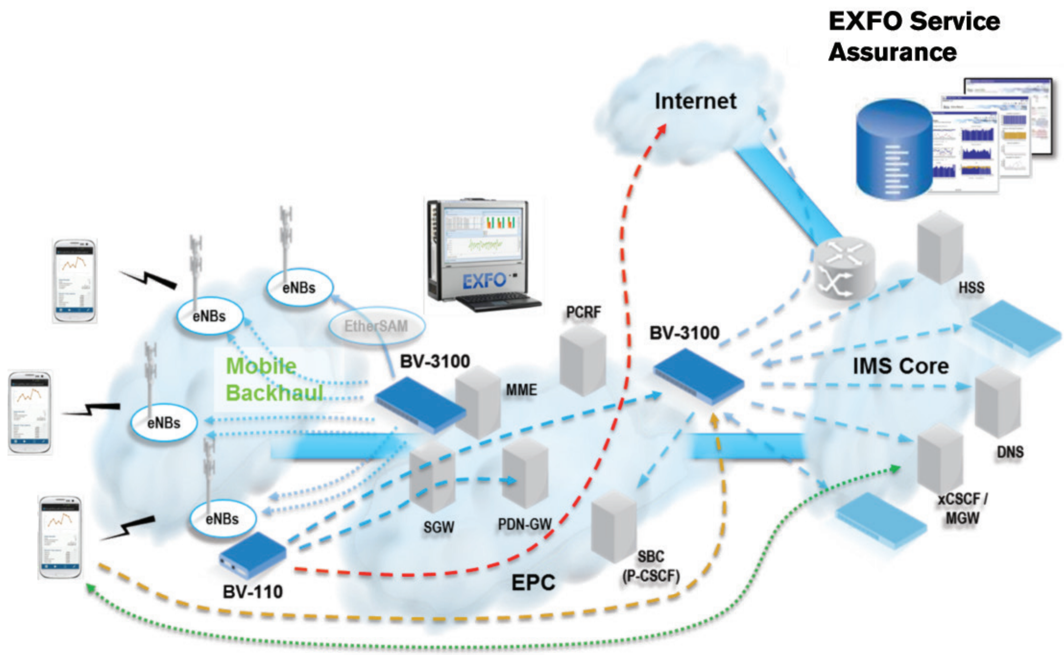

Figure 16. VoLTE Live Service Assurance.

VoLTE Live Service Assurance

However, VoLTE performance monitoring does not stop in the lab, because it is critical that VoLTE service performance and quality levels continue to be monitored under actual usage conditions in the live network.

Live network service assurance is absolutely essential for the following tasks:

- Baselining expected performance levels upon initial service turn-up
- Continuously monitoring performance and availability in real time during normal and heavy traffic periods
- Checking performance and availability levels before and after live network upgrades (i.e., as part of change management procedures)
- Quickly resolving live network performance issues using built-in troubleshooting tools and portable network analyzers

EXFO's Service Assurance product line provides 24/7 service assurance solutions that work at multiple layers, including:

- The CoS-differentiated mobile backhaul layer
- The EPC and IP core CoS-differentiated transport layer
- The IMS core network-element level
- The VoLTE AKA IPsec session, call and voice-quality service level

Network technician's productivity in relation to dealing with VoLTE live network support issues is also enhanced by ensuring that technicians have access to the right portable network troubleshooting tools: EXFO TravelHawk Pro Portable Analyzer.

CONCLUSION

This white paper has outlined the many challenges, in addition to the many benefits, that come with deploying VoLTE service. It should be noted; however, that all of the problems and risks associated with VoLTE rollout can be minimized with good planning and a well thought-out testing and service assurance program.

EXFO has excellent solutions to assist MNOs with both predeployment lab testing, live network service turn-up, ongoing 24/7 service monitoring and fast trouble resolution. These solutions help ensure that all of the benefits of next-generation VoLTE services become a reality.

GLOSSARY

3GPP	Third Generation Partnership Project
AKA	Authentication and Key Agreement
AMR	Adaptive Multi-Rate [Codec]
AS	Application Server
AuC	Authentication Center
BGW	Border Gateway
CoS	Class of Service
CS	Circuit Switched
CSCF	Call State Control Function
CSFB	Circuit-Switched Fallback
DoS	Denial of Service
DSCP	DiffServ Code Point
EB	ExaByte (10^18 Bytes)
EDGE	Enhanced Data Rates for Global Evolution
EPC	Evolved Packet Core
ESP	[IPsec] Encapsulating Secure Payload
E-UTRAN	Evolved UMTS Radio Access Network
GBR	Guaranteed Bit Rate
GPRS	General Packet Radio Service
GSM	General System for Mobile Communications
GSMA	GSM Association
HD	High Definition [Voice]
HSPA	High-Speed Packet Access
HSS	Home Subscriber Server
IM	Instant Messaging
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IRAT	Inter-Radio Access Technology
IPsec	IP Security [Framework]
ISIM	IMS Subscriber Identity Module
LTE	Long-Term Evolution
M2M	Machine to Machine
MGW	Media Gateway
MMTel	[IMS] Multimedia Telephony [AS]
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
MRF	Media Resource Function
MSC-S	Mobile Switching Center Server
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks [Alliance]
OTT	Over-the-Top
P2P	Peer-to-Peer
P-CSCF	Proxy Call State Control Function
PCRF	Policy Charging and Rules Function
PDN	Packet Data Network
PGW	PDN Gateway
PS	Packet Switched
PSTN	Public Switched Telephone Network
QCI	Quality Class Identifier
RAN	Radio Access Network
RCS	Rich Communications Suite
RTP	Real-time Transport Protocol
SA	[IPsec] Security Association
SBC	Session Border Controller
SDN	Software-Defined Network
SeGW	Security Gateway
SGW	Serving Gateway
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SMS	Short Message Service
SRVCC	Single Radio Voice Call Continuity
TAS	Telephony Application Server
UE	[Mobile] User Equipment
VoIP	Voice-over-Internet Protocol
VoLTE	Voice-over-Long-Term Evolution
WB	Wideband

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WHITEPAPER042.1AN

Printed in Canada 15/07