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Preparing for Voice over 5G: Why VoLTE is a critical enabler

White paper

Widespread LTE coverage is one of the main enablers of the rapid growth of Voice over LTE (VoLTE). At the same time, 3G is being phased out, with traffic being channelled onto LTE and 5G. Such modernization is enabling faster data rates and higher call quality and is paving the way for brand new digital services that will boost the use of IP Multimedia Subsystem (IMS) voice.

3GPP standardization dictates that 5G voice will use the same IMS-based architecture as that used in VoLTE. As Voice over 5G and VoLTE are just different ways to access the same IMS-based voice services, there are excellent reasons for Communications Service Providers (CSPs) that have not yet deployed VoLTE to introduce it in their LTE networks.

This paper explains the technology and benefits to be gained by these CSPs.

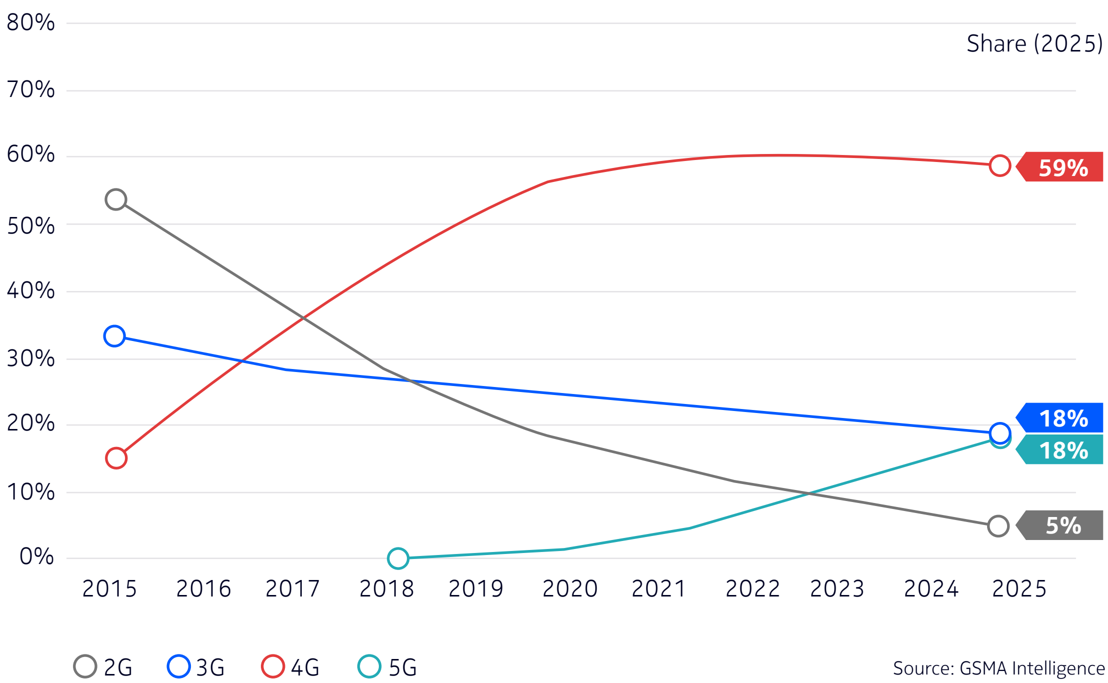
Contents

LTE is the dominant voice technology

Voice communication, both in private and business life, will remain vitally important even as communications networks evolve to 5G and deliver increased data capabilities.

LTE is today's most used mobile radio technology, connecting more than half of mobile users across the globe. Circuit Switched Fallback (CSFB) is the established voice solution for 4G subscribers for most Communications Service Providers (CSPs). However, leading CSPs are increasingly adopting Voice over LTE (VoLTE) in their networks, using the IP Multimedia Subsystem (IMS) as the voice core for VoLTE.

Figure 1. Global mobile connections by network generation Global Mobile Trends 2020, November 7, 2019 (The Mobile Economy 2020, GSMA)



LTE has been the fastest growing mobile technology of all time with more than 5 billion LTE subscriptions today, expected to grow to 6 billion in the next few years. At the beginning of 2020, about 40 percent of LTE users were also VoLTE subscribers, a number that is increasing rapidly.

CSP investments in 2G and 3G voice core technologies have been steadily declining over the last few years for a number of reasons:

- The foundation for VoLTE has been established
  - Extensive VoLTE coverage has been achieved
  - VoLTE terminals have become ubiquitous
  - LTE is highly mature and well-optimized

- Simplification is bringing many benefits
  - Frequencies are being re-farmed
  - The core network is being simplified
  - Modernization to the new IMS core is growing
  - 2G and 3G networks are being closed
- IMS is now well established
  - VoLTE has become dominant in LTE networks
  - VoWiFi is complementing VoLTE for improved indoor coverage and will support 5G voice
  - The IMS voice core is the only standardized option for 5G voice

CS voice will not fully disappear in the near future, but its role will diminish and be restricted to areas without LTE coverage. 2G or 3G technologies are also likely to be needed to support legacy Internet of Things (IoT) solutions.

The many benefits of implementing VoLTE

The trend in the market is for unlimited voice packages to become the default offer, which means voice must be delivered highly efficiently. It is also increasingly common for CSPs to bundle VoLTE with data and this trend is likely to continue.

In the early phases of LTE, CSFB was required because LTE coverage was limited compared to that of 2G/3G networks. However, today's wide LTE coverage provides a strong motivation for CSPs to introduce VoLTE services and simplify its use with one access and core implementation for both voice and data. In addition, a single voice core for LTE, Wi-Fi and 5G helps to ensure a similar end user experience regardless of the access technology used and without any additional need to synchronize services.

Growing demand for advanced services is driving the introduction of high-capacity, all-IP networks, with LTE providing the radio access for mobile connectivity. Fully packet-based, LTE delivers faster access rates, lower latency and a lower cost-per-transmitted-bit by using network resources more efficiently. LTE provides cost-effective capacity to help CSPs meet growing demand for high-bandwidth services such as mobile video.

VoLTE retains subscribers' data traffic in the LTE access network during a voice call, without degradation of the data services they receive. There are also fewer intersystem handovers and signaling between LTE and legacy networks with VoLTE than with CSFB voice. This all removes the need for CSPs to invest in the legacy 2G/3G packet core and radio networks.

The foundation for VoLTE has been established

Most mobile connections use LTE, a situation that will remain for many years even as 5G is rolled out globally. This has led to more than 250 CSPs investing in VoLTE with many end users already having a VoLTE capable terminal today. New services introduced in the IMS environment are unlocking new revenue potential, using IMS as the common service platform.

Key Performance Indicators (KPIs) from VoLTE networks show that the quality of VoLTE calls is the same or better than CS voice calls, thanks to the implementation of new features in terminals and networks, as well as optimized networks.

For more information on this topic please read Nokia White Paper "Voice over 5G: Readying the VoLTE network."

Simplification is bringing many benefits

Most 4G LTE deployments worldwide are running on re-farmed spectrum in existing bands. Reusing existing 2G and 3G spectrum reduces the need to acquire totally new spectrum, which leads to significantly lower deployment costs for CSPs. Moving from legacy radio technologies to 4G also enables twice as many calls to be handled within the same spectrum, thanks to LTE's higher spectral efficiency.

As 2G and 3G networks become less important, CS voice is, unsurprisingly, declining. In its place, the use of IMS voice for VoLTE is growing as LTE coverage expands and is complemented by indoor Wi-Fi (for VoWiFi).

A single voice core also simplifies mobility and services continuity between LTE, Wi-Fi and 5G accesses. The integration of network resources, business and operations support systems, the optimization of network and service management, and the simplification of service delivery all help reduce costs.

IMS is now well established

3GPP standardization dictates that 5G voice and Wi-Fi voice will use the same IMS based architecture as VoLTE. Voice over Wi-Fi (VoWiFi), Voice over 5G (Vo5G) and VoLTE are just different voice services running over different accesses using the same IMS.

VoLTE minutes already exceed CS voice (2G/3G) minutes in many countries. For some CSPs, VoLTE accounts for more than 90 percent of all voice minutes in their networks.

Despite this, a 2019 Nokia study revealed that the pace at which VoLTE becomes the dominant voice technology in different countries varies widely. In areas such as North America, good LTE coverage correlates with the higher percentage of VoLTE call minutes in the network. The growth rate of VoLTE in Europe shows that VoLTE call minutes will exceed 90 percent of all calls in many European CSP networks in 2023-2025. In Latin America, VoLTE is still in its early phase, leaving CS voice as the dominant technology.

There is clear evidence that VoLTE call minutes have increased substantially in CSP networks in 2019. During the second half of 2019 alone, total global voice minutes increased by 2 percent and in Europe by more than 3 percent. The growth in VoLTE minutes is likely to accelerate, with CS voice declining to obsolescence, or at least becoming marginal very quickly.

VoLTE offers many benefits

VoLTE offers many technical benefits for CSPs and end users. The technology has always offered high definition voice and video communications, an outcome of using high quality codecs. VoLTE call setup time is about one second or less, compared to several seconds in regular CS technology. LTE inherently provides low latency, which results in very short ear-to-mouth delay for high quality VoLTE calls, which is further enhanced by guaranteed bit rate. A high voice quality experience naturally leads to longer talk time and lower churn

With LTE, more data and voice can be packed into a given bandwidth than with 2G/3G. LTE voice packing density is double that of 3G voice, while LTE data packing density is three times higher. This achieves higher network capacity to serve more subscribers and deliver more data without the need for CSPs to buy more spectrum.

These technology benefits are especially important in the early phases of VoLTE. As markets mature and the technology is developed, there becomes a growing justification for CSPs to adopt IMS based VoLTE. Indeed, the 3GPP has defined that the same IMS machinery be used for 5G voice. In effect, IMS is mandatory for 5G voice.

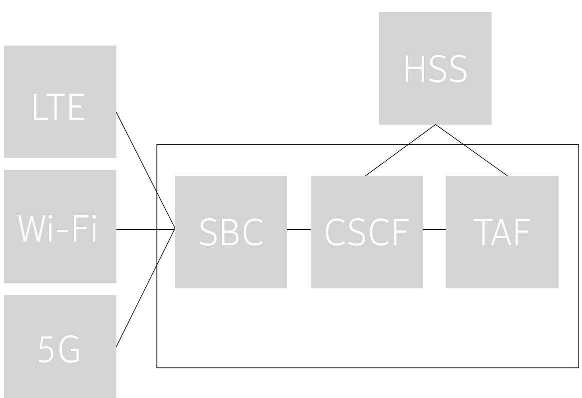
This has led to the development of Application Programming Interfaces (APIs) integrated with IMS to help CSPs implement service innovations rapidly and efficiently. For example, applications using call management APIs in the Telephony Application Server (TAS) are already in live commercial use.

The telecom industry is also moving towards cloud native architecture. This enables applications (like IMS) to be built as micro-services and run on containerized and dynamically orchestrated platforms that fully exploit the advantages of the cloud computing model.

IMS architecture

3GPP IMS is a generic architecture that provides multimedia and voice over IP services (VoIP). IMS enables the convergence of, and access to, real time services (voice, video), streaming, messaging, data and web-based technologies for the wireless user. The IMS system enables an easy-to-maintain and highly scalable IP multimedia communication network. IMS is access independent and provides a peer-to-peer addressing architecture for IP-based voice sessions, end-to-end Quality of Service (QoS), charging, authentication and security.

Figure 2. 3GPP IMS defines different network functions that can be combined in different network elements



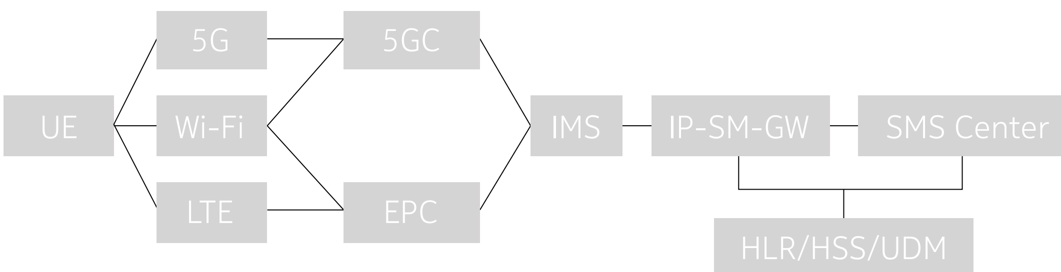
3GPP standardization defines many different functions that can be combined in different network elements. The key network elements in the IMS based architecture are typically Telephony Application Server (TAS), Call Session Control Functions (CSCF), Session Border Control (SBC) and Home Subscriber Server (HSS). TAS provides, for example, Multimedia Telephony services (MMTel) for mobile and fixed real time multimedia communication. CSCF controls the SIP signaling packets in the IMS; SBC enables secure connectivity to different networks; and HSS stores IMS subscription information.

Simplifying Short Message Service (SMS)

Introducing an IMS architecture for voice allows the SMS architecture to be simplified. In an LTE network, SMS over IP is treated as the payload traffic, not as signaling as it is in 2G/3G.

With the introduction of VoLTE, the IMS network can also support SMS over SIP. This is enabled by introducing an IP Short Message Gateway (IP-SM-GW) between the IMS core and the SMS Center. This uses the same subscriber database (HSS/HLR) as the SMS Center for guaranteed interoperability. The IP-SM-GW function is used to deliver SMS messages over the IP network. This interworking function translates between MAP or Diameter based signaling and SIP signaling to pass messages and responses between the two systems.

Figure 3. The IMS network can also support SMS services

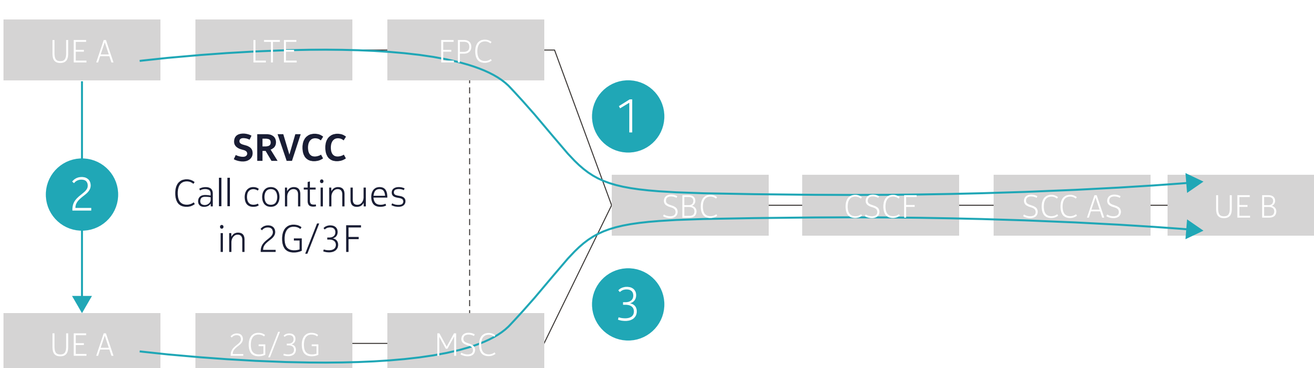


The same IMS VoLTE architecture can be used in WiFi and 5G to deliver SMS in both directions. The IP-SM-GW functionality is usually located in the IMS environment.

Achieving VoLTE and CS interworking

If a mobile device with an active VoLTE call moves beyond LTE coverage, the network will hand the call to the legacy (2G/3G) network. This procedure is called Single Radio Voice Call Continuity (SRVCC). SRVCC introduces Access Transfer Control Function (ATCF) and Access Transfer Gateway (ATGW), which anchor the signaling and media at the edge of the network throughout the call. Both functions are typically realized as part of the SBC functionality. Call signaling for the transfer takes place under the direction of the Service Centralization and Continuity Application Server (SCC AS). SCC AS can provide IMS-based mechanisms that enable service continuity of voice and multimedia sessions.

Figure 4. SRVCC ensures that voice calls are maintained as a device moves beyond LTE onto the legacy 2G/3G network



If LTE coverage is extensive, the probability of SRVCC being needed is low. A low SRVCC probability enables the full benefit of VoLTE capabilities and helps minimize loss of voice quality, or even call drops caused by a radio leg change. SRVCC probability also depends on parameter settings, like minimum Reference Signal Received Power (RSRP), which defines the threshold for the LTE network to initiate SRVCC.

SRVCC affects not just voice services. As a voice call is moved to the legacy network, data services will also follow and control is moved or suspended depending on the network's capabilities.

If the SRVCC probability is higher than 5 percent, LTE network optimization and/or LTE coverage improvement should be considered.

VoLTE and VoWiFi interworking

VoLTE has similarities with VoWiFi in which CSP voice calls run over Wi-Fi radio. Enhancing the evolved packet core with an evolved Packet Data Gateway (ePDG) enables VoWiFi to be considered as an extension of VoLTE, with seamless handovers between LTE and Wi-Fi accesses. Voice call mobility between LTE and Wi-Fi works in both directions, yet unlike mobility between 3GPP access, the device determines when the call is moved from/to the Wi-Fi access.

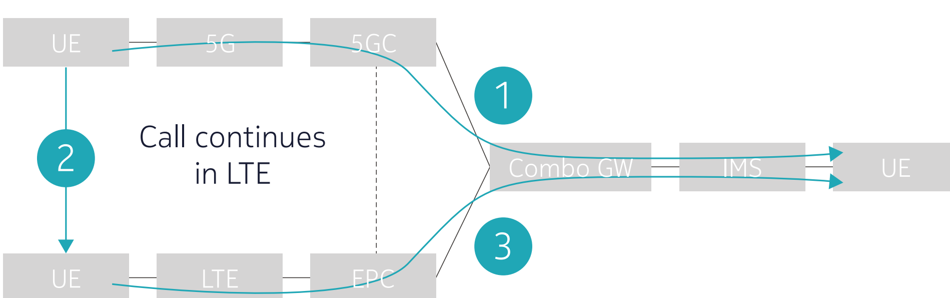
Figure 5. Voice over Wi-Fi acts as an extension of VoLTE with seamless handovers between the LTE and Wi-Fi

VoWiFi helps to improve indoor coverage. Devices can be configured to use selected Wi-Fi networks only and then connect to them automatically. The terminal will use VoWiFi once the network is available. A common PGW for the EPC ensures the same IP is maintained for the duration of the IMS voice call session. Call continuity enables CSPs to extend their LTE voice coverage to known Wi-Fi access points.

VoLTE and Vo5G interworking

CS voice is not an option in 5G, so a Vo5G call takes place purely in the IMS environment. Should 5G coverage become unavailable, the call is transferred to LTE following a similar procedure as moving a call between LTE and Wi-Fi.

Figure 6. Call continuity in Vo5G is maintained by transferring the call to LTE should 5G coverage be lost



Call continuity between 5G Voice over New Radio (VoNR) and VoLTE uses Packet Switched Hand Over (PSHO) mobility with the dedicated voice bearer and its defined QoS settings being maintained. In the core network, voice anchoring remains on the same gateway when the terminal moves between LTE and 5G networks. The existing IMS instance is kept. Mobility is similar for both directions between 5G and LTE access.

VoLTE roaming

VoLTE roaming extends the IMS based voice service beyond a CSP's serving area. VoLTE roaming is still in an early phase and most roaming agreements are based on the so the called S8 Home Routed (S8HR) architecture.

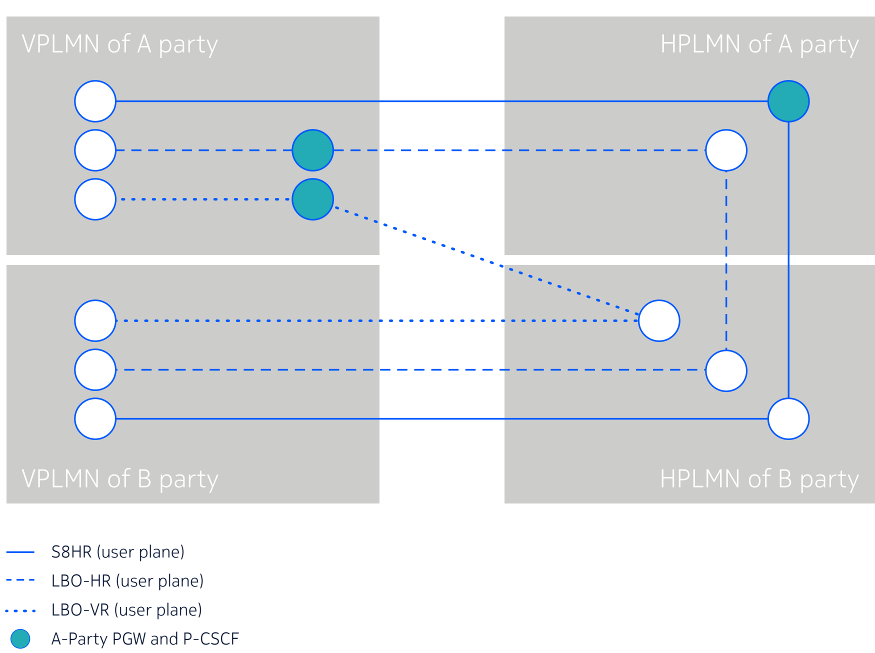
The GSMA Permanent Reference Document (PRD) IR.65 provides guidelines for standard VoLTE roaming and interworking. The document describes three reference architectures for IMS Roaming:

- Local Breakout VPLMN Routing (LBO-VR)
- Local Breakout HPLMN Routing (LBO-HR)
- S8 Home Routing (S8HR)

The first two of these implementations define an arrangement for the Local Breakout (LBO) of calls. These two LBO models are often referred to, collectively, as the Roaming Architecture for Voice over LTE with Local Breakout, or RAVEL.

The third option is S8 Home Routing (S8HR), where S8 is a standard reference interface between the Serving Gateway (SGW) and the Packet Data Network (PDN) Gateway (PGW).

Figure 7. GSMA reference architecture for VoLTE roaming



Based on GSMA IR.88 PRD guidelines for LTE Roaming, S8HR is recognized as the easiest architecture to implement and has therefore been used in most early VoLTE Roaming implementations. However, as all media traffic traverses the home network, S8HR calls may suffer noticeable delays.

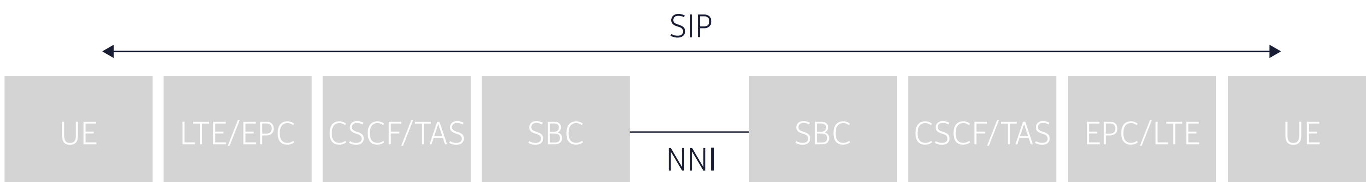
In the meantime, lawful interception and emergency calls can also be supported by S8HR.

- In the S8HR model, both P-GW and IMS (P-CSCF) are in the subscriber's home network. This means the inbound roaming network must have the capabilities to perform lawful interception of voice services even without these functional entities. 3GPP TS 33.107 describes lawful interception in the roaming network with S8HR roaming architecture.
- For emergency calls, the roaming device will use the IMS or CS domain in the visited network, as described in Annex K.3 of TS 23.167.

VoLTE interconnect

VoLTE Peering and Interconnect defines how two different CSP networks interwork to deliver end-to-end IMS services. Two or more CSP networks, either within a country or internationally, are linked so that the calls remain entirely on the IP network infrastructure and do not fall back to older legacy services during call routing.

Figure 8. VoLTE interconnect links CSP networks to ensure that calls stay on the IP infrastructure



Interconnection of two different IMS instances must be guaranteed in order to support end-to-end service interoperability. This is achieved by adopting the Inter-IMS Network-to-Network Interface (NNI) between two IMS networks. In the IMS environment, SBC (the 3GPP Interconnection Border Control Function, I-BCF) functionality takes care of control plane topology hiding, screening SIP signaling and the generation of Call Data Records (CDRs) and more on both sides and in both directions. Similarly, the SBC manages Network Address and Port Translation functionality in the user plane.

The crucial next step for CSPs is therefore to introduce IP and SIP-based interconnection for voice and real time services and to start using the Interworking function (I-BCF) of the Session Border Controller (I-SBC). The I-SBC should be able to route calls flexibly based on factors such as time, origin or destination routes. A programmable I-SBC can help to manage this complexity. Today though, most voice interconnections, even volte – volte, are based on existing legacy CS interconnections. The crucial next step for CSPs is therefore to introduce IP and SIP-based interconnection for voice and real time services and to start using the Interworking function (I-BCF) of the Session Border Controller (I-SBC). The I-SBC should be able to route calls flexibly based on factors such as time, origin or destination routes. A programmable I-SBC can help to manage this complexity.

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Conclusion

Deploying VoLTE is strategically important for CSPs and is typically part of their migration of voice services from 3G and legacy CS mobile networks to the 4G LTE network. VoLTE is based on the IMS architecture, so the rise of VoLTE also coincides with CSP adoption of IMS.

4G LTE was the first generation of mobile network technology that did not have dedicated voice channels in the radio interface. Instead, it provides an IP data connection to the endpoint device. To provide voice services, the GSMA IR.92 IMS profile is implemented on an IMS core, and this is known as VoLTE. GSMA IR.94 enhances VoLTE by including video to achieve ViLTE (Video and voice over LTE)

3GPP defined IMS is a generic architecture that provides multimedia and Voice over IP services (VoIP). The IMS voice core is part of the cloud native LTE and 5G architecture. In 5G, IMS is the only option for providing voice services, VoNR and EPS FB (Evolved Packet System Fallback), in line with 3GPP standardization, and 5G voice uses the same IMS-based architecture as that used in VoLTE. Circuit Switched Fallback (CSFB) to 3G or 2G radio access is not an option for 5G Voice.

LTE has proven to be a winning radio technology globally and CSPs are investing in VoLTE. There is clear evidence that VoLTE call minutes are increasing in networks, while investments in 2G and 3G voice core have been steadily declining over the last few years.

It is likely that the take up VoLTE will continue to accelerate, and that CS voice will quickly become obsolete or at least marginal. VoLTE is already dominant in some markets and will become dominant in those markets where CS is still the main technology today.

VoLTE service enablers in LTE can be re-used to provide Voice over NR services in 5G networks, provided that some small, but essential interface extensions are implemented and the service logic in the IMS is adjusted to handle these.

Nokia’s VoLTE solution offers a clear evolutionary path that allows CSPs to take full advantage of their LTE networks while working with their existing voice core.

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Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation (mobile radio)
5G	5th Generation (mobile radio)
5GC	5G Core
API	Application Programming Interface
ATCF	Access Transfer Control Function
ATGW	Access Transfer Gateway
CCSR	Call completion success rate
CDR	Call Data Record
CS	Circuit Switched
CSCF	Call Session Control Function
CSFB	CS Fallback
CSP	Communications Service Provider
CSSR	Call set-up success rate
EPC	Evolved Packet Core (4G)
EPDG	Evolved Packet Data Gateway
EPS	Evolved Packet System (4G)
EPS FB	Evolved Packet System Fallback
HLR	Home Location Register
HSS	Home Subscriber Server
I-BCF	Interconnection Border Control Function
IMS	IP Multimedia Subsystem
IP-SM-GW	IP Short Message Gateway
IoT	Internet of Things
KPI	Key Performance Indicator
LBO-HR	Local Breakout HPLMN Routing
LBO-VR	Local Breakout VPLMN Routing
LTE	Long Term Evolution (4G)
MMTel	Multimedia Telephony service
MSC	Mobile Switching Center
NNI	Network-to-Network Interface
NR	New Radio (5G)
PGW	Packet Data Network (PDN) Gateway
PSHO	Packet Switched Hand Over
QoS	Quality of Service
RAVEL	Roaming Architecture for Voice over LTE with Local Breakout
RSRP	Reference Signal Received Power
S8HR	S8 Home Routing
SBC	Session Border Control
SCC AS	Service Centralization and Continuity Application Server
SGW	Serving Gateway
SIP	Session Initiation Protocol
SMS	Short Messaging Service
SRVCC	Single Radio Voice Call Continuity
TAS	Telephony Application Server
ViLTE	Video and voice over LTE
Vo5G	Voice over 5G radio
VoIP	Voice over IP
VoLTE	Voice over LTE
VoNR	Voice over New Radio (5G)
VoWiFi	Voice over Wi-Fi

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