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Voice over 5G: Readying the VoLTE network

Practical insights to prepare your voice network for the leap to 5G

White paper

A good voice call is one that connects quickly, is always clear and is not disrupted or dropped. As the industry moves into the 5G era, voice will become more important, not less. A well optimized network for high quality Voice over LTE (VoLTE) is a solid foundation on the way to Voice over 5G.

3GPP standardization dictates that 5G voice will use the same IP Multimedia Subsystem (IMS)-based architecture used in Voice over LTE (VoLTE). Voice over 5G and VoLTE are just different ways to access the same IMS-based voice services.

Only a cloud native IMS core can take full advantage of the capabilities of 5G. IMS provides a network architecture that delivers innovative and reliable voice services enhanced with open API support, programmability, network slicing and automation.

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Executive Summary:
Voice is vital today and in the future

Talking to each other, whether in private or in business life, remains the most natural form of communication. So it's little surprise that voice calls will remain important, even when 5G networks offer new communications capabilities in the future.

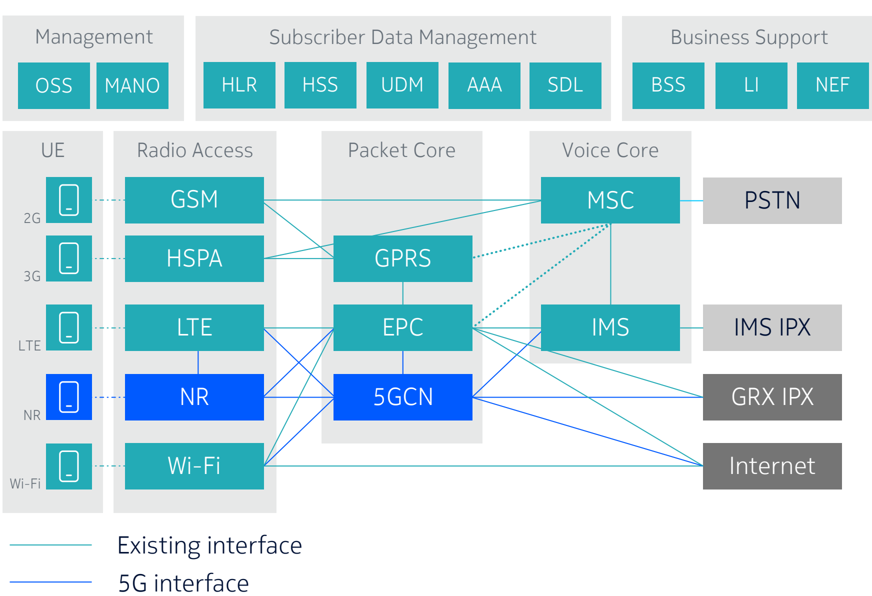
Many, if not most, mobile plans already offer unlimited voice. Yet many Communications Service Providers (CSPs) are switching off their 2G and 3G networks, reducing Circuit Switched (CS) voice traffic capacity. At the same time, Voice over LTE (VoLTE) is increasingly being bundled with data in most CSP networks. The result is that the use of IP Multimedia Subsystem (IMS)-based voice is growing rapidly, further boosted by continuous growth in Wi-Fi and LTE coverage indoors.

Users will accept nothing less than high quality, uninterrupted voice calls. This is especially true in these early days of 5G when most customers are premium users with stringent service requirements, including for voice. Consequently, it is important to deliver a voice experience that is the same or even better than that achieved in VoLTE.

5G must be fully integrated with existing legacy technologies. Tight 5G/LTE integration is essential to maintain high quality voice services and to ensure seamless call continuity when users move between different access technologies. Figure 1 shows how LTE and IMS interact with new 5G network elements, legacy networks and the Internet.

The good news for CSPs is that the Third Generation Partnership Project (3GPP) has specified that voice in 5G will use the same IMS architecture used for VoLTE in 4G. In effect, Voice over 5G (Vo5G) and VoLTE are just different ways to access the same IMS-based voice services. This means that any investments CSPs make in today's IMS-based VoLTE will support future Vo5G services.

Figure 1. Maintaining voice call continuity across different access technologies requires tight integration of 5G with legacy systems



Why it's important to prepare the VoLTE network for 5G

Good radio coverage is essential for top quality voice services. In practice it is not technically possible and not economical to build wide enough 5G coverage on day one. There is a need to provide services gradually and build service continuity for 5G users by leveraging the existing network. Table 1 shows the options for CSPs when evolving to VoLTE and Vo5G and the method used for maintaining Voice Call Continuity (VCC). This is important for CSPs that are deciding on their evolution strategy, since it is essential to maintain high quality voice Key Performance Indicators (KPIs).

Table 1. The most common LTE and 5G voice evolution phases (from left to right)

Radio coverage	LTE 2G/3G	LTE 2G/3G	5G LTE 2G/3G	5G LTE 2G/3G	5G LTE 2G/3G
Radio architecture option	1	1	3X	2	2
Voice machinery	MSC	IMS	IMS	IMS	IMS
Packet core	EPC	EPC	EPC	5GC / EPC	5GC
Voice option	CSFB	VoLTE	VoLTE	EPS fallback	Vo5G
Call setup starts	LTE	LTE	LTE	5G	5G
Call take place	2G/3G	LTE	LTE	LTE	5G
VCC method	CS HO	SRVCC	SRVCC	SRVCC	PSHO
First VCC target radio	3G/2G	3G	3G	3G	LTE

In 5G, IMS is the only option for delivering voice in line with 3GPP standardization, and 5G voice uses the same IMS-based architecture used in VoLTE. Circuit Switched Fallback (CSFB) to 3G or 2G radio access is not an option.

In the early phases of 5G, device makers can choose to support voice over LTE or voice over 5G, since Evolved Packet System Fallback (EPS FB) and Voice over New Radio (VoNR)/Vo5G are both available as 5G voice services in 3GPP 5G Option 2.

EPS FB in 5G is based on VoLTE so that the device can provide 5G voice services for 5G users by using LTE radio access. This happens when the call is initially established. VoNR natively delivers voice through the 5G radio and core directly back to the IMS system. Whichever route is adopted, the lesson from real network implementations is that service providers must optimize the LTE radio network to achieve the high KPIs needed for VoLTE calls. The same lessons apply to providing a VoNR service.

Ideally, operators would provide Vo5G/VoNR by deploying 5G New Radio (5GNR) throughout their entire coverage area. However, this is unrealistic in practice across large geographical areas because it requires lower radio frequencies which are not necessarily available for 5G. Mobility from 5G to 4G is therefore necessary. Since operators who are deploying 5G will also be deploying a 5G core there are mechanisms defined by 3GPP to seamlessly handover traffic from the 5G core to the 4G EPC, but be aware that this requires a change in the core network architecture.

Optimize VoLTE for the best user experience

Optimization of the network for VoLTE can be an intricate task, especially on complex multivendor networks. Optimization needs to be handled as a single, joined up exercise across the entire network. Simply asking individual vendors to optimize their parts of the network in isolation will not be effective. Coordinated optimization of the LTE radio access network, transmission, EPC, IMS, Telephony Access Server (TAS) and Subscriber Data Management (SDM) system is needed to ensure a good customer experience.

Optimization of software features and parameter settings is required to ensure VoLTE performance. Reliable handovers and inter-layer mobility are essential to maintain VoLTE HD quality.

The voice call experience can be measured by a range of different KPIs, but the most important include Call Set-up Success Rate (CSSR), Call Completion Success Rate (CCSR) and Single Radio Voice Call Continuity success rate (SRVCC SR).

CSSR measures the percentage of call attempts that result in a connection to the dialed number. CCSR refers to the total number of calls initiated and ended successfully, compared to the number of call attempts.

Success rate values are useful for CSPs, who must maintain good voice quality while they deal with the various constraints of coverage and network functions. Corresponding KPIs from 2G, 3G and LTE networks can be used as references.

CSPs worldwide have relied on Nokia for their VoLTE deployments. This has generated millions of staff hours of experience for Nokia in optimization experience supported by advanced tools and patented algorithms. As a result, Nokia has found that a well optimized live LTE network should be able to achieve CSSR and CCSR rates of at least 99.9 percent.

Harden VoLTE for reliable mobility

The success rate and maintenance of a VoLTE call must at least match the level provided by CS connections. Network optimization not only helps to achieve this, but also reduces the required bandwidth for voice to maximize capacity. Network optimization involves parameter optimization and feature activation, such as header compression, TTI (Transmission Time Interval) bundling and QoS.

A high VoLTE call success rate requires reliable control channel transmission, which can be obtained by optimized channel coding in the radio interface to protect signaling quality. Interference levels and excessive signaling also need to be controlled in highly loaded cells.

Another important factor is reliable mobility. The handover success rate can be optimized with Radio Frequency (RF) planning and radio optimization, including:

- Mobility robustness optimization to enable radio level connection re-establishment in the event of handover failure.
- Measurement-based optimization of SRVCC thresholds to reduce drops and delays.

VoLTE uplink performance can be enhanced when there is a weak signal with TTI bundling, which allows the handset to repeat the same transmission in four consecutive 1 millisecond TTIs. TTI bundling is switched on only when the handset hits the edge of the coverage area. TTI bundling runs between the base station and the handset.

A CCSR value of more than 99.9 percent is usually only achievable when a voice call is run on the same Radio Access Technology (RAT) from beginning to end. When an ongoing call is transferred to a different RAT the success rate will fall in even the best networks. Therefore, it is advisable to minimize call handovers between RATs.

The SRVCC Success Rate refers to the total number of calls handed over to another RAT and connected successfully, compared to the number of calls that fail during the handover. An SRVCC Success Rate of 98 percent is possible in a well-optimized network.

Until LTE coverage is rolled out across the entire network, SRVCC will need to be implemented to hand a VoLTE connection over to a CS connection in a 3G or 2G network when the handset leaves LTE coverage. These handovers should also be minimized.

A large data sample from live Nokia networks reveals that in 50 percent of Nokia's customer networks, SRVCC hand over from LTE to 3G takes place in fewer than five percent of VoLTE calls, as shown in Table 2. LTE network optimization and/or LTE coverage improvement should be considered when the probability of SRVCC handover exceeds five percent.

Similar KPIs can be achieved with Vo5G, as well as with Packet Switch Hand Over from 5G to LTE and SRVCC from 5G to 3G. 5G to 3G SRVCC is part of 3GPP Release 16.

Table 2. In over half of Nokia customers' networks, SRVCC hand over from LTE to 3G takes place in less than 5% of VoLTE calls

SRVCC probability (%)	CSP (%)
0-2	26
2-5	32
5-8	16
8-12	19
> 12	6

How IMS works in the 5G core

We have already discussed how voice is supported in a 5G network in the previous white paper in this series, Voice over 5G: the options for deployment. A brief summary follows.

IMS Support for SA Option 2 and Voice over NR

When 3GPP defined 5G in 3GPP Release 15 (Rel-15), the impact on IMS was minimized to help with 5G deployment. From an IMS point of view, Rel-15 5G Core is the 4G Evolved Packet Core (EPC). Key similarities can be found between 4G Core and VoLTE and 3GPP Rel 15 Core and 5G Voice:

- The Home Subscriber Server (HSS) remains responsible for handling the IMS user profile in VoLTE in 5G Voice for both 4G and 5G subscribers.
- Proxy-Call Session Control Function (P-CSCF) discovery is performed by the device during IMS signaling flow establishment, supported by the 5G Session Management Function (SMF) in a similar manner as it is done in 4G by EPC.
- The P-CSCF in IMS may continue to use the same Rx interface to the 5G Policy Control Function (PCF), as with PCRF in 4G. Equivalent QoS classes have been defined in 5G for IMS signaling and voice traffic as for VoLTE.
- Several new 5G capabilities have not been applied to IMS. Instead the 4G concepts continue to be used in 5G, such as continued use of a single bearer anchor and the preservation of the IP address.
- Existing 3GPP procedures linking the IMS with the packet core via the HSS and Unified Data Management (UDM) have been extended to support 5G access, e.g. the Terminating Access Domain Selection (T-ADS).

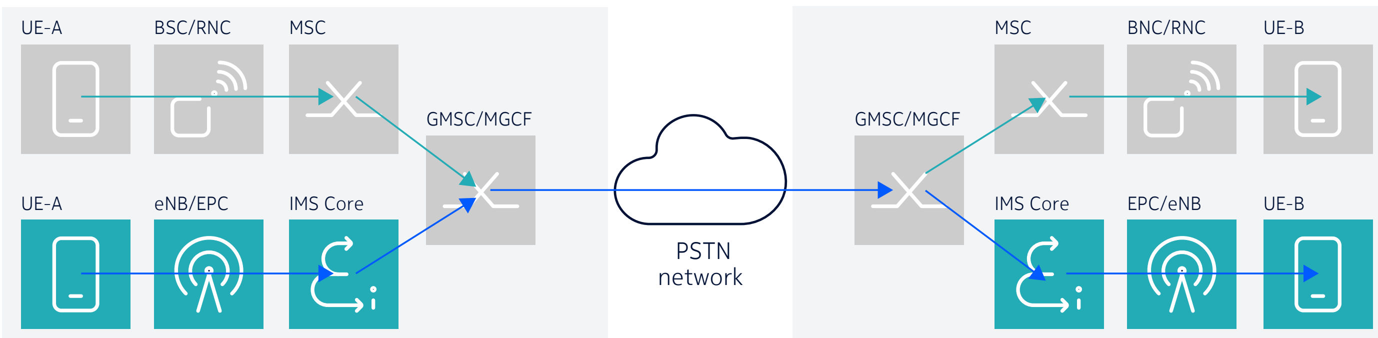
The IMS Private Identifier (IMPI) and the IMS Public Identifier (IMPU) remain unchanged for Vo5G support and the new 5G subscriber identifiers – Subscription Permanent Identifier (SUPI) and Generic Public Subscription Identifier (GPSI) – are not used in the IMS.

The net result is that the IMS solution used to provide VoLTE services in 4G can be re-used to provide Voice over NR services in 5G, provided some small, but essential interface extensions are provided and the service logic in the IMS must be adjusted to handle these.

VoLTE and interconnection

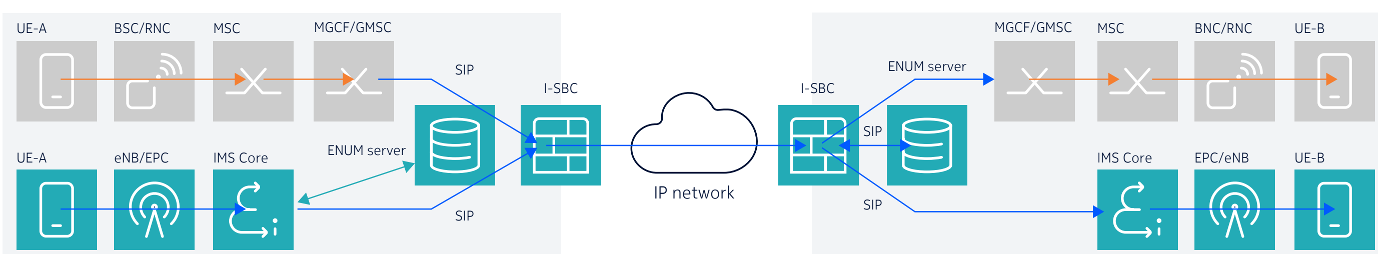
The next step after setting up and optimizing the 4G and 5G radio for voice services is to prepare the IMS system for IP- and Session Initiated Protocol (SIP)-based interconnection. Most of the interconnection between operators for voice are still based on legacy, CS core-based technologies. IP-based VoLTE calls may be even converted to CS-based calls.

Table 3. Today, most networks are still interconnected via the PSTN/CS



The crucial next step for operators is therefore to introduce IP and SIP-based interconnection for voice services and to start using the Interworking Session Boarder Controller (I-SBC).

Table 4. Introduce I-SBC as the central contact via IP networks



Some legacy voice traffic still exists, even as voice traffic continues to shift to VoLTE. CSPs need a flexible solution to manage the resulting complexity and optimization of the routing in I-SBC or P-CSCF functionality. 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.

In order to support increasing VoLTE / 5G subscriber numbers, CSPs need to set up their VoLTE networks to support inbound roamers and enable VoLTE roaming. Emergency call support and other regulatory requirements for voice services must also be set up. These VoLTE setup measures can be then also be used to support voice services for 5G subscribers.

Cloud native voice core delivers new capabilities

The 5G core network, as standardized by 3GPP, is fundamentally designed to be cloud native to create a more agile network architecture and enable automation and more efficient operations. As a result, it makes sense for the IMS voice core to be transitioned to a cloud-native design so that it can fully support the most important capabilities of 5G, such as flexible network slicing, open API capabilities, distributed edge computing, programmability and automation.

Flexible end-to-end network slicing

End-to-end network slicing includes the RAN, the core and the transport network. Network resources can be dedicated per slice, allowing end-to-end service differentiation.

Although the IMS core itself cannot be sliced, a cloud-native implementation allows easy spin-up of an IMS network dedicated to a slice to provide voice services. This gives CSPs an opportunity to offer voice alongside innovative data services as a complete, dedicated package. Adding voice may alter the throughput and latency requirements of the use case, but the flexibility of 5G slicing can accommodate this easily.

Supporting open API innovation

The cloud native IMS-based voice core also enables the creation of custom voice services with enhanced functionality using Application Programming Interfaces (APIs). APIs can use a wide range of advanced features including artificial intelligence, big data analytics, speech recognition, voice-based messaging and Internet of Things (IoT) analytics to enrich the communication experience, whether voice or video. APIs offer a huge degree of flexibility for call processing, can accept information from the network and be given direct access to and even control of calls, enabling browser-based apps for voice, chat, communications for location-based services and video conferencing. Most importantly, APIs allow the CSP to participate in a new, emerging 5G ecosystem of carriers, subscribers and third-party developers.

Automation and programmability

With 5G, a cloud native IMS core network is essential for highly automated network operations and minimum time-to-market for services. Cloud native architecture enables CSPs to quickly and easily monetize their core network investment. The architecture allows centralized or distributed deployment across the network, with network functions interconnecting to deliver any services consumers, enterprise users or millions of IoT devices demand at that instant.

Supporting programmability and analytics, a distributed cloud native IMS also enables CSPs to benefit from Machine Learning and Artificial Intelligence to adjust network resources dynamically in real-time according to changes in service demands.

Conclusion

Voice will continue to be an important part of the CSP business, since the majority of communication services include a voice component. However, voice is no longer a standalone service. Instead, it is becoming a feature that can be optionally added into a more comprehensive 5G service, or into a bundle aimed at mobile subscribers.

As 5G network deployments accelerate, and regardless of the chosen deployment option, voice must be considered as part of the overall network deployment plan. Fortunately, the 3GPP defined voice support for 5G so that it can rely on 4G VoLTE deployments. The result is that most carriers can base their voice services on their current network.

Good radio coverage alone is not enough to relay 5G users' voice services for 4G access and VoLTE. The entire LTE network, including radio access, transmission, EPC, IMS, TAS and SDM, must be optimized for voice services and service continuity.

However, some upgrades to the existing 4G IMS network may be necessary. To properly optimize the voice capability for the 5G network, the CSP may need to update the release on existing equipment. To fully participate in the new 5G ecosystem, a CSP might deploy modern IMS network elements that support APIs. And to take advantage of 5G capabilities that rely on cloud native design, CSPs may even need to modernize their IMS deployments to remove hardware appliances and redeploy IMS as a cloud application on their data centers.

Regardless, the new services that 5G enables create an enormous opportunity for CSPs, as communications become about much more than delivering voice and data to a mobile phone. In the new 5G ecosystem, brand new services allow CSPs to diversify and expand their businesses into completely new areas. It also allows expansion into new markets and a better business relationship with enterprises and web-scale companies. Voice plays a role in all of these.

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Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation (mobile radio)
5G	5th Generation (mobile radio)
5G Voice	A voice services solution for 5G enabled subscriber i.e. VoLTE, EPS FB, VoNR/Vo5G
5GC	5G Core
5G NR	5G New Radio
CCSR	Call completion success rate
CS	Circuit Switched
CSFB	CS Fallback
CSP	Communication Service Provider
CSSR	Call set-up success rate
EPC	Evolved Packet Core (4G)
EPS	Evolved Packet System (4G)
EPS	FB Evolved Packet Core Fall back (voice service over LTE for 5G user)
SRVCC	Single Radio Voice Call Continuity from 4G/LTE to 3G/2G
IMS	IP Multimedia Subsystem
LTE	Long Term Evolution (4G)
MSC	Mobile Switching Center
NR	New Radio (5G)
SRVCC SR	Single Radio Voice Call Continuity success rate
VCC	Voice Call Continuity
Vo5G	Voice over 5G radio (NR) (voice service over 5G radio (New Radio) for 5G user)
VoNR	Voice of New Radio (5G) (voice service over New Radio (5G) for 5G user)
QoS	Quality of Service

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