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ZTE

5G Voice
White Paper

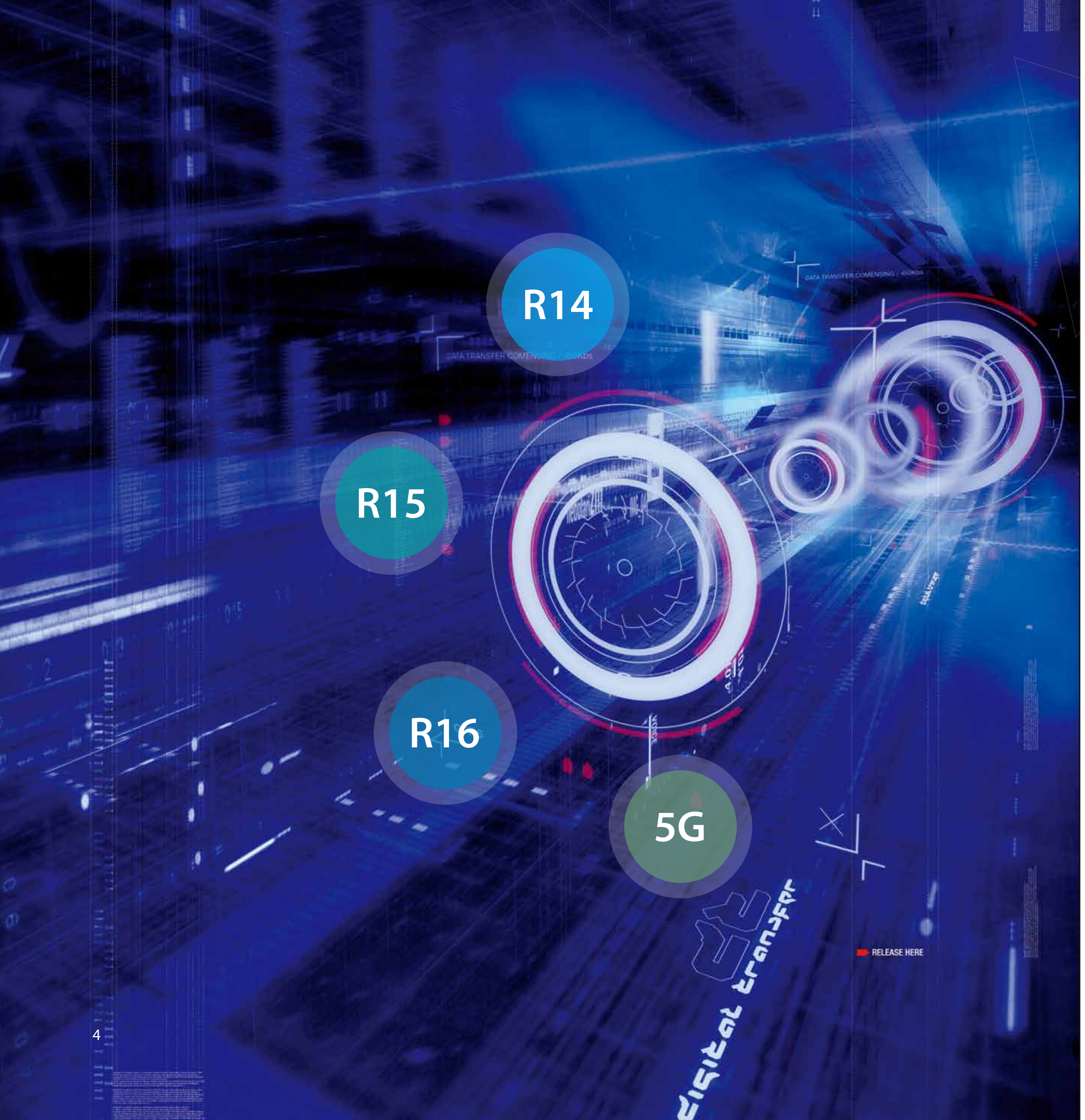
Table of Contents

Introduction

In June, 2018,
as 3GPP announced that the standalone (SA) standards have been frozen,
the standardization of 5G Core (5GC) is complete.
5G network commercialization has begun and the world-wide mainstream operators are dedicated to 5G network construction.
The 5G era has come.

According to 5G deployment options,
5G voice solutions not only include the target solution Voice over New Radio (VoNR) but also middle-phase supplementary solutions such as EPS Fallback, RAT Fallback,
VoLTE and 5G SRVCC (will be defined by 3GPP R16).

5G Voice Standardization Completion



5G Voice

Standard Progress

As defined in 3GPP R15 standard, 5G will adopt 4G VoLTE voice architecture for 5G voice implementation and deliver voice service based on IMS. The specific voice solution adopted by an operator depends on the actual 5G deployment mode and wireless network deployment progress. 5G Non-Standalone (NSA) Option 3 relies on EPC and LTE network deployment and 3GPP R15 NSA standard has been frozen in the end of 2017. 5G SA Option 2 is a service-based, innovative, independent construction scheme and 3GPP R16 SA standard has been frozen in June, 2018. 3GPP R16 will continue to apply the advantages of service-based architecture to IMS and enhance IMS architecture and some interfaces for Internet of Things (IoT) applications. In addition, it will provide support for interworking between 3G and 5G.

3GPP R15 standard has met the requirements for commercialization of 5G NSA/SA basic voice and SMS services. 3GPP R16 studies on IMS enhancement requirements in the industrial application scenario, but does not focus on man-man voice or SMS service.

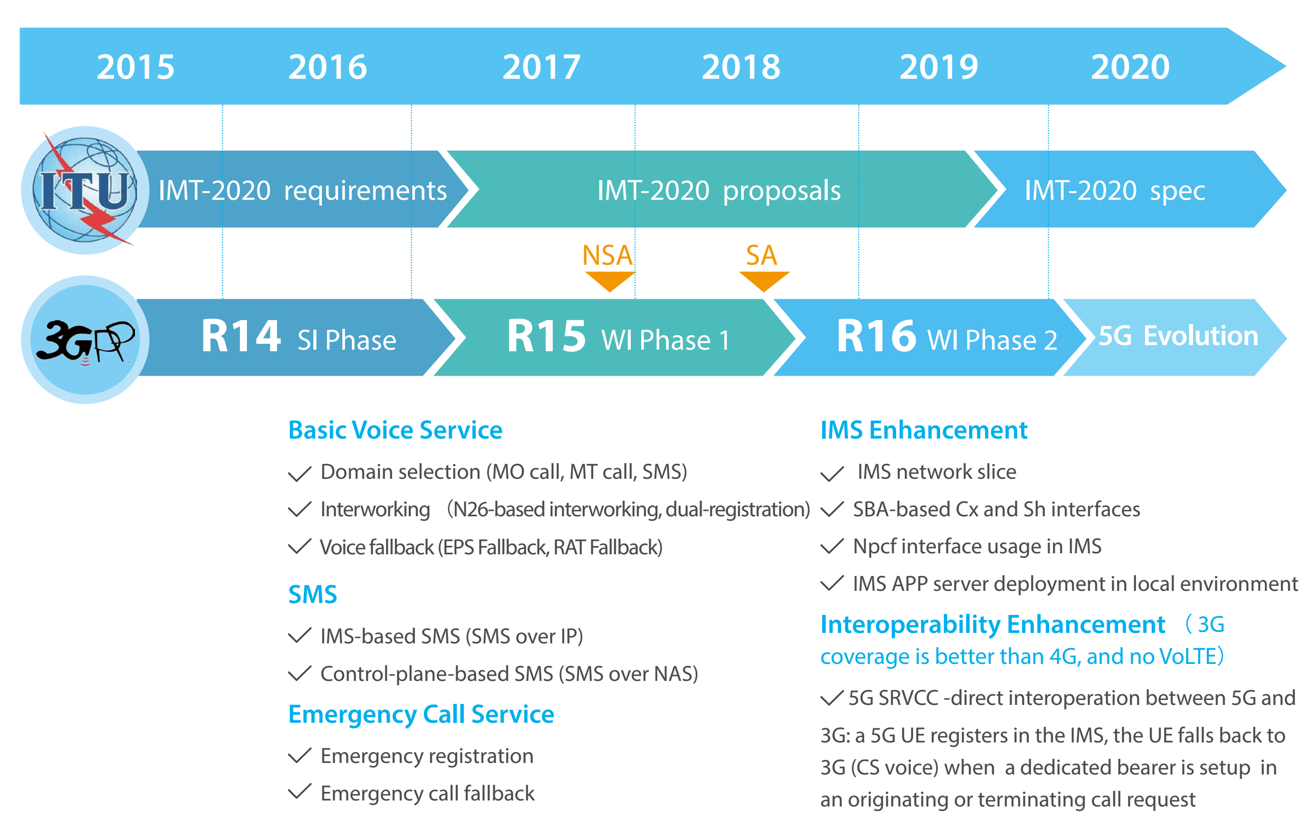


Figure 2-1 Vo5G Standard Progress

5G Voice
Implementation Solutions

VoNR

UE camps on NR. Voice and data services are transferred via NR. When UE moves to the edge of NR coverage, the voice service is handed-over to LTE. This solution is applied after large-scale deployment of 5G. As the target voice solution, it provides fast call setup (1.5 s) as well as high-speed data transmission, thus delivering better user experience.

EPS Fallback

UE camps on 5G NR to implement data service while falls back to LTE to implement voice service. After a UE makes a voice call, NR instructs the UE to access LTE by triggering a handover or redirection procedure. Then IMS provides VoLTE service for the UE. This solution is applicable to the early phase of 5G deployment where NR is deployed in 5GC for hotspot coverage. It can avoid voice interruption caused by frequent handovers, thus guaranteeing user experience.

RAT Fallback

UE camps on 5G NR to implement data service while falls back to eLTE to implement voice service. When a UE makes a voice call, NR instructs the UE to access eLTE by triggering a handover or redirection procedure. After the voice session is terminated, the UE moves back to 5G. Then IMS provides VoLTE service for the UE. This solution requires the existing LTE to be upgraded to eLTE, that is, eNodeB shall support N1/N2/N3 interface. Moreover, eLTE and NR shall be deployed together, which has a high requirement for existing network upgrade.

5G SRVCC

5G SRVCC is a topic studied by 3GPP R16. With 5G SRVCC, 5G UE camps on 5G NR and implements voice service using VoNR. At the edge of NG-RAN, voice can be handed-over to UTRAN CS by using 5G SRVCC technology; or UE falls back to UTRAN CS for call establishment and returns to NR immediately after the call is terminated.

VoLTE/CSFB

In Option 3 NSA deployment mode, UE accesses the network through the LTE control channel, so it can directly implement voice service by means of VoLTE or CSFB.

5G SMS
USSD Solution

Like 4G USSD service, 5G USSD service is still implemented over IMS (namely, USSD over IMS mechanism).

5G SMS will still exist as a basic message service and will interwork with the legacy CS SMS. SMS over IP solution is a preference for voice centric UE which enables voice and SMS to be transferred over IMS. SMS over NSA is a preference for data centric UE which enables UE not to load IMS client to simplify UE protocol stack.

- **SMSoNAS**

  SMSoNAS is applicable to IoT UEs, data-only SIM card UEs and other non-IMS UEs. UE registers to SMSF when registering to 5G and receives/sends SMS using N1 NSA messages. The interface between SMSF and SMS Center (SMSC) can use MAP or Diameter signalings for interworking.

- **SMSoIP**

SMSoIP is applicable to mobile phones. UE registers to IMS through 4G/5G and meanwhile registers to IP-SM-GW. The SMS is delivered to IP-SM-GW by using an IMS signaling and then delivered to SMSC.

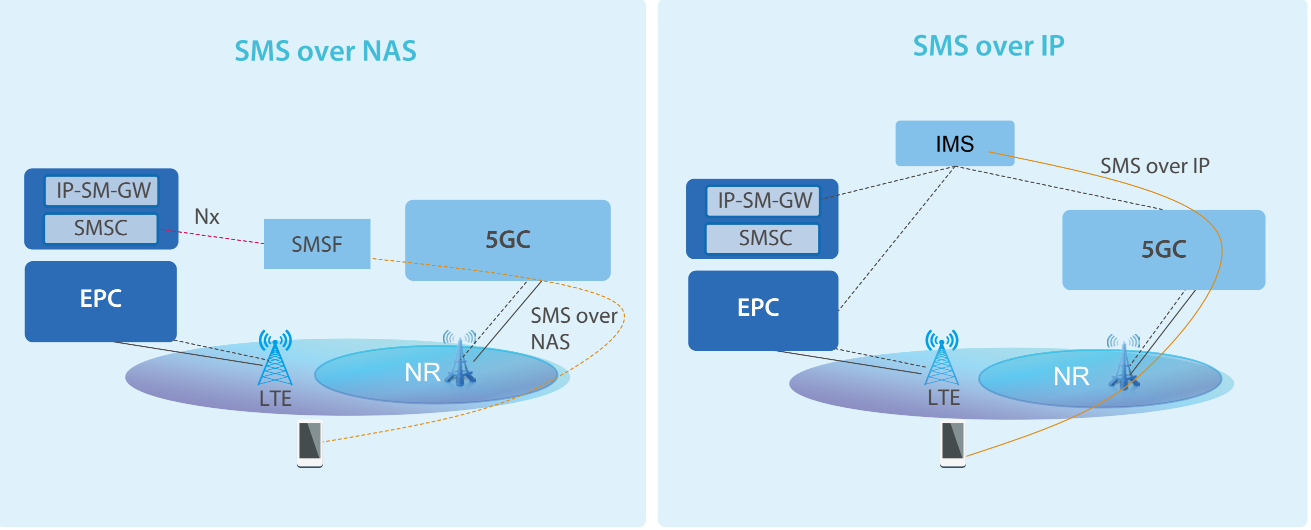
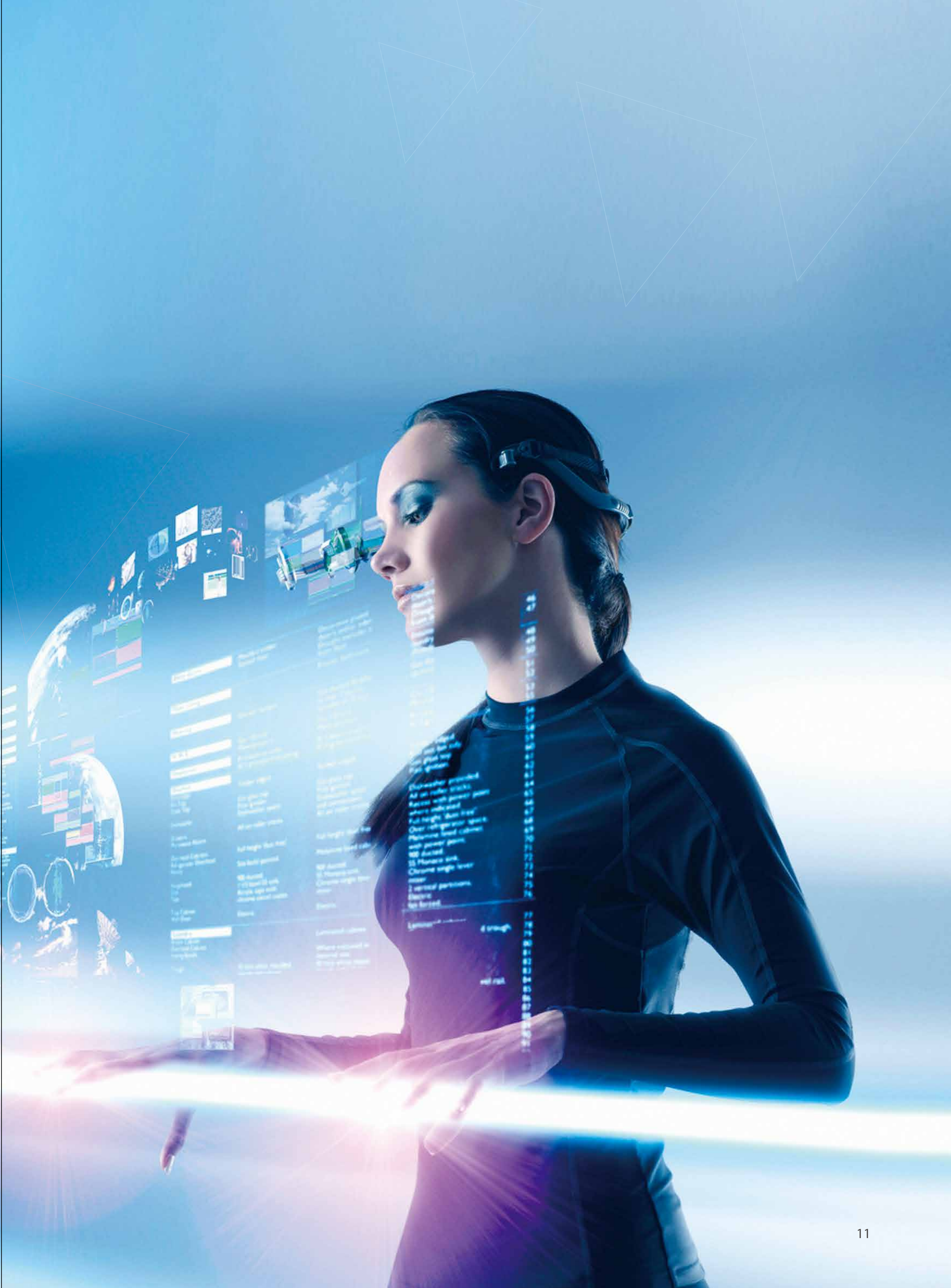


Figure 2-2 Two 5G SMS Solutions

At present many operators are facing new challenges regarding the short message service, such as old device upgrade, device expansion, and new IoT service requirements. To satisfy the requirements of various types of SMS services, the new convergent message platform shall be deployed in the cloud platform for the purpose of resource sharing, service convergence, and unified O&M. The convergent message platform shall provide package solutions and platform services, including interworking between SMS, IMS message, RCS, and MMS, as well as domain selection, in the scenario where a variety of network types co-exist.

Key Technologies of 5G Voice

In the early phase of 5G deployment, operators will focus on deployment of large-bandwidth data service for partial areas and will use 4G network to implement voice service. As more and more 5G services grow mature, voice service will be gradually migrated to 5G NR, which increases the spectrum efficiency and achieves spectrum re-farming to optimize the 5G frequency band.



5G Voice
Continuity

EPS Fallback Voice Continuity

In the early phase of 5G deployment (hotspot coverage), to reduce voice handovers between 4G and 5G, VoLTE will provide voice service, instead of NR. A fallback to 4G will be triggered once an IMS voice channel is setup on NR. The call setup time will be increased and data service will also be handed-over or fall back to 4G along with voice service.

EPS Fallback is performed in three modes: handover based on N26 interface, fallback without N26 interface, and dual-registration UE fallback.

- *Handover based on N26 interface: N26 interface supports mobility context delivery and handover signaling interaction. The base station instructs UE to fall back, session is anchored at the Session Management Function (SMF)/PGW-C, and media is anchored at UPF/PGW-U.*
- *Fallback without N26 interface: UE triggers a TAU/Attach procedure by domain selection to re-access 4G. UE must support handover attach.*
- *Dual-registration UE fallback: UE is registered in both 4G and 5G in advance and needs to maintain two mobility managements. UE triggers a TAU/Attach procedure by domain selection to re-access 4G.*

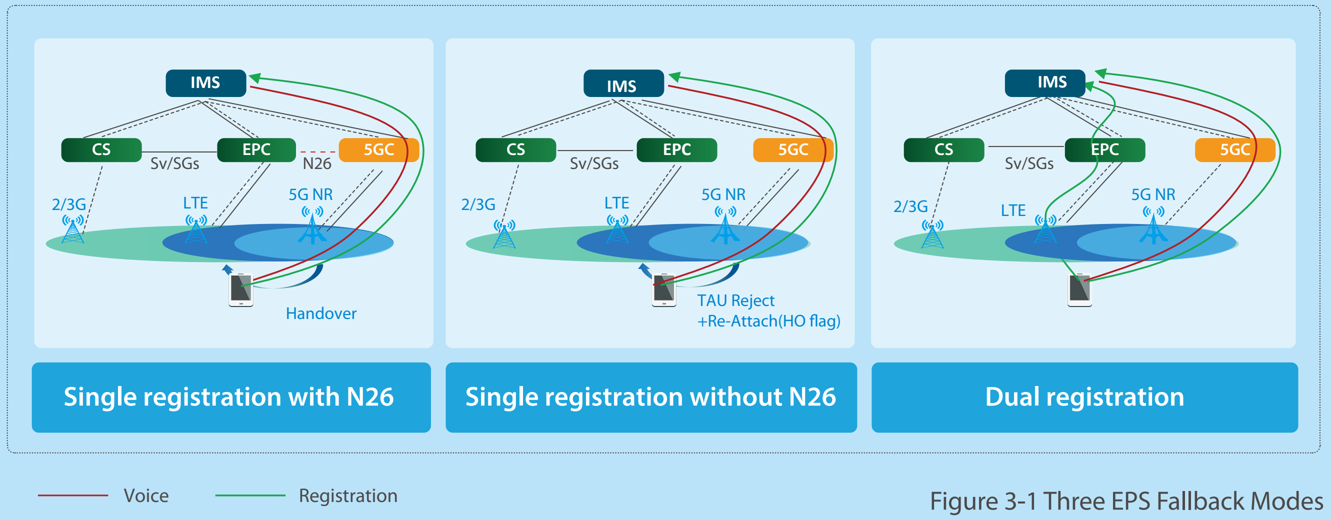


Figure 3-1 Three EPS Fallback Modes

The comparison between three EPS Fallback modes are described in the following table. The single registration with N26 interface mode minimizes the effect of handover/fallback on user experience, existing device, and UE, so it is highly recommended.

	Single registration+N26+HO	Single registration without N26	Dual registration
Data service experience	Data service is handed-over to 4G with voice service. Data interruption time: <200 ms	Data service is handed-over to 4G with voice service. Data interruption time: about 1600 ms	Data service is handed-over to 4G with voice service. Data interruption time: about 600 ms
Voice service experience	EPS FB call setup time is increased by 400 ms.	increased by 1600 ms.	EPS FB call setup time is increased by 600 ms.
Impact on existing network equipment	The MME shall be upgraded to support N26 interface.	The MME/AMF shall obtain the PGW-C/SMF ID from the UDM/HSS to ensure the same user-plane anchor point for UE.	The MME shall be upgraded to support dual registration.
Requirement for UE	Multi-mode single standby.	Multi-mode single standby. Supports handover attach.	Multi-mode single/dual standby. Supports dual registration.

Note: The call setup time is compared with that in VoLTE

VoNR Voice Continuity

With continuous NR coverage, voice can be transferred directly over NR, so both data and voice service can be implemented by NR, which delivers better user experience.

Voice call interruption caused by handover shall be less than 300 ms. With a N26 interface, the network can establish a bearer and indirect transmission channel at the target side in advance, so the call will be interrupted for less than 100 ms during radio interface handover. Without a N26 interface, UE needs to trigger a TAU/ATTACH/Registration procedure by domain selection to re-access 4G/5G and during the access procedure, the voice will be interrupted for more than 1s, which cannot meet the continuity requirement that the voice handover shall be less than 300 ms. Hence, deployment of a N26 interface can guarantee VoNR voice continuity.

5G Voice
Session Binding

VoLTE Gx and Rx interfaces are bind to one Policy and Charging Rules Function (PCRF) by Diameter Routing Agent (DRA). DRA stores the PCRF instance ID when a Gx session is setup and later routes the Rx session to the same PCRF. In 5GC, Rx interface does not change and N7 interface is HTTP based. Rx and N7 interfaces shall be bound for VoNR. Four session binding options are provided for different operators, as shown below.

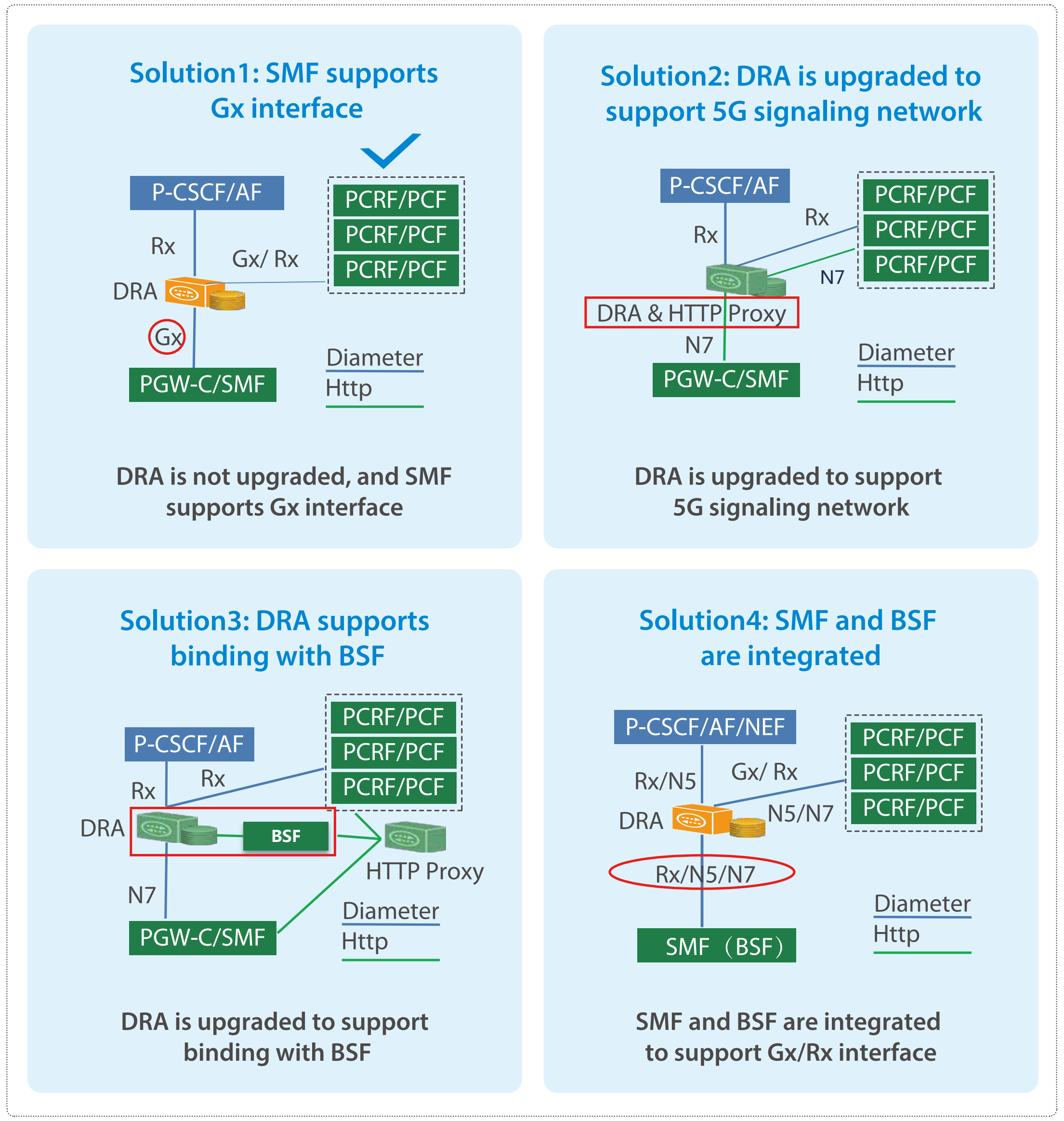
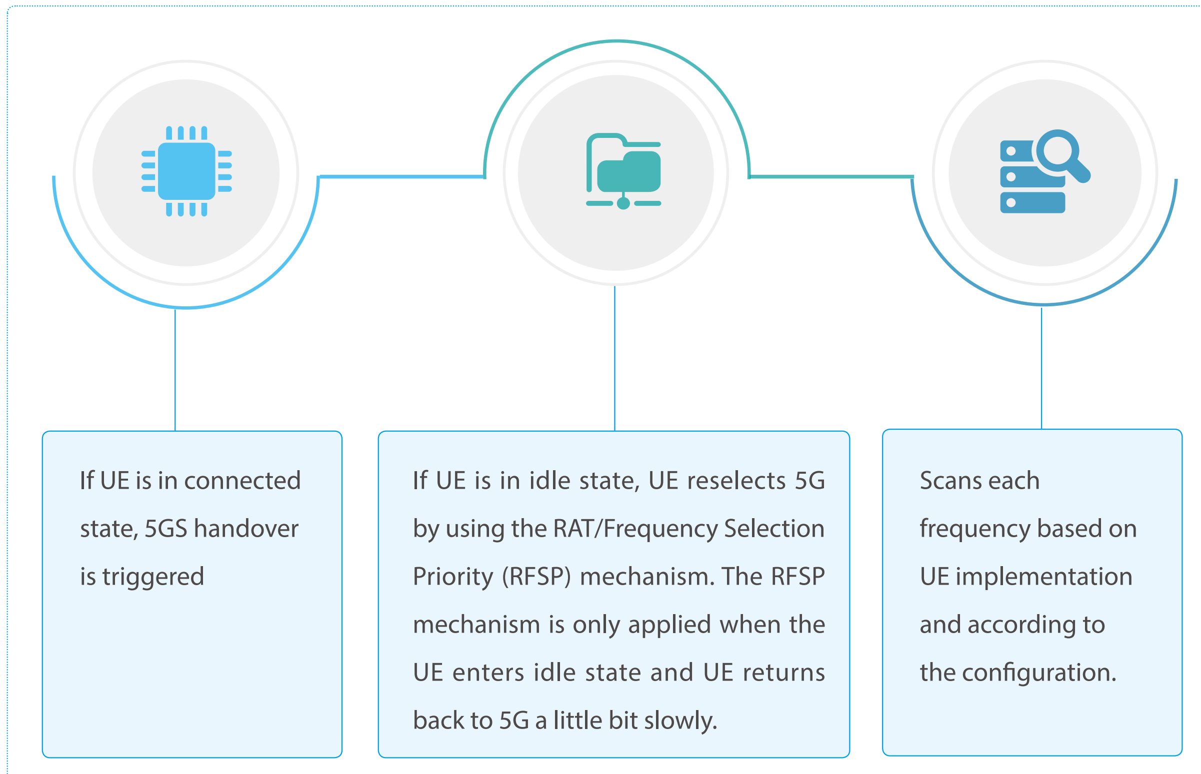


Figure 3-2 Four Session Binding Methods

	Impact on existing network	Method description	Advantage	Disadvantage
SMF supports Gx interface	No need to upgrade the existing network, minimum impact. 5GC SMF shall support Gx interface.	A Diameter-based Gx interface is used between SMF and Policy Control Function (PCF). Gx/Rx interface binding mechanism is the same as the mechanism implemented by DRA in 4G.	The existing DRA does not need an upgrade. 5G signaling network is independent.	SBI interface is not used between SMF and PCF, which might need to be added in the future.
DRA is upgraded to support 5G signaling network	The existing DRA shall be upgraded to support HTTP Proxy function and a great change will be made to the existing network.	DRA/HTTP Proxy is co-deployed to store the mapping relation between N7 IP address/user ID/DDN and PCF ID.	SMF supports standard SBI interface. One signaling network simplifies the network architecture.	
DRA supports binding with BSF	The existing DRA shall be upgraded to support 5G signaling network function.	When receiving an Rx session establishment message, DRA interacts with BSF to obtain the corresponding PCF ID.	It complies with the standard. The existing DRA and 5G signaling network can be constructed independently.	The existing DRA shall be upgraded to support BSF function.
SMF and BSF are integrated.	AF/NEF shall support static configuration of the relation between UE IP and SMF address range.	SMF returns the corresponding PCF ID according to the relation between UE ID/IP address/ DDN and PCF ID.	BSF is not to be deployed, saving the interaction messages between PCF and BSF.	AF/NEF shall support static configuration of the relation between UE IP and SMF address range.

Fast Return to 5G
After EPS Fallback

Three solutions are provided to enable UE to fast return back to 5G after it performs EPS Fallback to set up a VoLTE in 4G and then terminates the call.



Access Domain Selection
Terminating Access Domain Selection

When a UE registers to 5G, AMF notifies the UE of the network's VoPS support capability. It the network does not support VoPS, the voice centric UE will re-select LTE access. In EPS Fallback scenario, AMF also notifies the UE of the network's VoPS support capability.

During a MT call procedure, TAS queries the network capability and determines whether to initiate the MT call procedure from IMS or CS accordingly. Also, TAS shall support flexible configuration of second MT call policy for first MT call failure.

5G Voice
Charging

VoNR and EPS Fallback inherit VoLTE charging interfaces and architecture. The charging enterprise standard shall be updated for 5G access. In the early phase of commercial deployment, 5G continues to use EPC's charging architecture, Gy/Ga/Bx interfaces, and CDR format.

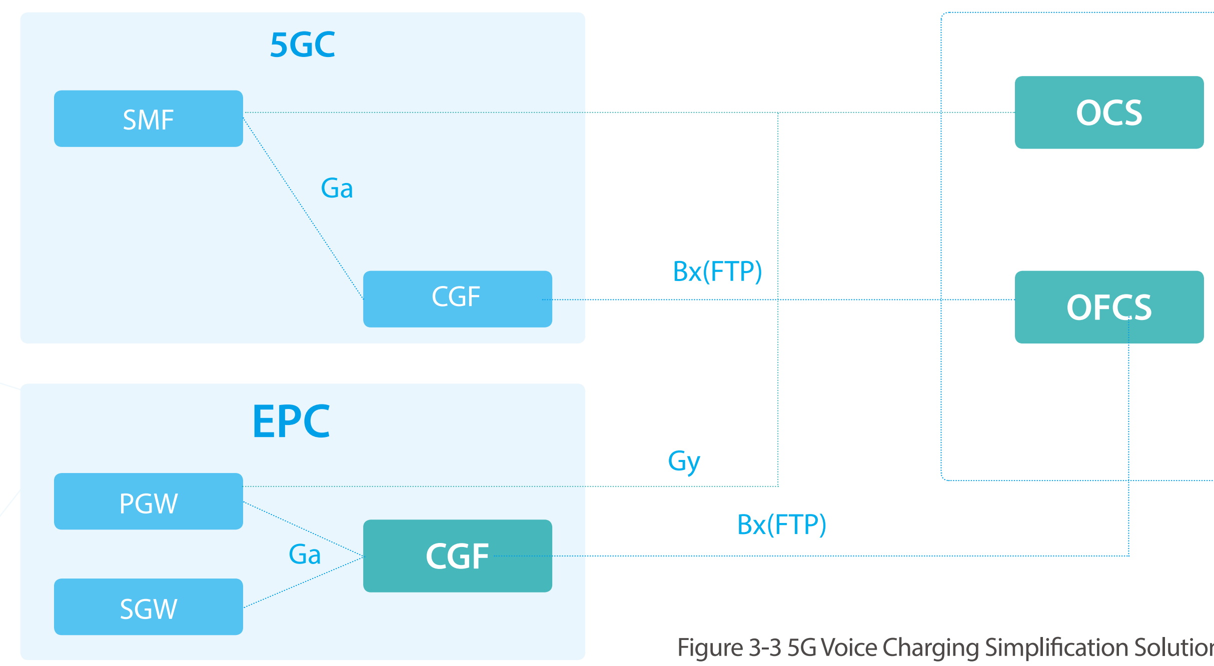


Figure 3-3 5G Voice Charging Simplification Solution

- The online charging interface is still the Gy interface. Three IEs including QoS extension, 5G RAT, and 5G traffic are added/modified for identifying 5G charging.
- The offline charging interfaces are Ga and Bx interfaces. Three IEs (optional) including QoS extension, 5G RAT, and 5G traffic are added to or modified in 4G CDRs, for identifying 5G charging.

5G Voice
Emergency Call

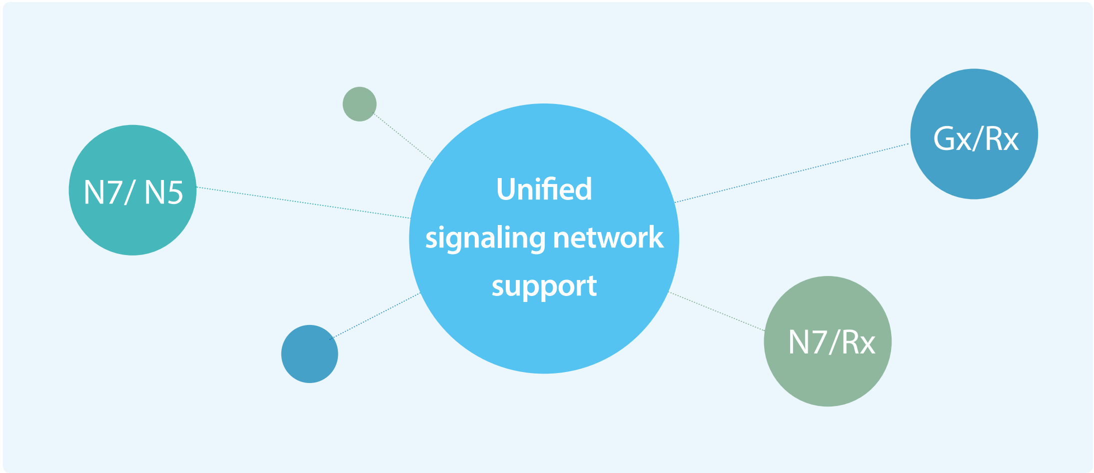
Operators can choose to directly support emergency call in 5G or notify UE to fall back to 4G/3G to perform emergency service. When a UE registers to 5G, AMF notifies the UE of the network's emergency service support capability, emergency call list, and the required emergency call fallback indication. When the UE makes an emergency call, if it has received an emergency call support indication but not received an emergency call fallback indication, then the UE initiates an emergency PDU session and then establishes an IMS emergency call on the emergency PDU session; if the UE has received an emergency call support indication and an emergency call fallback indication, it initiates an emergency service request and NR assists UE to fall back to 4G; otherwise, 5G does not support emergency service and UE directly leaves 5G and accesses 4G to perform emergency service.

5G
Signaling Network Construction

DRA and HTTP Proxy respectively implement signaling networking between 4G network devices and 5G network devices, which can reduce the number of TCP associations for security isolation and support inter-network service node routing and load balance. In a large-scale operator network, DRA and HTTP Proxy are required to support inter-province and inner-province layered networking and network topology replication; therefore, building up a convergent signaling network can perfectly simplify signaling network topology.

4G and 5G networks use the same signaling network to save cost for operators and simplify signaling network architecture. In an operator's network, different regions and NEs on different layers may evolve in different progresses, which leads to hybrid 4G/5G networking where 4G NEs only support Diameter while 5G NEs only support HTTP. ZTE's unified signaling network supports adaption between Diameter and HTTP, thus facilitating 4G/5G interworking.

In addition, the unified signaling network provides an in-built NSF, which can retrieve PCF information of 4G or 5G subscribers from the Gx and N7 interface and store the information in the unified Unstructured Data Storage Function (UDSF). The unified signaling network supports session binding procedure in multiple networking models, including N7/ N5, Gx/Rx, and N7/Rx combinations, which improves the PCF addressing efficiency and shortening the call setup time.



5G Voice

Roaming Maturity Analysis

5G voice roaming is similar to 4G VoLTE roaming. It supports two roaming methods: IMS roaming and PS roaming.

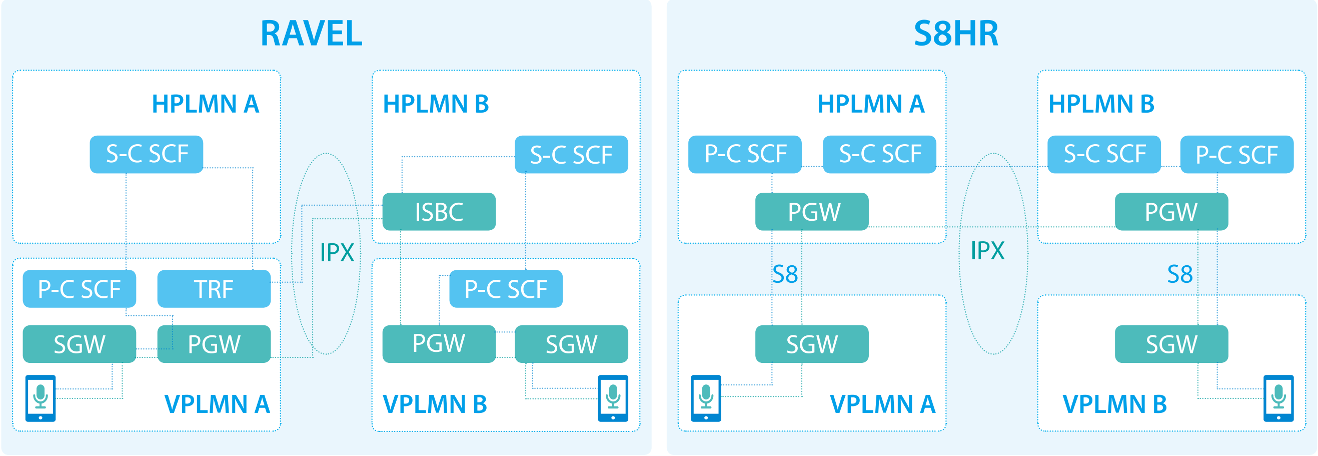
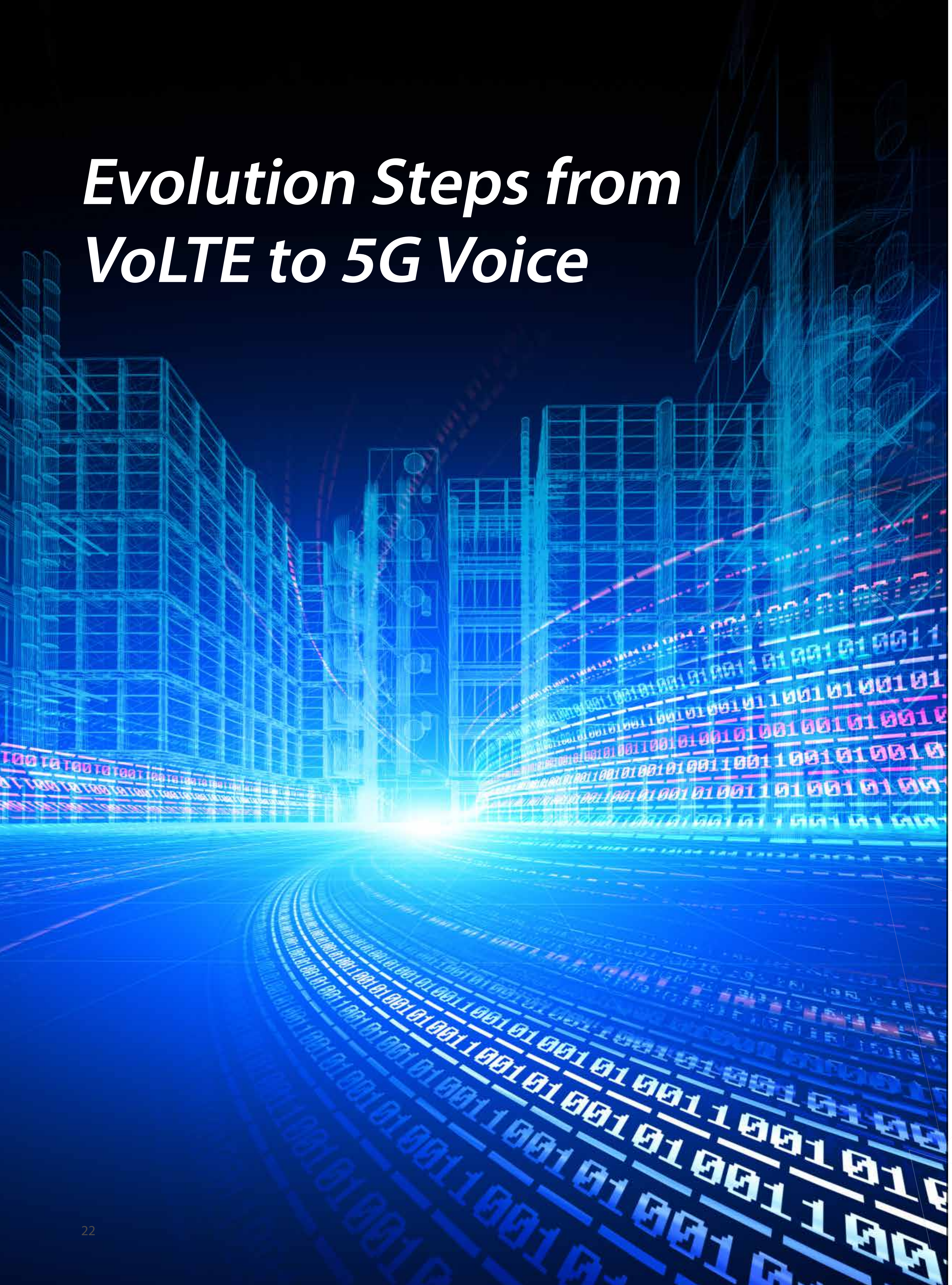


Figure 3-4 5G Voice Roaming Solutions

In the current 4G network, voice service in the international roaming case is implemented by using the CSFB mechanism. VoLTE international roaming solution is not widely applied. 3GPP 5G R15 does not support direct fallback from NR to CS, so 5G international roaming may be implemented by either of the following two solutions and the specific solution to be adopted depends on negotiation between two operators.

	Roaming method	Standard maturity	Advantage and Disadvantage
IMS roaming	PS Local Breakout: IMS P-CSCF is deployed in the VPLMN, which supports IMS to use signaling/ media transmission path. The charging method similar to CS roaming.	Roaming Architecture for Voice over IMS with Local Breakout (RAVEL) has been defined in 3GPP R11 in 2012.	**Advantage:** MO media is terminated in the VPLMN, low latency. Call connection simlar to CS roaming. charging mode similar to CS roaming. **Disadvantage:** IMS UNI interface is based on flexible SIP, which requires lots of tests.
PS roaming	PS Home Routed: P-CSCF is deployed in the HPLMN. IMS service charging mode is similar to data service charging.	The EPC-based S8 home routed roaming (S8HR) solution has defined in 3GPP R14 in 2016. For 5G voice, it is implemented by assistance of 5GC roaming method.	**Advantage:** GTP interworking based on N9 interface, same as data service, no additional test. 3GPP is considering charging mode implementation. **Disadvantage:** MO media routed to the HPLMN, higher latency.

Evolution Steps from VoLTE to 5G Voice



Voice and SMS Solution

in the Early Phase of 5G Deployment

In the early phase of 5G deployment, if a 5G network is built up in Option3/3a/3x deployment mode and relying on the EPC architecture, and 5G NR is only used as hotspot coverage, users will still register to EPC and 5G voice can be implemented by using VoLTE/CSFB solution.

In VoLTE/CSFB solution, 5G NR is only treated as a new user access mode and voice service is still handled by LTE. If LTE network coverage is unavailable or a handover occurs, UE will fall back to CS by virtue of CSFB or SRVCC mechanism. The handling mechanism is the same as the one in the existing network.

In the early and middle phases of 5G deployment, if a 5GC is built up but 5G NR is only used for hotspot coverage, NR cannot provide voice service on a large scale. In this case, 5G voice adopts EPS Fallback solution (fallback from 5GC to EPC or from 5G NR to LTE). In the case that LTE has been upgraded to eLTE, 5G voice can adopt RAT Fallback solution (from 5G NR to eLTE).

In EPS Fallback solution, if N26 interface is not used between MME and AMF, UE performs dual registrations to EPC and 5GC; if a N26 interface is added between MME and AMF, UE only performs a single registration and can fall back rapidly. ZTE recommends operators to deploy N26 interface.

In RAT Fallback solution, RAT Fallback is triggered once an IMS voice channel is set up over 5G NR. A fallback request is sent to 5GC to let the UE fall back to eLTE. Because the processing is performed within 5GC, the fallback speed mainly depends on wireless interaction. ZTE recommends that the CN shall support multiple wireless access modes.

Voice and SMS Solution

in the Middle/Later Phase of 5G Deployment

In the middle and later phases of 5G deployment, 5GC will be deployed in a large scale, and 5G NR will be continuous coverage and be directly connected to 5GC. VoNR solution will be adopted for 5G voice, which is an E2E 5G solution and also the target solution for 5G voice.

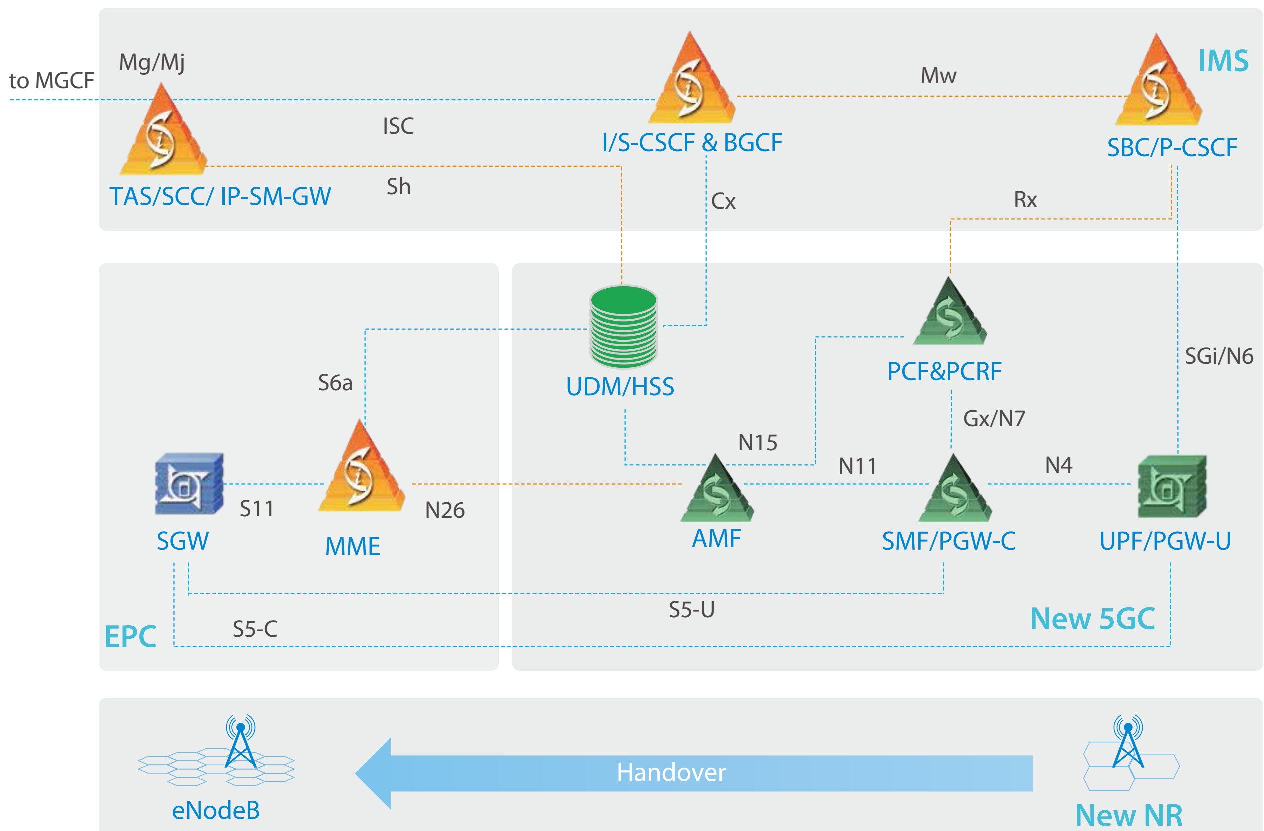
5GC-Oriented
Evolution of IMS

3GPP has defined that 5G voice service will be provided over IMS (5G is an access mode of IMS voice). Regardless of the 5G voice solutions (VoLTE, EPS Fallback, or VoNR), IMS is the essential service control network.

5G voice system architecture follows three basic principles, as described below:

- Voice service is provided still based on IMS.
- IMS architecture remains unchanged.
- Some of IMS interfaces need to be changed for interworking with 5GC. The 5G voice system architecture is shown below.

The 5G voice system architecture is shown below



Updating the existing network interfaces Updating NEs in the existing CN

Figure 4-1 5G Voice Architecture

Compared with the existing VoLTE solution, 5G voice solution has the following differences:

- A new 5GC is added on the same bearer. network layer with EPC
- A new 5G NR is added on the same access network layer with LTE.
- The collaboration between 5GC and EPC, between 5G NR and LTE, and between 5GC and IMS need to be implemented.

Following the third principle, on the CN side, the changes made to IMS include:

- To enhance the T-ADS policy on the SCC AS for dual-registration scenario.
- To add access type and location information parameters to related interfaces, including Rx, Sh, and Gm/Mw/ISC.
- To enable the Rf interface to support transparent transmission of 5G charging information.

ZTE 5G voice solution is illustrated in the following figure

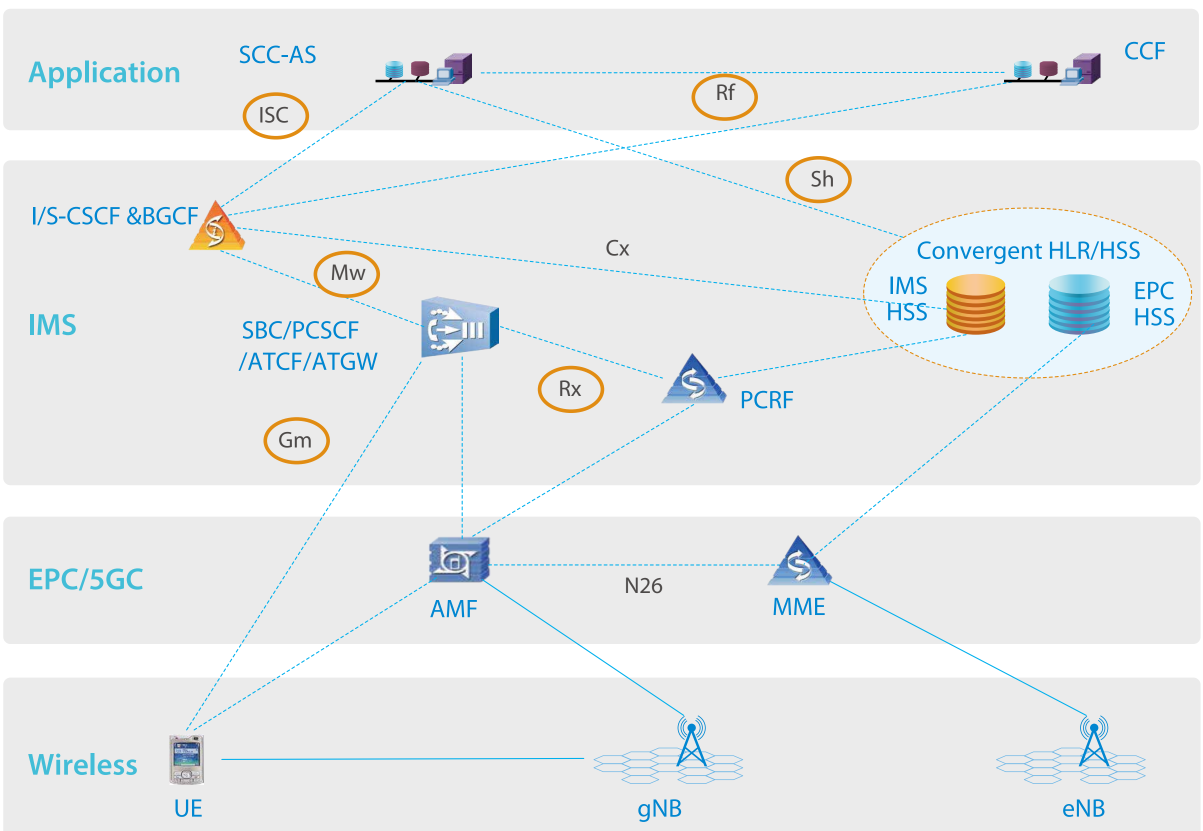


Figure 4-2 5G Voice Solution - To-be-upgraded IMS Interfaces

VoLTE / VoNR Voice Quality Guarantee

One of the core targets of 4/5G network construction is to provide users with high-fidelity service experience. At present, the operation and maintenance for the commercial VoLTE networks provides KPIs and KQIs, but does not provide the most important voice perception measurement indicators; therefore, user voice perception cannot be evaluated accurately in real time.

VoLTE/VoNR voice quality guarantee shall support:

E2E voice quality analysis

- voice quality analysis and voice MOS optimization
- IP QoS analysis and voice mute reason analysis
- Visual wave analysis for voice quality

Service monitoring and signaling trace

- Real-time monitoring for service quality
- E2E signaling retention and backtracking
- Network quality optimization to enable signaling trace for all users and fast troubleshooting

Network indicator optimization

- Service experience evaluation for KQI improvement
- Probe-based inter-vendor equipment data collection and signaling capture
- Call completion rate improvement and call connection latency reduction

Refined marketing analysis

- User perception analysis for VIP care
- User preference analysis for digging the potential consumption ability
- UE data analysis for accurate guide to UE marketing

ZTE IMS-based 5G Voice Solution

ZTE 5G voice solution is shown in the following figure

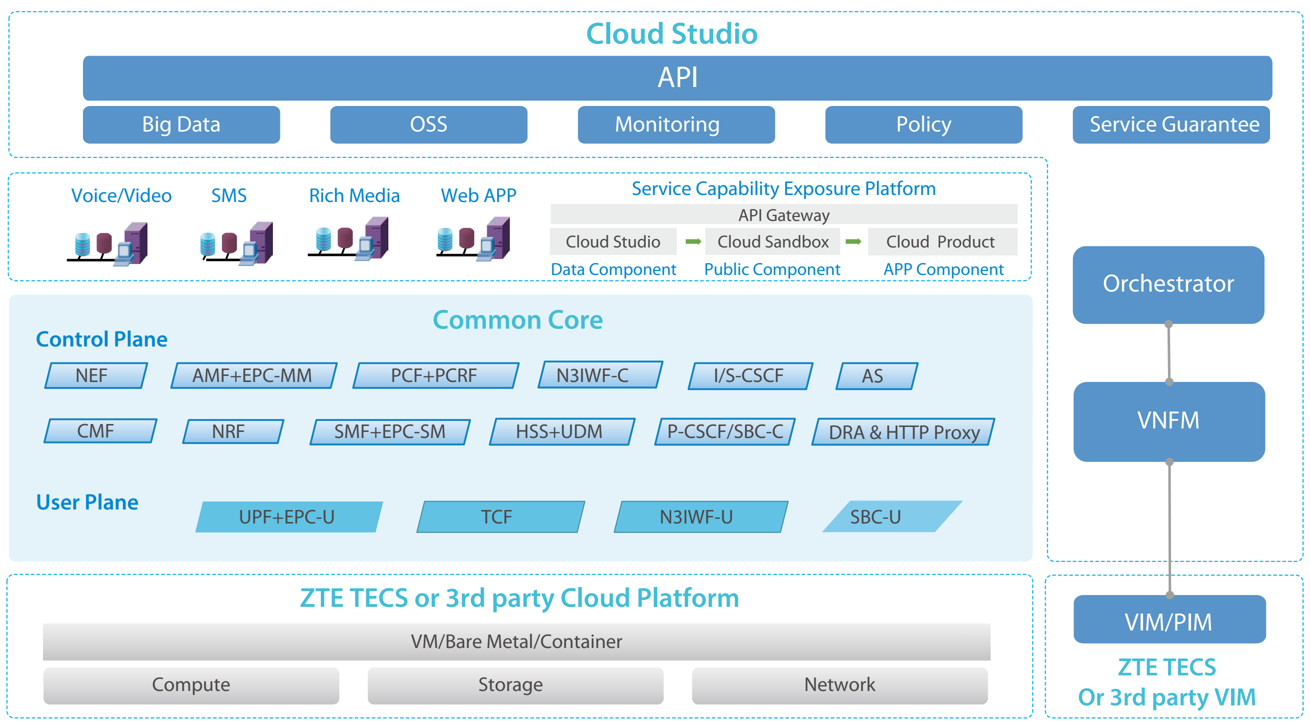


Figure 6-1 ZTE 5G Voice Solution

ZTE 5G voice solution is designed based on ZTE's full-convergent Common Core. It supports 4G/5G/WiFi access and various types of UEs, supports multi-system full service and user data convergence, and supports convergent 4G/5G signaling network. It provides comprehensive service capabilities, including legacy telecom services, RCS, Web real-time communication, and converged SMS. It supports individualized deployment for industrial applications.

ZTE 5G voice solution implements E2E O&M. It supports integration of design, provisioning and O&M, provides closed-loop service guarantee based on big data analysis and policy, and offers E2E visual O&M for voice. Centered on proactive O&M, correlative analysis, and expert system solidification, ZTE creatively introduces a multi-dimensional intelligent voice perception analysis solution to provide low-cost and E2E evaluation for all calls, thus efficiently handling the problems of user voice perception evaluation and improvement.

Summary

“

5G voice service will be implemented on VoLTE's IMS control architecture and inherit all the voice services in the existing network.

After a 5G network is deployed, voice services will be migrated to the IMS-controlled PS network and the spectrum efficiency will be greatly improved compared with the CS network. Thanks to this, operators will accelerate network virtualization and old device upgrade. Spectrum reallocation will help operators to gradually phase out the CS network, accelerate operator equipment IT-ization, and promote continuous development of automated O&M.

IMS service-based architecture will be optimized in 3GPP R16, so as to further satisfy the requirements of IoT. We believe, as the 5G wireless technology, service-based architecture technology, and network slicing technology continuously innovate and grow mature, the voice and video services in 5G era will deliver extraordinary new capability and new experience to users.

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