ZTE

ZTE 5G Core Network White Paper



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Foreword

5G, in addition to enabling the seamless connection between people and people, also strengthens the high-speed connection between "people and things" and "things and things", to create a new digital ecosystem and accelerate the growth of network traffic. 5G will be the most important foundation of the M-ICT era, developing around the centricity of "human experience", to achieve further integration and innovation in the terminal, wireless, network, service and other areas. At the same time, 5G will bring a revolutionary impact to capabilities of "people" in perception, access, participation, and information control. The service object of 5G will be expanded from public users to industry users. 5G network will absorb the excellent characteristics of cellular networks and local area networks (LAN) to form a more intelligent, more friendly and more widely used network.

This white paper starts from the driving force of 5G network evolution, makes in-depth analysis on main scenes and key technology of the 5G, and provides solutions for how to enhance the competitiveness of operators and how to reduce the TCO in the 5G stage. On this basis, combined with standards and industry trends, it proposes the technical route of 5G network deployment and evolution.

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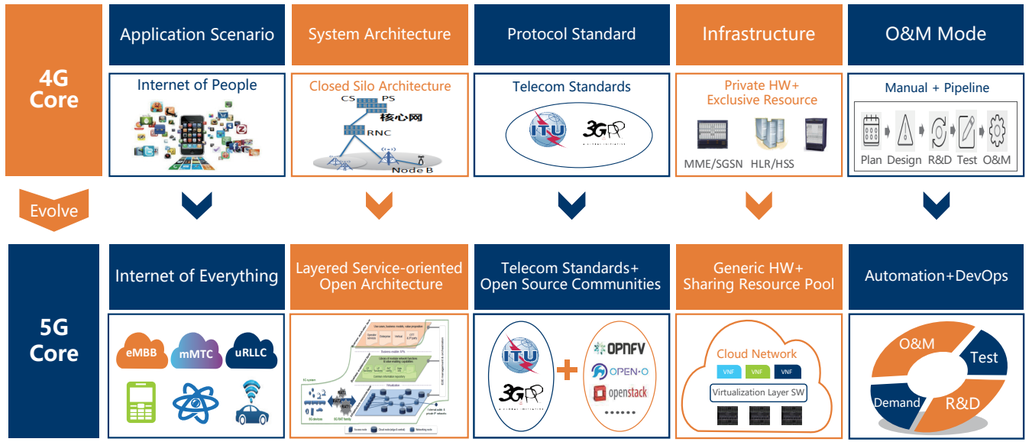
5G Core Network vs. 4G Core Network

Differences between 5G Core Network and 4G Core Network

4G network changes the way of life, while 5G network changes the way of production, and it is a new architecture and transformation from meeting the single demand of "Internet of People" to meeting a wide variety of demands of "Internet of Things (IoT)" and industry users. It evolves from the traditional silo architecture with integrated hardware and software to the horizontal decoupling architecture with separated hardware and software and using micro-service and slicing mode.



5G requires a shorter latency of air interface, and faster user experience speed, respectively 10 and 100 times higher than 4G, which is impossible to be achieved in the 4G network architecture. Therefore, the core network architecture needs to be more flat, and the user plane needs to get much closer to the user side. The original 4G centralized core network deployment architecture needs to evolve into a 5G distributed core network deployment. Part of functions of the core network needs to go down to the wireless side or edge DC, getting closer to the end user, and reducing the latency.

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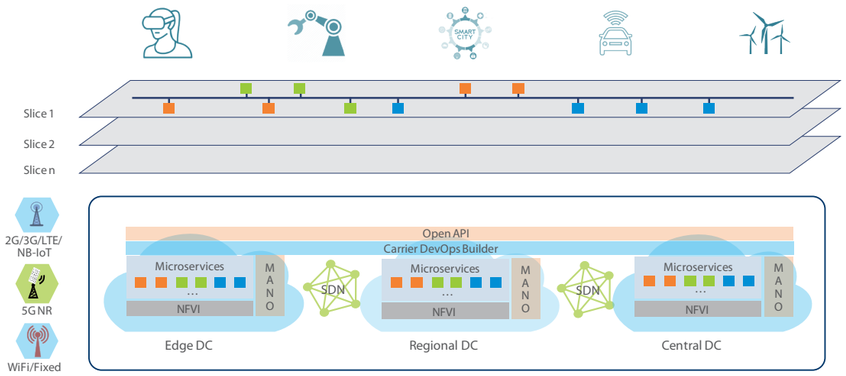
Driving Force of Evolution

The current 2/3/4G core networks are designed for voice communication of "Internet of People" and conventional MBB services. They not only have a large number of network elements, but also are not able to meet the demands of "Internet of Everything" which is featured in massive connections, ultra low latency and large bandwidth.

As a wireless mobile communication system for the demands of human information society beyond 2020, 5G core network will be a full-service, multi-technology converged network that will meet the future rapid development needs of various services with a wide range of data and connection through ICT technology evolution and innovation, to meet the user-centered network needs. Its main driving forces include:

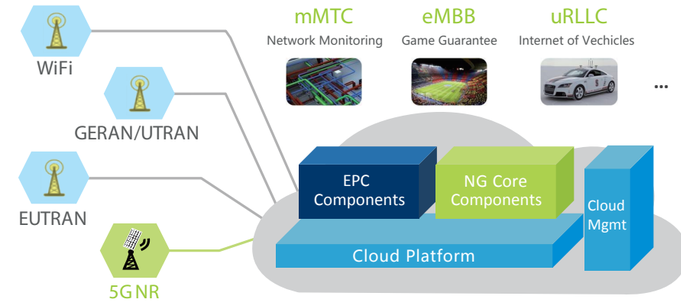
◆ Cloud network, on-demand slicing, to achieve agile network for multiple scenarios, multiple service and multiple access technologies

The end-to-end network slicing is the basis for 5G network supporting on-demand agile networking, and also the key technology of 5G network architecture evolution. The underlying physical infrastructure of 5G network architecture is a networking mode with base stations plus a three-layer data center. Base stations include 2/3/4G, 5G, NB-IoT, Wi-Fi and other access standards as well as macro-stations, small stations, and micro-stations and other different access patterns. The three-layer data center is composed of computing, storage and resources. The closest to the base station side is edge DC, the second layer is regional DC, and the third layer is central DC.



◆ A variety of accesses, co-integration, to meet the service continuity requirement, to achieve fixed and mobile convergence

The long-term evolution of LTE and Wi-Fi access is also a part of the 5G network. According to the user terminal capabilities and user mobility needs, 5G network needs to achieve a variety of connectivity technologies to provide users with adequate data throughput capability and mobile service continuity.



◆ Open source and openness, agile O&M, to shorten TTM and improve efficiency

Different services have different demands on network functions. The eMBB service needs the scheduling with large throughput rate, and the uRLLC service needs ultra-low latency and ultra-high reliability assurance. When the service is going to be launched, the network needs to carry out flexible and agile orchestration according to service characteristics, which will significantly simplify the network function and improve network efficiency.

◆ Internet of Everything, Green and Efficient

The 4G-based M2M feature will continue to evolve and enhance technology and implementation to meet the needs of certain scenarios. But 4G enhancement is not able to meet the 1ms latency of air interface and 99.999% reliability requirements proposed by 5G, which is crucial to the Internet or Vehicle, industrial control and other uRLLC scenes. Therefore, it is needed to design a new air interface for the 5G IoT service which is featured in low power, large connection, low cost and deep coverage, and design new system bandwidth, select a reasonable carrier design, optimize signaling process and service process, enhance Multi-Access Edge Computing (MEC) capabilities, to meet the future needs of widely-used IoT with over 100 billion connections at a very low cost.

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Application Scenarios of 5G

According to the main application scenarios, service needs and challenges of Mobile Internet and IoT, we can summarize out following four main 5G technical scenarios.

◆ Continuous wide-area coverage



Continuous wide-area coverage is the most basic coverage mode of mobile communication, aimed at ensuring the user's mobility and service continuity, to provide users with seamless high-speed service experience. The main challenge of this scenario is to provide a user experience rate of more than 100Mbps at anytime and anywhere (including harsh environments such as cell edge, high speed movement).



◆ High-capacity hotspot

High-capacity hotspot scenarios are geared to local hotspots, providing users with extremely high data rate to meet the network's extremely high traffic density requirement. 1Gbps user experience rate, dozens of Gbps peak rate and tens of Tbps/km^2 traffic density requirements are the main challenges to this scenario.

◆ Low power, large connection



Low-power and large-connection scene is mainly for smart city, environmental monitoring, intelligent agriculture, forest fire prevention and other sensing and data collection scenarios which are featured in small data packets, low power consumption, massive connections and so on. This type of terminals distribute in a wide range with a large number, not only requiring the network with the support capability of over 100 billion connections to meet the density index requirement of 1 million / km^2 connection number, but also to ensure the terminal's ultra-low power and ultra-low cost.

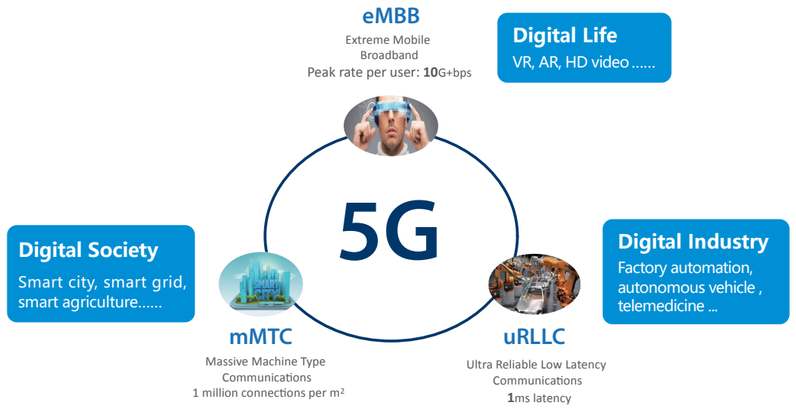
◆ Low latency, high reliability

Low-latency and high-reliability scene is mainly for special application needs of Internet of Vehicles, industrial control and other vertical industries, such applications have very high indicator requirements on delay and reliability, and need to provide users with millisecond-level end-to-end latency and the service reliability guarantee close to 100%.



Continuous wide-area coverage and high-capacity hotspot scenes mainly meet the demands of future mobile Internet services, and are also the traditional 4G technical scenarios. Low-power and large-connection as well as low-latency and high-reliability scenes are for IoT services, newly developed for 5G, and aim at solving the problem that traditional mobile communication cannot support applications of IoT and vertical industries.

From the different perspectives of information interaction objects, 5G defines three typical service scenarios: eMBB (extreme Mobile Broadband), uRLLC (ultra Reliable Low Latency Communications) and mMTC (massive Machine Type Communications). The eMBB focuses on services with high bandwidth requirements, such as high-definition video augmented reality/virtual reality (AR/VR), to meet people's needs for digital life, and the peak rate of eMBB service should be 10Gbps or more; the uRLLC focuses on services with high reliability and low latency, such as automatic driving and remote control, to meet people's demand for digital industry, and the latency requirement of uRLLC service is ms level; the mMTC covers scenarios with high connection density requirements, such as smart city and intelligent agriculture, to meet people's need of digital society, and the mMTC service requires the million-level connection density.



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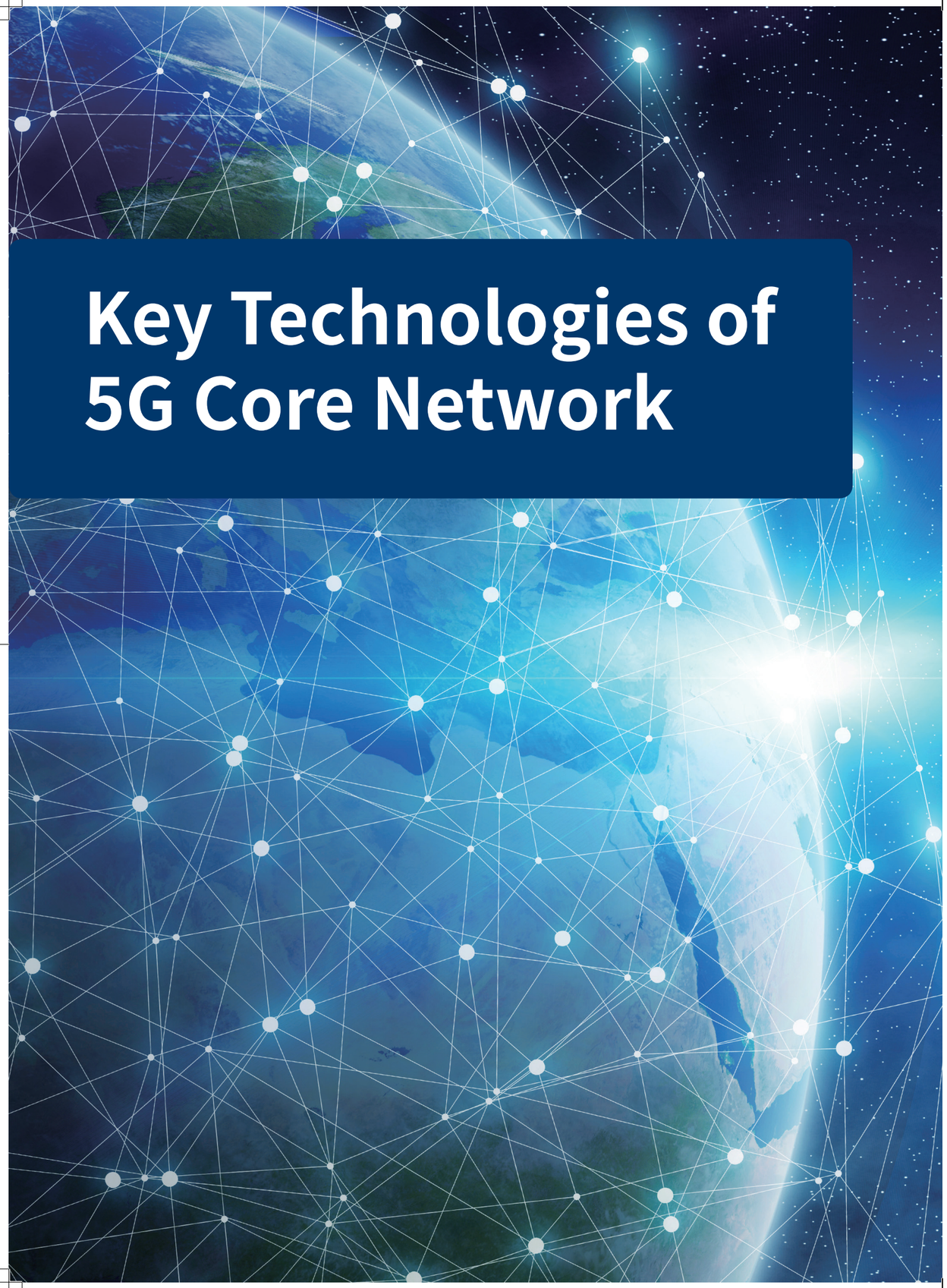

Key Technologies of 5G Core Network

SDN/NFV Enables Operators Network Reconstruction

The concept of Software Defined Network (SDN) is to let the software to control the network, to fully open network capabilities. It is a new network architecture and network technology with three characteristics: control and forwarding separation, logic centralized control, and open API. The introduction of SDN changes the closed vertical integrated network architecture into the convergent, open, elastic horizontal hierarchical architecture focusing on applications.

The concept of Network Function Virtualization (NFV) is hardware and software decoupling, leveraging IT means to transform CT, and to build a telecom infrastructure environment with the adoption of COTS (Commercial Off-The-Shelf) platform, to significantly reduce infrastructure hardware costs. Through the NFV, the basic hardware resources and environment can be purchased or customized by the operators in a unification manner. The agility and flexibility of the network have been greatly improved, and the service deployment time has been greatly shortened.

As the basic technology of 5G network, SDN/NFV help operators to adjust the network architecture, better adapt to the service deployment and innovation in the Internet era, to meet the needs of the evolution of network architecture.

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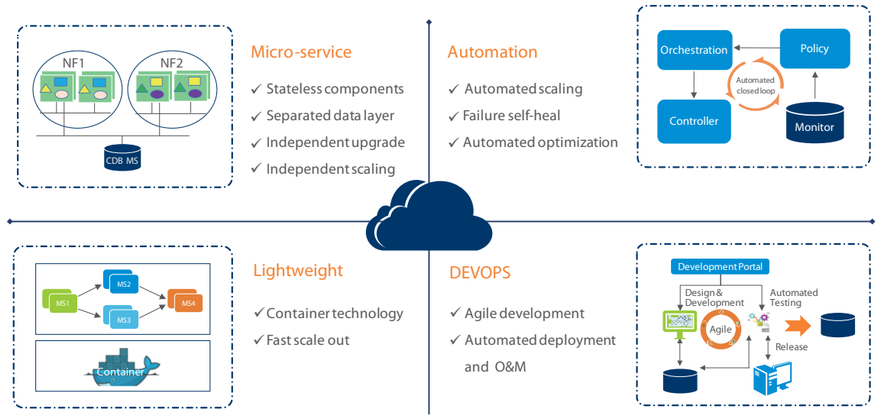
Cloud Native is the foundation of 5G core network architecture

To design the system architecture of 5G core network, it is needed to consider the unique stability requirement of telecom applications, and also to introduce concepts widely used in the IT field to achieve optimization and transformation. ZTE believes that the Cloud Native core network application should have the following four characteristics:



◆ Micro-service Architecture

The application is designed with the concept of "high cohesion and low coupling" and is divided into a series of small services. Each service concentrates on a single service function, running in a separate process. These services, with a clear boundary between each other, use a lightweight communication mechanism (such as HTTP / REST) to communicate and collaborate with each other to achieve a complete application, so as to meet the needs of services and users.

◆ Self-service

Based on the micro-service architecture, it is highly automated from blueprint design, resource scheduling, lifecycle management, to application status monitoring, control policy updates and other links, and the effective connections of the various links achieve a closed-loop feedback mechanism, so that it realizes one-key deployment installation, comprehensive automated and efficient management.

◆ Lightweight Virtualization

Compared with the virtual machine (VM), container technology is advanced in fast scale-in/out, lightweight, high performance and other aspects, which is developing rapidly and widely used in the IT industry. Cloud Native applications and the underlying virtualization technology achieve decoupling and can be deployed in the container technology to promote resource utilization rate and achieve rapid delivery and agile maintenance of services.

◆ Stateless

5G core network adopts stateless hierarchical design. The user's access and session information are stored in the data sharing layer, and various micro-service instances at different locations obtain the user's latest state through the data sharing layer. The stateless application design achieves the separation of applications and data, realizing rapid network elasticity, fault recovery and so on.

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Network slice meets diversified business demands

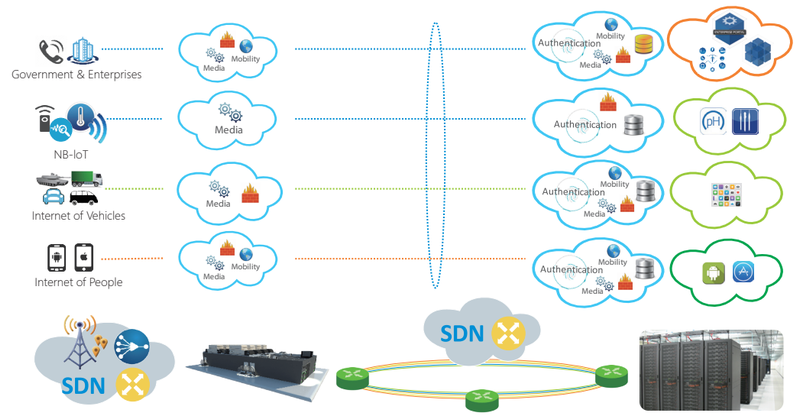
Network slices are different proprietary networks logically completely isolated from each other, and are the indispensable key technology that enables operators to meet different service needs and scenarios and achieve new profit models. The 5G core network provides customized web-based services for specific business and network scenarios. In order to achieve this "network slice as a service", according to different service needs, the network generates appropriate network topology and network functions through virtualization on the unified underlying physical facilities, and the combination of a series of network functions generated for one specific service type is called a network slice. Physically, each network slice runs on a unified network infrastructure, so as to greatly reduce the cost of building multiple service types; logically, each network slice is isolated to meet the function customization and independent O&M requirement of every service type.



Forms and deployment scenarios of network slice:

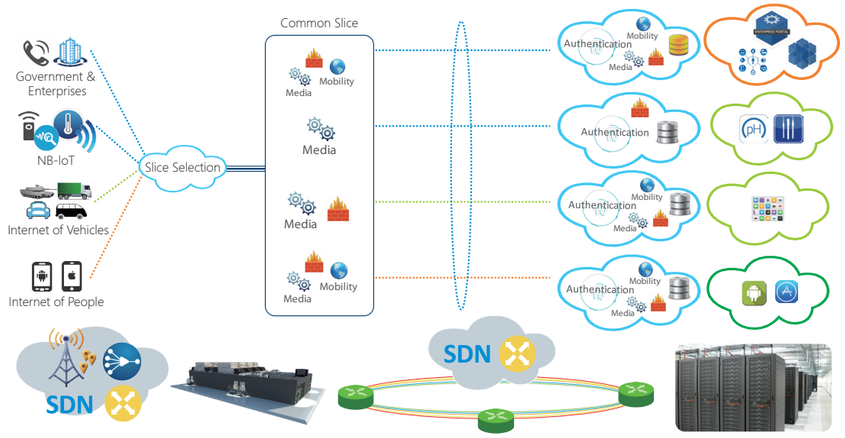
◆ Independent slices

Slices with separate functions, including control plane, user plane and various function modules, to provide independent end-to-end private network services or some specific functional services for specific user groups such as NB-IoT, eMBB, enterprise network.



◆ Shared slices

Slices whose resources are available for a variety of independent slices, to provide end-to-end functions or part of shared functions. Typical application scenarios include shared vEPC + Gi LAN service chain network, MVNO and others.



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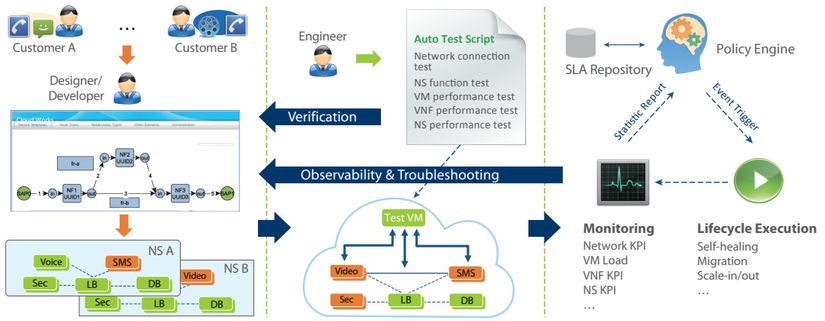
DevOps Achieves Zero Touch Smart O&M

DevOps is targeted to reduce the communication costs of R&D and O&M departments, improve R&D efficiency, shorten the TTM of application, and break down departmental barriers to achieve rapid response. DevOps is currently widely used in the IT field, and it can enhance the competitiveness of operators in the market and reduce CAPEX and OPEX.

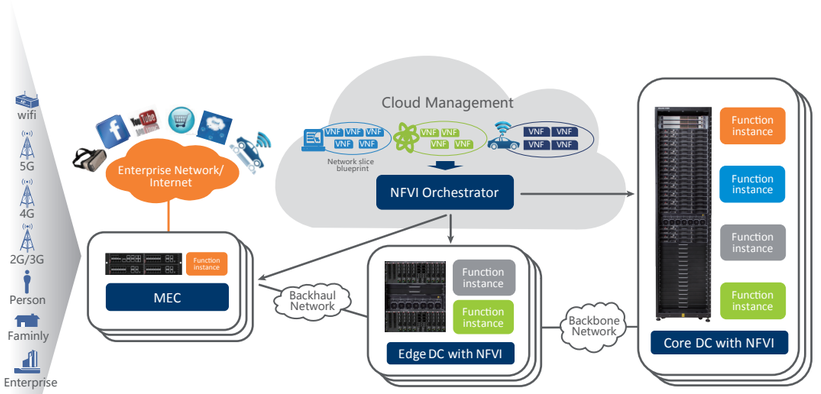
The closed-loop strategy control DevOps system based on big data analysis, as shown below, provides VNF / NS developers or operator service designers with full lifecycle DevOps services from development and design to deployment and management, to support operators and partners transforming to the DevOps mode for the future agile delivery, to equip the network with self-optimization and self-healing capability, and to speed up the O&M automation process. It keeps optimizing customer experience and networking through the self-evolving process of "design – deployment – run –analyze - redesign". The future introduction of artificial intelligence and machine learning will achieve intelligent strategy forecast, and further enhance the intelligent O&M system construction.



Hour-level New Service Development | **Automatic Function Performance Verification** | **Lifecycle Automatic SLA Guarantee**

MEC Technology Improves User Experience

Recently, ETSI extended the Mobile Edge Computing concept to Multi-Access Edge Computing to further extend edge computing capabilities from telecommunications cellular networks to other wireless access networks such as Wi-Fi.



MEC will introduce the virtualized service platform into the wireless network, effectively make the service anchor going down to the edge DC, shorten the service response time, and move the computing capability to the mobile edge node, to quickly use local content and real-time information of the edge node, to achieve much faster distribution and download of network contents, services and applications, thereby effectively alleviating the pressure of the mobile core network, improving the telecommunications service environment, allowing users to enjoy a higher quality network experience.

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MEC provides development, test and deployment environments for application developers and content providers, and makes APP or video resource being deployed closed to the user, so as to achieve network information access with ultra-low latency, high bandwidth and in real time. It includes the following key technologies.

◆ Content cache at the wireless side

MEC server integrates with the server system to gain hot contents, including video, picture and documents, and then carries out local cache. During the process of the service, the MEC server implements in-depth packet analysis on the data of the base station side in real time. If the service content applied by the terminal is already in the local cache, the MEC server will directly push the cached content to the terminal.

◆ Local offload

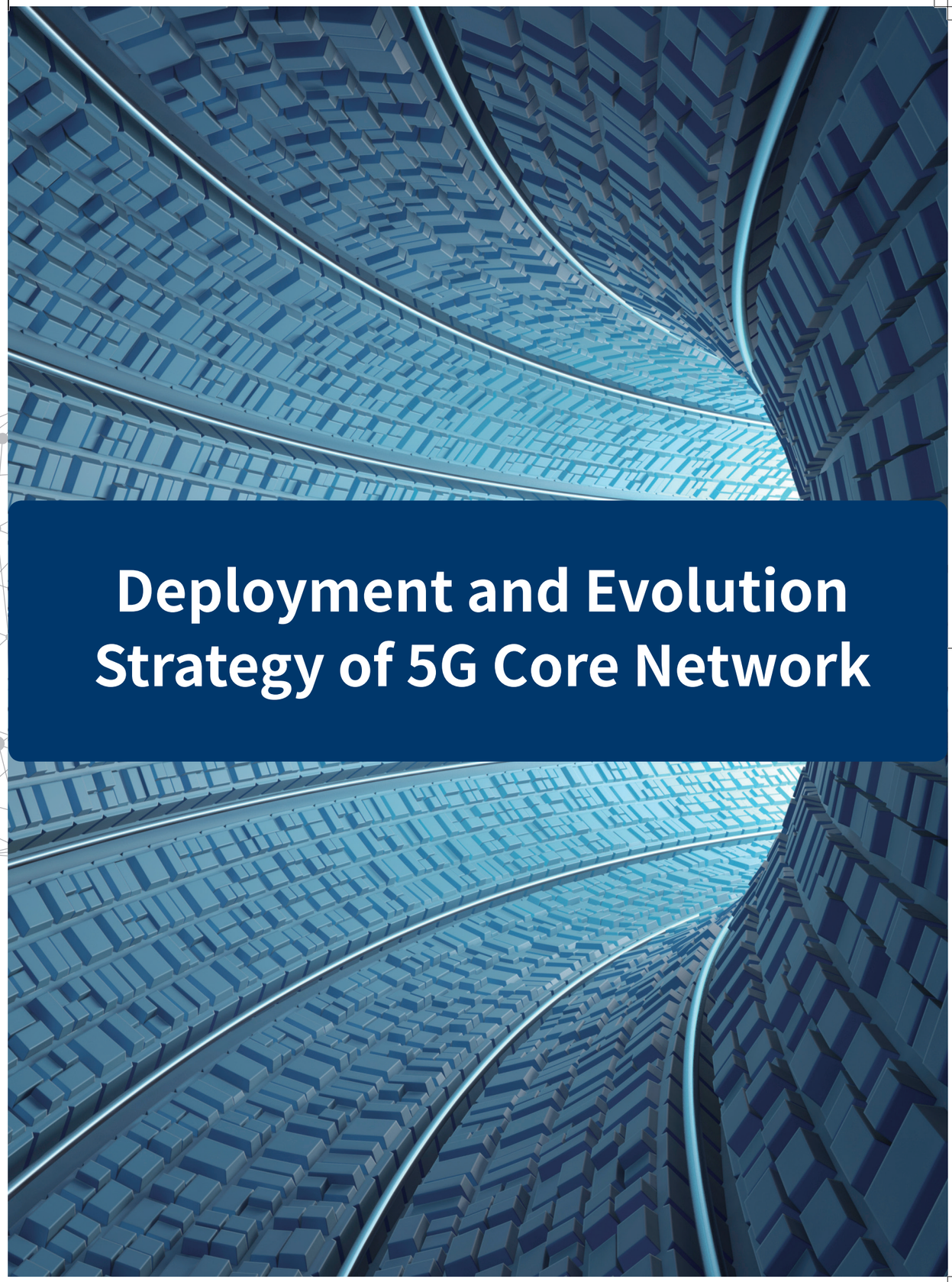
Users can access the local network directly through the MEC platform. The local service data stream is directly routed to the local network by the MEC platform without going through the core network. Local traffic offload reduces backhaul bandwidth consumption and service access latency to improve service experience.

◆ Service optimization

Through the MEC server near the wireless side, it can collect and analyze the information of the wireless network in real time, dynamically optimize the service based on the obtained network situation, and select appropriate service rate, content distribution mechanism, congestion control policy and so on.

◆ Network capability exposure

Through the MEC platform, the mobile network can provide network resources and capabilities for the third party, and expose capabilities such as network monitoring, network infrastructure, QoS control, location and big data analysis, to fully exploit the network potential and achieve win-win with partners.



Deployment and Evolution Strategy of 5G Core Network

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Core Network Deployment Mode Defined by Standard

The 5G network deployment scenario is divided as non-standalone and standalone:

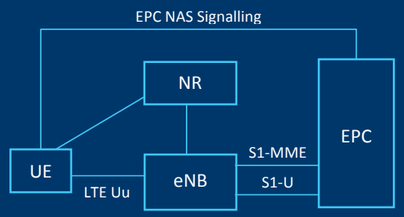
◆ Non-standalone（NSA）

Refers to the non-independent new 5G air interface (Non-Standalone 5G NR), taking the forwarding compatibility as the key design principle, leveraging the existing LTE wireless and EPC network to provide mobility management and network coverage, and add a new 5G wireless access carrier to achieve the combination of 4G network and new 5G NR air interface technology. This approach is conducive to speed up the deployment of 5G and achieve flexible network transition. 3GPP defines three kinds of NSA deployment modes, as follows:

- Scenario 3/3a: Non-Standalone, LTE assistance, NR accessing EPC

  This scenario indicates to build a new NR wireless network, and the control plane signaling of air interface access the EPC network through the LTE base station.

  Difference of scenario 3 and 3a: in scenario 3, the user plane accesses the EPC network through the LTE base station, while in scenario 3a, the user plane directly accesses the EPC network. This scenario may be the earliest 5G network scenario for commercial deployment.



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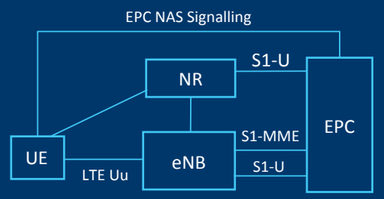
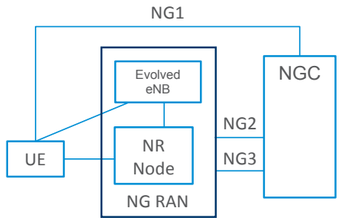


(3a)

Through the approach of signaling anchor, the 5G NR is connected to the LTE EPC network, which is a dual-connection mode, and the 5G NR is just a supplement. After the addition of 5G NR, EPC's function needs to be further enhanced. These enhancements include extended QoS parameters, the capability of MME handling the UE containing 5G parameters, and the access of 5G NR.

- Scenario 4/4a: Non-Standalone, NR assistance, NGC core network

The scenario represents to build new NR wireless and NGC network. The control plane signaling of the LTE base station air interface accesses to the NGC network through the NR base station. The main difference between scenario 4 and scenario 4a: the LTE user plane in scenario 4 accesses to the NGC network through the NR base station, and the LTE user plane in scenario 4a directly accesses to the NGC network.



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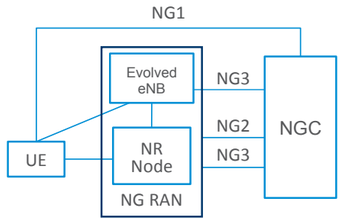
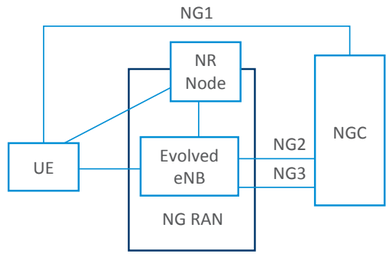


(4a)

- Scenario 7/7a: Non-Standalone, LTE assistance, NGC core network

The scenario represents to build new NR wireless and NGC network. The control plane signaling of NR base station air interface accesses to the NGC network through the LTE base station. The main difference between scenario 7 and scenario 7a: the NR user plane in scenario 7 accesses to the NGC network through the LTE base station, while the NR user plane in scenario 7a directly accesses to the LTE network.



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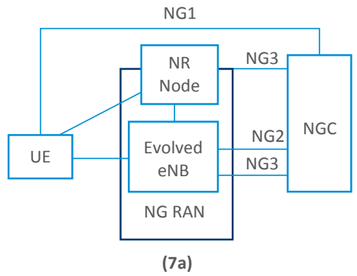

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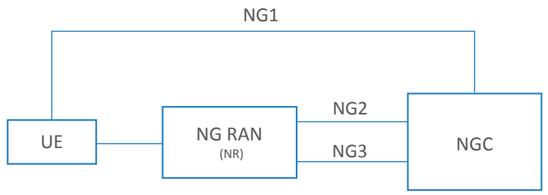
◆ Standalone（SA）

NR accesses to 5G core network. It refers that the independent new 5G air interface (Standalone 5G NR) and 5G core network NGC are deployed in a unified manner. 3GPP defines two SA approaches.

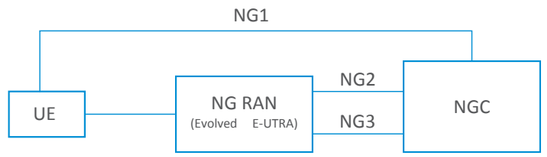
- Scenario 2: Standalone NR, NGC core network

The scenario represents to build new NGC core network and new wireless network, no traditional LTE access nor EPC network. This scenario may also be the ultimate network goal that LTE is completely replaced by NR.



- Scenario 5: Standalone

The scenario is eLTE accessing to NGC. This deployment is for the evolution-based E-UTRA NG RAN access in the independent configuration of the NextGen system.



5G Core Network Evolution Strategy

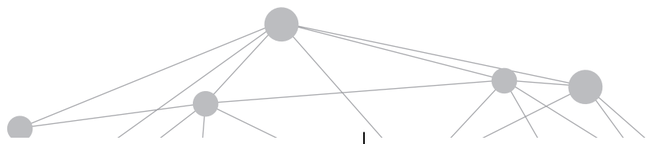
5G technology development is a gradually mature process. Therefore, the 5G core network needs to be constructed and deployed in multiple phases. It needs to fully consider the O&M and management capabilities of 5G and the existing network, to achieve the convergence and gradual evolution of 5G network and 2/3/4G network.

◆ Exploration period of 5G network construction (2018-2019)

The first version of the 5G NR standard will be completed in 2018, and with the freeze of the 5G NR standard, the commercial terminal of 5G NR will appear. Mainstream chip manufacturers of 5G NR will support the multi-connection technology between LTE/NR. This technology can be used to meet the user's various requirements of seamless network coverage and service experience enhancement.

In the stage that 5G network begins to be used, the LTE terminal and NR terminal will coexist in the network for a long time. At the beginning, a large proportion is the LTE terminal, and a small proportion is the NR terminal; 5G network begins to be deployed in the some local areas. The 4G/5G convergent deployment networking mode is the best way to meet user network experience.

At this stage, the initial deployment of the 5G network may focus on urban areas with high capacity requirements, to meet the access of friendly users or test users. As time goes on, the coverage will extend to areas with low user density.



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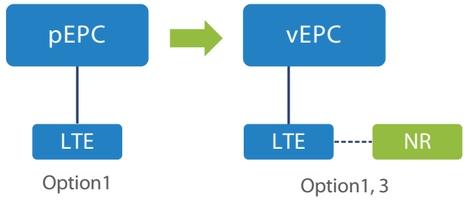
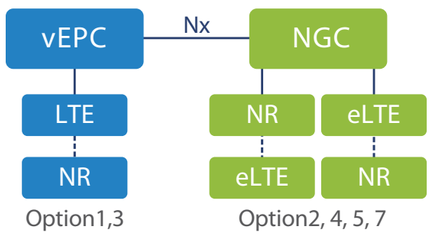
The eMBB can be selected as the main 5G application scenario, to verify the deployment and operational experience of eMBB slice, to provide a strong experience support for the follow-up upgrade and deployment of the 5G network and service model changes.



◆ Early stage of 5G network construction early (2020-2025)

In this stage, the 5G standard is almost frozen, and 5G core network is commercial ready. It can provide users with end-to-end 5G capabilities and cloud native applications, and will achieve the function reconstruction of control plane, and network slices will be fully deployed. The MEC is deployed on the edge DC to identify services and users at the mobile edge, so as to optimize the use of local network resources, improve network QoS, provide users with differentiated services, and bring a better user experience.



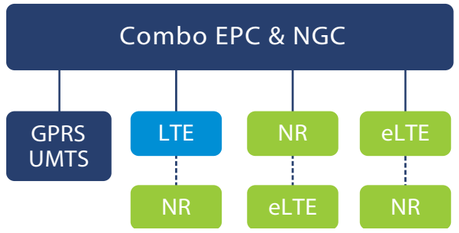


◆ The mature period of 5G network construction (2025-)

5G standard is completely frozen. Operators can reduce the investment on the 4G network, and expand the investment and construction of 5G wireless and core network.

5G core network is deployed in convergence with the vEPC to meet service demands of different industries through slicing. It supports the access of 2/3/4G/WiFi network.

The convergent deployment gradually cuts users of the original EPC network into the Combo NGC core network. The Combo supports the wireless access of 2/3/4/5G, reduces message sending between NEs, to enhance the signaling processing efficiency.



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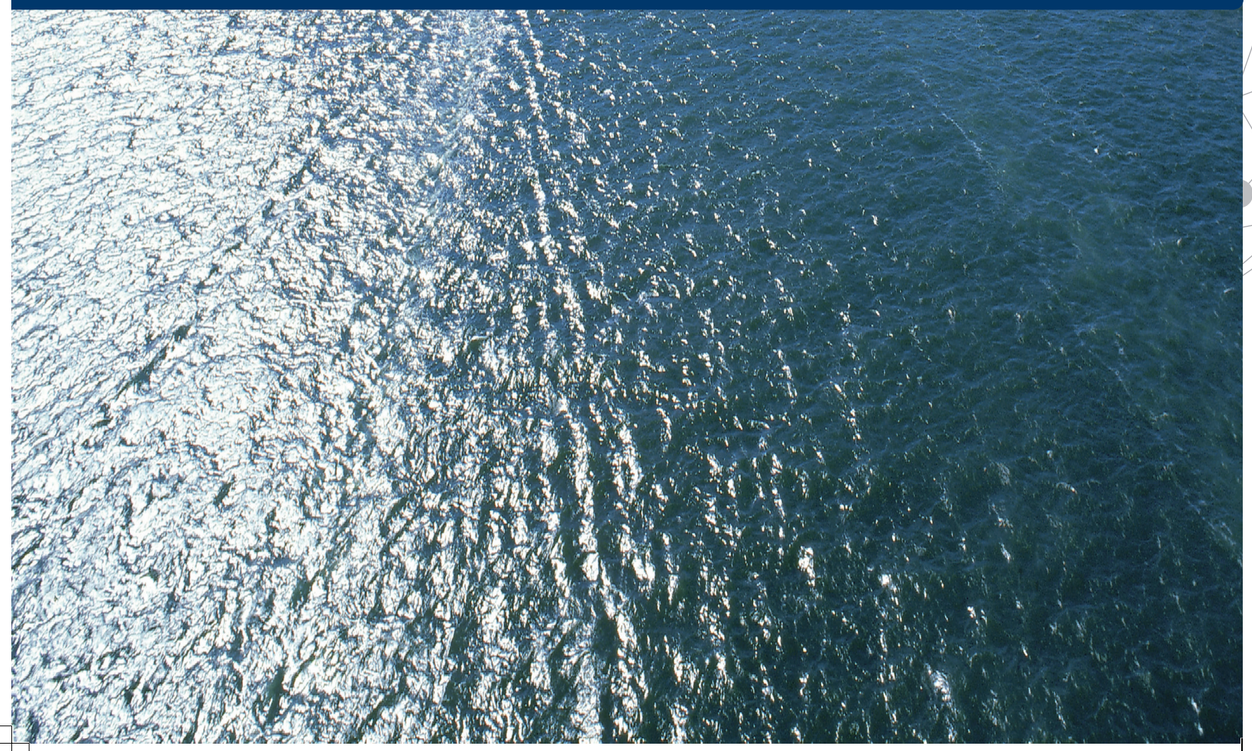
Conclusion



The development goal of 5G is to achieve continuous wide-area network coverage, high-capacity hotspot, low-power and large-connection as well as low-latency and high-reliability, to meet diversified service needs of eMBB, mMTC, uRLLC and other application scenarios.

In 2018 there may be a small amount of commercial launches of 5G eMBB scenarios, close to 3/4G network, and it will reflect features such as high-speed, C/U separation, and service-oriented software architecture. In 2019, there may be pilots of the 5G uRLLC scenario, which needs to deploy the 5G core network. It can support 4K/8K HD video, AR/VR and other services; but such services as Internet of Vehicles and D2D adjacent communications will come later due to some objective factors. 5G will be in large-scale application in 2025.

The NE deployment modes of 5G core network are very flexible. The different functions of one NE can be flexibly distributed at the central DC, regional DC or edge DC according to different service demands.

For example, in the uRLLC scenario, multiple micro-service instances that are responsible for forwarding packets can be deployed near the service network and base stations to meet the stringent latency requirement; in the mMTC scenario, according to the characteristics of small-traffic service, micro-service instances of control plane and message forwarding are deployed at the core DC.

Compared with the traditional network architecture, Cloud Native is advanced in efficiency, flexibility and openness, keeps in line with the requirement of 5G software architecture, and is the best choice for operators adding and replacing core network equipment.

ZTE is a major participant and contributor to 5G global technology and standards research activities. ZTE has actively participated in the discussion and formulation of the 5G standards. It has joined more than 40 standardization organizations, alliances and forums, and is a member of ITU, 3GPP, IEEE, NGMN, China IMT2020 (5G) Promotion Group and other international standards organizations / industry alliances.

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