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IMT-2020
IMT-2020 (5G) Promotion Group

5G Network Technology Architecture

Contents

IMT-2020 (5G) Promotion Group was jointly established in February 2013 by three ministries of China (including MIIT, NDRC, and MOST) based on the original IMT-Advanced Promotion Group. The members include the main operators, vendors, universities, and research institutes in China. The Promotion Group is the major platform to promote 5G technology research in China and to facilitate international communication and cooperation.

Introduction

Mobile communication technology and industry is moving into the stage of the fifth generation of mobile technology (5G) towards 2020 and beyond. 5G is expected to fulfill requirements of ultra-high traffic volume density, connection density, and mobility. Ultimate service experiences, including ultra-high definition video, augmented reality, virtual reality, cloud desktop, and online gaming, could be perfectly guaranteed. Moreover, 5G will infiltrate into the Internet of Things (IoT) and a variety of other industries, where it can be integrated with industrial facilities, medical equipment, vehicles, etc., achieving a real "Internet of Everything" to satisfy service requirements of manufacturing, medicine, transportation, and other vertical industries. 5G will also significantly improve the energy consumption and cost efficiency of network construction and operation, to promote service innovation capability and expand the space of mobile communication industry.

The revolution of previous mobile communication is marked by the innovation of multiple access technology. Compared with previous generations, 5G will be extended from wireless side to complete network scope. 5G concept proposed by IMT-2020 (5G) Promotion Group is defined as "One iconic KPI + A group of key technologies". The group of key technologies includes new network architecture. Driven by 5G service requirements and new technologies, such as SDN and NFV, 5G network will be innovated to support diverse radio access technology scenarios, meet end-to-end user experienced requirements and provide capability of flexible network deployment and efficient operations. Eventually, the network technology revolution will promote the development of 5G, together with wireless technology.

Currently, 5G vision and requirements have been explicit. There is a urgent need to start-up the research on 5G new network architecture, infrastructure platform and network key technologies, define the network design principles and technology roadmap and form the consensus on the 5G network technology framework, in order to guide 5G international standardization and promote industrial development.

Network Challenges and Development Trends

1. Network Challenges

As shown in Figure 1, challenges for the development of 5G network include key performance indicators (KPI), network operating capacity and network evolution considerations.

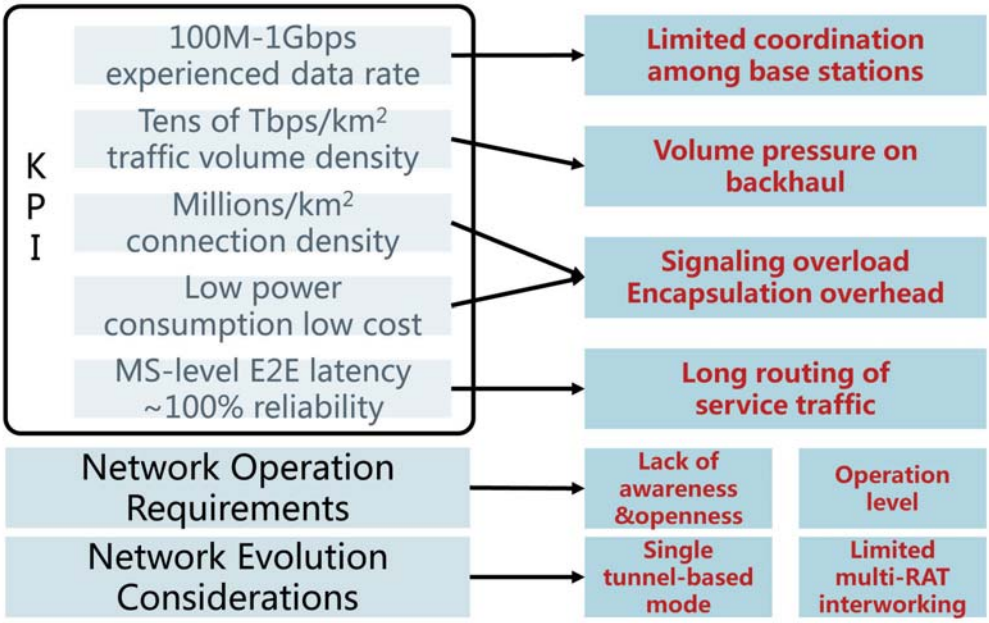

Figure 1 Key Performance Indicators

1) Key Performance Indicators

Four typical technical scenarios of 5G are derived from the main application scenarios and service requirements of mobile Internet and IoT. They are seamless wide-area coverage scenario, high-capacity hot-spot scenario, low-power massive-connections scenario, and low-latency high-reliability scenario. Existing network architecture and function cannot support all the KPI in 5G scenarios well.

- 100Mbps to 1Gbps experienced data rate

  In existing network architecture, interaction function among Base Stations (BS) is limited to support efficient radio resource scheduling, high performance mobility management and interference coordination. Access rate varies greatly from cell center to cell edge. The user experienced data rate of 100Mbps in wide-area coverage scenario is hard to be met, even more

difficult in hot-spot where requires 1Gbps.

- Tens of Tbps/km^2 traffic volume density in hot-spot

  In current core network, centralized deployment packet data gateway and single data forwarding mode force user service dataflow converging to network center. Capability pressure is likely to happen to mobile backhaul network, especially in high-capacity hot-spot scenario.

- Millions/ km^2 connection density

  The single network architecture and assimilative control function cannot adapt to IoT terminals with high grade of dissimilar access requirements. If the same mobility and connection management mechanism was adopted to low-power massive-connections scenario and mobile Internet scenario, a serious risk of signaling storm would be caused. Tunnel-based connection management mechanism may lead to great encapsulation overhead, when carrying small data for IoT services.

- Low-latency and high-reliability

  End-to-end communication in existing network tends to experience a long transmission path in both the user plane and control plane. Transmission delay is difficult to reduce. Local service may suffer from serious circuitous routing, and low-latency high-reliability communication service cannot be supported well.

2) Network Operation Requirements

In addition to the requirements of service performance indicators, 5G network also needs to face challenges related to network operation.

- Lack of network awareness and openness

  Owing to lack of user and service awareness ability, radio access network becomes “blind pipe” and is difficult to carry out accurate management. Despite of the introduction of deep packet inspection (DPI), core network data analysis and mining ability is still limited. It is unable to realize network resources optimal deployment and automated operation.

  In current network, limited network openness cannot satisfy the requirements of fine-grained and all-around network service exposure. Because of the lacks of well-defined APIs, the third party cannot acquire the rich real-time information of network. Network resource, such as bandwidth and quality of service (QoS), cannot be matched friendly with the third party service requirements to improve service experience and network operating efficiency.

- Improving Network operating capability

  In 5G period, with the increase of service traffic and terminal density, operators need to further reduce Capex/Opex and improve network operating capability continually. At the same time, new space of network operation from IoT and vertical industry is of critical importance for operators, to dig their new profitable sources.

3) Network Evolution Considerations

- Limited network cooperation capacity

  The existing solution on multi-access interworking is using different schemes to

realize connection management, QoS control and certification process for different RATs. The comprehensive consideration of multi-access with different characteristics finally results in an extremely complex framework of network interconnection and roaming, complicated handover and interoperability process of terminals and limited network cooperation abilities.

- Single tunnel-based forwarding mechanism

  Due to the gap between rich service types and single functional tunnel mechanism, the requirements of flexible traffic scheduling and efficient data forwarding cannot be achieved currently. At the same time, the bounding of user IP address and packet data gateway is the impediment not only to the subsidence of service surface, but also to the improvement of service access rate and the decrease of latency.

2. Network Development Trends

As shown in Figure 2, 5G network will provide superior performance, more flexible function, smarter operation and friendlier ecosystem.

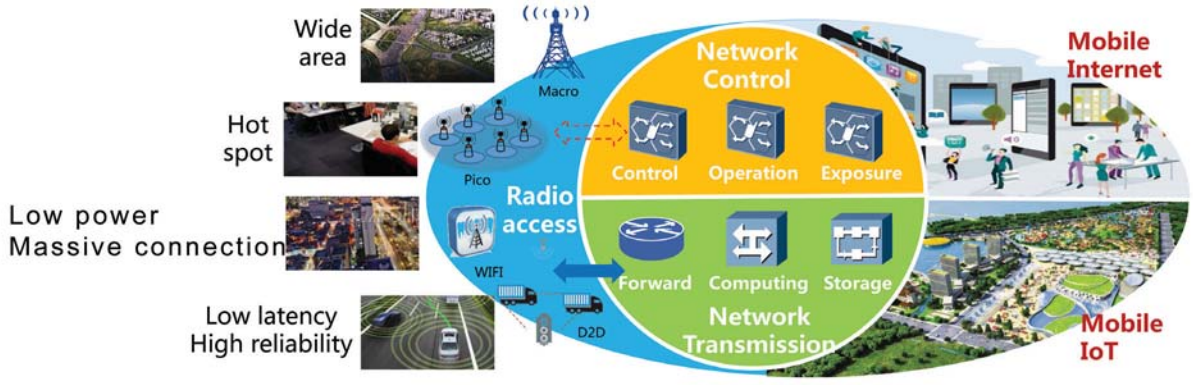

Figure 2 5G Network Development Trends

- Superior network performance

  5G network is aimed to provide extreme broadband, ultra-low latency, and ultra-high reliability. At the same time, 5G will improve energy efficiency and decrease bit cost more than 100 times and improve spectrum efficiency several times.

- More flexible network function

  Focusing on user experience, 5G network will support diverse mobile Internet and IoT service requirements. In access network, 5G will support the Plug and Play (PnP) of BS and self-organizing network, and be able to realize easier deployment and maintenance of lightweight access network topology. In core network, the network function is further simplified and reconstructed based on Evolved Packet Core (EPC) to offer efficient and flexible network control and forwarding function.

- Smarter network operation

  5G network will improve intellisense and decision-making ability. Optimum decision scheme can be derived from the real time awareness and integrated analysis of the network "big data" such as geographical location, user preferences, terminal status, network context, and so on, achieving the function of data driven fine network deployment, resource dynamic scaling and automated operations.

- More friendly network ecosystem

  5G network will be friendlier and open to new industry ecosystem and vertical industries. By enhanced network exposure mechanism, flexible service deployment environment can be provided to the third party, realizing the friendly interaction with the third party applications. 5G network provides on-demand customization service and stimulates service and network innovation environment, promoting the value of network services.

5G Network Architecture Design

1. Design Principle

To win the challenges brought from 5G requirements and scenarios and achieve the overall vision characterized by superior-quality, flexibility, smart and friendliness, 5G network needs to take technology innovation and coordinated development in the domain of new infrastructure and architecture to accomplish the total network revolution.

The present telecommunication infrastructure is constructed by dedicated hardware platform. By introducing in information technology and virtualization technology, 5G network will implement a brand new infrastructure platform with industrial standard hardware to overcome the shortage of legacy infrastructure platform such as high cost, inflexible resource configuration and long time to market.

At the aspect of architecture, the concept like control and forwarding separation and control function re-construction are considered as the basic direction of architecture innovation. The new 5G network architecture is constituted by high-performance access network, simplified but efficient core network control and forwarding function, to meet the complex 5G scenario requirements, support smart operation, expose network capacities to the third party, and promote end-to-end network services level.

2. Innovation of Infrastructure Platform

NFV/SDN technology is the foundation of 5G infrastructure platform innovation. NFV offers 5G very flexible deployment choices by the means of software and hardware decoupling. Firstly, the control plane can be reconstructed by softwarized network function component. Secondly, reconstructed control function can be deployed in every place of the common hardware-based platform. Finally, the best usage of network resource is achieved by on-demand allocation and auto-scaling. SDN technology implements the separation of the control function and forwarding function, then the extracted control functions can be integrated into a centralized control plane to implement the awareness and scheduling of network resource, and the programmability of network connection.

3. 5G Network Logical Architecture

In order to meet the demand of services and operations, the access network and core network functions need to be further enhanced. The logical function interface of access network and core network is distinct, but deployment mode is more flexible, or even integrated.

5G access network is a user-centric multi-layer heterogeneous network, satisfying various scenarios. Combination of macro BS and micro BS and unified multi-access technologies can improve cooperative processing efficiency of cell edge and utilization of wireless and backhaul resource. 5G access network

transfers from an isolated access "blind" pipeline to a complicated network topology with support for multi-access and multi-connection, distribution and centralization, self-backhaul and self-organization, wireless resource management and sharability, PnP of BS.

5G core network needs to support low latency, large capacity and high rate of all kinds of services and offer a more efficient way to realize differential service requirements on-demand orchestration. Forwarding plane need further simplification and subsidence. Storage and computing capacity migrates from network center to network edge, to support service requirements of high traffic volume, low latency with a flexible and balancing traffic scheduling mechanism.

The introduction and development of NFV and SDN in mobile network will promote the innovation of 5G network architecture. Recombine network with control and forwarding separation technology, making network logical function more aggregated and network logical plane clearer. Network function can be orchestrated on demand. Operators can combine function module based on requirements of different scenarios and services. Network resource and service logic can be customized on demand, to increase network flexibility and self-adaptability.

The logical architecture of 5G network is shown as Figure 3.

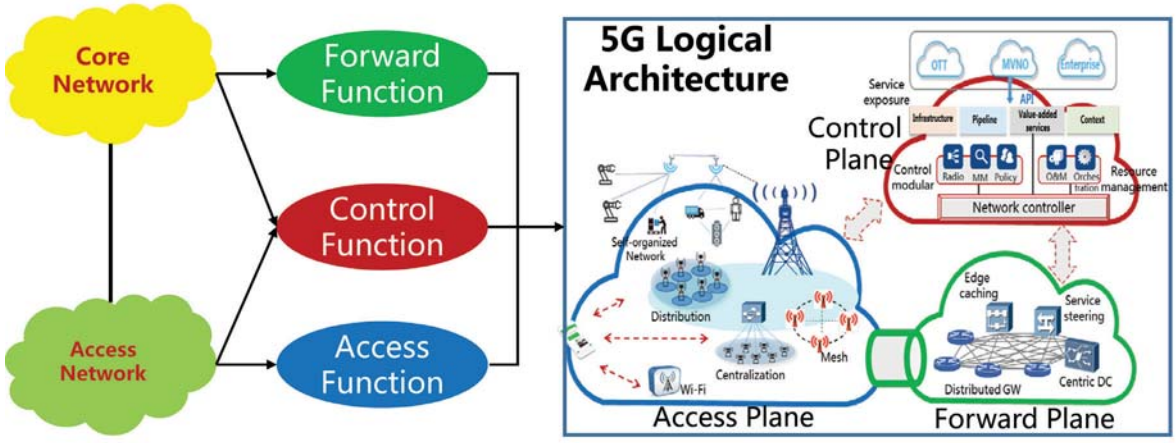

Figure 3 5G Network Logical Architecture

5G new network architecture includes access, control and forwarding plane. Control plane is primarily responsible for generating global control strategy. Access and forwarding planes are responsible for the implementation of strategy.

- Access plane: Access plane is composed of various types of BS and wireless access devices. Enhanced interactive ability among BS and rich networking topology can realize flexible wireless access cooperative control and higher wireless

resource utilization.

- Control plane: Centralized control function, simplified control process and global access and forwarding resource scheduling are realized by network function reconstruction. Customized network resource and friendly capacity open platform are provided to differential service requirements through network function orchestrated on-demand.
- Forwarding plane: Distributed gateway containing sunk user plane integrates with edge content caching, service steering, etc.. Data forwarding efficiency and flexibility can be achieved by means of the schedule policies generated by the unified control plane.

4. Network and Service Deployment Diagram

As Figure 4 depicts, 5G network deployment is composed of edge access network, metropolitan area network and backbone.

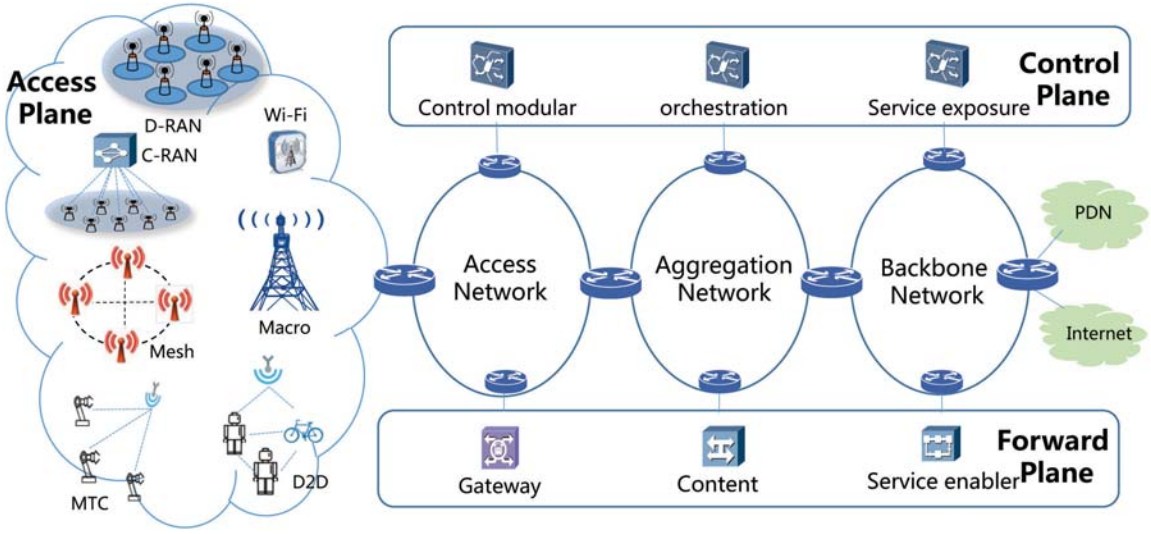

Figure 4 5G Network Deployment

Network control function includes the core network control functions and access network control functions. Core network control functions are deployed centrally within metropolitan area network and backbone. For low latency service scenario, the core network control functions need to be deployed in the access network edge or integrated with BS. Data gateway and service enabled devices can be deployed flexibly according to service requirements in the whole network, to reduce the pressure of the backhaul network, reduce delay and improve the user experienced data rate. It is beneficial to open network service and management function to the third party to deploy network capability openness function on

control plane.

The 5G network will exhibit as “One Logical Architectures, Multiple Service Architecture". Oriented from one single base architecture, the network can generate variant network instance on-demand by network slicing technology, as Figure 5 shows. Each sliced network will be logically separated. The congestion, overload, and configuration on slicing will not impact on other sliced network. For different slices but same location, the network function can share the same hardware and software infrastructure. There are four classes of network scaling designed for the four scenarios as shown in Figure 5:

- Seamless wide-area coverage:Support for mobility in a large area, the roaming among operators. The data traffic is relatively small, that makes it possible to use a centralized gateway. The high mobility anchor enables wide area mobility;
- High-capacity hot-spot:Signaling process is centralized, and user plane gateway is deployed near the access network. Service anchor and content are localized. The local routing can be achieved, and the backhaul capacity can be much saved;
- Low-power massive-connections:Simplified connection, mobility, and roaming management, etc.. Signaling reduction and simplification for low-power consumption and high number of connections;
- Low-latency high-reliability:The terminal can achieve low latency through device-to-device (D2D) and local control. Via end-to-end QoS, and high availability of infrastructure and application, high-reliability can be achieved.

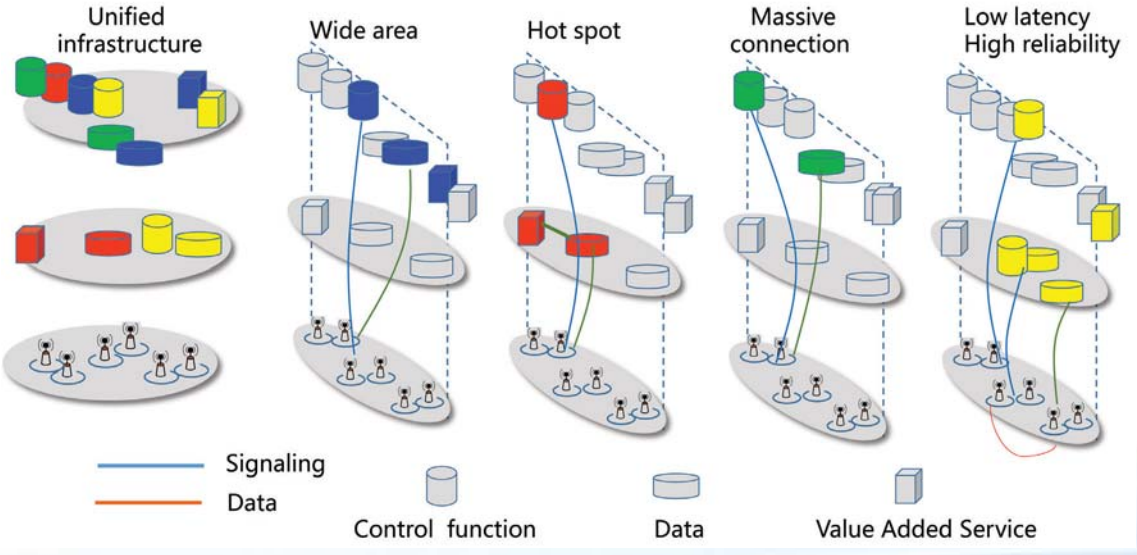

Figure 5 Service Diagram for 5G Network

5G Network Characteristics

5G network logical architecture consists of access plane, control plane and forwarding plane. The network characteristics of three planes is as shown in Figure 6.

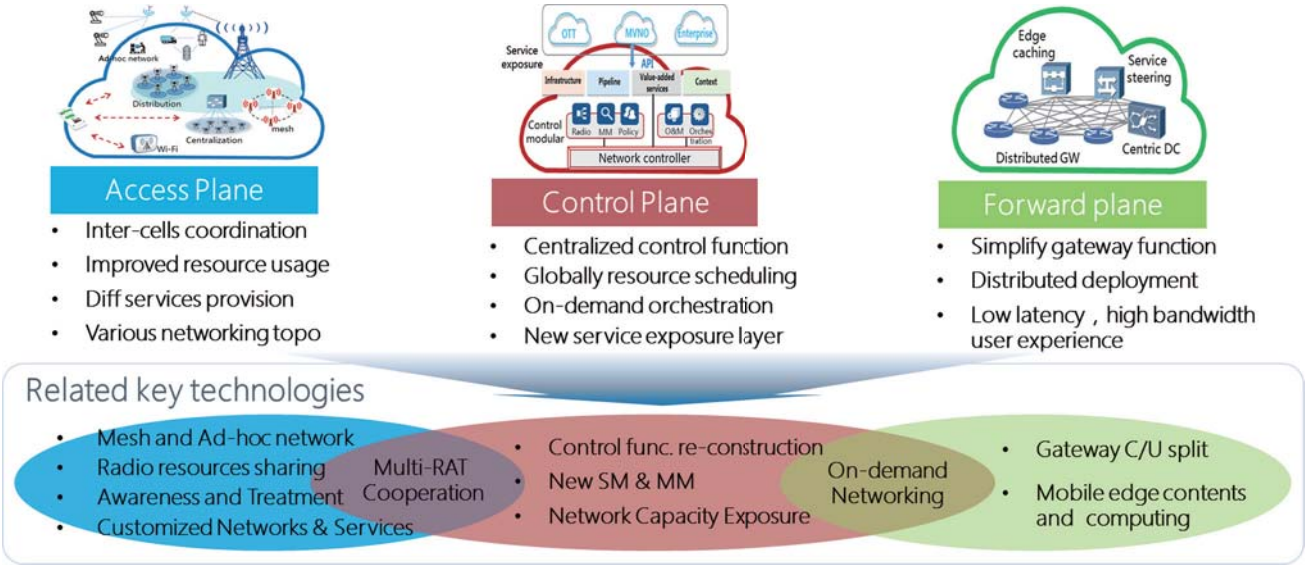

Figure 6 5G Network Characteristics

1. Access Plane Characteristics

In order to accommodate various service requirements and use cases, the access plane needs to enhance the coordination among different base stations, and improve the capability of flexible wireless resource scheduling and sharing. Through the comprehensive utilization of distributed and centralized networking mode, inter-cell radio interference can be reduced effectively, and mobility management becomes much easier. With perception to users and services, the access plane defines network topology and protocol stack on-demand, to provide guaranteed services performance. The access plane has ability to support new networking technologies such as wireless mesh, dynamic self-organizing network and unified multi RAT convergence.

2. Control Plane Characteristics

The function of control plane includes control logic, on-demand orchestration and exposure of network capabilities.

In the aspect of control logic, based on separation and reconstruction of network control function, it will create access control, mobility management, connection management and other functional

elements independently. Different functional elements can be assembled flexibly, to meet various scenarios and service requirements.

With the help of virtualized platform, control plane can do agile network resource orchestration. By the network slicing technology, control plane has ability to construct special and isolated logical network for different services that will promote the flexibility and elasticity of whole network.

Control plane will have an exposure layer of network capabilities. Through the Open APIs and ignoring technology detail of lower layers, network capabilities are abstracted and open to the third party friendly, including infrastructure, pipeline capacity and value-added services, etc.

3. Forward Plane Characteristics

On the forwarding plane, gateway's control function will be separated completely, and gateway's deployment will be distributed and localized. Data forwarding is scheduled by the control plane. Based on flexible gateway anchor and MECC technology, E2E various requirements of extreme broadband, ultra-low latency, and ultra-high reliability and load balance can be achieved. The efficiency of packet data transmission and user experience also can be promoted.

5G Network Key Technologies

1. Decoupling of GW's Control and Forwarding Plane

Traditional S/P-Gateway includes forwarding function and control function (signaling processing and service processing) which are tightly coupled. In the 5G network, the control plane and forwarding plane of mobile core network should be separated according to SDN architecture, so as to realize the centralization of the control function and distribution of the forwarding function. As shown in Figure 7.

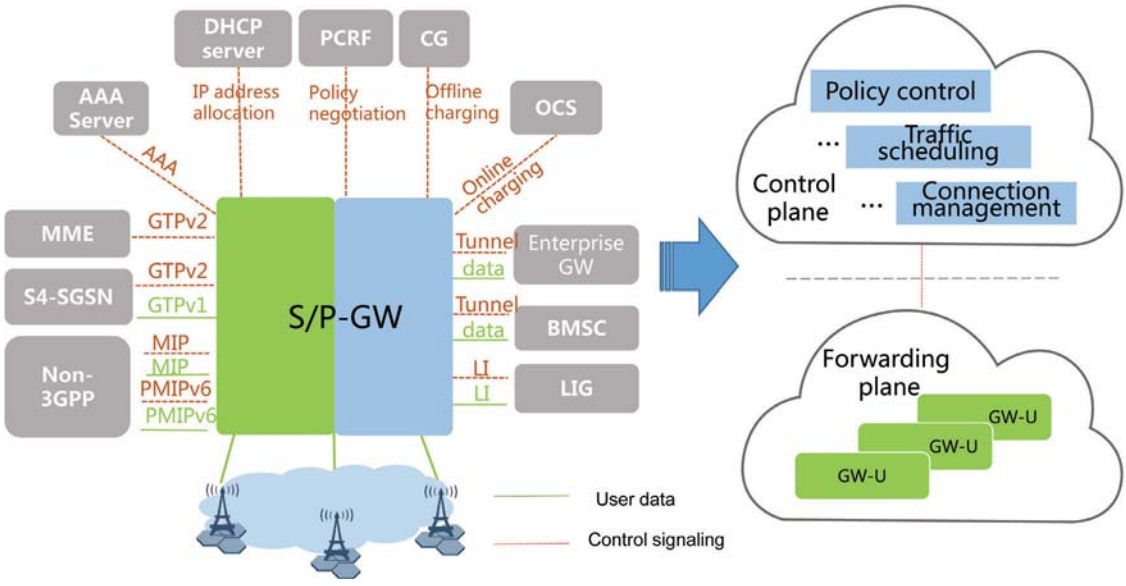

Figure 7 Decoupling of Control Plane and Forwarding Plane

After the separation, the forwarding plane will concentrate on the forwarding function, and will have the features of simplification, high sustainability and high performance, so as to meet the forwarding request of massive mobile traffic in the future. The centralized control plane will realize unified policy control, guarantee flexible mobile traffic scheduling and connection management. The centralized control plane connects to the programmable forwarding plane via a mobile flow control interface. Separation will make the network architecture more flat, the distributed GW deployment can effectively reduce transmission delay. Finally, it could realize the function evolution and performance promotion of the control plane and forwarding plane separately, so as to promote the flexibility and efficiency of overall network system.

2. Control Functions Reconstruction

Control functions reconstruction is to divide the control plane functions into independent modules with different control logics, in which case these modules can be composed to form specific network control planes for different scenarios to address the existing problems of the current core network, where the control functions are redundant, the number of the network interfaces is large, and the work on standardization is time-consuming. Differentiated network features can be delivered by combing different modules to meet the demand for the network diversity in the 5G era.

Control functions reconstruction has the following technical features:

- Modularized Control Functions: The functions of the control plane elements are decomposed into modules, and the reusability of modules should be considered in the process of separation that according to processing logic. The application scenarios need to be analyzed to identify the mandatory and optional modules.
- Optimized Processing Logic of Control Plane: When composing function module of control plane to optimize the signaling interaction among modules, how to reduce the load on the control plane, how to improve the efficiency of signaling processing, and how to decrease the delay of the signaling plane should be taken into account. As different applications have varied requirements on the control plane, the formed virtual core network control planes and their interfaces may vary.
- State Separated Core: In the 5G network, the state information (e.g., user's mobility management and session management context) and the processing logic of the control plane can be decoupled. The state information can be stored in a centralized database or a distributed storage system. It improves the robustness of the system, while achieving dynamic adjustment of capacity and system load balancing.

3. New Connection and Mobility Management

The 5G network contains more complicated application scenarios, in which case the new connection mechanism should be deployed to guarantee the QoS of user and application and provide customized and differential service in various communication scenarios.

The connection management in 5G network will be simplified, efficient and flexible. It should be able to determine the parameters of connections based on terminal attributes (e.g. terminal capability, location and mobility history), request type, service feature, network conditions and operator's policy etc., then the control plane function generates the commands for connection management, and the forwarding plane runs the commands to complete the connection management procedure.

There are two mobility management protocols (GTP and PMIP) in 4G networks, which complicate the architecture designing and interoperability standardizing. So unified mobility management protocol will be an

important target of 5G network designing. So unified mobility management protocol will be an important target of 5G network designing. 5G network will be a convergence of multiple access technologies. Therefore, in order to achieve seamless handover between heterogeneous networks, the mobility management should be independent of all kinds of access technologies. The diversity of 5G network business asks for the differentiated requirements of mobility management. 5G network should provide the mobility management on-demand, i.e. "mobility as a service". Which means mobility can be available to users as a network service, and the mobility management scheme can be chosen intelligently, according to the requirements of different business. According to different scenarios and business needs, the protocols and schemes of location management, handover control, and attachment state should be optimized and improved on demand. In scenario of ultra-dense network (UDN), to ensure the success ratio of handover and reduce the signaling overhead, the assisted mobility technology and the improved handover control protocols can be adopted; in the Internet of Things scenario, to reduce the signaling interaction, the protocol related to location management can be simplified.

4. Mobile Edge Contents and Computing

Mobile Edge Contents and Computing (MECC) is a capacity that provides IT service and cloud computing to the mobile users at the closest, and pushes contents delivery capabilities to the places near user, e.g., edge of base station to deploy the application, service and contents in a highly distributed environment, so that it can better meet the low latency and high bandwidth requirements in 5G. As shown in Figure 8.

Figure 8 MECC

As an emerging technology, MECC faces lots of challenges, as follows:

- Collaboration problem, it needs the operators, vendors, content providers and application developers to cooperate and be open, so as to integrate MECC with 5G to create and offer value;
- Security problem, designing a mechanism to guarantee the services on MECC to be reliable and secure;
- Mobility problem, how to provide seamless user experience when the users move among multi base stations;
- Charging problem, how to charge for the services on MECC.

5. On-demand Networking

Various scenarios have various performance requirements and functional requirements on the 5G network. The 5G network shall be able to adapt to the scenario, i.e. provide the control functions and performance guarantee which are optimum for the scenario, no more and no less. On-demand networking is one goal of the 5G network. And network slicing is one way to realize on-demand networking.

The 5G network physical infrastructure is virtualized into several parallel network slices according to the scenarios. Each network slice can tailor its network functions and orchestrate its network resources based on the scenario requirements and the traffic pattern. A network slice can be seen as an instance of the 5G network. The operator can further divide the virtualized network resources and create sub networks inside a network slice.

The network orchestration function creates, manages and deletes the network slices. The operator designs the network slice template, including required network functions, interfaces between network functions and the required network resources for each network function. The network orchestration function applies the network resources according to the network slice template, and instantiates the virtualized network functions and their interfaces on the allocated network resources, as shown in Figure 9.

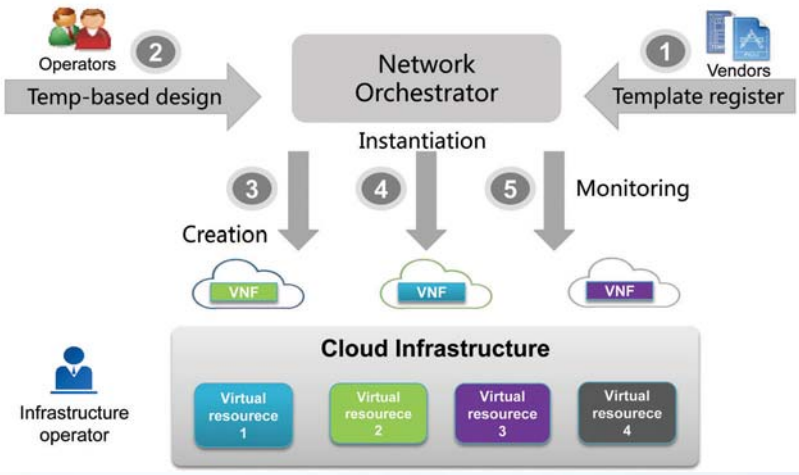

Figure 9 On-demand Networking

The network orchestration function also monitors and manages the network slices. It can dynamically adjust the network resource allocation according to the real time traffic volume and delete the network slice at the end of its lifetime. Network optimization based on big data can be used to create the network slices and allocate the network resources in a more appropriate way, realizing automatic operation and maintenance, reacting to service and network changes in time, improving user experience and network efficiency.

On-demand networking has the following advantages:

- Tailor the required network functions and networking in a flexible way, realizing optimum service procedure and data routing;
- Dynamically allocate and adjust the network resources based on traffic pattern, improving network efficiency;
- Isolate the network resources for different scenarios, providing resource guarantee, improving the robustness and reliability.

It is noticeable that on-demand networking based on network slicing will change the traditional mode of network planning, network deployment and network operation and maintenance. This puts new technology requirements on the above mentioned aspects.

6. Multi-RAT Cooperation

A variety of radio access technologies in the 5G network will co-exist for a long time. How to use various wireless technologies, improve network overall operating efficiency and user experience is the problem that the coordination of multiple RAT technology needs to solve. A number of RATs are fused by focusing on wireless network control entity, or need the interfaces between RATs to realize distributed collaboration. There are foul aspects need be considered as below:

- Intelligent access control and management: according to current network state, wireless environment, UE capability, and combining the technology of smart service sensing to map each service to the most appropriate access technology, to improve the user experience and network efficiency.
- Multi-RAT wireless resource management: according to service types, network loads, interference levels etc., to achieve joint management and optimization of the multiple networks radio resources, which realizes the interference coordination among multiple RATs, and it achieves resource complete sharing and allocation.
- Protocol and signal optimization: enhance the interfaces between access network nodes, construct a more flexible network interface relationships, and support the dynamic network function distribution.
- Multiple modes and multiple connections technology: UE may access to multiple nodes of different RAT at the same time, which allows transmit parallel flows.

7. Wireless MESH and Dynamic Ad-hoc Network

The wireless MESH is a crucial networking technology that be used for seamless wide-area coverage and ultra-dense network (UDN) scenarios of the 5G network.

As show in Figure-10, the wireless mesh networks enable to construct high-speed, high efficient wireless transmission networks between base stations, enhance the capability and efficiency of the coordination, reduce the latency of the data transmission and the signaling exchange, provide backhauls dynamically and flexibly and enable plug-and-play base stations in different scenarios and facilitate an easy network with easy deployment, easy maintenance and delightful user experience.

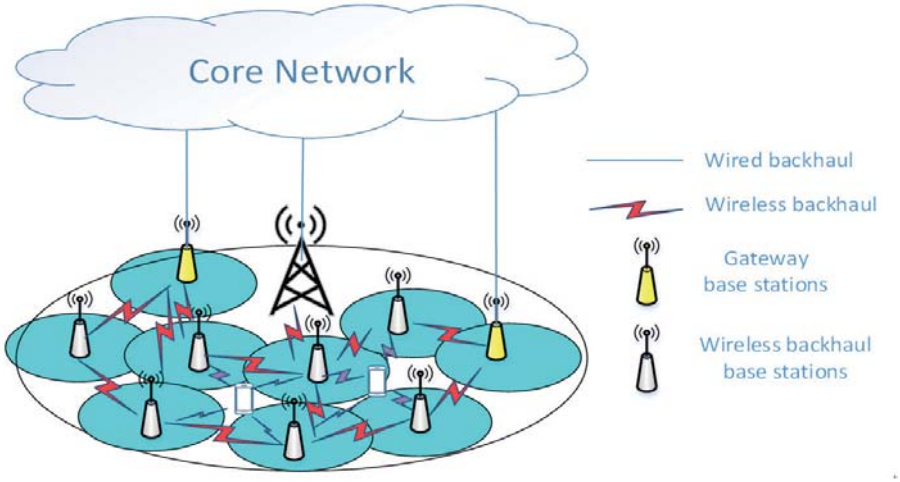

Figure 10 Wireless MESH Network

5G wireless MESH contains following aspects:

- The overall design and optimization of wireless backhaul links and wireless access links. For example, Radio access that based on capacity and efficiency, optimization for backhaul resource;
- Planning and management of backhaul gateway;
- Management and optimization of the wireless backhaul topology;
- Resource management of the wireless mesh network;
- Protocol and interface study of the wireless mesh network that includes control plane and user plane.

Dynamic Ad-hoc network is authorized and controlled by cellular network, and to make up for the weakness of networking flexibility in traditional cellular network architecture, it can include base stations, terminals and other new type end nodes locally distributed to dynamically form a network. In addition, the formation of dynamic Ad-hoc network can enable device-to-device communication, which improves system spectrum efficiency.

The application scenario of dynamic Ad-hoc network includes:

- For Low Latency High Reliable communication scenario, to reduce end-to-end latency and enhance transmission reliability;
- For low power consumption massive-connections scenario, to extend network coverage and availability; moreover to adapt to other emergency scenario (e.g. disasters), and enhance network robustness.

8. Wireless resource management and sharing

Wireless resource management and sharing technology is used to meet all kinds of scenarios and services request of the 5G network depends on centralized control and management, wireless network resource virtualization and spectrum sharing.

- Centralized control and management

  Following C/U separation concept, centralized control and management functionality could be built and deployed on BS cluster for dynamic multi-cell resource allocation and intelligent resource management. Here wireless resource indicates all-dimension key resource of wireless network including spectrum, time, code, space, power, backhaul and so on. With comprehensive consideration of some important factors, including service feature, terminal attribute, network load and user preference, centralized control and management functionality is very helpful to dynamic load balance and auto-adaptive traffic distribution, which will finally solve interference problem, improve system resource utilization and promote system capacity. Considering physical network topology and specific requirement towards resource management, centralized control and management functionality might be deployed flexibly in some of access nodes. For the distributed access network deployment scenario, the RAN nodes have complete user plane process ability to support flexible and refined user plane resource coordination depending upon the transport network capabilities. Cooperative multi point transmission can be further implemented to improve the spectrum efficiency.

- Wireless network resource virtualization

  By sharing and flexible slicing wireless resource (such as time domain, frequency domain, radio domain, coding domain, power domain and so on), wireless access platform and transmission resource, this technology could be used to build up several wireless network slices, which keep rigorous separation and totally different configurations, on the basis of one physical wireless network to meet diversified requirement from operators, OTT players and end users. Therefore, wireless network resource virtualization is greatly helpful to fast deployment, low cost and efficient resource utilization. It should guarantee strict resource isolation between different virtual networks by different wireless software algorithms.

- Spectrum sharing

  Spectrum share is dynamic and optimized allocation of multi-RAT spectrum resource with consideration of some key factors, including deployment scenario, network load, user experience etc. It is beneficial to spectrum efficiency improvement and interference control. There are some implementation choices for spectrum share, such as independent control node, database based control etc. The specific functionalities of spectrum share include multi-priority spectrum allocation, interference coordination and so on.

9. Awareness and Treatment of Services and Users

In view of diverse service requirements and user needs, awareness and treatment of services and users

can help 5G networks to allocate radio access network (RAN) resources on demand, improve user experience, and consequently optimize services.

This function module could deploy in 5G base stations to get the features of all kinds of applications in traffic and signaling aspects by collect and analyze the communication data on access network equipment, collect user location, movement speed and battery status, finally provide precision radio resource strategy to control plane on the basis of application feature, channel changing and load spending to meet the optimal matching among application, user and resource.

The working process of this technology is as follows: Mobile terminals collect service data, as well as user information, including user's location, velocity, and battery status, etc. Based on the collected information, base station can establish the traffic models and feature libraries for requirements of signaling overhead and resource. Besides, base station can find the correlation between service and user experience. With these information, user-centric and service-oriented resources allocation strategies, e.g., personalized allocation of bandwidth, optimized selection of cell, predictive caching of user preferred contents, and adaptive adjustment of power, can be formed to manage and control the RAN resources. Consequently, 5G RAN becomes smarter to optimally match up services and users with network resources.

10. Customized Networks and Services

Via user/service awareness and identification, the 5G network could provide differentiated services efficiently on radio access network according to different network topologies and protocols to meet the performance request for various applications. There are two aspects as following:

- Software Defined Protocol (SDP): SDP re-designs flexible protocol stacks based on software-hardware decoupling and control-data plane decoupling. SDP need an excellent control plane to meet the latency requirement of radio protocol processing and the radio performance.
- Software Defined Topology (SDT): SDT can achieve network self-configuration, self-optimization and self-organization. In the 5G network, ultra dense heterogeneous network deployment will be a typical deployment scenario. Virtualized data plane will deploy the Virtualized Network Function (VNF) depends on service characteristic and traffic distribution. Therefore, there is no fixed network topology for Macro/Pico Cell, thus rapid reconstruction capability of network topology should be take into account.

11. Network Services Exposure

Network service exposure technology is to provide the network capabilities that are in need by the third party ISP/ICP. Network capabilities include user location information, network element load and running status and operator networking resources. Via network service exposure architecture shown in Figure 11, operator could adapt these information with specific demand and offer the to the third party users.

- Application layer: The third party platform and server located at the highest layer is the consumer of the network services which

invoke the API provided by capability layer to retrieve network information, schedule pipeline resources, apply for value-added services and build dedicated network slices.

- Capability layer: This layer is located between application layer (north) and resources layer (south). The main function of this layer is to integrate and analyses the information from resources layer, implement atomic network capability encapsulation and on-demand orchestration, and create related API.
- Resources layer: The task of resources layer is to abstract the underlayer network resources and interact with 5G network to map the capability invocation logic into the control signaling for on-demand orchestration of network resource. For example, resources layer will integrate the monitoring requirement from upper layer and set the monitoring devices policies such as location, data type and triggering threshold.

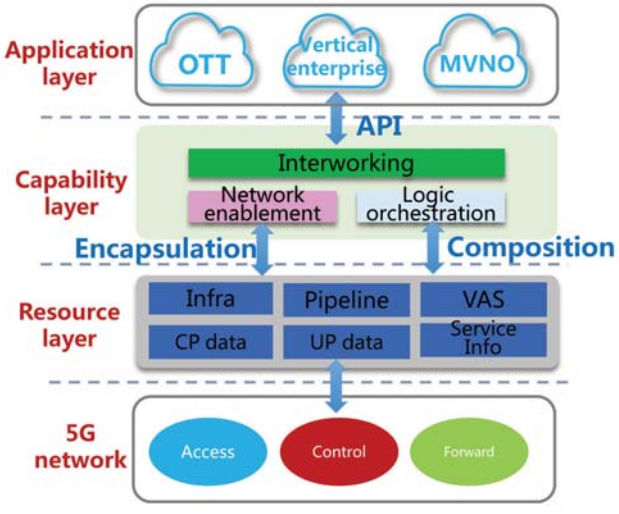

Figure 11 Network Services Exposure Platform

As the core of the 5G network service exposure platform, capability layer is to aggregate the capabilities information from physical or virtualized network elements, orchestrate all the above mentioned capabilities information by the technology such as big data analyses and user figuring, and finally encapsulate them into API invoked by application layer. The function of this layer can be divided into three units:

- Network enablement units: this unit provides the map between the third party invocation and network capabilities and expose the information from the underlayer network such as state data of control plane, user plane and service, value-added services, pipeline control function and infrastructure resources(computing, storage and connection).
- Resource orchestration unit: An orchestrator to compose all the network functions such into network service executable logic according to the third party application requirement.
- Interworking unit: The task of this unit is to import the requirement and service information from the third party, then offer the required network capabilities to fulfill the interaction with the third party application.

Conclusions and Prospects

5G network needs architecture innovation and builds a comprehensive network services platform, which is superior, flexible, intelligent and friendly, to meet requirements of mobile Internet and IoT towards 2020 and beyond. 5G network is based on the deep integration of information technology (IT) and communication technology (CT), promoting and developing each other in two aspects of brand new infrastructure platform and network architecture.

The development of 5G not only need satisfy requirements of future service and scenario, but also should fully consider the compatibility with existing 4G network evolution path. The development of network architecture and platform technology would behave as a minor change to the entire network change step by step. The integration of communication technology and information technology will extend from core network to the wireless access network gradually, finally forming the overall change of network architecture.

IMT-2020 (5G) Promotion Group is willing to cooperate closely with global organizations, enterprises, universitieIMT-2020 (5G) Promotion Group is willing to cooperate closely with global organizations, enterprises, universities, and research institutes around 5G network, platform and technology roadmap, through diversified working forms, to promote global standardization of 5G network and exploit brand-new 5G industry and application development jointly.

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