Analysis of the Application of SDN in 5G Mobile Communication Network Architecture

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Abstract: The 4G communication technology is becoming increasingly popular and widely used at present, which improves the transmission speed of information and the information storage capacity is also larger. However, users propose higher requirements for mobile communication, and people's diversified communication demand needs to be met as well. Software-defined network and network function virtualization are the key points of current industry research, in order to achieve optimization of the mobile communication network architecture, it is necessary to summarize the problems in the current network; the technological advantages of SDN and NFV and the 5G mobile communication network architecture based on SDN and NFV are brought into full play, which promotes the development of communication technology and provides convenience for people.

1. Introduction of SDN Technology

SDN was put forward by researchers at Stanford University, operators hope to Operators hope to solve complexity, clumsiness, difficult innovative application and unfavorable to expansion of existing network hardware equipment and so on, besides, can furthest use their existing networks to protect investment. For this reason, the concept of network function virtualization is proposed to replace the private and dedicated network element equipment of the communication network by using commonly used hardware such as x86 servers, storage, and switches based on industry standards, based on these common equipment, virtualization technology is adopted to realize the functions of various network element equipment through software.

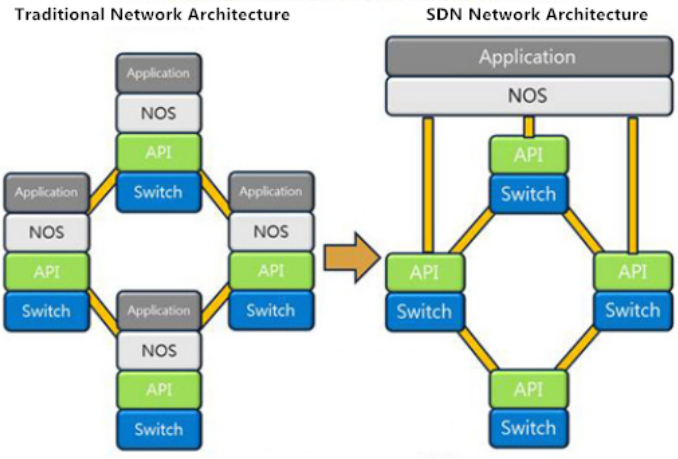

Fig.1 SDN and traditional network architecture

When the network control functions are independent of the programming software, the underlying infrastructure can be abstractly identified as application program and network facility, and the

network is logical or virtual. SDN architecture as shown in Fig.1; and network intelligence functions are all concentrated in the SDN controller. Enterprises and operators can manage and control the network after receiving the commands of the SDN controller, and control without using the interface of the protocol standard. With the development of SDN controller and network applications, the API protocols are unified, and they are not restricted by configuration when applied to services, network services and network performance can operate normally.

1.1 Progress of SDN

With the mutual participation of the industry, the cloud network represented by SDN/NFV is facing rapid changes; the following approaches the progress of SDN and NFV from the aspects of standardization, equipment and solutions, and operator practice.

At present, China's Communications Standards Association (CCSA) also advances with the times, dominates the SDN/NFV standardization work in China, and it has carried out research work on SDN/NFV in various TC, which mainly involve TCl, TC3, TC5, TC6 and so on. Among them, the SVN research group was set up under TC3, at present, the focus is on the research of intelligent pipeline technology based on SDN and the core network based on virtualization, on the one hand, it maintain a global grasp from the network architecture, on the other hand, it finds the foothold of the cloud network from the specific implementation.

At present, the momentum of diversified development appears in the software implementation of the SDN core component controller. Although most manufacturers use open source code and achieve based on common hardware, they are not completely open in the functions of the software, only a small portion of commercial code (charge) can provide a complete function set, so there is still some closure; moreover, tuning of controller performance (such as the coordination of underlying hardware and development code/language). It also needs to be implemented by the manufacturer's own hardware system; it is often difficult to achieve telecom-level requirements based on standard x86 controllers and temporarily unable to unify.

China Telecom establishes a group-level cloud computing key laboratory in China, takes cloud data center as an breakthrough point to explore SDN technology, hopes to solve function, performance, security, scalability and other the core problems of cloud platform network resource pool, controllers are designed for operators' data center needs, which can support typical network services such as multi-tenant networks and virtual firewalls. China Mobile and China Unicom also put forward the concept of SDN2.0 and SCN (service customized network) in combination with their own needs, and introduce related technologies from the laboratory to the market.

1.2 Challenges SDN Face

As a new thing, SDN can't be perfect. Some problems worthy of attention have also been discovered when gradually study, test and deployment, which need to be solved. In general, SDN currently faces the following six major challenges.

(1) Problems of interface/protocol standardization;
(2) Security problem;
(3) Key performance of SDN equipment;
(4) Centralized control concept of SDN;
(5) Interoperability problems;
(6) The network needs cloud computing service cannot well met.

1.3 Advantages of SDN

IT technology is adjusted according to different network requirements in the current network framework, the configuration steps of corresponding network equipment such as router, switch, and firewall are tedious, and the fault-tolerant rate is low, which has not been able to meet the constantly changing situation of Internet services, a more flexible and agile network is needed to respond accordingly. SDN technology can be isolated the control right of network equipment and centrally control, thus avoiding the dependence on the router, switch and other underlying network equipment,

and the differences caused by the underlying network equipment to the network are eliminated. Users can achieve any customized network router and transmission strategy at will, and greatly improve flexibility for managing the centralized control network equipment.

Moreover, after the network upgraded SDN technology, the routers of the network nodes cannot be configured repeatedly; and only need to lay down simple network application rules when using them, for example, if people do not like the built-in related protocols of the router, people can then rewrite the rules by program, thus can exchange data better. In addition, the bandwidth of the network is certain in the traditional network, but after being processed by the SDN technology, the traffic can be arranged, and the "pipeline" of the network is temporarily thicker, which has made the network as a "pipeline" has a greater room for development. In the future era of big data, the service model of cloud storage can be simply processed as "cloud-pipeline-client", and then SDN technology will be an important technical support for the "pipeline".

2. 5G Mobile Network and its Key Technologies

2.1 The Development Status and Existing Problems of 5G Network

The current challenges development of mobile communication networks face is mainly the contradiction between the explosive growth of the mobile communication market and users, and service needs and the current technical capabilities of mobile communication networks.

Higher user experience speed and peak speed, future technical goals require user experience speed and peak speed to be more than 10 times the current user experience speed of current 4G technology.

The lower latency and higher reliability, the Internet of Things and the Internet of Vehicles put forward harsher requirements for network latency and reliability, which require achieving millisecond access requirements.

Low-power and large-connection, IoT applications such as car networking, environmental monitoring, smart cities, sensors and so on, which has a high requirement for the endurance of mobile terminals, and require low-power and large connection.

Mobile broadband demand, hotspot high capacity, virtual reality, augmented reality, ultra-high definition 3D video and so on. Continuous wide-area coverage, such as wide-area coverage, high-speed rail, expressway, etc., current mobile communication networks have technical bottlenecks in transmission speed.

For different scenarios, higher experience rates, lower end-to-end latencys, massively connected terminals, and lower unit-bit costs, 4G technology has been unable to meet relevant application indexes. It is necessary to solve based on subversive technology, 5G network and its key technologies emerge as the times require.

According to the demand analysis of 5G, NGMN gives the design principle of 5G network, which can be summarized as follows:

(1) Adopt cost-effective and dense layout;

(2) Support dynamic wireless topology;

(3) Simplify the core network, such as using SDN technology;

(4) Adopt network fragmentation to improve the flexible functions and capabilities of the system;

(5) Encourage value creation and reduce the complexity of new service deployments;

(6) Protect the privacy of users;

(7) Simplify operation and maintenance and management.

Based on these design principles, NGMN proposes 5G network architecture based on advanced technologies such as SDN, NFV (Network Function Virtualization) and cloud computing, and realizes user-centered, more flexible, intelligent, efficient and open 5G network.

2.2 Key Technologies of 5G Network

In order to cope with the exponential growth trend of data traffic and the number of mobile terminals caused by the development of mobile Internet and Internet of Things in the future, and solve the problems and challenges faced by current mobile communication networks for future needs,

research on 5G networks and its key technologies is extremely urgent, including ultra-dense networking technology, large-scale antenna technology, device to device technology (D2D), cloud base station architecture, etc., and achieve new mobile communication networks with hotspot high-capacity coverage, low latency and high reliability, fixed power consumption and large power consumption, and continuous wide coverage.

(1) Scene application technology

Ultra-dense networking technology, mainly based on ultra-dense heterogeneous networks, macro-micro collaboration and high-low frequency cooperative networking, using macro stations and micro-station, low-frequency and high-frequency advantages to improve system performance; various nodes form virtual cells; hybrid hierarchical deployment, virtual cells are formed in the floors, and macro stations provide mobility management between floors and buildings.

High frequency communication technology, mobile communication continues to develop, and the current status of frequency band resources for mobile communication is: the low-band communication bandwidth resources are limited and approach to saturation. Future wireless spectrum resources for mobile communication networks need to be increased significantly, and will focus on acquiring new authorized spectrum, developing mobile communications based on unauthorized spectrum, and developing high-band (such as millimeter-wave) mobile communications. High frequency bands have abundant available spectrum resources, and the bandwidth can reach more than 1G, it is easy to achieve extremely high-speed short-distance communication, which can meet the requirements of 5G capacity and transmission rate. However, the transmission characteristics of high-band channel also determine its large path loss, as the frequency increases, the path loss increases; for example, the path loss of 60 GHz is more than 20 dB higher than 5 GHz. Moreover, air absorption causes additional losses. These are all problems that 5G communication needs to solve.

(2) Wireless transmission technology

Large-scale MIMO technology uses a large number of antennas to form an antenna array for transmitting and receiving wireless signals, because the number of antennas significantly increases, the 3D MIMO antenna is formed. By increasing the number of antennas, the spectrum efficiency of the system can be doubled, the newly added vertical dimension can reduce inter-cell interference, distinguish more users by horizontal and vertical dimensions, and serve more users at the same time and frequency, improve system performance and capacity, and deploy flexibly, the 3D-MIMO declination angle can be dynamically adjusted to achieve dynamic adjustment of coverage. Large-scale MIMO technology is another milestone in the development of wireless transmission technology and it is an effective means to cope with the explosive growth of data service. It can be widely used in high-rise scenes, indoor distribution system scenes, urban coverage, and so on.

(3) Network architecture technology

The 5G network architecture has been widely recognized, one is that the access network adopts heterogeneous access hybrid networking mode, the other is that the forwarding plane is flattened, and the service data flow is forwarded from the access side. NFV/SDN drives the transformation and innovation of network element functions and network connections, and promotes the formation of a new network infrastructure environment that meets 5G requirements.

3. 5G Mobile Communication Network Architecture Design based on SDN

The 5G communication network architecture based on SDN and NFV is shown in Fig.2, ITS design thoughts are as follows:

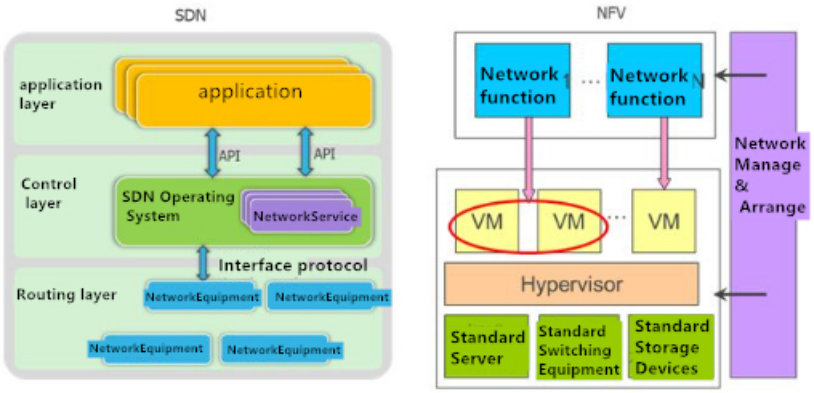

Fig.2 SDN / NFV network architecture diagram

3.1 Functional Decomposition of Network Element

The current communication network is relatively closed, and some functions are repeated, it is necessary to optimize the existing communication network architecture and untangle the network functions. In order to realize the separation of control and forwarding, and carry out decoupling software and hardware, the control function is set to on the SDN controller, and the forwarding plane transmits information according to the current standard universal forwarding equipment, thereby reducing the cost. The control panel and forwarding plane need to be expanded and upgraded, the operation of network architecture function is more efficient and the regulation and control are more flexible. The decoupling of the software and hardware can make the function modules of the network element equipment more independent and realize virtualization. Each function can be realized by software, interface standardization, high performance, the equipment can be optimized based on the X86 general hardware platforms to reduce the investment amount of equipment.

3.2 Network Function Abstraction

Decomposing the current network element functions requires carrying out common extraction and summarization, logical architecture is abstractly summarized and encapsulated, and the functional modules are refined, however, the decomposed and processed interfaces and protocols are more complicated, the internal interfaces of the network element are properly deployed, and the privatization, software, and componentization of the interfaces also make the service deployment of the operators more convenient. The network function abstraction, and each function module can adopt the API interface and reorganize according to the current standard, and display the new network element function in the situation of the whole network view, combine all the contexts to comprehensively consider the service requirements, provide the user with the transmission service of data stream transport, can reasonably process the data stream of the network terminal, improve the quality of the network service, and bring into play the utilization value of the resource. For example, different access systems have similarities in mobility management; the main functions are switching management, lawful interception, tracking and paging, and network edge equipment selection, they lay the foundation for the implementation of the integrated flow mobility management function for heterogeneous access systems.

3.3 Network Function Reconstruction

The functional sub-modules of the open interface are recombined to realize the independent operation of functions and components, newly added service is deeply developed, and performance of functional modules is tested to realize functional expansion. This kind of resources sharing and recombined based on existing service requirements, service requirements are deployed, flexibly scaled, and faults are isolated to achieve automatic processing of faults. The mobile communication network can fully give play to the advantages of IT technology, the network architecture of the 5G era cannot be limited to the constraints of the traditional architecture, and can be analyzed through

virtualization technology. Modularized functional components and open API interfaces can be combined according to the actual requirements of the service, and can provide corresponding network resources for a certain type of service or a special requirement of a user's service data flow. The division and reconstruction of the module realizes the functions of the existing network, and has the function of reducing redundancy. For example, some functional modules and services have reached a certain operating life and can be delisted in time. The existing circuit switch has more than 2000 functions, but only plays 1% role in actual use. Under the modularized operation mode, Operators can optimize and deploy investment based on personalized development needs and business strategies, reduce costs and redundancy.

4. The Advantages of Introducing SDN and NFV into 5G Network Architecture

SDN as one network innovation architecture, which has the following distinctive features:

(1) Separation of control and forwarding;

(2) Centralized control;

(3) Use a widely defined software interface.

Its core is to separate the control plane from the data plane of the network equipment, only keeping forwarding function at the bottom of network hardware equipment, the upper layer can carry out centralized control functions, and then the application and functions of the network can be programmed, namely so-called software definition.

Operators can deploy common hardware and advanced software to replace expensive professional equipment with open, programmable SDN technology, which makes enterprises and operators get rid of constraints of various equipment of different manufacturers. The standardization of hardware equipment and the virtualization of network functions make the network more open and more programmable; operators no longer need hardware upgrades to revolutionize networks and applications, which greatly reduce the capital expenditure and operational and maintenance cost of operators, and it also provides a good opportunity for the operator's network architecture innovation and transformation. The centralization of control can obtain a unified view of the whole network, thus achieving flexible control of network traffic, dynamic allocation of network resources, greatly enhancing the use efficiency of network resources, shortening the development and deployment cycle of services, and it provides a good platform for innovation and business expansion of system-level applications..

These outstanding features of SDN can be used to effectively define future networks, and make application prospects of SDN in the Internet and communications fields widely promising. The use of SDN technology in mobile networks will also make the implementation of basic functions of mobile networks more reasonable and efficient, and enable vertical integration of the network, thereby further simplifying the network to adapt to the ever-increasing access rate.

SDN technology focuses on abstracting network functions and service processes as the center, and setting up controllers to control these abstract functions and services, the related discussions of 5G networks are all in the wireless field, and virtualized network functions and services can be processed quickly through 5G networks, the efficiency of the network is greatly improved and make resources can be used and shared flexibly. The SADN controls and forwards the network functions and services, and separates them into a control panel and a forwarding panel; there is a standard interface between the control panel and the forwarding panel, which is also convenient for controlling. Although similar to the router's architectural design, SDN is not simple control forwarding, it processes network functions and services more flexibly in external equipment. The realization of 5G network will not be possible without the support of SDN technology.

The architecture of SDN is characterized by high openness, larger flexibility and independent programming, a large number of basic network equipment at the infrastructure layer at the bottom of the network is utilized to process and apply various data according to the rules specified by the control layer. The control layer mainly sorts resources at the level of data forwarding, collects network information and feeds it back to application services at the application level, thus calling

network-related resources. SDN separates the control layer in the network equipment and places it in the controller of the network control function for centralized control, called by an application through an open API, a lot of manual configuration processes are eliminated, the network management process is simplified, the efficiency of business handling and upgrading is improved. In the future 5G networks, it is necessary to separate the control panel from the forwarding panel to achieve optimal processing of the network, so the SDN technology can be used to drive the entire network system.

5. Conclusion

Ultra-dense heterogeneous network has become the key technology for 5G network to improve data traffic in the future. Virtualization of network function can list a series of network function, reduces network dialogue as far as possible, that is to say, when we try a new network function, we can need not worry about its conflict with existing web standards, arrange specific functions into special hardware, it is of great significance to realize resource optimization and sharing.. However, in terms of the current development, there are still many problems in SDN/NFV technology, the standardization of technology is not perfect, SDN/NFV technology lacks mutual coordination, and the current SDN corresponding products are mainly concentrated in the data side, other research directions are relatively lagging behind. However, with the continuous development of network communication technology, it has higher requirements for the scalability and security of the Internet and so on, 5G as the main development direction of new generation of mobile communication technology, which is an important part of the next generation of information infrastructure, it will more need a secure, scalable, and growing network environment. SDN/NFV will be used as the basic technology to support the development of 5G network in the future; it advocates the separation of control and data, and makes equipment software and virtualization, this kind of thinking will bring hope to the existing dilemma of 5G networks.

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