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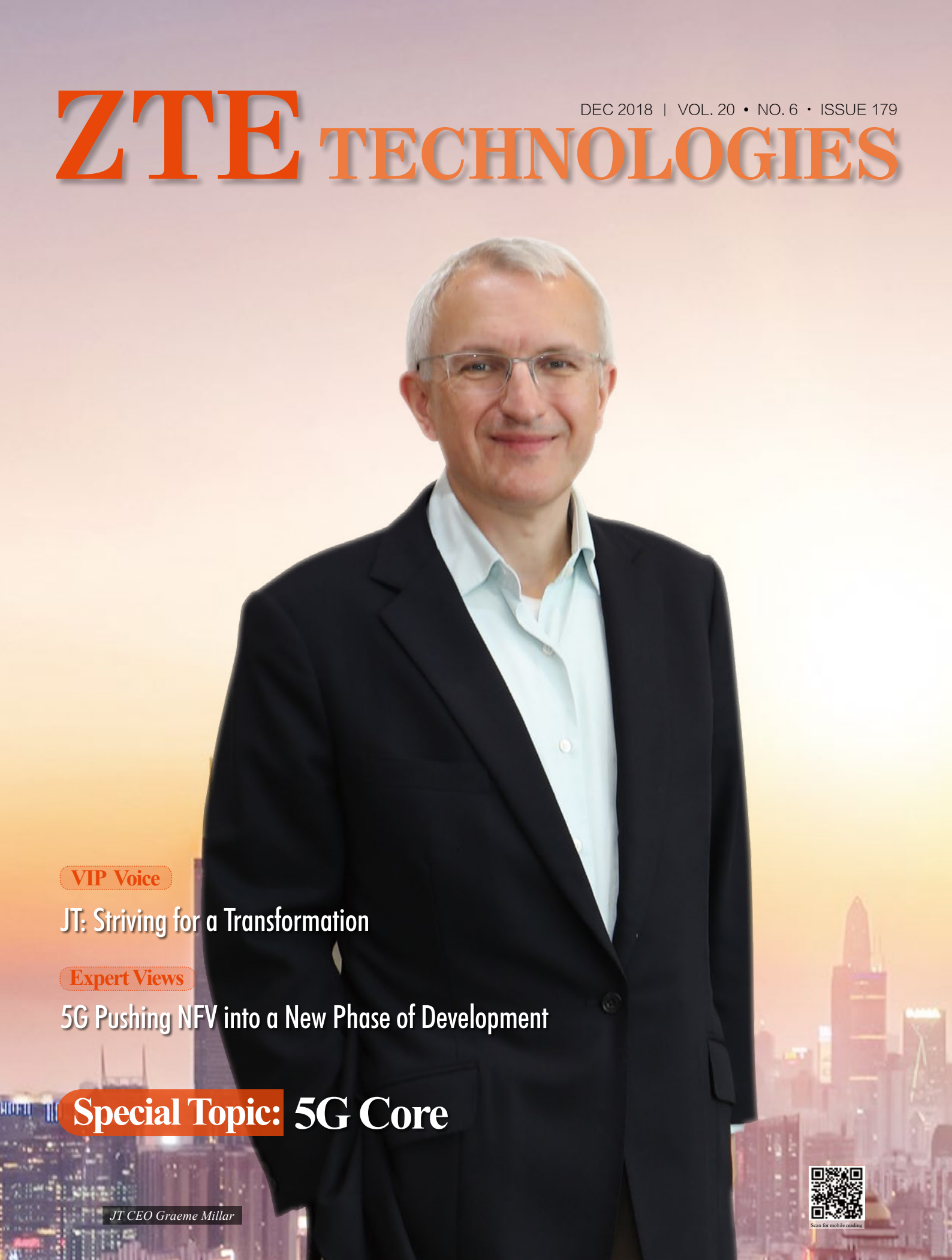

VIP Voice

JT: Striving for a Transformation

Expert Views

5G Pushing NFV into a New Phase of Development

Special Topic: 5G Core

JT CEO Graeme Millar

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ZTE Reports Net Profit of RMB 564 Million in 3rd Quarter

25 October 2018, Shenzhen, China — ZTE Corporation (0763.HK / 000063.SZ) reported net profit of RMB 564 million for the third quarter. The company strengthened its cost control, and reduced its sales and management expenses on a year-on-year basis.

In the third quarter, ZTE posted operating revenue of RMB 19.3 billion, and its R&D investment reached RMB 3.47 billion, covering 17.9% of the quarter's revenue, a year-on-year increase of 6.7%, compared with 11.2% of the same period last year.

According to ZTE's results announcement, operating revenue of the first nine months ended 30 September 2018 reached RMB 58.8 billion, and net profit attributable to holders of ordinary shares of the listed company amounted to RMB –7.26 billion.

Meanwhile, the company published its Preliminary Announcement of 2018 Annual Results, estimating that net profit attributable to holders of ordinary shares of the listed company for the year of 2018 amounted from RMB –7.2 billion to RMB –6.2 billion.

During the first three quarters, ZTE adhered to the innovation-driven strategy, focused on valued customers and core products, proactively explored emerging technologies, and maintained great R&D investments in critical fields such as 5G wireless, core network, bearer, access and chipset. ZTE's R&D expense reached RMB 8.5 billion, making up 14.5% of 9-month revenue, a year-on-year increase of 2.5%, compared with 12.0% of the same period last year.

ZTE's major business are rapidly recovering with the negotiation and signing of new orders and the further implementation of existing orders. Meanwhile, the company has resumed normal operations in R&D, production and logistics. Specifically, its production and purchasing capabilities have been back on track, and its R&D progress has kept pace with the target preset at the beginning of the year. Also, ZTE has fully restored its customer services.

In addition, ZTE has deepened the negotiations with major global operators to constantly obtain new orders.

Taking the opportunity of 5G initiatives, ZTE had a smooth progress in a variety of 5G tests. For instance, ZTE participated into the phase 3 China's technology R&D test with its end-to-end products. It takes the lead to complete several 3.5 GHz base station tests in SA modes. The company is also the industry's first to complete all NSA low-frequency tests and all functional tests of core network, fully demonstrating great capability and maturity of ZTE's 5G end-to-end system.

Meanwhile, ZTE has further deepened its 5G cooperation with operators so that its 5G products and solutions can well match the global commercialization schedule. ZTE has provided China Telecom with its end-to-end solutions in Xiong'an New District, completing China's first joint test on 5G-based driverless vehicles, first 5G water surface coverage test and panoramic live broadcast.

ZTE Teams with China Mobile in Bringing Excellent Wireless Coverage with World's Longest Sea Crossing Bridge

25 October 2018, Shenzhen, China — ZTE announced that it has provided a comprehensive solution for customized wireless network coverage for the world's longest sea-crossing bridge, Hong Kong-Zhuhai-Macao Bridge (HZMB) in partnership with the Guangdong arm of China Mobile.

The mobile 4G download and upload rates reach 50 Mbps and up to 18 Mbps respectively at a high speed scene, recording the world's advanced level.

After eight years' consecutive construction and investment of over RMB 100 billion, the 55-kilometer HongKong-Zhuhai-Macao Bridge is the first "Super infrastructure" integrated with bridge, tunnel and artificial island. Nevertheless, the bridge belongs to special linear coverage scenarios, and is located in the South Coast of China where typhoon, thunderstorm, high temperature and other extreme weather regularly rage in this region.

In respect to the equipment model, the project adopts ZTE's TDD LTE multi-mode RRU and FDD LTE high-power RRU for the purpose of supporting varied modes of network coverage while addressing the storage enhancement resulting from eMBB in future.

In addition, ZTE customized the fastened component in case of extreme weathers. All the components are specially treated to protect equipment from high humidity and salinity. To address the linear coverage scenario of HZMB, ZTE located the equipment rooms on the Zhuhai-Macao Artificial Island and West Artificial Island beside the bridge, extending the range of RRU to over 10 kilometers. ZTE adopted "two directional single core" solution, thereby saving 75% of fiber core.

In terms of solution verification, ZTE creatively proposed to employ the crane on the land to carry RRU in order to conduct an efficient field trial on the bridge. By means of 5G-Ready and Cloud RAN solutions, ZTE's network enables GSM/FDD/NB/TDD multi-mode, multi-band integration and deployment while adopting the architecture of shared MEC and CU server for future 5G.

More than 100 experts from ZTE spent 43 months in total bringing the world's longest sea-crossing bridge with comprehensive wireless coverage, satisfying the requirements of GSM, TDD-LTE, International Roaming FDD-LTE, NB-IoT and future 5G.

ZTE Ranks Among the Top 100 in PwC's 2018 Top Global Innovation 1000 Study

5 November 2018, Shenzhen, China — ZTE announced that it was ranked among the top 100 by PwC in its latest report titled "The 2018 Global Innovation 1000 Study", which was published on October 30, 2018.

According to PwC's study, ZTE ranks 77th among global innovators, being the exclusive Chinese telecom company included on the list.

The 2018 Global Innovation 1000 Study analyses spending at the world's 1000 largest publicly listed corporate R&D spenders, identifying the 1,000 public companies around the world that spent the most on R&D during the last fiscal year, as of June 30, 2018.

In 2018, 145 Chinese companies were among the top 1,000 spenders, and their innovation spending increased 34.4% over 2017, or nearly three times the overall rate of increase among the Global Innovation 1000 between 2017 and 2018.

ZTE has been ranked in PwC's Global Innovation 1000 Study for three consecutive years. In 2016, ZTE ranked 70th, only one position behind Alibaba among Chinese companies, and in 2017, ZTE maintained its ranking of 70th.

JT CEO Graeme Millar

JT: Striving for a Transformation

Reporter: Liu Yang

JT's goal over the next five years is to have one-third of its technical staff to be software developers, said JT CEO Graeme Millar, in an interview with *ZTE Technologies*, focusing mainly on the operator's journey to success, management philosophy, and transformation strategy. JT is a full-service global consumer and business enterprise provider headquartered in the Channel Islands.

What trends do you see shaping today's telecom market?

I think the biggest trend at the moment is the massive growth of data. For an operator, that presents a lot of challenges. On one level, it is good news—people want to use more and more of the products we produce. But as the volume goes up, the price we can get per unit goes down. Customers expect higher data throughput at lower price with higher reliability than ever before. Meeting that demand is our biggest challenge.

JT has maintained great growth momentum, especially in the international markets. What's your recipe for success?

About 70 percent of our business is now outside our home market. We had almost nothing outside the Channel Islands market 10 years ago. I think the two keys to success are listening to what customers want and to be innovative. From nothing, we have grown a very large IoT business. We now have over two million active IoT devices worldwide, from a base of zero five years ago. We have also developed a number of fraud protection services. We have grown our roaming business significantly, whereby we resell our roaming agreements to the other operators. All of these have come from listening to customers and moving quickly and in an agile way to service those needs. I should also say it is important to have a very reliable base product.

How do you cater to the needs of a sophisticated user base in the Channel Islands? Could you give us some examples?

Because we are a full-service operator in the Channel Islands, we provide a whole range of services including fixed service, mobile service, broadband and hosting. We've achieved two big innovations. We bought and installed the LTE-A network. In parallel to that, we rolled out fixed broadband with fiber to every home and business in Jersey. Since June this year, every customer in Jersey gets a 1 Gbps point-to-point synchronous fiber connection to their home. That is a great complementary service to the mobile LTE-A network. We provide the most reliable,

lowest-latency fixed and mobile broadband services to our customers. This has created a huge amount of growth in the market, whether it is a consumer customer using more and more things like smart home applications or many of our customers who've actually started digital business even in their home because they now have the connectivity they could never have dreamed of before.

Work approach is also a success factor for a company. Could you share with us your management philosophy?

I think the most important job of senior management is, to use an expression I've learned when I was working in Holland, getting everyone's nose pointing in the same direction. That's really the key, I would say, to what we have been trying to do at the management of JT. It's about explaining what the vision for the company is, what the strategic direction of the company is, and then working with all the stakeholders (the employees, the unions, the shareholders, the regulator, and the government) to get everyone aligned to go in that common direction. I think that if you can achieve that as a management team, you can achieve quite extraordinary results even if each of us is quite ordinary ourselves.

What's your strategy to maintain sustainable growth?

We did a reorganization this year and launched a new five-year strategy. We have organized ourselves into local domestic business based in the Channel Islands and international business. We recognized that the two businesses have different characteristics. Locally, we seek to provide the best possible network quality at an affordable price and a reliable service to our customers. Internationally, we've got four product groups—IoT, fraud protection services, messaging, and roaming services.

The thing that pulls them together is our vision for 10 years' time—we'll increasingly buy services rather than hardware from companies. At the moment, we are considering buying a 5G core. In the future we think ZTE will actually have a core as a service, a virtualized product, and we'll buy a slice from you. Then the question is how to differentiate yourself in a market

where everyone is buying the same thing from vendors. For us, the answer is to create a service wrap around the products we deliver.

To provide a service wrap that differentiates itself from competition, we need to develop software to do that. So, we are transforming the company, our goal over the next five years is to have one-third of our technical staff to be software developers, which is a very big change for JT as today almost everyone is an electrical or mechanical engineer. Our vision for five or six years' time is buying common network components from vendors but making terrific services for our customers through the software we write to make the billing, provisioning and management of those services very easy and transparent for our customers.

Telcos worldwide are facing the dilemma of reducing cost without compromising the technological development of their networks. How do you balance your technology ambitions with the need to reduce costs?

In our case, it's about growth. In a way, we are lucky. We are relatively small so there's a huge potential for us to grow. We have grown very substantially over the last few years, and we hope to grow again. Actually, as you grow, you spread your costs over a bigger customer base, and naturally you see a reduced cost per customer. That's how we are tackling it. As I said, we are luckier than many bigger operators around the world because we've got potential for growth, which is a lot more difficult for big carriers.

What are your primary goals for JT in the next three to five years?

In five years' time, in the domestic market, we'll evolve the product offering so that we have a fully converged fixed and mobile, full IP network that has high reliability, low latency, and is very easy to access and remotely configure and provision which customers will be able to do themselves.

For the international business, I would hope that we'll be a major player in the IoT business, focusing on not only on connectivity. Recently, we bought a software platform called NOMAD. We see us offering IoT products that combine connectivity with security, with the ability to manage and switch SIMs and also manage the devices remotely. I think that will be our biggest international area.

What are your expectations and suggestions for ZTE?

I think ZTE has been very successful by focusing on technology, in a very short period of time, you have become a strong technology leader. At the moment you are going through a business transformation and as regulation changes there is a need to consider compliance in a way you haven't in the past. I would say embrace that as an opportunity. It will make your business better. There is a potential in three or five years' time that you will be a leader in compliance. There will be a lot of opportunities to sell your experience in compliance. It's a developing area in the world.

The future is about collaboration, partnership and working together. You have a new young leadership who I think will lead you into a world of partnership and collaboration. The most important thing for a company to do is always to keep the customer at the heart of everything you do and develop your people so that they grow with you, and finally it is good to remember to be humble even if you are big and strong.

5G Pushing NFV into a New Phase of Development

Wang Weibin
Chief Engineer of ZTE Cloud and Core Network

By Wang Weibin

Telecom operators have suffered from complex dedicated hardware devices for many years. With the penetration of IT virtualization and cloud computing into the communications technology (CT) field, network function virtualization (NFV) has become the first choice of operators for their network evolution. According to the market research, the compound average growth rate (CAGR) of the global NFV market is 51.57% from 2013 to 2018, and it will reach 45 billion US dollars by the end of 2020. However, NFV also faces some inevitable issues during the network evolution. Pushing NFV into maturity in a rapid manner is key to successful 5G commercialization.

Challenges Faced by NFV Maturity

Unified Management and Interoperability of Cloud Native VNFs

The microservice architecture required by cloud native virtual network functions (VNFs) not only helps operators get rid of dedicated hardware devices, but also allows them to dynamically expand their network functions and improve the flexibility and efficiency of service deployment. However, the majority of current VNFs are transplanted from legacy platforms to virtual machines. The microservice re-architecture by different vendors is implemented based on their own software frameworks, so these microservices are difficult to integrate or interoperate with each other for unified management in a multi-vendor cloud environment.

Effective NFV Operations with Vertical Industries

At present, the unified management and orchestration (MANO) only provides the deployment and orchestration capabilities of NFV network services, but fails to be efficiently collaborated with the BOSS system to deliver end-to-end network services from different vendors and different network domains. Therefore, the demands for tailor-made differentiated services by various vertical industrial customers cannot be met, nor can their needs for microservice self-management like monitoring, optimization, and DevOps be satisfied.

Evolution of Infrastructure Capabilities

NFV is constructed on the infrastructure that is composed of universal hardware and virtual resource management systems. Along with the continuous

development of telecom networks, the IT infrastructure also needs to be optimized continuously in terms of reliability, performance, timeliness, maintainability, security, and lightweight so as to meet the application demands of CT networks.

Balancing Between Openness and Integration

The multi-vendor component-based environment makes operators quite difficult to integrate their own network services. The interoperability of the multi-layer decoupling architecture is facing bigger challenges than what is expected. Therefore, it is necessary to redefine technical specifications on practical NFV implementations based on various open source frameworks and ETSI specifications.

5G Pushing NFV into a New Phase of Development

On June 13th, 2018, 3GPP plenary session (TSG#80) approved the freeze of 5G standalone (SA) networking function, which marks the official birth of the complete international 5G standards. 5G SA network based on SDN/NFV enables the smart development of vertical industries, bringing new business modes to operators and industrial collaborators. By using a brand-new network different from 4G, 5G SA requires standard service-based architecture (SBA), slice-based operations, and distributed cloud infrastructure. All this will help address the challenges related to NFV and will push NFV into a new phase of development.

Standard Service-Based Architecture

3GPP SBA realizes the service-based standardization of VNFs. It has three major characteristics: service-based components, standard API for telecom services, and service-based framework. SBA decouples existing network elements (NEs) by their functions into mutually-

independent modular functions, and organizes them through the unified service-based framework. The standard APIs are used to provide services for external applications. Each service component can be iterated and updated independently for easy development and openness to other third parties. In this way, flexible orchestration and rapid service innovation can be realized.

The SBA-based 5G network has many advantages. One advantage is agility. 5G network services can be upgraded rapidly and conveniently. Another advantage is easy scalability. New network elements and services can be added to the network without introducing new interface design. Services enable plug and play as well as automatic registration and discovery. A third one is flexibility. Network functions can be combined to meet the need for flexible network slicing. The last advantage is openness. Network functions can be easily called for creating new third-party services.

Slice-Based Operations

The concept of network service orchestration is proposed for operations in NFV environments. MANO is a used for unified service and resource orchestration. Furthermore, slice-based operations are also adopted to effectively interoperate with BOSS and MANO.

The end-to-end 5G network slicing services include terminal, base stations, bearer, core network, and even vertical industrial services (Fig. 1). 5G slices can be divided based on different service types such as eMBB, uRLLC, and mMTC or be created based on users from different vertical industries. A user can access multiple slices at the same time, and one slice can also serve different users. Each slice has its own SLA assurance and is isolated from other slices. The slice services can be temporarily and dynamically created or deleted to release network resources. The 5G network slicing provides a basis for smart allocation of service-based pipeline resources and capabilities, allowing operators to offer differentiated services in different scenarios.

Distributed Cloud Infrastructure

Traditional virtual technologies such as KVM

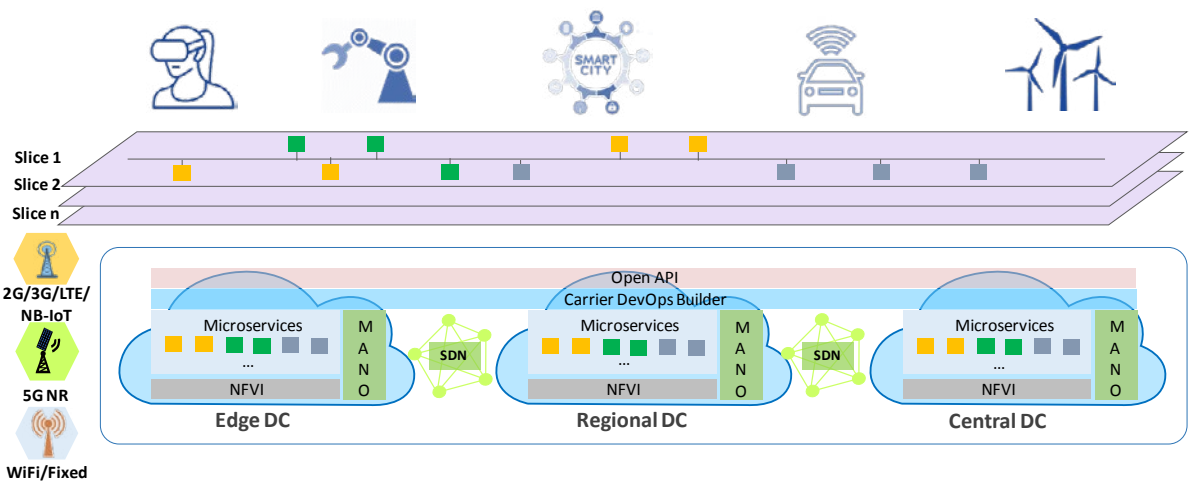

Fig. 1. End-to-end 5G network slicing services.

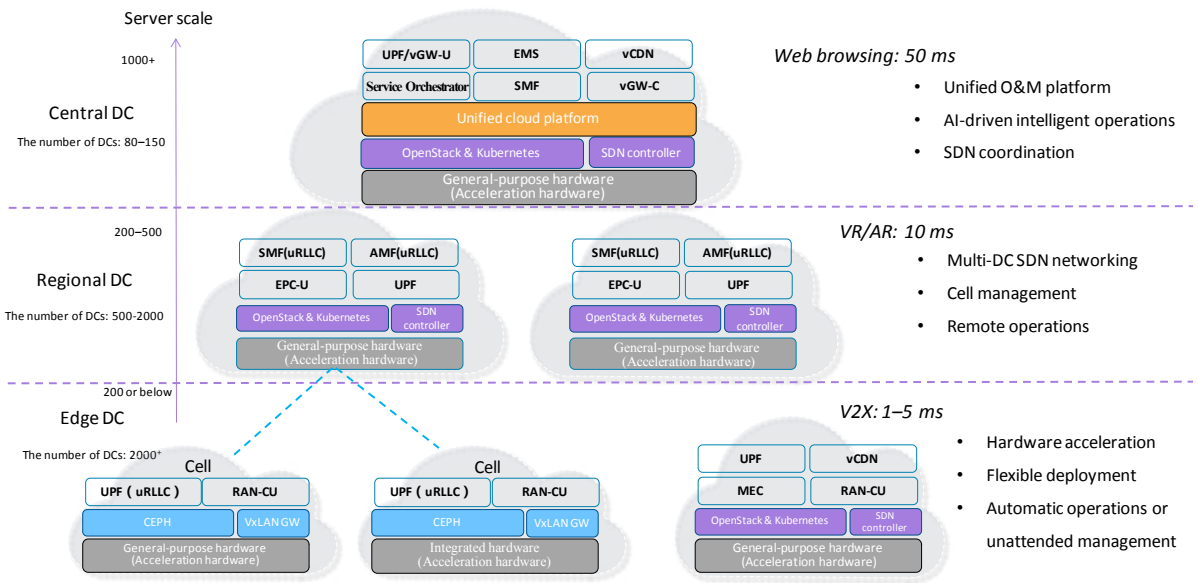

Fig. 2. 5G distributed telecom cloud infrastructure.

and OpenStack cannot completely meet the latency and reliability needs of telecom networks. These problems are more serious especially when ultra-reliable and low-latency communications (uRLLC) and multi-access edge computing (MEC) are introduced to 5G networks. The container technology is characterized by lightweight operation and efficient application deployment, so it can be used to guarantee real-time communication while improving the flexibility in deploying telecom services and the upgrade capability without service interruption. The service-based architecture has been prepared to some extent for containers used in a 5G network.

As new requirements are placed on the NFV-based 5G network, the container technology is also enhanced for NFV, which involves higher network performance and SDN multi-plane adaptation. Although NFV has not yet been put into large-scale commercial applications based on the containers, the demands for multiple services in a 5G network will certainly give rise to the distributed telecom cloud infrastructure that can be built on the hybrid resource pool from the network center to the edge (Fig. 2).

Summary

After developing over a certain period of time, NFV has become an important fundamental technology for re-architecturing telecom networks. The 5G development depends on the advantages of cost, openness, and flexibility that NFV has brought about. As the 5G network speeds up its commercial process, the NFV-related challenges with 5G commercialization will be addressed as soon as possible. This will push NFV into a new phase of development.

Wu Jiangtao
Chief Engineer of ZTE MANO Products

The Road to 5G

Network Intelligence

By Wu Jiangtao

Trends of 5G and Network Intelligence

In June 2018, 3GPP approved the freezing of the standalone (SA) 5G new radio (NR) network functions, which marks the completion of 5G Phase-I standardization task. The 5G industry has entered its last stage.

5G brings vast industry ecosystems and innovative applications, but it also presents unprecedented challenges for network operations. Cloud-based infrastructure, full software-based application systems, and massive data are the best soil for developing artificial intelligence (AI) applications. It is commonly agreed in the industry that AI is essential to building 5G network competitiveness. In 2017, 3GPP introduced the network data analytics function (NWDAF) that was expect to become the AI engine for network functions, and ETSI established the zero-touch network and service management industry specification group (ZSM ISG) aiming at achieving automatic and intelligent network operations. Meanwhile, globally-leading network operators and equipment vendors have strengthened cooperation in the network realm by using AI. The whole industry is using the AI technology to realize 5G network intelligence.

Progress of ZTE's Network Intelligence

As a globally-leading telecom equipment and service provider, ZTE has maintained high investment and played a leading role in the 5G field. It will proactively integrate AI with the cloud technology to explore the road to intelligent operations in a 5G network.

The target of network intelligence is to implement a closed-loop self-organizing, self-healing, self-optimizing network that can significantly improve network operational efficiency (Fig. 1). The intelligent closed-loop network involves two aspects. From the service perspective, it is necessary to implement a big closed-loop self-organization of network services that cover end-to-end sub-slices, bearer network, and cloud-based infrastructure, such as slice self-configuration and self-optimization. From the local function perspective, it is necessary to implement a self-closed loop of network functions in certain scenarios requiring intelligence, such as network function self-healing. The big closed-loop has the AI-related data and computing capability that can comprehensively consider the priority according to the value sequence and technology maturity of application scenarios. The self-closed loop of network functions, which

is limited by factors such as computing capability, will be gradually implemented along with the improvement of equipment performance. The application mode lays emphasis on using existing models and knowledge for reasoning.

Network intelligence needs to be promoted and implemented by three major forces. The first is the programmable AI platform, which is the accelerator for network intelligence. The second is the DevOps automation in the cloud network, which is the cornerstone of network intelligence. The third is the specific application scenario, which is the implementation tool to generate value. ZTE has worked with cooperative partners to have a good start for network intelligence.

AI Platform: The Accelerator for Network Intelligence

ZTE's self-developed AI platform supports visual programming mode, traditional machine learning algorithms, and deep learning. The platform also supports GPU cluster for high-speed parallel model training. The platform can significantly reduce the threshold of AI application development, helping the developers quickly find an appropriate algorithm. As a result, the developers can focus their attention on application logic, and the development efficiency can be multiplied by several times.

The service-based architecture (SBA) of the platform makes it easy to rapidly integrate AI applications into a product, so that the product can be intelligent in a quick manner. Based on its self-developed AI platform, ZTE has developed intelligent network products in several sectors covering wireless, bearer, and cloud core network.

DevOps Automation: The Cornerstone of Network Intelligence

Abundant 5G services are based on a cloud network. The process from service development (Dev) to service deployment and operations (Ops) can be iterated continuously in the cloud network. DevOps automation is the basis for intelligent networks. Only when the whole service

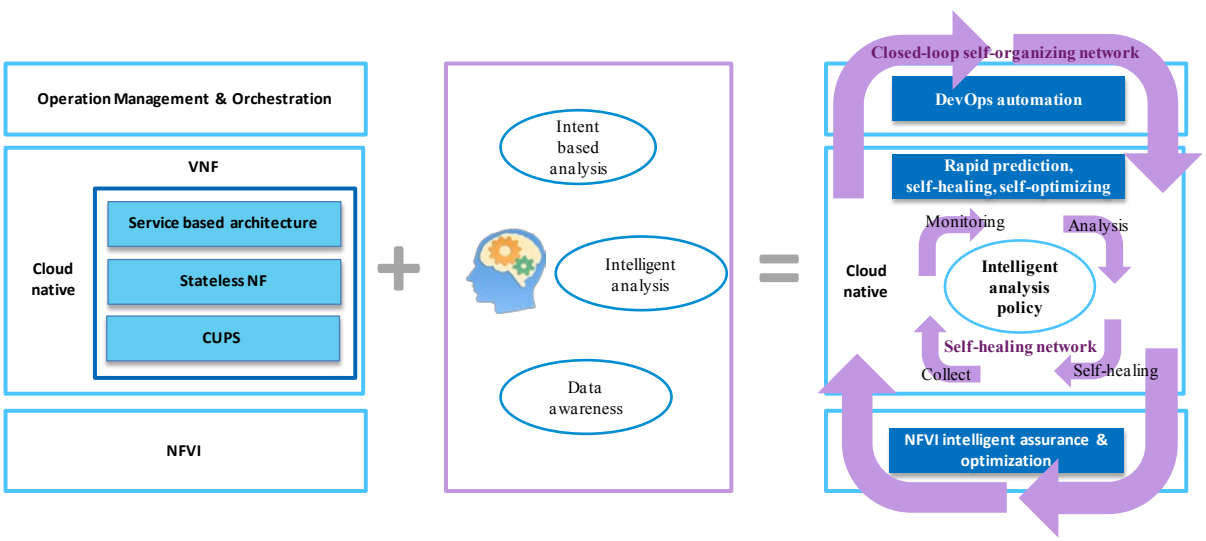

Fig. 1. Network intelligence target: building a fully closed-loop self-organizing network.

development and operations (Dev/Ops) process is automated, the result or action from the intelligent analysis can be implemented.

ZTE implements the whole DevOps automation process for 5G network covering network design, deployment and operations. In the design phase, a sandbox system provides the test capability that can realize automation from development to test release. In the installation and deployment phase, DevOps automation allows for automatic installation and deployment from the network function virtual infrastructure (NFVI) to upper services. The whole deployment can be orchestrated flexibly as required. In the operations phase, DevOps automation provides one-key upgrade and gray upgrade, and supports the strategy-based automatic closed-loop assurance. The automation capability is decoupled with the service scenario, and the automation capability is orchestrated as required by the scenario.

Network Intelligence Implementation Scenario

The expectations from the industry on the application scenarios based on the network intelligence are mainly reflected in fault location, slice management, performance optimization, and user experience. From the perspective of network operations, network stability is the cornerstone, and rapidly locating network faults is an optimal scenario to realize the value of network intelligence. With self-developed AI platform, ZTE can offer intelligent fault location.

A common scheme for fault location involves analyzing network performance, alarms and logs, and locating the fault root cause. With its rich experience in network operations, ZTE implements multiple intelligent fault location functions such as network performance anomaly detection, alarm root cause analysis, and intelligent log analysis. The performance anomaly detection is made in the cloud management platform and network system to find out the system anomaly in advance and eliminate it. The alarm root cause analysis can help predict rapidly the root cause of the fault, and the prediction efficiency can be promoted by 70%. The intelligent log analysis can help locate a problem precisely, find out the anomaly, and set the alarm. With the applications and feedbacks of intelligent fault location functions, the scheme for fault location is continually developed and optimized. In a 5G network, fault location will surely become more intelligent.

Prospects of Network Intelligence

The evolution of 5G network intelligence is a long-term systematic project. As 5G speeds up its commercialization process, 5G applications are gradually booming in various vertical industries. The assistance of AI in 5G networks will be quite imaginative and creative.

As the NWDAF specifications are completed, an intelligent closed-loop of the network function hierarchy will be realized: NWDAF can be used for smart choices of slices as well as real-time QoS management and optimization. Moreover, it is possible to implement an intelligent closed-loop of higher network function hierarchy that involves analyzing customer intent and automatically creating and optimizing a network. For example, you can just speak a few words to an interactive terminal about when, where, and how to host a sports event, the network will automatically create and activate all the eMBB slices necessary for the match. The wonderful 5G intelligence network will enjoy a promising prospect.

Simplified 5GC Solution

Speeds up 5G Development

By Lu Guanghui

Network Innovations Call for a New Core

5G will enable a diverse array of services and meet varying connectivity need. The three major application scenarios defined by ITU for 5G include eMBB, uRLLC and mMTC. To meet the needs of these scenarios, 3GPP has defined a new 5G core network (5GC), featuring service-based architecture, network slicing, CUPS and stateless function, as well as two architectural options (5GC and EPC) to adapt to different wireless deployment scenarios.

- 5GC: Depending on wireless deployment mode, a 5G new radio (NR) base station and a 4G eNodeB are independent from each other or mutually dependent. The 5G NR directly connects to the 5GC or serves as a secondary RAT to access the 4G eNodeB; the UE is in single connection or dual connections with the 5G or 4G RAN.
- EPC: This is a non-standalone deployment based on the existing 4G core. The 4G eNodeB serves as the anchor RAT and the 5G NR as the secondary RAT; the UE simultaneously connects to the 5G NR and 4G eNodeB; and the 4G/5G interoperability is achieved through RAN.

Operators can select different core network architectures according to their commercial 5G deployment plans, available spectrum resources, the maturity of terminals and industry chains, and TCO.

5G is targeted at coping with the OTT challenge, exploiting the vertical industry, and increasing revenue streams for operators. It should be capable of rapid customization, slice-based network operation, and highly-automated, intelligent O&M. The 4G EPC based on the traditional architecture cannot meet those requirements. The cloud- and SBA-based 5GC is the target 5G network architecture. Its advanced network architecture can help operators

Lu Guanghui
Chief Architect of ZTE Core Products

avoid overlapping investments, frequent network transformations and achieve a leading market position. The 5GC with SBA is a one-step-to-reach approach to architecture, and makes centralized construction and intensive O&M easy. With the support for FMC, it also facilitates the introduction of big data and AI to improve the level of network intelligence. By leveraging the 5GC, operators will be able to expand cooperation with industry verticals and quickly roll out new services. Therefore, adopting a 5GC architecture is aligned with world-leading operators' goal for strategic innovations and the needs of 5G commercialization.

Challenges on the Way to Innovation

As a brand-new core network, 5GC adopts new technologies and is naturally accompanied by various challenges and speculations. Only by facing challenges and finding solutions can an operator stand out from the market competition. Considering the needs of commercial 5G deployments, building a new 5GC has three major challenges: network deployment, network function, and new service development.

Network Deployment

Virtualization is central to 5G. All the new 5GC-enabling technologies are based on virtualization. The virtualized 5GC built around the COTS severs maximizes resource sharing, and operators can enjoy the benefits of Moore's Law (i.e. performance improved by 30% at least every 18 months). 5GC is based on the VM or container technology, and the brand-new SBA and interfaces. It uses a lot of horizontal and vertical interfaces. When operators test new network functions, they have to complete the interoperability tests between horizontal and vertical interfaces. Therefore, how to fast deploy a commercial 5GC based on virtualization and SBA is a big challenge.

Network Function

A 5G network provides many service functions, mostly related to key functions such as user data and billing. For user data, full convergence is the goal of network construction. Operators have to consider how to implement the network migration from 4G to 5G so that users don't have to change their SIM cards or phone numbers. With respect to billing, there is a big difference between the target converged online/offline charging system based on the SBA and the existing architecture with online/offline separation based on traditional equipment. The challenge is to how to rapidly put the convergent billing system into commercial use while achieving compatibility with the existing billing system.

New Service Deployment

Network slicing is a critical service for 5G. It is a key technology for operators to adapt to different service needs and scenarios and build new profit models. For the differentiated requirements from vertical industries, government and enterprise

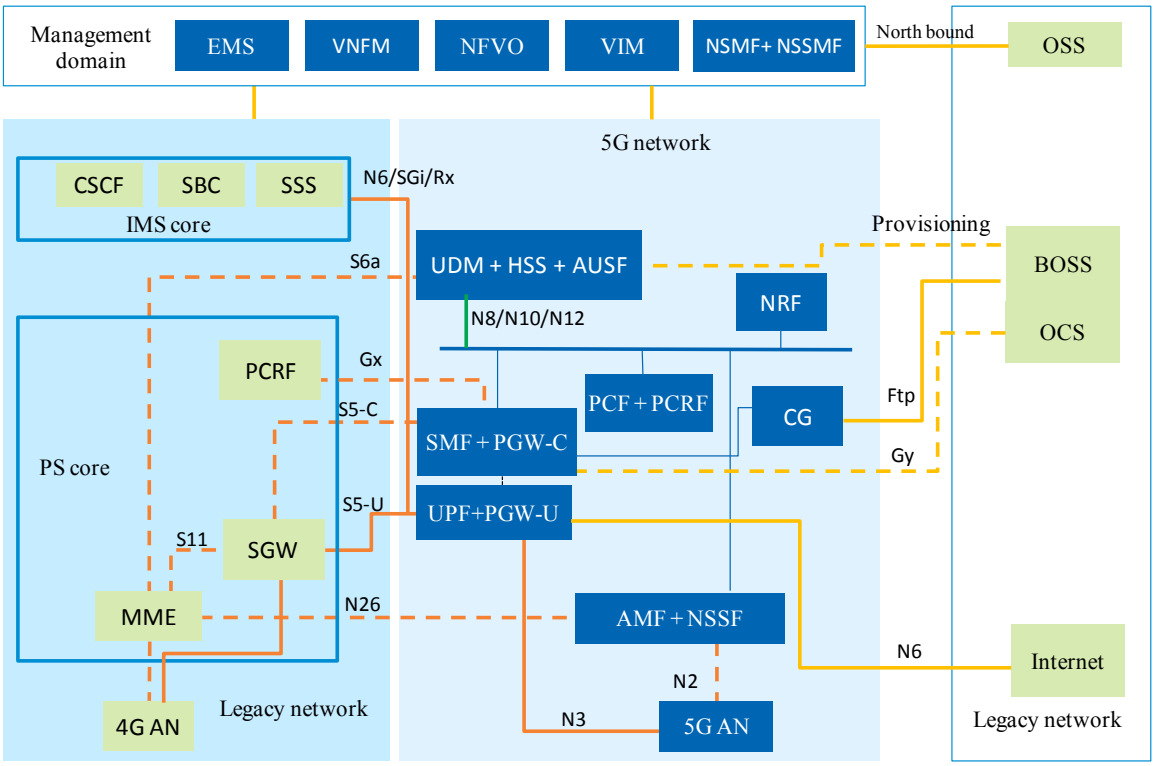

Fig. 1. ZTE's simplified 5GC solution.

customers, and low-latency ISPs, how to flexibly divide a network into slices is the key challenge for network slicing deployment. Voice and SMS services will continue to be essential in the 5G network, for which, several solutions have been defined by 3GPP. It is important to find out which solution allows speedy deployment of 5G voice and SMS services while having the least impact on the existing network, and how to ensure service continuity and quality.

Simplified 5GC Solution

ZTE proposes a simplified 5GC solution (Fig. 1) to help operators gain a lead in 5G network construction and benefit from 5GC's new technologies.

Streamlined Deployment

At present, traditional networks are due for an upgrade and are no longer suitable for large-scale investments. Industry-leading operators are actively promoting the commercialization of virtualization. The deployment of 5GC can speed up virtualization, and it often uses the following concepts :

- Centralized deployment of control plane: Centralized deployment of 5GC control plane helps unify services across the whole network, develop slice-based services, and achieve centralized and intelligent O&M to reduce Opex.
- Layered and phased deployment of user plane: The user plane can be deployed in centralized mode for early-stage 5G deployments. A layered approach will be adopted at the middle and later stages with the user-plane functions deployed close to the access network as needed to reduce latency and improve customer experience. User plane virtualization allows resources to be shared across layers, solving the holiday tidal effect.
- Phased construction of 5GC NF: At the early stage of 5G, basic NFs can be deployed, and optional and unimportant NFs deployed later as needed. At the early stage, 3GPP-compliant 4G/5G convergent NFs can be deployed for interoperability, and more NFs deployed later to achieve full convergence of

4G/5G NFs.

- Phased opening of interoperability interfaces: At its early stage, the 5GC needs to open interfaces for subscription, RAN, UE, 4G/5G interoperation, network management and billing to reduce testing and deployment time. More interfaces should be gradually opened to achieve features like international roaming.

Simplified NF

To build a 5GC, it is necessary to deploy convergent UDM+HSS for unified, centralized management of 2G/3G/4G/5G user subscription data. At the early stage, data migration can be carried out for users who have upgraded from 4G to 5G. At the middle and later stages, the existing 4G users will be gradually migrated to the new convergent UDM+HSS, depending on the aging degree of legacy HLR/HSS. The flexible number routing (FNR) scheme is used to solve the call routing problem of users with discrete number sections at the initial stage.

To support 4G/5G interoperability, the 5G SMF and 4G PGW-C will be converged. At the early stage of 5G, 4G billing interfaces, which are supported by the convergent SMF+PGW-C, can still be used. This avoids large transformation work and delay of commercial 5GC use that might be caused by the introduction of 5G billing system.

Simplified Service Deployment

At the early stage of 5G with limited industrial applications, it is preferred to perform sub-slice management first in the core network, and then gradually carry out slice trials and verifications based on the 5GC. The initial focus is on eMBB slice services such as HD video, AR/VR and HD game, and with the 5GC user plane moved to the edge, the demands of some ultra-low latency services will be met. At this stage, the ability of slices to fulfill the differentiated SLAs can be verified, so as to set up exemplary industrial applications. With the maturity of 5G slice standard, transmission/wireless sub-slices will be gradually introduced. Based on the orchestration and management system constructed in the previous stage, the 5GC will add the functions of slice design, assurance analysis, and policy management, and provide the life-cycle management of E2E slices. It is necessary to consider network slice operation, including slice delivery, pricing, billing, and opening of capabilities, accumulating operational experience and related technologies for slicing commercialization.

The 5G voice standard defined by 3GPP R15 has been mature, and commercial 5G terminals will reach the market in 2019. Mainstream operators have deployed IMS networks to support VoLTE. At the early stage of 5G with only hotspot coverage, to reduce the voice handover between 5G and 4G, it is preferred to upgrade the software for IMS and perform 5GC EPS fallback for VoLTE. Along with the expansion of 5G coverage, VoNR can be used to provide 5G voice services.

E2E 5GC Products

5GC is the key technology for 5G network construction and service bearing. ZTE's core network products address the urgent needs of the world's leading operators to construct a 5GC with advanced architecture and innovative technologies. Based on previous simplified solutions, ZTE provides the following products to meet different deployment demands.

CloudStudio (O&M system): It is the ZTE 5G oriented O&M system that will continuously optimize user experience and networks with its self-evolution capabilities (design – deployment – operation – analysis – redesign). In the future, it will introduce AI and machine learning to achieve intelligent policy prediction, a more intelligent system, and zero-touch operations.

Common Core (5G convergent core network): It is the ZTE fully convergent 5GC product, which is based on SBA and supports mobile access (2G/3G/4G/5G) and fixed access (trusted and un-trusted non-3GPP access).

Tulip Elastic Cloud System (TECS): It is the ZTE cloud platform product that provides 5G-ready VIM and NFVI functionalities and creates a robust and reliable infrastructure for operators.

Considered the brain of 5G network, 5GC directly impacts the realization of operators' network innovation strategy. ZTE's simplified 5GC solutions and products speed the way to 5G deployment and help operators step into the 5G/IoE era.

Innovative 5GC Slicing Solution Activates New Business Models

By Zhang Qiang

Scenarios of 5G Slicing

5G empowers various vertical industrial applications, while each 5G service has a great different requirement on latency, bandwidth, and the number of connections. Therefore 5G defines three typical scenarios: eMBB, uRLLC, and mMTC.

- eMBB: VR/AR, HD video, and 3D applications requiring peak data rates of more than 10 Gbps
- uRLLC: industrial control, e-health, remote monitoring, and IoV applications placing high requirements on E2E latency (less than 5 ms), security and reliability (above 99.999%)
- mMTC: smart home, smart city, environmental monitoring, intelligent agriculture and other IoT services requiring low power consumption and massive connections (more than 1M connections per km^2).

In the 5G era, a single physical network cannot meet SLA requirements of the above-mentioned vertical industries. The need for personalized and differentiated services gives rise to 5G network slicing.

ZTE's 5GC Slicing Solution

ZTE's 5GC slicing solution provides standard and open interfaces, supporting DevOps-based automatic and intelligent network slice design, orchestration and assurance. It also provides a full set of 5GC network elements such as AMF, SMF, UPF, NSSF, NRF, PCF, UDM, NEF, and NWDAF, supporting the construction, subscription and selection of all kinds of slices (Fig. 1).

The 5GC slicing solution allows customers, enterprises or partners to subscribe online slices through the self-service portal or API gateway and submit relative SLA requirements to the Communication Service Management Function (CSMF), including online user number, average data rate, latency, security isolation, service type, cost , coverage area, etc. The CSMF converts

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them into slice SLA requirements and triggers NSMF and NSSMF to perform automatic orchestration and deployment of slices and sub-slices.

Key 5GC Slicing Technologies

ZTE's 5GC slicing solution supports cloud native and service-based slicing, allowing for automatic slice design, orchestration and deployment as well as intelligent slice selection.

Service-Based Slicing

ZTE adopts microservice architecture to split services for 5GC network functions (NFs). The microservice architecture supports 3GPP-defined network function services (NFSs) and provides enhanced public services such as cloud database (CDB), load balancer (LB), and virtual router (VR). According to slice SLA requirements, appropriate NFSs can be selected and combined into NFs necessary for various slices such as UPF_eMBB, UPF_uRLLC and UPF_mMTC, and the NFs are then combined into the corresponding network slices.

Intelligent Slice Selection

ZTE has actively proposed the deployment of network slice selection function (NSSF) in 3GPP and its proposals have been accepted. NSSF intelligently selects slices based on the network slice selection assistance information (NSSAI) requested and subscribed by a user, user location, slice capacity, and current slice load. The intelligent slice selection is also based on the slice related performance data obtained by NWDAF and on the AI technology.

Network slice selection policy (NSSP) is set through the policy control function (PCF) and is sent to the user equipment (UE), in which the mapping relationship of APP and slice is defined, such as IMS APP→eMBB.

Automatic Slice Design, Deployment and Assurance

ZTE's 5GC Slicing solution adopts visual design,

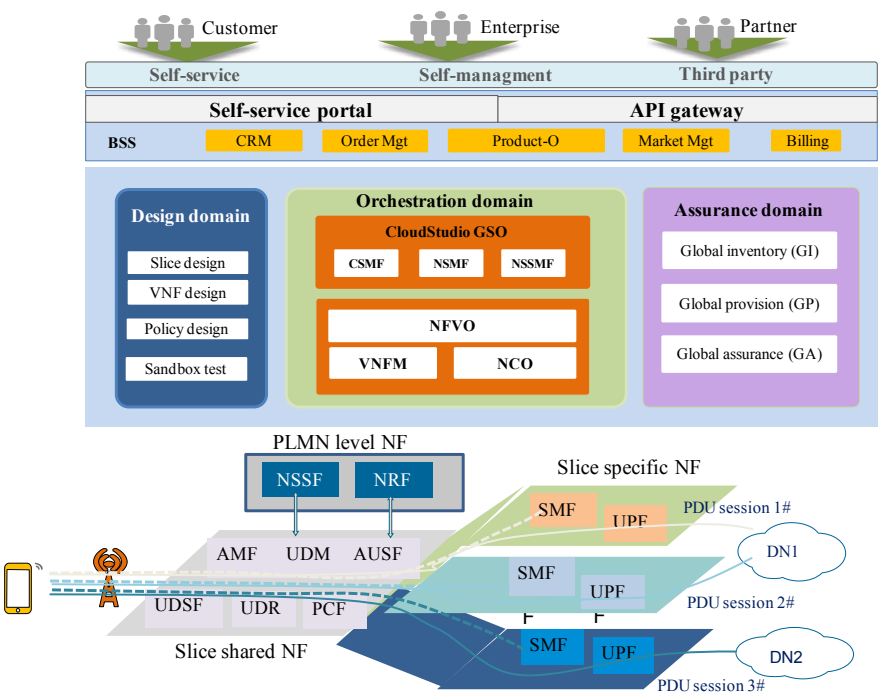

Fig. 1. ZTE's 5GC network slicing architecture.

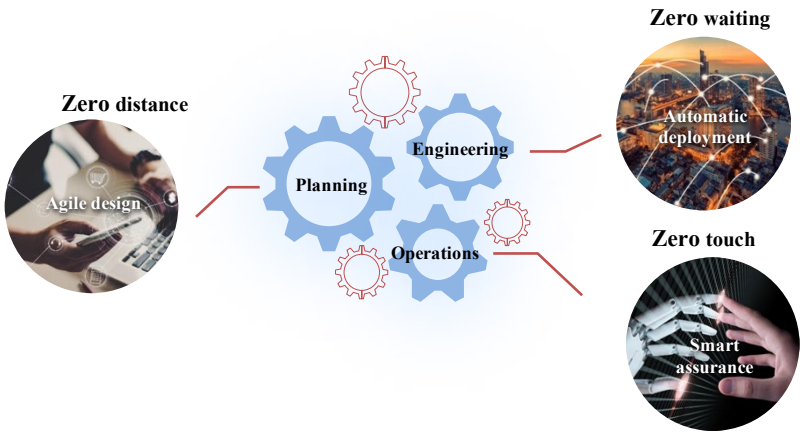

Fig. 2. Automatic slice design, deployment and assurance.

automatic deployment, intelligent operations for rapid slice design, deployment and assurance (Fig. 2).

- Zero distance: agile design, zero distance between the demand and design, drag-and-drop visual design based on template modification to enable what you see is what you get (WYSIWYG)
- Zero waiting: automatic service provisioning, zero waiting from design to deployment, buy & play service, full automation from slice subscription, orchestration, deployment to activation
- Zero touch: intelligent assurance, zero touch operations, intelligent and automatic slice operations based on automatic closed-loop assurance, route cause analysis, and the AI technology.

Layered Slice Isolation

ZTE's 5GC slicing solution provides multi-layer security isolation covering the NFVI, VNF and management layers. At the NFVI layer, the solution provides high security isolation based on independent hardware as well as virtual resource isolation based on NFVI tenants. At the VNF application layer, it supports logic isolation. At the management layer, it provides failure, configuration, accounting, performance and security (FCAPS) isolation for different tenants based on the slice ID.

Suggestions for 5G Slicing Division and Deployment

5G slices can be divided by industry, region, and virtual operator to meet specific needs of different industries and regions. Thus differentiated slices can be provided.

- Division by industry: As different vertical industries raise different SLA requirements on slices, different slices can be divided for a specific industry. For example, there are eMBB slices available for the VR/AR and HD video industry, mMTC slices for the industry of smart city and intelligent agriculture, and uRLLC slices for self-driving and telemedicine. According to service requirements, a slice can be subdivided into several subslices such as eMBB_vr/ar and eMBB_3D, and slices can also be combined into one slice such as eMBB/uRLLC for high-bandwidth and low-latency V2X service.
- Division by region: Based on the large slice covering province, city or country, an operator can build hot slices or microslices for different regions such as industrial parks, business centers, and stadiums. When a UE enters the region, it prefers to access the slice of this region. When the UE leaves this region, it will access a large slice.
- Division by virtual operator: Different slices are built for different virtual operators to guarantee that each operator can operate independently and develop its new business model.

Business Models of 5G Slicing

ZTE has actively cooperated with vertical industries and operators on network slicing that involves smart grid, industrial control and drone, promoting the commercial slice deployment. Its E2E slicing solution supports not only B2C slice service but also network slice as a service (NSaaS), offering wholesale and online sale of slices such as slice stores and slice markets. The solution also provides new B2B and B2B2C business models for operators. Operators can sale slices to enterprises or wholesale the slices to their partners, and the partners then retail the slices to different enterprise users. In this way, a new 5G business ecosystem can be established.

Container Fuels the Evolution to Cloud Native Network

By Zhang Mingxing

Zhang Mingxing
Virtualization Solution Architect, ZTE

Cloud Native Network

Network re-architecture has become a hot topic in the telecom field, and the re-architecturing process is accelerated by the gradual commercialization of diverse 5G service scenarios and its convergence with OTT vertical industries. Therefore, operators have a pressing need to build more elastic networks to gain competitiveness. Since the commercial practice of cloud-based networks in recent years, 66% of global mainstream operators have begun or are beginning their cloud deployments according to the IHS report. In this phase, general-purpose hardware is used for transport, virtual platform is used for deployment, and cloud virtual resources are used for content orchestration. Network function virtualization (NFV) is represented by virtual evolved parket core (vEP, virtual IP multimedia system (vIMS) and internet of things (IoT). Cloud native network is used in the further evolution phase of network re-architecture, where agile service deployment, efficient resource utilization, low-cost operation, and open capabilities are realized based on the cloud networks. Container has its intrinsic lightweight, agile, stateless, and self-contain features, so it has become the focus and best technical practice that supports lightweight infrastructure, service-based architecture and DevOps-based orchestration and management in the phase of cloud native network.

Container is not a new technology as it has found wide and mature applications in the IT and cloud service field. Global top five public cloud service providers have launched their container services. The container industrial ecosystem was well established in 2017.

- The Cloud Native Computing Foundation (CNCF) made remarkable achievements in the field of native cloud in 2017. Kubernetes

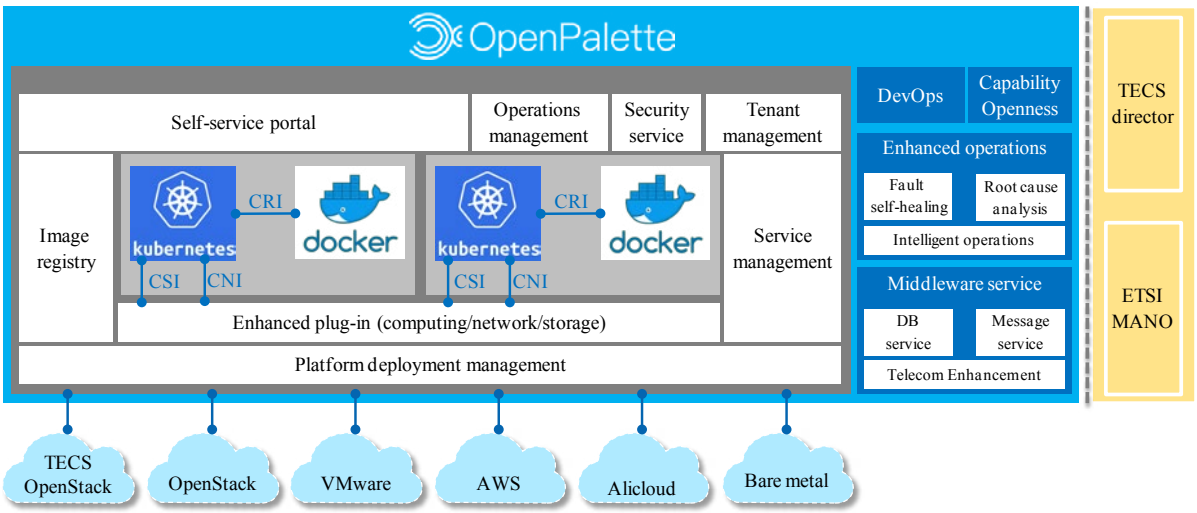

Fig. 1. Architecture of ZTE's TECS OpenPalette.

has became the de facto standard for container orchestration and management, and the surrounding ecosystem of cloud native is further enriched.

- Open source communities such as OpenStack, ONAP, and OPNFV have embraced the container technology. Mature specifications released by Open Container Initiative (OCI) gave rise to the first container runtime in 2018. Various container engines that adapt to different scenarios such as Kata Container and gVisor have gained attention in the industry.
- Since 2017 telecom operators in the process of ICT convergence and digital transformation have all participated in developing the container technology. The container technology has experienced an explosive growth in the feasibility survey and commercial trial of the next-generation data center (NGDC) and NFV.
- Industry standards organizations such as ETSI, SDN/NFV, and CCSA began to pay attention to and set up projects concerning the container technology, promoting the standardization of container in the NFV field.

To address the evolution of cloud native networks, ZTE rolled out its carrier-grade container cloud platform product—TECS OpenPalette in 2017. It collaborated with mainstream telcos to advance small-scale commercial use and relative trials. Network functions focus on 5G core (5GC), vEPC and IoT.

TECS OpenPalette: Container Cloud Platform

ZTE's TECS OpenPalette implements carrier-grade enhancement based on open source container engine Docker and container orchestration management system Kubernetes, meeting carrier-grade service requirements for high performance and high reliability (Fig. 1).

Openness

OpenPalette built on the core of open source projects provides carrier-grade enhancement through non-invasive modification. Externally, it also provides native and enhanced application programming interfaces (APIs). On the basis of Kubernetes container runtime interface (CRI), OpenPalette supports multiple container runtime engines for different application scenarios. It supports Docker container engines, Kata container lightweight security engines, and Virtlet VMs, meeting the need for unified VM applications management. Moreover, ZTE has actively participated

in open source projects to promote the enhancement features and contribute to the community.

High Performance

OpenPalette improves performance on the basis of the container's native efficient feature. It improves the computing performance of container applications via the CPU pinning and NUMA affinity features and enhances the network performance of container applications by supporting SR-IOV and DPDK features via the CNI-Knitter—ZTE's open source network plugin under the Kuberenetes CNI framework. It adopts self-developed general-purpose high-performance middleware such as HSMQ and SLB to provide component support for container orchestration. It also supports acceleration hardware resources such as GPU and FPGA to satisfy the permanence enhancement requirement of container applications.

High Reliability

OpenPalette provides a complete high-availability solution at multiple layers ranging from the containers, cluster nodes, platform components to the whole system based on container applications provided by Kubernetes and high-availability framework of container clusters. This helps achieve zero loss of applications and systems.

Full Security

OpenPalette reinforces system security from multiple dimensions. It supports kernel capability mechanism and SElinux enhanced security mechanism, strictly controls container authority allocation, and guarantees host security. It supports name space and control group, core isolation and binding, and whole system resource quota supervision to ensure the security of resource isolation, supports image digital signature and security scan service to guarantee the security of application image, and supports multi-plane isolation of container network to guarantee the security of network isolation. It provides unified authority and user management based on the role access control system, and uses security components like distributed software firewall to prevent DDOS attacks, so as to guarantee access security. It supports the Kata container security technology to improve virtualization security. It also provides a complete log audit and monitoring to meet the privacy protection requirement of GDPR.

Integration and Decoupling

OpenPalette uses microservice architecture and the DevOps concept to support more efficient component customization deployment and grey release and to guarantee efficient solution integration. Relying on the advanced carrier-grade cloud platform TECS, OpenPalatte provides OpenStack and Kubernetes dual-core engine that can fully share data center infrastructure and management system and provide an efficient cloud network synergy solution. OpenPalatte also supports bare metal, third-party IaaS cloud, and public cloud such as AWS and alicloud. This helps achieve the layered decoupling of the entire system and guarantee no lock-in of vendors and technology stacks.

Scenarios for Introducing Containers

Like Hypervisor, container is a virtualization technology that provides virtualization resources and management capabilities for upper-layer applications. Container supports NFV as described in ETSI GS NFV-EVE 004. The current NFV architecture is based on VM bearer, and there are two scenarios for introducing containers in the NFV architecture (Fig. 2).

Scenario 1: Building a Container Cloud Platform Based on a VM Resource Pool

A contain cluster management system (OpenPalette Master) is added to the original NFVi/VIM to provide container resource management for up-layer applications and is centered around Kubernetes to provide certain software micro-service support capabilities. NFVO/VNFM interfaces with OpenPalette Master to complete the orchestration and management of containerized VNFs. The containerized VNFs act as tenant applications of the container cluster,

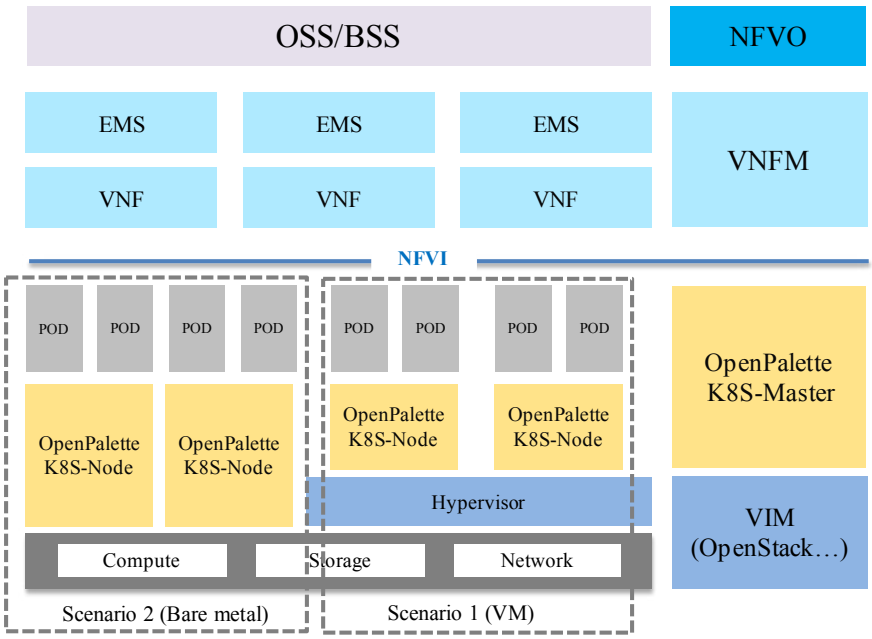

Fig. 2. The introduction of containers in the NFV architecture.

using container resource services and microservice support capabilities. The container cloud platform exists as a tenant on the existing VM resource pool. It exclusively occupies a DC or shares the DC with existing VM tenants, using VMs as the infrastructure. The original NFVi/VIM completes the management of underlying hardware and VM resources. This scenario is suitable for large or central DCs, leveraging existing infrastructure to unify the orchestration and management portal.

Scenario 2: Building an Efficient Container Cloud Platform Based on Bare Metal Resources

The container cloud platform is deployed directly on bare metal resources and does not rely on the underlying Hypervisor hardware-assisted virtualization to improve performance and resource utilization. The container cloud platform is responsible for management and capability virtualization of underlying hardware resources and provides container resource management and certain software microservice support capability for the upper layer. This scenario is suitable for regional or edge DCs as well as the service scenario that requires higher performance and resource utilization such as edge computing.

The container cloud platform is centered on the container and Kubernetes, allowing it to build a management system around the lifecycle of cloud native applications from the beginning, not just around the resources. The container cloud platform will gradually evolve from IaaS to PaaS attributes, continuously enriching software support capabilities of the underlying platform and supporting the service-based architecture evolution of upper-layer network functions and the agile management of differentiated services.

The container technology is at the trial stage in the NFV field. It needs more widespread cooperation from the upstream and downstream industry on key technology verification, standardization and scenario value. As an active explorer and leader in network cloudification, ZTE will continue extensive cooperation with global operators and mainstream open source projects to jointly promote the maturity and application of the container technology in the NFV field, helping operators achieve cloud native network evolution, rebuild core competitiveness, and implement digital transformation and upgrade.

A Probe into Big-Area Deployment of Virtualized Core Network

By Jin Youxing

Jin Youxing
System Architect of ZTE Core Network

Network function virtualization (NFV) is the development trend of core network. The most important feature of NFV is to use the common hardware and NFVI to provide unified operation resources for all the higher-level VNFs. The NFV technology provides the basis for flexible deployment, rapid delivery, smart and automated O&M of VNFs, and network transformation. It enables the decoupling of NE software from underlying hardware so that the deployment of VNFs no longer depends on the dedicated hardware, which also makes centralized and large-scale network deployment possible. This article briefly analyzes centralized deployment of a virtualized core network shared across a big area.

The big-area centralized deployment is opposed to distributed deployment by province. In the existing telecom networks (physical equipment), each provincial branch of the operator has its independent equipment room, hardware, software, and BOSS. Resources from different provinces are mutually independent, so both hardware and software are maintained on a provincial basis. The big-area centralized deployment means that the network devices from multiple provinces are centrally deployed and maintained to provide network services to all the users in the coverage area. In general, NEs that are deployed centrally in a big-area DC include service NEs, data management NEs, control plane NEs, and latency-insensitive user plane NEs. User plane NEs are deployed on demand according to the geographical area size. If the area is small, 4G EPC user planes and 5G eMBB UPFs can be

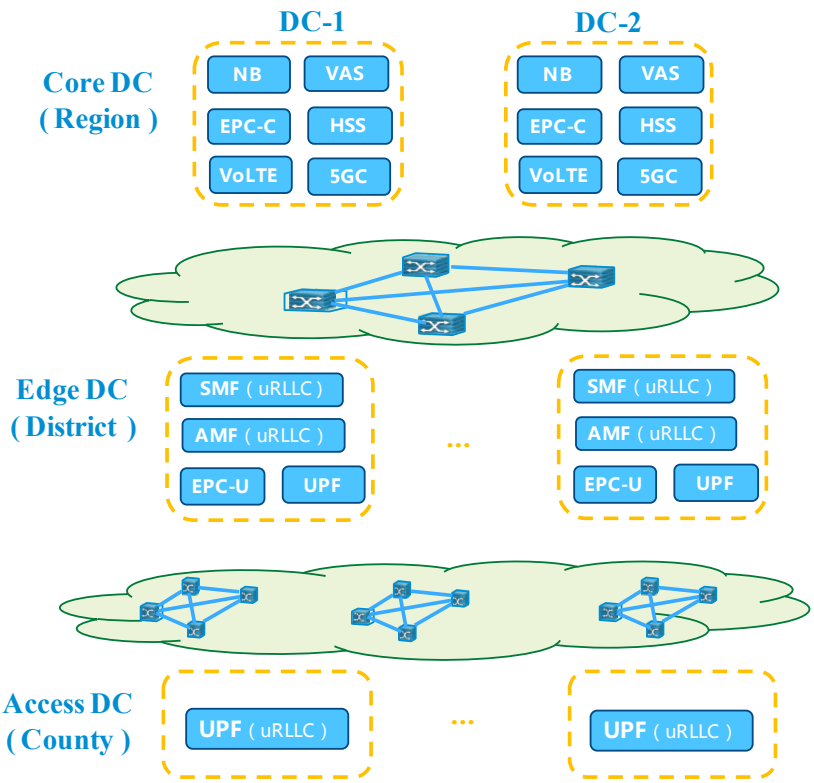

Fig. 1. Diagram for big-area deployment.

deployed centrally. If the area is large, 4G EPC user planes and 5G UPFs can be moved to edge DCs or access DCs (Fig. 1).

Issues in Big-Area Centralized Deployment

Since the big-area centralized core network deployment is significantly different from the distributed deployment in different provinces, it is necessary to make comprehensive analysis. Great attention should be paid to the following issues.

Transmission

The big-area centralized deployment means that the traffic needs to be converged. The control plane traffic and user plane traffic (all or partial) need to be converged in the DCs where VNFs are centralized. It is necessary to build a new transmission network or transform the existing transmission network, especially that between wireless network and core network. Wireless networks are deployed in different provinces. Core network centralization means that the backhaul networks must be converged in the big area. The larger user base a big area has, the higher transmission bandwidth is required. In addition, along with the increase of user traffic, the demand for higher transmission bandwidth will also be increasing.

Latency

In a wireless network, services have varying QoS demands. There are latency-insensitive services (e.g. NB-IoT), latency-sensitive services (e.g. real-time gaming, voice, and real-time video), and ultra-low latency services (e.g. connected autonomous driving and industry control). Different levels of QoS should be deployed to ensure a good user experience.

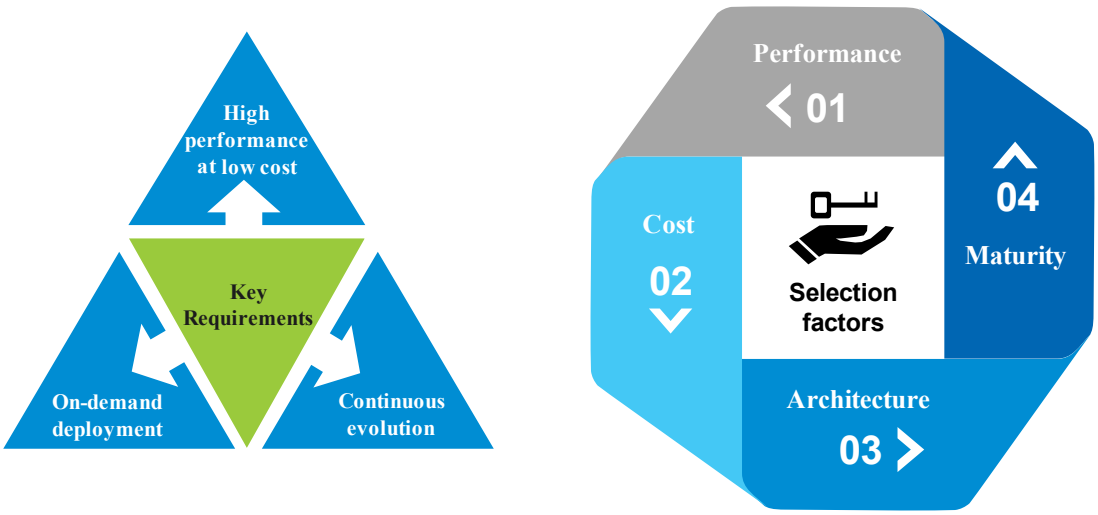

Fig. 2. Factors to be considered in user plane deployment.

Disaster Recovery

It is necessary to take disaster recovery into consideration so that large-area centralized deployment have the same disaster recovery capability as the existing provincially distributed deployment mode.

Interoperation

It is also necessary to consider the interoperation with the existing network in each province to ensure the service continuity and promote user experience.

Service Migration

The large-area centralized deployment mode will coexist for a long time with the existing provincially distributed deployment mode, and a long-term plan should be made to ensure that users can be migrated smoothly from a province to a big area.

Resource Use Ratio

The resource utilization ratio could be increased by giving full play to the centralization advantage and exploiting the potential of cloudified networks.

O&M

One of the advantages of the large-area centralized deployment lies in the large-scale resource pool. Both NFVI and VNFs can centrally operated and maintained, and automation tools must be deployed to promote O&M efficiency. Technologies such as big data analysis and AI can be used to increase O&M automation levels and reduce the maintenance costs.

Coordination

While core networks are centralized to support a large area, wireless networks and existing networks are still configured for different provinces. It is necessary to consider the coordination between a large area and a provincial branch, including organization structure change, division of responsibilities, fault processing flow, service development coordination, and differentiated operations.

Analysis of User Plane Deployment Forms

In the big-area core network deployment scenario, control plane NEs would normally use the NFV equipment. The deployment form of user plane NEs (such as 4G GW-U and 5G UPF) is currently one of the hot topics. The user plane deployment should take the following factors into consideration (Fig. 2).

Three Major Demands

- High performance at low cost: High throughput and low latency need to be provided at lower costs to accommodate the explosive growth of traffic and support high bandwidth, low latency services.
- On-demand deployment: The user plane should be capable of rapid deployment, dynamic position adjustments, rapid enablement of new services, and elastic resource scaling to meet the specific QoS requirements of each vertical industry.
- Continuous evolution: There should be smooth evolution towards a 4G/5G converged user plane and unified access to ensure voice and data continuity.

Four Big Factors in User Plane Selection

- Performance: A user plane should not only support existing EPC scenarios but also exponential traffic growth envisaged for 5G networks. With the reduction of tariffs and emergence of more high-bandwidth services, user traffic has been increasing at an enormous pace, and thus the user-plane performance must match the traffic growth. With the improved performance of COTS servers, the user plane performance of the NFV architecture is equivalent to that of the traditional equipment. In addition, with the rapid improvement of the performance of universal CPU and the development of software acceleration and hardware acceleration technologies, the NFV user plane performance is being promoted rapidly.
- Cost: When the data roaming charges are removed and the number of unlimited data users is increasing rapidly, the operator faces the problem of how to reduce TCO. The traditional dedicated CPU equipment evolves slowly, and its cost is not controllable. However, the cost of NFV equipment is transparent, and its purchase cost decreases at a speed faster than that of traditional equipment. NFV devices can be deployed in centralized mode to cover a large area for centralized O&M and management, significantly reducing O&M costs and improving the resource utilization ratio.
- Architecture: The user plane architecture needs to meet the demands for on-demand, flexible deployment and long-term evolution. 5G will be designed to support diverse types of services with different QoS requirements, which requires that the user plane can be deployed on demand to meet different service requirements. Traditional user plane devices based on the solidified hardware architecture cannot be elastically expanded or deployed, whereas the NFV user plane equipment offers deployment flexibility. In the 5G network slicing scenario, the NFV equipment can better meet the personalized demands of users.
- Maturity: The selection of the form of a user plane depends on the maturity of the industry chain. In the IT field, the virtualized equipment has been deployed on a big scale, and in the CT field, hundreds of commercial vEPC networks have been running stably across the world. Thus, extensive experience has been accumulated.

To sum up, the virtualized user plane has more advanced architecture, transparent hardware cost, low O&M costs and good scalability, meeting key demands and long-term evolution targets of the network. Under the condition of meeting QoS, the user plane can be deployed for a big area to enlarge the capacity of a resource pool, improve the utilization ratio of the resource pool, and increase the maintenance efficiency.

ZTE's Security Solution Advances Convergence and Innovation of Telecom Cloud Networks

By Wang Quan, Fang Yanwei

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Marketing Director of CCN Products, ZTE

Network function virtualization (NFV) is considered as an advanced and disruptive technological innovation that allows telecom operators to have more open network architecture and more flexible service deployment. NFV decouples hardware and software, that is, by using virtualization technology, general-purpose hardware such as X86 can carry telecom function software, which is more convenient to maintain. This helps telecom operators greatly reduce their Capex and Opex. However, under the NFV architecture, in order to achieve interoperability at all layers, NFV components must be open, which brings open security risks to component interaction. Compared with traditional networks, NFV introduces management and orchestration (MANO) and Hypervisor management software. The introduction of new network elements and the virtualization platform also brings new challenges to security.

Security is a basic requirement of telecom networks. ZTE's security solution can eliminate the security risks in the NFV system and ensure safe operation of the virtual telecom cloud network.

Architecture of NFV Security Solution

At the beginning of building a telecom cloud network, operators need to examine security threats faced by a NFV system based on the ETSI NFV architecture and build the NFV system without a security blind zone.

Based on the specifications defined by the Cloud Security Alliance (CSA), ZTE has created various components of the telecom network according

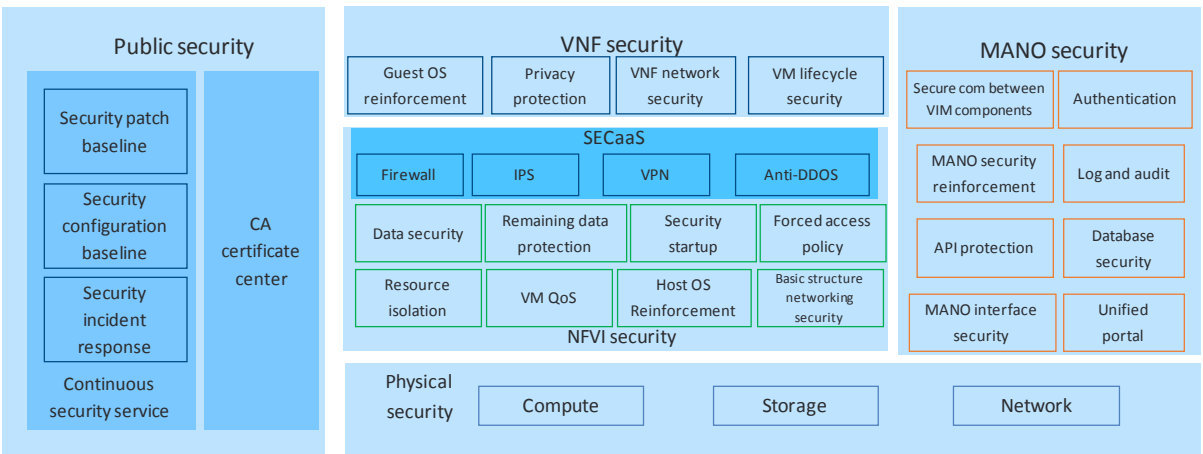


Fig. 1. The architecture of ZTE's NFV security solution.

to the best security practice in the industry and established cloud security checkpoints at various stages during the NFV product lifecycle. ZTE has also developed a series of security initiatives in terms of physical security, NFVI security, VNF security, MANO security, and public security by taking the passing through of the cloud security checkpoints as a necessary condition for this link to be closed. The architecture of ZTE's NFV security solution is shown in Fig. 1.

NFVI Security Architecture and Key Technologies

Reliable NFVI security architecture can meet the security enhancement requirements at the NFVI level and provide security as a service (SECaaS) for NFV multi-tenant networks. ZTE's security solution leverages carrier-grade operation system (OS) as the host OS of NFV and uses multiple key technologies to optimize and reinforce cloud security.

NFVI Networking Security

Secure networking deployment enables isolation between VNF components as well as between infrastructure and VNF services. The infrastructure network is divided into the cloud management network, storage network, service network, and out-of-band management network. The four types of networks must be physically isolated. A network security service chain based on software designed network (SDN) can also be deployed.

Security Startup and Enhanced Hypervisor

ZTE's security solution provides CPU isolation, memory isolation, network isolation, and storage isolation to ensure resource independence and information security of virtual machines (VMs), and provides Guest/Host instruction space isolation to prohibit a VM running under high privilege mode from threatening another VM. Moreover, a series of QoS guarantees are also applied to VMs. The VM's CPU, memory, network I/O, and storage I/O resources are set with upper limit, lower limit, and priority control, which can not only carry out common services but also ensure the operation of key services. ZTE's cloud platform provides an excellent VM resource isolation mechanism and guarantees trusted

components of the shared resources through the authentication mechanism.

Data Security

ZTE's security solution provides the password management function that can manage tenants' password lifecycle and access control rights. The account password needs to meet the complexity management requirements and is encrypted and saved through message digest algorithms5 (MD5). When transmitting user passwords, ZTE's telecom cloud network platform uses HTTPS connections to prevent them from being leaked. The solution also provides the storage encryption function that can encrypt VM data before writing it into the disk and ensure user data privacy. The volume in block storage is encrypted when it is mounted on the host, and then the encrypted block device is provided for the VM to use.

VNF Security Solution and Key Technologies

VNF is the functional logic implementation of telecom network elements and also the core information asset of the NFV system. Its security is quite important. ZTE has designed a trusted security solution for VNF that can guarantee security of the entire VNF lifecycle and business process.

Service Networking

Service networking must first consider service network isolation. VNF networks involve VNF-internal and VNF-external interworking. Each interworking network plane of the VNF component (VNFC) has a dedicated virtual network port that connects to the external physical network through the virtual switch (vSwitch) or single-root I/O virtualization (SR-IOV). According to the security risk level, VNF is divided into multiple security domains. Once the interworking traffic between the VNFs crosses the security domain, it must be isolated by the firewall. It is unnecessary to set a firewall for inter-domain interworking traffic between VNFs.

VM Lifecycle

A complete security solution works throughout the lifecycle of VMs and is reflected in all phases of the lifecycle. In the VNF template, NFV needs to use digital signature and MD5 to support integrity verification and source authentication of NSD and VNFD during the registration, loading and update. To meet the security requirements of VNF, the solution designs the affinity and anti-affinity principles and limits the VNFs carrying sensitive data to share the physical server with those VNFs with external access interfaces. The mirror and snapshot of the VM must be stored in a secure path. The storage encryption function is adopted to prevent malicious tampering after illegally authorized access.

MANO Security Reinforcement and Key Technologies

MANO is the control node of NFV. ZTE has developed a security solution to leverage the features of MANO and to prevent global security risks.

Unified Access Portal and Control Node Authentication

ZTE's security solution implements unified authentication, single sign-on, and log operations of the NFV system. Reverse proxy is used to provide centralized account management and establish global real-name management based on the unique identity. Through centralized access control and fine-grained command-level authorization policies, centralized and orderly operations are managed based on the principle of least privilege. Through centralized security auditing, the system audits the user's entire operation behavior from login to logout, monitors all sensitive operations of the user to the target device, focuses on key events, and realizes timely and accurate detection of security incidents.

NFVO and VNFM Security Reinforcement

ZTE's security solution implements multiple security reinforcements for network function virtualization orchestrator (NFVO) and virtual network function manager (VNFM) to ensure VM security, end-to-end security, interface interaction security, and image storage security.

Centralized Log Audit and Secure Resource Recycling

ZTE's security solution supports centralized log collection and analysis of each node in the NFV system, so that the O&M personnel can know security events and running status of the system in real time. The solution collects and stores operation logs, security logs and system logs generated by the NFV system, and comprehensively records the running status of the system.

The NFV-based telecom cloud network is more complex, flexible and open than a traditional telecom network. While providing a technical basis for the IT telecom network, the NFV system also brings more security risks and poses potential hazards and challenges to NFV commercial networks. Telecom operators need to comprehensively review potential security threats in the NFV systen based on the ETSI NFV architecture and to form a multidimensional, in-depth security protection solution to block security vulnerabilities. Moreover, in daily operation and maintenance, operators need to establish a professional network security service team. They can set up a sustainable telecom network security service guarantee system to protect the security of telecom cloud networks. ZTE TECHNOLOGIES

VELCOM: BUILDING WORLD'S FIRST 5G-READY CORE

By Huang Yan

Huang Yan
CN Product Planning Manager, ZTE

velcom: An Innovative Telecom Operator

Velcom, the second largest branch of Telekom Austria Group (TAG), is one of the three mainstream mobile operators in Belarus, with a market share of more than 40% and about 5 million mobile users. In recent years, the telecom industry of Belarus has developed well, with a total of 13.6 million mobile users and a penetration rate of 143%. According to Ovum's prediction, the number of mobile users will keep increasing in the next five years.

With the growing demand for data and multimedia services, 4G has risen in Belarus and operators have enabled 4G service development plans. As the first deployment and development of 4G services is of great significance for future market share improvement, velcom has begun to consider service development strategies: how to deploy EPC services quickly and inexpensively in 2016? how to enhance velcom's market competitiveness and obtain a dominant position? and how to reduce the high cost of equipment upgrade and reconstruction? Legacy network equipment has operated for

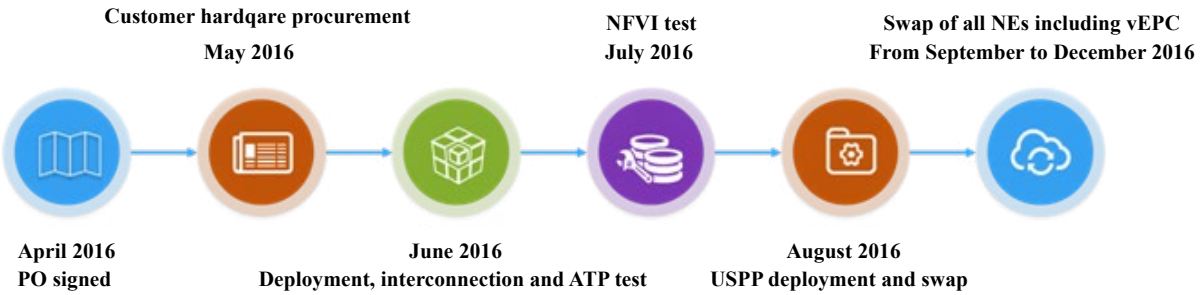


Fig. 1. The milestones achieved in the project.

a long period of time and the equipment failure rate has shown a rising trend, so velcom needs to pay a high cost for equipment upgrade and reconstruction. velcom has also observed that the adoption of NFV/SDN to promote network transformation is increasingly recognized by operators around the world. NFV/SDN will not only shorten the service deployment time of operators, but also improve basic resource usage efficiency and help operators reduce the TCO effectively. As a result, velcom who focuses on innovation has started the virtualization strategy practice trip.

Working with ZTE to Commercialize 4G Services within 4 Months

TAG is a long-term strategic partner of ZTE in many fields. ZTE has won recognition from velcom in the NFV field. After in-depth discussions and exchanges with ZTE in the NFV field, velcom finally chose ZTE to deploy a fully virtualized commercial core network to meet the growing demand for telecom services.

ZTE signed a purchase order (PO) with velcom and began to implement delivery plan in April 2016. Having overcome the difficulties of delayed procured hardware arrival and a large number of network elements (NEs) to be swapped, ZTE took only four months to complete USPP deployment and swap, indicating that the commercial use of velcom's 4G services had started. In the following three months, velcom and ZTE worked together closely and completed the swap of vEPC, vIMS and other services with a total of over 20 NFs and 45 NEs and put them into operation, completing ahead of time the plan developed by velcom: the services shall be all put into operation by the end of 2016 (Fig. 1).

Building a Fully Virtualized 5G-Ready Core Network

velcom decided to work with ZTE in this project not only because ZTE's rapid delivery capability can help velcom achieve the commercial use of 4G services ahead of time, but also because ZTE NFV-based full cloud core network solution can help velcom maximize return with the smallest investment.

ZTE's cloud core network solution based on the ETSI reference architecture uses open source technologies to achieve software and hardware decoupling and provide carrier-class enhancement. The highly-reliable, easy-to-manage and easy-to-integrate full range of core network solution,

which covers 2G, 3G, 4G, and 5G core networks, takes the leading position in the industry. In this project, the solution involves all core network elements such as vEPC/vSDM/vIMS/vCS. The NEs are deployed in three DCs in load sharing mode (Fig. 2).

COTS Hardware Resource Pool

The project uses COTS hardware such as HP C7000s to reduce costs and power consumption. All HP C7000s are deployed in three DCs to achieve load sharing and enhance reliability.

Carrier-Grade Cloud Platform

Based on open-source OpenStack, the cloud platform (ZTE TECS) integrates the NFV architecture and implements centralized scheduling and management through a unified interface for computing, storage, and network resources of the three DCs. Through the virtual DC capability, the complexity of management and operation is reduced and network-wide resources can be coordinated.

Most Complete Range of vCN

The project contains more than 20 NFs such as vEPC, vIMS, vSDM, and vCS, and 45 NEs, allowing the functional modules of different NEs to be combined flexibly based on the sharing of DC infrastructure. This meets velcom's requirements for fast service deployment.

Easy Evolution to 5G

The maturity of virtualization is the basis of 5G evolution. The fully virtualized core network of velcom adopts network virtualization to achieve three-layer decoupling and prepare for the evolution to 5G. When combined with distributed DC, edge computing and containerized deployment, ZTE's cloud core network solution can also provide

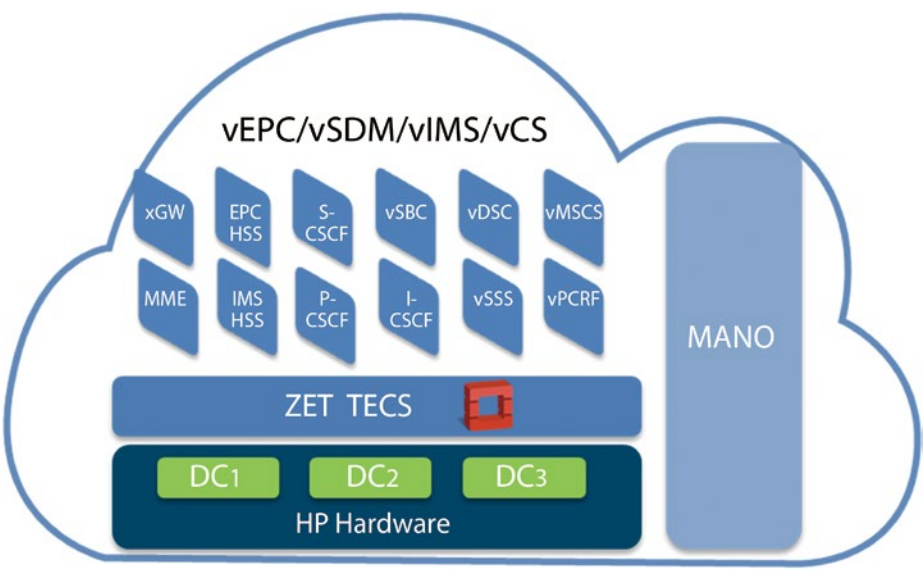


Fig. 2. Logical architecture of the cloud core network solution.

"We were able to set up a cutting-edge technology as an open standard by implementing a flexible solution. Now we are ready to face upcoming requirements for future 5G applications by marginal upgrades. Therefore we will continue to be at the edge of innovation. This outstanding achievement is only feasible with a reliable and strong partner," said velcom CTO Christian Laqué.

cloud-native service-based architecture, stateless design, and control and user plane separation (CUPS) to support eMBB, mMTC, URLLC and other vertical industry applications. This promotes 5G business innovation and evolution. MANO (ZTE CloudStudio) is also used in the project for flexible NF orchestration and management, and it will be upgraded to support end-to-end network slice orchestration and management during the evolution to 5G.

Through the close cooperation with ZTE, velcom successfully built Belarus's first, and even the world's first, complete virtualized 5G-ready core network. This not only helps velcom become the market leader in Belarus, but also plays a pioneer role in network transformation for global operators.

Project Benefits

velcom builds a simpler, more cost-effective, more reliable, and more open core network with ZTE's cloud core network solution. The network can be compatible with the future-oriented 5G core network architecture:

- Automatic NF orchestration and flexible resource allocation can greatly improve the release efficiency of new products and new services by 42%.
- Infrastructure virtualization and resource sharing by multiple DCs greatly increase the flexibility of resource allocation, and also bring a twofold increase in resource use efficiency.
- After technological innovation, total cost of ownership (TCO) can be saved by more than 50%, mainly in hardware procurement cost, power consumption, land occupation, and O&M.

"With this major step towards the next generation network architecture we are able to significantly reduce our Opex spending, benefit on massive economies of scale for further growth and provide highest flexibility and service value to our customers on the way towards a fully cloud-based network architecture," says Sascha Zabransky, Director Technology of TAG.

Christian Laqué, CTO of velcom stated, "We were able to set up a cutting-edge technology as an open standard by implementing a flexible solution. Now we are ready to face upcoming requirements for future 5G applications by marginal upgrades. Therefore we will continue to be at the edge of innovation. This outstanding achievement is only feasible with a reliable and strong partner."

Christian Woschitz, COO of ZTE Austria added, "5G is a significant game-changer technology, which will have a revolutionary impact on the society. Our fully virtualized architecture implemented in velcom ensures a seamless evolution towards 5G as one of the first projects globally. I very much appreciate our strategic partnership and I am looking forward to further cooperation with velcom."

BELTELECOM'S UPGRADE PATH TO FIBER BROADBAND

By Guo Zhihua

Beltelecom is the largest fixed-line network operator and a major ISP in Belarus. For many years, Beltelecom has built extensive networks, and its backbone fiber networks are interconnected with the backbone networks of neighboring countries. As the largest state-owned telecom company, Beltelecom secures a leading position in fixed-line network services and data transmission services and has a monopoly over international long-haul, internet and backbone access services in Belarus. It provides all mobile operators with undifferentiated operational conditions such as switching and international and domestic roaming.

Beltelecom has approximately 4.3 million fixed-line users and more than 2.5 million broadband user lines including 1.6 million GPON lines and 900,000 ADSL/VDSL lines. With abundant broadband resources, Beltelecom has inherent advantages in IPTV development. After years of operation, Beltelecom has built its IPTV services branded "ZALA", and the users have exceeded 1.6 million lines and will continue to expand in the future.

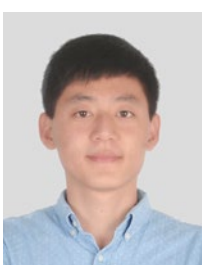
Double Challenges

Beltelecom has a pressing need to develop broadband services. The PSTN and DSLAM devices Beltelecom built more than a decade ago are obsoleted and outside the suppliers' warranty period, resulting in a year-on-year increase in Opex. As IPTV develops, the limited bandwidth provided by ADSL can no longer meet the demands for emerging services such as bandwidth-hungry and big video services. Beltelecom's revenues are declining year by year because of the sharp churn of voice users affected by mobile networks coupled with ruble devaluation. Therefore, Beltelecom urgently needs to develop high value-added services, increase ARPU, and improve its financial status.

With the development of optical fiber communications, Belarus proposed a national NGN development strategy requiring vigorous growth of fiber networks to improve nationwide broadband services. The Belarus Ministry of Communications and Information requires Beltelecom implement this strategic NGN plan. This is another huge challenge to Beltelecom.

Broadband Acceleration Initiative

According to the national NGN plan, Belarus will develop broadband as the nationwide fixed access mode. In response to the national strategy and in keeping up with the fiber-in and copper-out trend, Beltelecom has worked out the strategy to develop an integrated fiber and copper network that can



Guo Zhihua
FN Product Solution Manager, ZTE

smoothly upgrade its out-of-date networks and increase revenues. Beltelecom plans to have its GPON networks cover 3 million subscribers across the country in 2020 and strives to set a good example for telecom network development in the Commonwealth of Independent States (CIS) and even in European countries.

Through prudent analysis, Beltelecom has formulated the dual growth strategy for its networks and services: deploying MSAN on existing networks and FTTH in developed new regions, developing IPTV services for all users, and implementing optimized video operations.

- Stage 1: Deploying GPON-based FTTH for broadband acceleration. After a series of tests and exchanges in 2011, Beltelecom accepted ZTE's FTTH solutions that can cover key commercial users and high-value areas by deploying fiber to the home. By the end of 2015, Beltelecom had completed the deployment for 350,000 GPON users.
- Stage 2: Deploying the unified MSAN platform for GPON/VDSL/ADSL/POTS access. Considering wide coverage of home users and high costs of ODN construction in some areas, Beltelecom hoped to make use of the existing copper cable resources and keep some of its legacy services. ZTE's unified MSAN platform provides fiber access to a majority of users while keeping compatibility with existing copper services, which is in line with Beltelecom's requirements for network element evolution at a lower cost in its entire network lifecycle. In 2015, the MSAN platform passed the strict acceptance tests carried out by Beltelecom. In 2016, Beltelecom chose ZTE as a cooperative partner to build its MSAN project.

The end-to-end design concept of ZTE's broadband products and solutions can help Beltelecom maintain a leading position in technology evolution and business operations for a long time in the future.

Achieving the Broadband Goal, Creating a Better Future

With outstanding broadband solutions, fast delivery and stable after-sales guarantee, ZTE helped Beltelecom make steady progress towards its goal for fiber broadband development. Since 2011, Beltelecom has developed 1.6 million lines of GPON users. Its broadband and service quality has been considerably improved, which can perfectly support IPTV service deployment and migration. Based on broadband network development, IPTV has become the major revenue source for Beltelecom. The exquisite channel and content design is well suited to the Belarusian needs for cultural life improvement. To address the explosive user growth within a short period of time, Beltelecom has also introduced more value-added services and popular contents to achieve sustainable ARPU growth.

Through successful cooperation with ZTE, Beltelecom has built stable and highly-efficient modernized networks, cementing its monopoly over the fixed-line network market. Through diverse service portfolio solutions, Beltelecom has effectively increased its ARPU from fixed telephony, fixed broadband and IPTV services, significantly optimizing its financial situation.

Beltelecom is an incumbent fixed-line operator, but it is not encumbered by obsolete networks nor even by any conservative development idea. From PSTN to copper-based broadband and to fiber-based broadband, Beltelecom has actively followed the network development trend and has chosen the development strategy suitable for its own conditions. Beltelecom has not only increased its user base and revenue growth, but has also made the Belarusian people and the national economy benefit from technology development. The network development of Beltelecom is an excellent case for the development of incumbent fixed-line operators.

Export Control Compliance in ZTE

Wu Hua
Export Control Compliance Supervisor, ZTE

ZTE, as the world's leading provider of integrated communications solutions, because of its global characteristics, is inevitably involved in complying with the import and export related laws and regulations in its production and operation activities. Compliance is a matter of survival for the company and we must manage to control the compliance risks. Over the past two years, ZTE has continuously explored to develop an export control compliance system suitable for its business.

The export control compliance means that all export activities involving countries, regions, enterprises, products, raw materials, and end uses must comply with all applicable export control requirements.

ZTE determines the compliance of all business activities in accordance with the four elements of the U.S. Export Administration Regulations (hereinafter referred to as the "EAR"), and establishes a suitable export control compliance system for itself based on the Export Compliance Program (hereinafter referred to as "ECP") guidelines.

Four Elements of the EAR

There are four elements that organizations or individuals need to consider and comply with when the EAR applies.

- The controlled countries element requires determining whether the countries involved in an activity are restricted countries or regions under the EAR. The policy of ZTE is that it will not participate in or promote any transaction that is associated with the sanctioned countries, the embargoed countries, or the restricted regions.
- The controlled parties, including institutions, companies, research institutes, schools, individuals, etc., are the sanctioned or restricted parties under the EAR. The policy of ZTE is that it will not participate in or promote any transaction with any sanctioned or restricted parties.
- The controlled items include hardware, software, and technology that need to be controlled in two ways. One is to track the country of origin and content of those hardware, software, and technology, and classify them appropriately; the other way is to screen correctly all projects transferred by ZTE to determine whether export or re-export licenses are needed or not.
- The controlled use is the end use of an activity. According to relevant provisions of the EAR, ZTE needs to focus on whether the end use of its business activities involves military or surveillance or not. If so, such activities must be strictly reviewed.

Eight Elements of the ECP Guidelines

A series of procedures have been developed in the ECP to help enterprises comply with the EAR for export activities. By implementing the ECP, each enterprise effectively ensures that controlled US products and technologies are not exported to embargoed countries, sanctioned parties, and are not used for illegal purposes. The enterprise can also develop and implement its own export compliance program based on the eight elements of ECP to ensure that all export activities are legal and the company can continue to develop steadily.

- Management commitment. The company management must clearly communicate on the importance of compliance with export control requirements from the top down, and that all transactions must not violate export control laws and regulations. Currently ZTE publishes an export control compliance statement that is signed and issued by the CEO every year and this effort is gradually covering ZTE subsidiaries.
- Risk assessment. This element requires the company to identify internal preventable risks and conduct a regular assessment. The risk assessment of ZTE and its subsidiaries is carried out from three aspects: 1) the degree and nature of the technology, hardware, and software regulated by US export controls; 2) the risk of ZTE products being sold or transferred to restricted areas or restricted parties; and 3) the assessment for business partners and end users.
- Export authorization. This element means the process used to confirm the scope, classification, licensing requirements, and export of products (including re-export). ZTE has established a team of ECCN classification experts to work with external consulting agencies to assess and determine the classification of products and issues related to whether "export/re-export" is permitted.
- Record keeping. This element requires the company's record keeping process to meet regulatory and mandatory requirements. ZTE has made clear requirements for record keeping in various activities of the company.
- Training. This element requires the company to conduct compliance trainings to improve employees' general compliance awareness and conduct compliance trainings for specific functional departments, and such trainings should be carried out on a regular basis. ZTE has always attached great importance to employee compliance awareness training. Since 2016, the company has organized two export control compliance trainings for all employees and embedded export control compliance training content in the company's new employee training and management and leader training. Since August 2018, the company has comprehensively pushed the company-wide trainings for export control expertise such as ECP, ECCN, blacklist, and GTS.
- Audits. This element requires the company's audit work to meet the requirements, cover all departments, and update the audit methodology to reflect changes in regulatory requirements. At present, ZTE's Export Control Compliance Department works with other internal audit departments to conduct the company's export control compliance audit, in order to ensure that its business units and entities implement applicable standards on a global scale, and if necessary, invites external experts or third parties appointed by the government to conduct the audit work.
- Handling export violations and taking corrective actions. ZTE has set up a compliance reporting email box and a hotline for employees to report in anonymity actual or potential violations of export control compliance. It is also prohibited to take retaliatory measures against such employees.
- Building and maintaining your export compliance manual. This element requires the company's Export Compliance Manual to include all the key points of the ECP and to specify the processes that all employees should follow. ZTE released the *ZTE Export Control Compliance Manual* in 2016, and revised it in 2018 which has also been released to all employees.


Leading 5G
Innovations