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04/2019
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Simplified 5G for better 5G business

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Welcome to the new intelligent world – a world that anticipates our needs and doesn't just connect us to each other, but connects us to everything we see and touch.

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Building a Fully Connected, Intelligent World

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Sponsor:
Corporate Communications Dept.
Huawei Technologies Co., Ltd.

Editor-in-Chief:
Sally Gao

Editors:
Gary Maidment, Kyra Mi
Cao Zhihui, Linda Xu, Xue Hua
Amanda He

Art Editor:
Zhou Shumin

Contributors:
Lu Xingang, Li Haifeng
Zhao Guanglei, Guo Jun
Wang Kening, Liu Jiangping
Shen Yimeng, Meng Guangyao
Nie Yi

E-mail: HWtech@huawei.com

Tel: +86 755 89243011
Fax: +86 755 89242946
Address: H1, Huawei Industrial Base, Bantian, Longgang, Shenzhen 518129, China

Publication Registration No.:
Yue B No. L015060003

Partnering together for autonomous driving networks

From manual production to mechanization to electrification to today's automation and intelligence, each industrial revolution has driven human society to a new age of development.

Once we enter the AI-driven fourth industrial revolution, a qualitative breakthrough in productivity will be achieved, bringing revolutionary changes in production methods. In the automobile, aerospace, and manufacturing industries, the introduction of autonomous technologies is gathering momentum, spurring the rapid development of these sectors. In the ICT industry, which lies at the core of the information society, the demand for autonomous driving networks is even more pressing. As networks grow in scale and OPEX increases, structural issues in the industry are ever-more prominent.

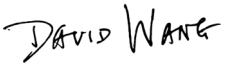
As a significant contributor to the telecoms industry, Huawei is actively engaged in deliberating and exploring autonomous driving networks in partnership with operators and industry customers. The autonomous driving network is not a single product innovation, but an innovation in system architecture and business models. As such, the whole industry needs to collaborate to define clear standards to drive technological innovation and guide implementation.

Focusing on service experience and operating efficiency, Huawei has released a five-level standard proposal for evolving the telecom industry towards the autonomous driving network, and help upstream and downstream industries jointly explore how to arrive at this future network.

Huawei is also exploring innovation in the autonomous driving network in the spheres of wireless, broadband access, IP, optical networks and data center networks. The aim is to develop a simplified network oriented to user experience that will enhance network operation and maintenance efficiency and enable self-healing, autonomous networks.

Huawei unveiled its AI strategy in October 2018. As part of the strategy, Huawei aims to harness its full-stack, all-scenario AI solution to provide economical yet abundant computing power and make AI more inclusive through full-stack capabilities and all-scenario products and services.

It will be a long journey to reach autonomous driving networks. To make our dream a reality, the industry must work together and forge ahead. Huawei is committed to facing the complexity ourselves while making things simple for our customers. We will accelerate the deep integration of AI and telecom networks and develop autonomous driving networks to build a fully connected, intelligent world.



David Wang
Huawei Executive Director of the Board
Chairman of Investment Review Board

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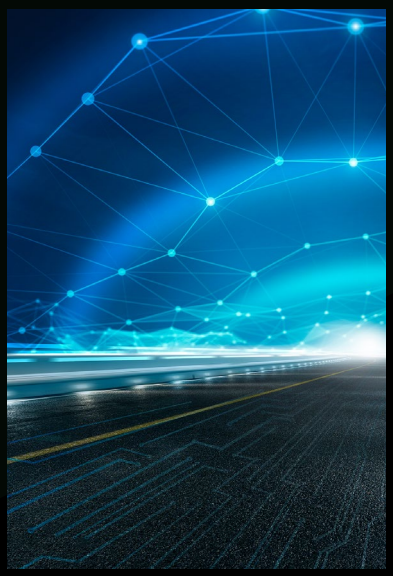

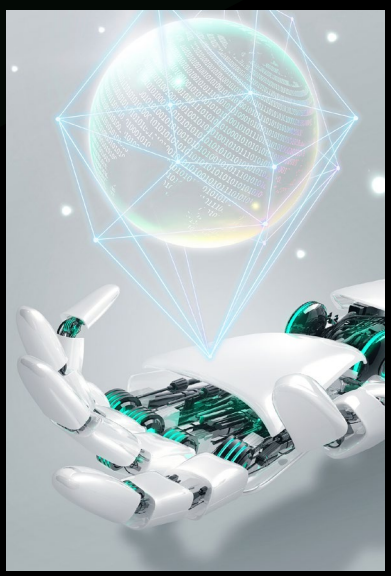

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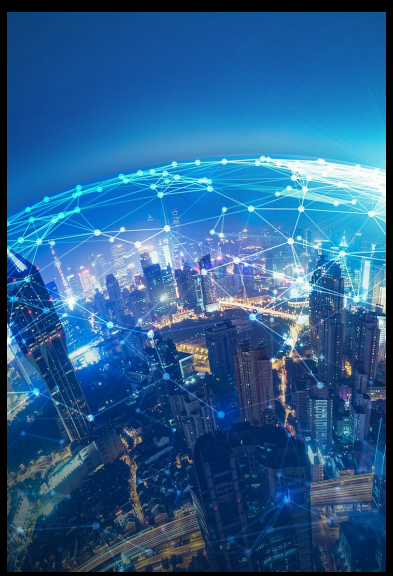

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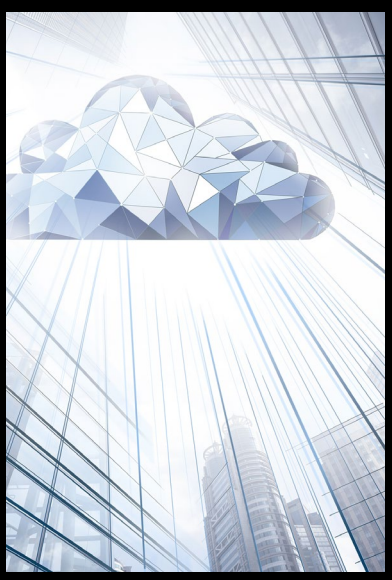


Simplified 5G for better 5G business

By Peter Zhou
Chief Marketing Officer, Huawei Wireless Network Product Line

At MWC Barcelona 2019, Huawei unveiled its "Simplified 5G" network construction strategy for guiding future network development with network simplification, automation, and business simplification.

The strategy reflects Huawei's core design philosophy of taking on the complexity to make things simple for its customers, helping operators build simplified networks for the 5G era.

In the past year, operators across the globe have launched 5G deployment plans, and the speed and scale of 5G development has been unprecedented. In 2019, more than 50 countries will distribute 5G spectrum, 60-plus operators will deploy large-scale 5G networks, and over 40 commercial 5G devices will be available.

This is the first time in nearly 40 years of mobile communications that network hardware and devices will have matured at the same time.

According to statistics, it took 10 years to reach 500 million 3G users globally, and for 4G it was 5 years. With 5G, it will take only 3 years. 5G is developing rapidly, and the market size of the first wave will far exceed that seen during similar periods for 3G and 4G.

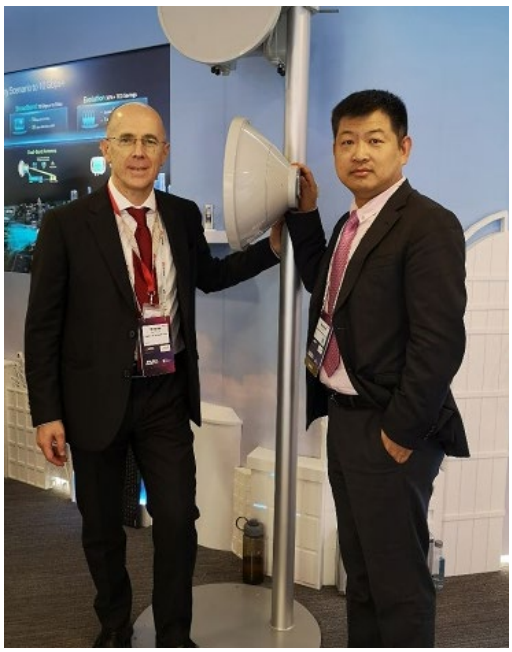
Simplified networks will accelerate 5G deployment

As operators embrace 5G development opportunities, they will also face challenges in this new era. These include increased complexity from multi-band, multi-RAT networks, and ever-increasing network O&M costs, with rental for indoor site equipment and energy costs surging year on year. Operators are eager to liberate site equipment from equipment rooms to reduce OPEX.

Huawei has proposed an LTE+NR target network construction concept for 5G era, which involves the gradual migration of basic voice, IoT, data services to LTE networks, and finally to 5G. This will transform LTE into a basic service bearer solution and create a network with simplified systems.

In terms of site deployment, Huawei has launched a new outdoor site solution for 5G, the Super Blade Site, which includes Blade RRU, Blade AAU, Blade BBU, Blade Power, and Blade Battery. Each boasts full-outdoor modular designs to solve the following site construction issues: large footprint, high rent, high energy consumption, and complex O&M. The Super Blade Site solution also fully leverages existing site resources to improve deployment efficiency. With sites simplified to "zero", operators' reliance on basic resources is reduced, enabling rapid site construction and substantially lowering site TCO.

According to statistics, it took 10 years to reach 500 million 3G users globally, and for 4G it was 5 years. With 5G, it will take only 3 years.



On the antenna mount deployment side, Huawei's "1+1" site helps operators to roll out full-band, full-RAT networks. Huawei's leading Blade AAU product integrates passive antenna and active Massive MIMO. The passive antenna supports full-band 4T4R on sub 3 GHz, while the active Massive MIMO unit supports C-band 64T64R. This offers a powerful solution for the issue of limited antenna mount space.

For microwave solutions, Huawei has launched simplified 5G microwave "1+2" architecture. The solution supports large bandwidth while minimizing demands on tower space. "1" dual-band antenna supports any combination of two frequency bands, alleviating space demands on towers, reducing TCO, and making upgrades easier. Meanwhile, "2" any-frequency-band (6 to 86 GHz) RF units provide up to 8 channels. One RF unit has 4 channels, four times higher than a traditional ODU, making this the only carrier aggregation ODU in the industry. The RF units support over 10 Gbps bandwidth for easier upgrades to large bandwidth microwave.

The high diversity of 5G deployment scenarios mean that only a simplified network will make it possible to handle complex deployment environments and accelerate the large-scale commercial adoption of 5G.

Developing the autonomous driving mobile network

With the advent of the 5G era, new standards and new services have led to exponential growth in various network parameters, as well as increased network complexity and O&M costs. In response, Huawei has unveiled a series of Autonomous

Driving Mobile Network solutions. These include the MBB Automation Engine (MAE) and the new BTS5900 base station, which offers more computing power. The two products can help operators achieve full-scenario automation, reduce network OPEX, and accelerate 5G construction by providing hierarchical autonomy, vertical coordination, O&M efficiency, resource efficiency, energy efficiency, and better user experience.

MAE acts as the brain of the mobile network, the control engine that enables wireless network automation. MAE enables two kinds of transformation: first, a shift from network-oriented O&M to scenario-oriented O&M, and second, a shift from simple network management to integrated network management and control. Leveraging a cloud data platform and powerful network prediction and reasoning capabilities, MAE provides various scenario-based solutions that closely match the needs of operators' deployment, maintenance, optimization, and service provisioning processes. The MAE also enables end-to-end closed-loop automation on each process.

Equipped with an additional 8 TFlops of computing power, the new BTS5900 base station also maximizes resource utilization through the high-precision management of wireless radio resources, including refined radio channel state, real-time matching, trend prediction, and rapid codec rate adjustment.

As the radio resource state managed by the base station changes every 0.1 ms, precise management calculations need to be completed in a very brief time. The shorter the processing time, the greater the computational power required. This calls for powerful computing capabilities to achieve precise management and a closed loop in the base station.

The hierarchical integration of the MAE and the BTS5900 automates whole sites, increasing O&M efficiency tenfold, boosting user rates by 30 percent, and cutting energy use by 30 percent. Huawei has already collaborated with a number of operators, and the autonomous driving mobile network solution is already generating value in some key scenarios.

Business simplification means 5G business success

MAE provides various scenario-based solutions that closely match the needs of operators' deployment, maintenance, optimization, and service provisioning processes.

In the initial phase of 5G, eMBB service is key. eMBB is the continuation and development of mature 4G business models. It primarily emphasizes three business forms: unlimited services, wireless home broadband, and Cloud X. Today, 70 percent of operators globally have launched unlimited services. Of these, 40 percent have boosted ARPU. In the coming unlimited era, there will be an increased need for differentiated network experiences and service experiences, including speed and latency.

Wireless home broadband

In the 4G era, wireless home broadband was a commercial success. In 2018, there were approximately 30 million more wireless home broadband users. According to the European Union's Digital Economy and Society Index Report 2018, in the EU fixed broadband speeds range from 7 Mbps to 23 Mbps while LTE rates range from 20 Mbps to 42 Mbps. In Finland and Italy, 37 percent and 23 percent of households respectively use LTE wireless technology to access the Internet. The 5G era is set to usher in a golden age of development for wireless home broadband.

Huawei's WTTx Wireless Fiber solution is based on LTE or 5G technology. It harnesses large bandwidth (over 40 MHz), Massive MIMO multi-antenna technology, and high-performance indoor and outdoor CPE. The solution boasts five main benefits: full-service support, fiber-like experience, rapid deployment, flexible service quality, flexible speeds on demand, and 5G-oriented evolution. At MWC Barcelona 2019, Huawei unveiled four new wireless fiber use cases: Wireless to the Home (WTTh), Wireless to the Enterprise (WTTe), Wireless to the Building (WTTb), and Wireless to the Camera (WTTc). More mobile operators are adopting wireless fiber to offer a variety of services. These include new FMC services, with bundled personal and family packages that enable rapid increases in revenue; stable broadband access for small and medium businesses; and remote cameras for image and video backhaul deployed in places with high satellite access costs, such as mines, oil fields, and marine fisheries. Wireless fiber will help more families cross the digital divide and drive the development of the digital society.

Cloud X: Smart devices, broad pipes, and cloud applications

Cloud X is a new service for the 5G era based on smart devices, broad pipes, and cloud apps. Cloud X will introduce new business models and become a key way that operators can use to expand their business scope.

Cloud X services include Cloud PC, Cloud Gaming, and Cloud AR/VR. These harness powerful cloud computing capabilities to overcome the performance limitations of individual devices, allowing for simplified,

lightweight devices, lowering usage barriers for consumers. 5G features such as low latency, large bandwidth, guaranteed networks, and operators' edge cloud infrastructure, provide the foundation for implementing Cloud X services. 5G and cloud are the twin engines that will drive Cloud X services.

Cloud enables devices to go beyond their inherent capabilities. Users no longer have to configure the chassis of on-premise PCs, use high-performance devices to play high-spec games, or require on-premise dedicated PCs for rendering AR/VR. With 5G, Cloud X services can be ubiquitous and will ensure a consistent user experience.

Huawei began exploring cloud PC services at a very early stage. In 2010, Huawei began to replace its office PCs with cloud PCs. Over the past 8 or so years, more than 80,000 Huawei R&D engineers have switched to cloud PCs. Huawei devices' latest EMUI 9.0 system has a built-in Cloud PC app, meaning that 100 million Huawei smartphones in the Chinese market now support cloud computing services.

Huawei's newly released Mate X – the fastest 5G foldable smartphone in the industry – will provide an unparalleled way to experience Cloud PC and Cloud Gaming. By connecting to the Cloud Gaming service via a 5G network, it will be possible to run triple-A games at 4K resolution/60 fps on smartphones, transforming them into super gaming devices.

Cloud PCs will form the infrastructure for Cloud VR. Operators will be able to use Cloud PC service platforms and add GPU rendering capabilities, Cloud VR service middleware, and Cloud VR applications can easily build Cloud VR service platforms. Huawei unveiled a global version of its 5G Cloud VR service at MWC 2019, launching the industry's first public-cloud Cloud VR virtual machine service.

The technical feasibility of Cloud PC, Cloud Gaming, and Cloud VR has been verified on a live network. Now the industry must build a sound ecosystem and provide better 5G network services.

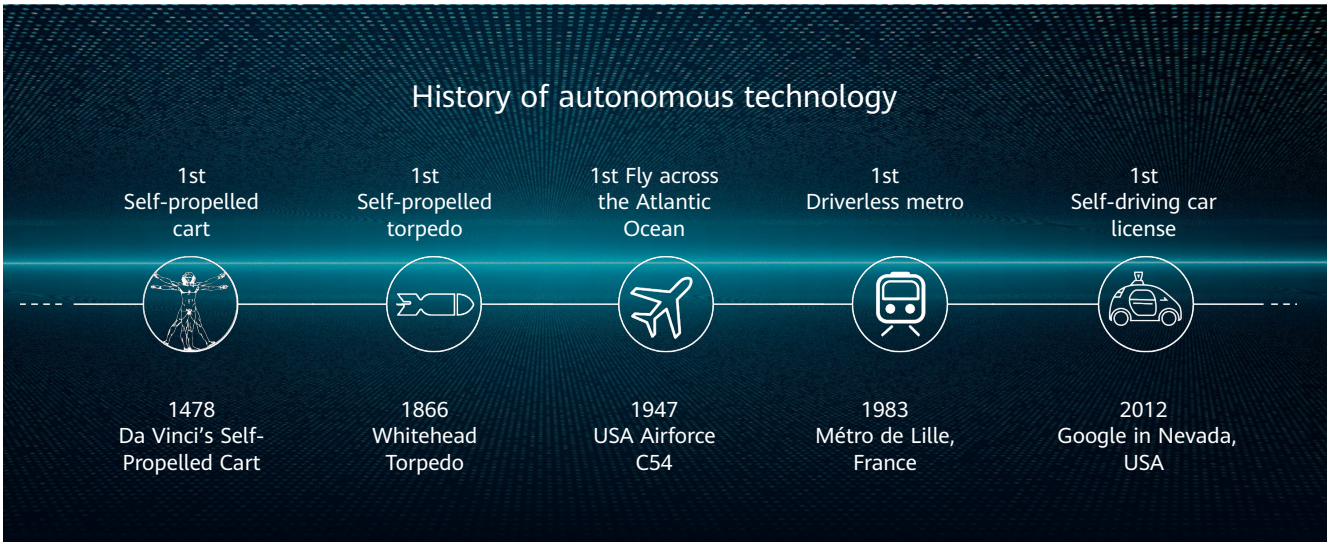
In the future, 5G will enable industry-wide digitalization, opening up more revenue sources for operators. Huawei is actively exploring new applications in its X Labs with more than 280 partners worldwide. In addition, Huawei hopes to work with operators to discover more application scenarios and develop the simplified 5G network to embrace rapid development in the 5G era.

Cloud enables devices to go beyond their inherent capabilities. Users no longer have to configure the chassis of on-premise PCs, use high-performance devices to play high-spec games, or require on-premise dedicated PCs for rendering AR/VR.

Moving towards autonomous driving networks

Each new industrial revolution from industrialization and digitalization to today's focus on robotics and artificial intelligence (AI) has seen giant leaps in industrial efficiency.

By David Wang
Huawei Executive Director of the Board, Chairman of Investment Review Board



In 1947, the US completed the first autonomous transatlantic flight. In 1983, the world's first driverless metro, the Métro de Lille, went live in France. 2012 saw Google obtain the world's first self-driving car license in Nevada and by March 2018, its self-driving cars had traveled 8 million kilometers. Today, with the massive strides made in autonomous driving technologies, companies like Tesla are making it possible for people to travel in comfort in an eco-friendly way. In the fully connected and intelligent era, autonomous driving is becoming a reality.

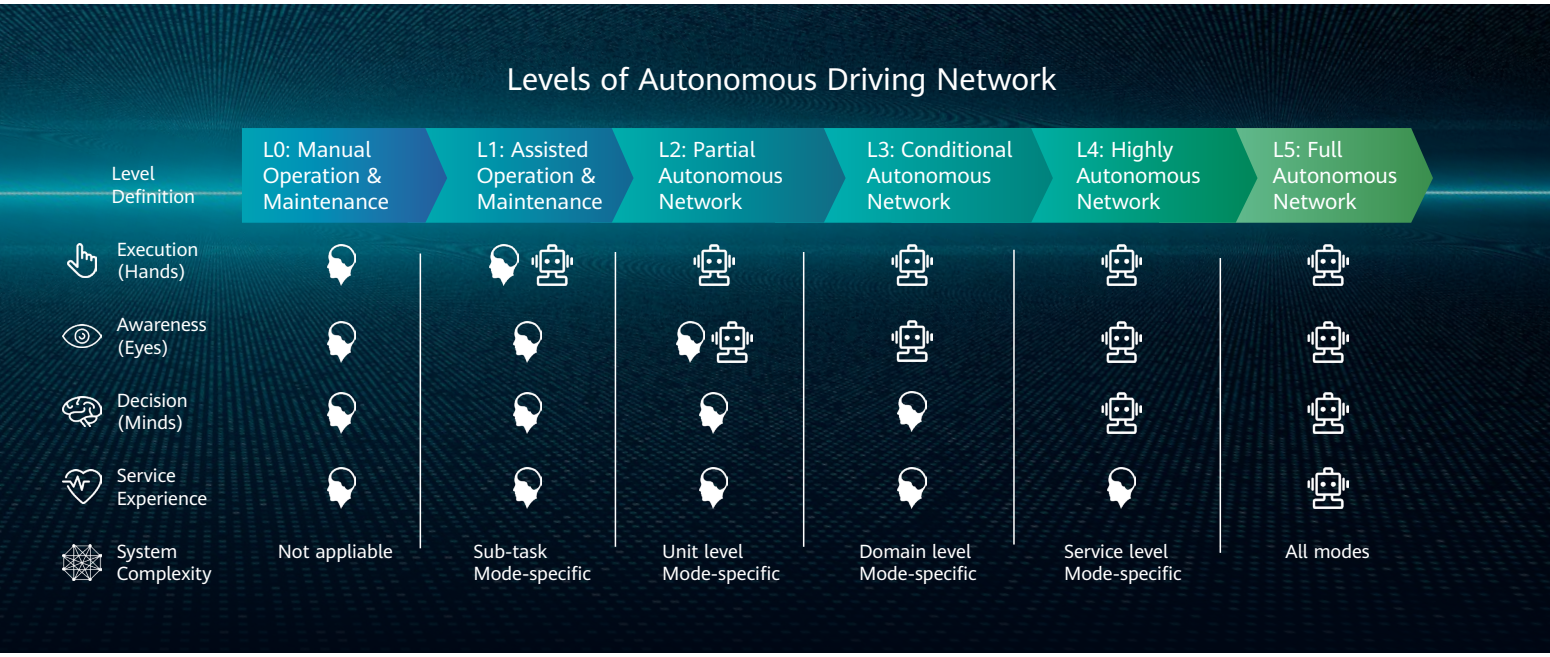
Why telcos need autonomous driving networks

As networks have increased in size, so has OPEX. Over the past decade, OPEX growth has always outstripped revenue growth for telcos, in turn causing structural challenges to the telecoms industry. For example, 249 engineers can maintain one million devices for OTT companies compared with about 300 engineers maintaining 10,000 devices for operators, as a result of the higher O&M skillset the latter requires.

Telecom networks also face huge challenges in managing user experience – 58 percent of people's problems with home broadband are only identified when they file a complaint.

Unlike the autonomous vehicle market, the telecom industry faces unique complexities. A telecom network provides multiple services such as mobile, home broadband, and enterprise services. Therefore, an autonomous driving system must accurately understand the intent behind different services. In contrast, the operating environments and road conditions of autonomous driving feature "highways" of data centers as well as "urban and rural roads" that provide broadband access for citizens. Therefore, autonomous driving systems must be able to adapt to complex environments that involve multiple technologies. From the perspective of full lifecycle operations, different roles, such as planning, O&M, and service provisioning, face different challenges.

Huawei has been exploring autonomous driving networks with operators in an attempt to address the structural issues of telecom networks through innovative architecture, helping operators achieve a better service experience and higher operational and resource



efficiency.

5 levels of Autonomous Driving Network

Autonomous driving networks go far beyond innovating a single product and are more about innovating system architecture and business models, which requires industry players to work together to define standards and guide technology development and rollout.

Huawei has proposed five levels of Autonomous Driving Network systems for the telecom industry:

L0 manual O&M: delivers assisted monitoring capabilities and all dynamic tasks must be executed manually.

L1 assisted O&M: executes a certain sub-task based on existing rules to increase execution efficiency.

L2 partial autonomous networks: enables closed-loop O&M for certain units under certain external environments, lowering the bar for personnel experience and skills.

L3 conditional autonomous networks: builds on L2 capabilities, so the system can sense real-time environmental changes, and in certain domains, optimize and adjust to the external environment to enable intent-based closed-loop management.

L4 highly autonomous networks: builds on L3 capabilities to accommodate more complex cross-domain environments and achieve predictive or active closed-loop management of service and customer experience-driven networks. Operators can then resolve network faults prior to customer complaints, reduce service outages, and ultimately, improve customer satisfaction.

L5 fully autonomous networks: represents the goal of telecom network evolution. The system possesses closed-loop automation capabilities across multiple services, multiple domains, and the entire lifecycle for true Autonomous Driving Network.

Step by step

Evolution towards autonomous driving networks must be scenario-

based and follow three key principles. One, we should focus on major issues relating to OPEX. Having analyzed the OPEX structures of several typical operators, it appears that 50 percent of current OPEX challenges can be addressed through autonomous driving networks. Two, we need to start from single domains and tasks before moving to multiple domains and tasks, and then form a closed-loop system. Three, we must develop experience-driven and top-down data models and sharing capabilities.

Reference architecture of autonomous driving networks

One of the major difficulties when it comes to autonomous driving is sensors and how to deal with various uncertainties. Whether on a highway or a rural road, vehicles need to be able to accurately identify their surrounding environment and respond quickly. Sensors – radar, microwave, and laser – detect surrounding road conditions. Local, edge, and cloud computing enable vehicles to respond accurately to various scenarios such as emergency braking, pedestrian crossings, and uphill and downhill gradients.

Telecom networks today are encountering similar problems when developing autonomous driving. With perception, there are problems with unclear and inaccurate telecom network statuses. With O&M, discrete and closed systems cause data fragmentation and process separation. Cross-field and cross-vendor data flows are difficult to transfer and get value from. At the same time, telecom networks aren't completely intelligent – making decisions and processing uncertainties depends almost entirely on the experience of engineers and experts.

So, what's our solution?

Autonomous driving in the telecom industry requires us to systematically reshape and innovate the network architecture and key technologies, and to construct a three-layer intelligent system architecture.

First, we need to build an edge intelligence layer on physical networks to sense network status in real time, and simplify network architecture and protocols to improve network automation capabilities.

Second, we will use unified modeling to build digital twins on physical networks to make network status traceable and predictable. AI can also be introduced to enable predictive O&M and closed-loop optimization.

Finally, an open cloud platform is needed to train and optimize AI algorithms and develop applications for planning, design, service provisioning, O&M guarantees, and network optimization. The aim is to automate closed-loop network operations throughout the entire lifecycle.

The future of autonomous driving networks

At Mobile World Congress 2018, Huawei launched its Intent-Driven Network (IDN) solution, which builds a digital twin between

We should focus on major issues relating to OPEX. Having analyzed the OPEX structures of several typical operators, it appears that 50 percent of current OPEX challenges can be addressed through autonomous driving networks.

physical networks and business goals, and helps evolve networks from SDNs towards autonomous driving networks. The solution also helps operators and enterprises implement digital network transformation centered on service experience.

The solution requires the industry to undertake four transformations: from network-centric to user-experience-centric; from open-loop to closed-loop; from passive response to proactive prediction; and, from skill-dependent to automation and AI.

Huawei's IDN solution covers various scenarios, including broadband access, IP networks, and optical and data center networks. It enables telecom networks to evolve towards Autonomous Driving Networks.

For example, in the broadband access field, for every 10,000 users, there's an average of 1,000 customer complaints and 300 door-to-door maintenance visits every year. Due to a lack of data, about 20 percent of customer complaints cannot be completely resolved. The IDN, however, perceives broadband services in real time. Big data and AI algorithms quickly locate faults and optimize the network, which reduces home visits by 30 percent and improves service experience.

In September 2018, Huawei upgraded its Intent-Driven Network (IDN) solution and proposed its "digital world + physical network two-wheel drive" strategy to speed up IDN innovation.

Huawei is also accelerating the deployment of autonomous driving networks in wireless network scenarios. At the 9th Global Mobile Broadband Forum, Huawei released the *Key Scenarios of Autonomous Driving Mobile Network white paper*, which outlines seven key sub-scenarios, such as base station deployment and network energy efficiency, to gradually realize network automation. As research advances, Huawei will continue to update its application scenarios and publish its research results.

Huawei and leading global operators have jointly launched the NetCity project aimed at promoting the application of new technologies such as big data, AI, and cloud computing in telecom networks. By defining business scenarios and implementing innovations following the DevOps model, Huawei and its operator partners have introduced cutting-edge technologies to improve users' service experience, driving telecom networks to evolve towards Autonomous Driving Networks.

As of the end of 2018, Huawei had joined forces with leading customers to launch 25 NetCity innovation projects. It will be a long journey to achieving autonomous driving networks. To make our dream a reality, the industry must work together. Huawei is committed to developing leading ICT solutions through continuous innovation, and taking on the complexity itself while making things simple for customers. Together, we will embrace a fully connected, intelligent world.

By Edward Deng
President of Huawei Wireless Solutions

SingleRAN Pro enables simplified target networks in the 5G era, leading the MBB industry to new heights

5G is on the fast track for widespread commercial deployment in 2019. According to GSMA, 139 operators in 70 countries are currently conducting 5G trials, and 117 5G networks are expected to be deployed for commercial use by 2025. Huawei has already signed 30 5G commercial contracts with global operators, and delivered more than 40,000 5G base stations around the world.

With powerful network performance, Gbps-level data rates, and millisecond-level latency, 5G networks will open up new business opportunities. There will be new Cloud X business models for individuals (cloud applications, broad pipes, and smart terminals), Wireless Fiber solution for home broadband (HBB), Cellular Internet of Things (C-IoT) for vertical industries, and a cellular vehicle-to-everything (C-V2X) network for the Internet of Vehicles (IoV) industry. Massive wireless connectivity has become an inevitable trend and a fully digitalized, intelligent life is coming.

However, new opportunities come with new challenges. OPEX reduction is becoming operators' primary concern. The total cost of ownership (TCO) of a site is high; and today's multi-RAT (2G/3G/4G/5G) networks are complex and difficult to maintain. In addition, due to limited 4G network coverage, voice services in some regions have to fall back to 2G/3G networks, which impacts user experience with these services. Limited 4G coverage also means that

The critical issues for operators today are how to evolve existing networks and how to rapidly roll out 5G while continuing to support business development.

the development of Narrowband Internet of Things (NB-IoT) and enhanced Machine Type Communication (eMTC) services will be restricted, which further hinders the phaseout of legacy 2G/3G networks. The critical issues for operators today are how to evolve existing networks and how to rapidly roll out 5G while continuing to support business development. SingleRAN Pro is the key to simplifying the target network in the 5G era, and to leading MBB industry to new heights.

"LTE Evolution+5G NR" is gaining the industry's consensus for 5G wireless target networks.

Network evolution over the next five to ten years can be divided into two phases: First, all sub-3 GHz bands will evolve to LTE and make the LTE network a fundamental network while 5G NR is being introduced. In the second stage, these sub-3 GHz bands will be gradually evolved to support 5G NR. We believe that the wireless target network in the 5G era will evolve to "LTE Evolution+5G NR" and the LTE and 5G networks will coexist for a long time.

SingleRAN Pro enables the simplified target network in the 5G era.

There are three elements of the evolutionary strategy for the 5G target network: site simplification, RAT simplification, and network intelligence.

Site simplification changes site deployment, enables full-outdoor base stations, and reduces site deployment difficulty and TCO.

The cost of site engineering, construction, and rental fees, and the acquisition of transmission resources accounts for more than 40 percent of site TCO. To reduce TCO, we need to change how sites are deployed.

Antenna reconstruction is required for 5G deployment on the new frequency bands. Huawei created the "1+1" antenna solution to address this challenge. With this solution, passive antennas for sub-3 GHz bands can be installed horizontally or vertically with Massive MIMO antennas, allowing for the accelerated deployment of Massive MIMO. In scenarios where it's difficult to run the optical fibers out to the sites, Huawei provides full-outdoor microwave products (supporting 10 Gbps+ data rate) to help handle the entire 5G backhaul, so that operators can roll out 5G networks faster.

To address the difficulty in site acquisition and high rental costs, Huawei has proposed the Super Blade Site solution. It consists of not just blade RRUs, BBUs, but also a blade power supply and a blade battery. These Super Blade sites can be installed on a pole, tower, wall, or rooftop, anywhere you want. This new solution features a modular design that doesn't require cabinets or even an equipment room, enabling full outdoor site deployment for the 5G era.

RAT simplification breaks through limits to spectrum use and realizes "LTE Evolution+5G NR".

The industry is transitioning from addition to subtraction. Instead of figuring out how to add a new RAT, the question today is how to retire one or two old ones. Modernizing

2G/3G networks means a transition to 4G/5G networks. Huawei recommends a three-step process. First, develop 4G into a full-service fundamental network, a network that can fully replace the coverage provided by 2G and 3G networks combined. Second, preferentially cultivate new 4G and 5G users while migrating 2G and 3G users to more advanced networks. Then finally, when the number of 2G/3G users declines to a certain level, retire the 2G and 3G networks.

Huawei has developed the CloudAIR™ and SuperBAND solutions to ensure a smooth transition. To ensure 4G coverage and a smooth transition between RATs, CloudAIR™ frees up valuable low-frequency spectrum for 4G networks by facilitating GSM/UMTS/LTE spectrum sharing. Universal 4G coverage is provided at low cost. The evolution from 4G to 5G is also ensured as a result of dynamic spectrum sharing between 4G and 5G NR. The SuperBAND solution aggregates scattered spectrum bands. It allows for flexible, unified spectrum allocation, maximizing the spectral efficiency.

Network intelligence implements a shift from NE-centric O&M to full-scenario automated operations by introducing automation capabilities into sites, networks, and the cloud.

The launch of automated intelligent (autonomous driving) networks goes far beyond a single innovative new product. It represents a significant breakthrough in network system architecture and business models, and introduces automation capabilities into sites, networks, and the cloud.

The sites will be provided with real-time analysis and fast, efficient decision making with extremely low latency. At the network level, operations and maintenance (O&M) will no longer focus on NEs. It will focus on specific service scenarios. Management and control functions will combine to provide predictions, reasoning, and identification capabilities. Mobile networks will be automated. And in the cloud, intelligent modeling and machine learning will be added to operators' cloud systems. Operators can have their AI models and services continuously upgraded. Currently, many operators see energy efficiency as an integral part of reducing OPEX. Huawei's PowerStar™ solution is a strong example of network automation.

At the 2019 Mobile World Congress, Huawei launched a series of solutions for autonomous driving mobile networks, including the MBB Automation Engine (MAE) and BTS5900 series base stations with powerful computing capability.

The past decade has witnessed rapid development and great prosperity in the mobile broadband industry. SingleRAN has led the industry in terms of technological innovation and business development, substantially reducing CAPEX. In the future, addressing the high OPEX will be the industry's top priority. SingleRAN Pro will help build a target network featuring site simplification, RAT simplification, and network intelligence, and continuously support operators' business development. Huawei is keen to collaborate with global operators and industry partners to keep innovating, realize 'Everything Wireless First', and bring the MBB industry to as new level of advancement and prosperity."

A roadmap for operators in the 5G and cloud era

By Kevin Hu
President of Huawei Network Product Line

In 2018, the curtain rose on 5G commercial adoption. Data from Huawei Global Industry Vision (GIV) shows that by 2025, daily communication traffic per capita will hit 4 GB. Cloudification is pervading enterprise and industry digital transformation – 85 percent of enterprise applications will undergo cloudification, driving change in network traffic models.

As we look to the future, what kind of network do operators need to build to support the network requirements of the 5G and cloud?

Three challenges for operators

- How to invest in networks so data traffic can increase tenfold every five years.
- How to support a 10x increase in network size and complexity with simplified network architecture.
- How to improve end-user experience with proactive O&M to move beyond complaints-initiated O&M.

Transforming the structural problems of telecom networks requires innovation in system architecture. Operators' existing network architecture has generally failed to support the development needs of future services. In particular, with service development models increasingly focused on user experience, telecom networks will only be able to meet service needs by fully switching to a future network architecture that's driven by user experience.

In 2018, Huawei released its Intent-Driven Network (IDN) solution based on this goal. The solution enables operators to evolve from legacy networks to a target network architecture that's user-centric by building a digital twin that bridges the physical network and business intentions, and is driven by user business logic and service strategy intentions.

Working with customers

To build networks that are intelligent, simplified, ultra-broadband, open and secure, Huawei launched a series of IDN-based joint innovations with leading global operators and enterprise customers, exploring the solutions using the innovative NetCity model and implementing DevOps. The value of IDN has been gradually verified on live networks, further accelerating the progress of IDN innovation.

NetCity is a joint innovation mechanism based on the IDN concept. In NetCity projects, Huawei collaborates with world-leading operators and enterprises/industry customers to implement fast closed-loop technology innovation and business innovation through joint business design, defining use cases, DevOps iterative development, and local lab verification.

At Mobile World Congress 2018, Swisscom and Huawei jointly signed strategic cooperation MoU for the NetCity project, committing to jointly build a world-leading, highly reliable next-gen network infrastructure to provide new communication network services and the best user experience for Swiss users.

At Huawei Global Analyst Summit 2018 in April, Ping An Technology and Huawei signed a joint innovation agreement to innovate IDN and promote digital transformation in the financial sector.

In May 2018, China Mobile Beijing and Huawei signed a MoU covering big video and a premium network in Shenzhen. China Mobile Beijing will build competitive strengths in future-oriented networks based on Huawei's innovative quality broadband solutions, and gradually evolve towards IDN.

Huawei's Intelligent Transportation solution offers unique competitive strengths in many areas to support road digitalization and vehicle-road synergy.

In October 2018, during HUAWEI CONNECT, Huawei and China Merchants Bank (CMB) announced plans to reconstruct the bank's data plane, operation plane, and O&M plane through joint innovation. This will help CMB carry out digital transformation and drive retail 3.0.

By the end of 2018, Huawei had cooperated with world-leading customers to launch 25 NetCity innovation projects covering multiple application scenarios, including premium broadband, 5G transport, IP metropolitan area, optical transmission, data centers, and enterprise campuses. In total, 61 commercial use cases have been incubated.

During joint innovation with customers, Huawei iteratively upgrades IDN to better support global customers' network development needs. In the operator sphere, Huawei upgraded its telecoms-oriented IDN solution in September 2018, and proposed a two-wheel drive strategy to span the digital and physical worlds and speed up the progress of IDN innovation. The solution has three core benefits:

- Introducing a network brain to build an intelligent network.
- Supporting service model innovation through network-service separation.
- Dealing with the surge in network traffic through Moore's Law for networks.

Intelligent Network Brain

It's crucial to fully consider the end-to-end network as a whole. And building a unified network brain is key. Huawei's IDN solution includes the industry's first network cloud engine (NCE). The innovative NCE integrates management, control, analysis, and AI functions, and consists of four engines: intent, automation, analysis, and intelligence. They form a full-lifecycle complete closed-loop driven by the data on which the intelligent network brain is built. For operator scenarios, NCE has four key benefits.

Achieving user-centric operations by building a digital twin for the physical network. Based on telemetry technology, NCE enables the real-time collection of physical network data, and constructs a digital twin for the end-to-end physical network. This supports real-time perception of the physical network and the playback of physical network historical states, allowing operators to implement user intention-based predictive network operations.

Full-lifecycle closed-loop management using digital twins. NCE harnesses the digital twin to integrate previously fragmented, discrete network data. It enables closed-loop, automated and smart management covering digital planning and design, simulated and visual assessments, automated physical deployment, and continuous authentication. This supports full-lifecycle closed-loop operations for end-to-end networks.

Exclusive Design Studio forms a programmable platform that accelerates network service innovation and IT integration. As part of NCE, we launched the innovative Design Studio open platform to support network programming. The platform integrates operators' strengths in network operation experience as well as manufacturers' strengths in product innovation, shortening the service innovation cycle. NCE is based on an open north-south interface – it can already connect with seven mainstream cloud platforms and has passed the integration and testing certification of over 40 industry partners.

Building use cases service models based on service scenarios to drive business closed-loops. Aimed at different operator service scenarios, the NCE has a service-centric service model for different business scenarios and use cases. We've also launched a series of scenario solutions through joint innovation and verification incubation with customers.

Network and service separation

Compared to OTT companies' simplified network architecture and

automated service delivery, the problems plaguing traditional carrier networks, such as complex architectures and low service delivery efficiency, are especially striking. The main issue is that carrier networks are coupled with services. Service changes necessitate network changes. This leads to problems such as low network efficiency.

Huawei IDN builds a stable and reliable network bearer layer and an agile network service layer. This helps operators to separate the network from services and innovate system architecture.

The network bearer layer provides capabilities for agile automation and differentiated SLAs for connection services. Constructing an all-optical base and implementing ubiquitous one-hop transmission with OTN technology supports point-to-point, point-to-multipoint, and multi-point to multi-point connection services. The bearer layer automatically establishes connections to the pipe based on service connection intent. Introducing the unified SR/SRv6 network protocol, SR-based differentiated latency guarantees, and bandwidth-capable connection services enable seamless networking for the bearer layer.

The network service layer provides a barbell-type architecture that enables business automation. Layered decoupling of the network improves service agility and unifies cloud and service side access models, creating a foundation for network automation, and drives the on-demand smooth evolution of the service layer BRAS, ultimately enabling full cloudification.

Dealing with traffic surges

Ultra-broadband is still the cornerstone of future network evolution. Huawei continues to promote innovation in physical networks, applying Moore's Law to support cyclical improvements in network equipment capacity and reduce bandwidth cost per bit.

In the access network domain, Huawei has introduced technologies like XGS PON and PON Combo, doubling access network bandwidth every four years. Huawei's next-generation high-capacity distributed intelligent OLT platform MA5800 supports compatibility with six types of PON on the same board, supporting ultra-long-distance coverage that surpasses industry competitors by 10 km.

In optical networks, Huawei has doubled the capacity of optical network equipment every three years using innovative technologies including oDSP chips, silicon photonics, and Super C spectrum. It released the industry's first commercial OXC (all-optical switching) equipment, which has already been widely commercially adopted.

In the IP field, Huawei has doubled the capacity of router equipment every two years with innovative technologies like NP chips, and cable backplanes, reducing the cost per bit.

Developing IDN is a process of continual evolution, and it's the road that must be taken before we arrive at autonomous driving networking. Looking to the future, Huawei will work with global partners to accelerate the progress of IDN innovation, promote the mature rollout of the IDN industry, and jointly build a fully connected, intelligent world.

Layered decoupling of the network improves service agility and unifies cloud and service side access models, creating a foundation for network automation.

Pushing bandwidth limits and moving towards optical networking 2.0

By Richard Jin
President of Huawei Transmission and Access Network Product Line

According to a new GSMA study, the number of 5G connections globally will reach 1.3 billion by 2025, covering 40 percent of the world's population. And the number of 5G connections will reach 1.4 billion by 2025. 5G will bring key growth opportunities for immersive personal services such as VR, AR, and live streaming. It will revitalize the enterprise market and power new business models for fields like vehicles, drones, and smart manufacturing.

Today, more than 967 million households have broadband access, and 286 operators in 49 countries provide gigabit broadband services. What's more, the emergence of smart home appliances and related services will promote new business models centered on homes.

The fast development of innovative 2C, 2B, and 2H services will drive the CT industry to enter a new development era. However, existing optical networks are unable to support the fast growth of these services and severely hamper the business growth of operators.

The development of bandwidth-driven transport networks faces severe challenges

In the 2C field, due to unlimited data plans becoming more common, operators are finding that revenue is not increasing at the same rate as data usage. In the 2B field, operators face increasing challenges from cloud service providers (CSPs). Specifically, in addition to being unable to match the flexible

provisioning of enterprise services and on-demand services offered by CSPs, operators cannot make the most of their advantages in network connections, and the strategic market of enterprise digitalization is shrinking. In the 2H field, bandwidth is increasing, but user experience is not improving. As a result, end users are not interested in the emerging services of operators. The bandwidth-driven business model can no longer support the business growth of operators. On the contrary, it exacerbates problems, such as the lack of optical fiber and equipment room resources. Meanwhile, service diversity makes networks more complex, which in turn increases network O&M costs. This leads to OPEX accounting for 70 percent (and rising) of the TCO for a large number of operators.

In terms of transport network development, the development model of the industry is facing a bottleneck. In the past 10 years, operators have upgraded their basic transport networks from copper to all-fiber, solving the problem of limited network capacity. Deploying fiber optics access networks for broadband Internet access and WDM in transmission networks for large-capacity service transmission has enabled operators to increase network bandwidth from 512 kbps to 10 Mbps 100 Mbps and even 1 Gbps and 10 Gbps. After moving to all-fiber networks, optical transport network evolution will be achieved by progressively ramping up the single-carrier rate from 10 Gbps to 40 Gbps, 100 Gbps, and 200/400 Gbps. However, Shannon's theorem states that channel capacity (single-carrier rate) is limited by channel SNR (transmission distance) and channel bandwidth (effective spectral width). Thus, the single-carrier rate cannot be increased indefinitely. By increasing the optical network's single-carrier transmission rate beyond 200/400 Gbps, the Shannon limit is quickly approached. And at 200/400 Gbps, balancing transmission rate and transmission distance becomes extremely challenging. For optical access networks, the uplink and downlink rate of home networks are improving, from EPON/GPON, 10G EPON/10G GPON, XGS-PON. While focusing on improving bandwidth in the optical access network domain, operators failed to ensure end-to-end service quality. The root cause is that such a bandwidth-driven development model of transport networks can no longer support the business growth of operators.

Redefining optical networking

The global optical network industry is experiencing a generational inflection point. The upstream and downstream partners in the industry need to think about the development direction of the next-generation optical network, and the consensus of the industry is that the next-generation optical network must be constructed based on user experience.

We believe that the next-generation optical networks need to have the following three key features:

Bandwidth upgrade as per Moore's law of bandwidth: The capacity of optical network devices must go up and the per-bit cost must go down through technology innovation to meet the bandwidth requirements of innovative services.

Simplified sites: Networks need to be flattened and site integration needs to be improved to continuously reduce network construction costs, including those incurred from equipment room space, equipment and air conditioning power consumption, and manual fiber connection and grooming.

Evolution to autonomous-driving networks: Networks must be autonomous and intelligent to support the agile provisioning of new services, shorten the time to roll out new services, and achieve intelligent O&M, of which the latter implements accurate fault prediction and automatic fault locating to reduce OPEX and provide end-to-end O&M assurance for end users.

Future optical networks will no longer be dumb pipes. They will be key to ensuring optimal experience of end users. We need to shift our mindset

from bandwidth-driven and pipe-focused to experience-driven and user-focused, with the aim of flexibly allocating resources on optical networks based on user requirements. This enables the business success of operators while ensuring optimal user experience. To this end, Huawei proposes the concept of Optical Networking 2.0 (ON2.0).

Huawei's ON2.0 showcased at MWC 2019

Huawei is committed to building ubiquitous connectivity and expects the cooperation between upstream and downstream partners to jointly promote next-generation optical networks centered on user experience. With this in mind, Huawei launches the ON2.0 strategy to enable the generational evolution of the entire optical network industry in these areas: new speed, new site, and new smart O&M.

New speed: Single-carrier 200/400 Gbps will be a standard rate for the next generation of optical transmission, which will be pushed closer to the Shannon limit through chip and spectrum innovation. Symmetric 10G PON will be used as the next-generation optical access standard, and Wi-Fi home access with assured experience will be achieved through continuous innovation in the last mile such as ODN and ONT.

Huawei has launched the industry's first single-fiber Super C solution, improving fiber resource utilization by 50 percent. Huawei's Super 200G/400G solution uses the latest OptiXtreme series oDSP chips and supports rates ranging from 200 to 600 Gbps. The symmetric 10G PON ONT, which supports Wi-Fi 6, provides up to 10 Gbps of bandwidth in both uplink and downlink directions, zero-freezing Wi-Fi experience, and full-coverage with no blind spots, allowing home users to enjoy carrier-class Wi-Fi experience.

New site: The wide application of optical-electrical convergence and all-optical cross-connection will be promoted through continuous innovation in optical and electrical layers, and backbone and metro networks will be flattened to achieve unified transmission of 2C, 2B, and 2H services. Unified access over multiple types of media such as coaxial, copper, and optical cables will be implemented through innovations in technologies and platforms, supporting multiple PON access modes and significantly simplifying CO sites.

Huawei has launched the industry's first all-optical switching OXC product, which achieves zero fiber connection within the site, reduces the equipment room footprint by 80 percent and power consumption by 60 percent. In addition, Huawei uses its proprietary OTN+ chip to implement converged transport at different service granularities and in different 5G scenarios, such as 2B, 2C, and 2H. The chip reduces latency by more than 80 percent and improves bandwidth utilization by more than 30 percent, significantly reducing both the number of different devices required and O&M costs. Huawei also launched the industry's first 6-mode Flex-PON2.0 solution to help operators protect existing investments, reduce engineering and reconstruction costs, build simplified CO sites, and reduce TCO by 20 percent.

New smart O&M: Intelligent optical networks will be built, and automated and intelligent solutions will be developed to achieve automatic service provisioning and intelligent network O&M, which in turn will greatly shorten new service rollout, reduce network fault rate, and improve O&M efficiency and user experience.

Huawei has launched the industry's first intelligent home broadband O&M solution. The solution reduces onsite visits by 30 percent through accurate fault diagnosis, improves onsite troubleshooting efficiency by 20 percent through the online analysis of user-reported faults, and supports end-to-end network topology inference and network status playback for fast network fault location.

Huawei has also launched a premium private line solution, which ensures lifecycle O&M and shortens TTM by 20 percent through visualized management and analysis of network resources and fault prediction. The solution also uses an AI algorithm and vast fault expert database to perform deep machine learning, transforming O&M from passive reaction to proactive prevention. The solution supports one-click intelligent optimization, which, combined with alarm compression and root cause location, improves O&M efficiency by 30 percent. Huawei has also launched the Network Cloud Engine (NCE), the industry's first cloud engine that integrates management, control, and analysis functions to build a digital brain for networks and support lifecycle automation.

Accelerating the business incubation and innovation with ON2.0

In addition to ON2.0, Huawei is also promoting the business incubation for innovating optical network technology, realizing a closed loop of technology innovation, industry innovation, and business innovation. Huawei has worked with operators to formulate innovative business models in many new fields, helping them maximize their business value.

In the high-speed transmission domain, UAE's telecom operator Etisalat and Huawei jointly completed the industry's first pilot of a single-carrier 600G trial site in February 2019. This pilot cements Etisalat's leading position in transport network technological innovation, and verifies the readiness of single-carrier 600G technology for large-scale commercialization, supporting the development of emerging services of Etisalat. This innovative pilot has verified the planned items, particularly key performance indicators (KPIs), such as transmission performance, stability, and reliability indicators, which exceeded our expectations.

In the enterprise private line domain, Huawei helped China Mobile build the world's largest OTN premium private line network in November 2018. The premium private line network has optimal latency, wide coverage, high reliability, and the ability to support cloud-and-network synergy, helping China Mobile significantly improve the competitiveness of its private line products and expand its business in the high-value government and enterprise market.

In the premium broadband access domain, Huawei and China Mobile started joint innovation in February 2019. By using Huawei's intelligent home broadband O&M solution, China Mobile Beijing significantly improved user experience and O&M efficiency and reduced onsite visits and user churn rate.

Looking to the future, Huawei is also working with the world's leading operators to explore service scenarios for next-generation optical networks, launching NetCity joint innovation projects and using DevOps to quickly implement solutions and help operators maximize business value. We believe that there's still extensive room for development in the optical network industry and that ON2.0 will lead the industry into this new age of development. Huawei will work together with operators and industry partners globally to implement a new era of optical networks and build a fully connected, intelligent world.

Building E2E IP networks for the 5G and cloud era

By Gao Ji
President of Huawei Router & Carrier Ethernet Product Line

Thanks to their strengths of reachability, interoperability, and flexibility, IP networks have grown over the past 30 years to become the foundation of ICT information networks.

Today, all Internet traffic is connected using the large-scale distributed router system. However, improving the utilization rate of IP networks and realizing new congestion-free, high-availability IP networks for the 5G and cloud era is a key goal for operators.

Congestion-free, high-availability

In its earliest design form, the router was developed as part of the US Department of Defense's Advanced Research Projects Agency Network (ARPANET), with its main function being to interconnect heterogeneous networks. It also reroutes traffic during network failures, and is ultimately designed to support a highly accessible distributed interconnected system.

IP networks forward traffic based on a destination IP address. Paths between nodes and global network topology are calculated with standardized IGP or BGP. Routing tables are updated based on changes in network routing. Since the standard routing system uses the shortest path tree algorithm, it's easy for the IP load on IP networks to become unbalanced. On the same network at the same time, the load on some links may exceed 90 percent, while on others it's just 10 percent. Just as with the road network system, this kind of situation is likely to cause some network utilization to be too high, resulting in congestion and packet loss, while utilization of other links is very low, leading to wasted network resources.

To solve this problem, traffic engineering technology was developed, and today traffic tuning algorithms are being continuously optimized. Manually planning network configuration supports scheduling and O&M of the routing system.

The advent of the 5G and cloud era will bring higher demands on the network from various service applications. There's an urgent need to rethink the design of router network architecture. AI can be harnessed to create a semi-distributed, semi-centralized system on top of the traditional distributed system. This will better support requirements for traffic engineering, QoS, high utilization, and the high self-healing capabilities of 5G and cloud era networks.

AI can be harnessed to create a semi-distributed, semi-centralized system on top of the traditional distributed system.

5G and cloud services will place demands on networks in three main respects.

First, the emergence of VR/AR and 4K/8K live broadcast will require 10x more network capacity, but network construction costs must not change significantly. Meanwhile, with telecom service cloudification accelerating, a large amount of telecom cloud deployment has moved down the network, and cloud network convergence has become a problem that operators must face in network deployment.

The key is a simplified network core in the target network architecture design. When improving network capacity, existing IP network architecture needs to be simplified and the node functions integrated to realize cloud-network synergy.

Second, according to *Huawei's Global*

Industry Vision 2025, the number of global connections will reach 100 billion by 2025. At the same time, there will be an explosion in growth of not only north-south traffic but also east-west traffic, due to the large number of enterprises migrating to the cloud. Various interactive experience services and financial private lines will also impose more stringent demands on latency.

This will pose a considerable challenge on the scheduling capability of IP networks. Manually configured networks based on traditional traffic engineering and traffic optimization technologies cannot meet network optimization requirements for high levels of complex traffic. Solving this requires adopting AI-oriented global traffic engineering and queue management to realize network-wide, global service scheduling through network-wide automation.

Third, with the rapid development of 5G and cloud services and increased bandwidth, the complexity of service traffic and latency requirements will rise, and network complexity will grow. The traditional command-line user interface-based O&M model cannot meet the future requirements of network O&M. There is an urgent need for automated, smart O&M systems to enable smart O&M through network self-healing.

In Huawei's view, the key to solving the above problems lies in building a comprehensive IP network for the 5G and cloud era that boasts high availability, non-blocking, automated, smart, and self-healing capabilities. Such an IP network will support the development of 5G and cloud line services, fast service innovation, and efficient intelligent O&M, enabling operators to enter the fully-connected intelligent era.

New IP networks for the 5G era with four new features

Huawei proposes reshaping IP networks with new architecture, new interfaces, new protocols, and new O&M.

New interfaces: The traditional networking interfaces are GE, 10GE, and 100GE. With the continued advance of chip technology, optical-electrical (PAM4) technology has reduced cost per bit by more than 30 percent, thereby further lowering operator network construction costs. With PAM4 technology maturing, 50GE, 200GE, and 400GE have been defined as new standards for the next-generation of Ethernet network interfaces by the IEEE. Huawei's full range of routers support new 50GE, 200GE, and 400GE series interfaces. They have passed testing by the international authority ETANC, and are widely used in operator networks, helping to significantly reduce networking costs.

New architecture: With advances in chip technology, single-chip SOC has a capacity of 1.2 Tbit/s, making it possible to simplify the network layer. At the same time, the growth of 5G and telecom cloud services are placing higher requirements on network bandwidth and latency. Operators universally hope to simplify the network layer, integrate node functions, and implement comprehensive service-independent bearer capabilities.

In backbone networks, Huawei has enabled P+PE and MDS (multi domain system) capabilities using integrated backbone solutions. FBB/MBB/private line networks are integrated through physical devices, while still enabling logical partition management, significantly reducing IP backbone network construction costs.

At the metro network level, Huawei introduced the Metro Fabric solution, which is based on its Fabric architecture. The solution decouples the network bearer layer and service layer, so that the bearer network can be expanded on demand, providing high-capacity, non-blocking integrated bearer capabilities.

As for telecom cloud solutions, Huawei proposed a cloud network architecture with separate forwarding and control planes based

on actual needs, which solves the three challenges: low resource utilization, complex management and maintenance, and slow service provisioning.

CU-separated architecture separates the BRAS into two parts: vBRAS-CP (control plane) and vBRAS-UP (user plane). The vBRAS-CP is centrally deployed like a telecom cloud to fully utilize the computing power of the cloud, and the vBRAS-UP uses high-performance hardware. This supports large-bandwidth and low-latency services (like Cloud VR) and enables forwarding capability in the Tbit range per router.

At the same time, thanks to telecom cloud sharing and powerful computing capabilities, the architecture can pool network resources, improving resource utilization by 50 percent. The cloud-based CP can carry millions of users, TTM is increased by 5 to 6 times, and O&M configuration is reduced by 90 percent.

By reducing network layers, integrating node functions, and migrating some functions to the telecom cloud, a simplified target network architecture for the 5G and telecom cloud era has started to take shape based on this.

New protocols: After 30 plus years of routing protocol development, the problem with traditional network protocols is that there are so many and they have complex configurations. In particular, there are numerous difficulties with mechanisms in implementing traffic engineering, automated configuration, and network self-healing.

This is why SR and SRv6 emerged. SRv6 unifies over 10 existing complex protocols into a forwarding plane with the capability to program the source address router and path. This reduces protocol configuration and O&M complexity. Application-driven service paths can also be configured with SRv6. Whole-network Traffic Engineer optimization and AI-based queue management capabilities, including automated TI-LFA, micro-loop avoidance, and distributed and centralized traffic engineering, enable changes to traditional router Traffic Engineer, QoS, and protection solutions at the mechanism level, creating a new high-availability, congestion-free IP network.

Huawei's SRv6 solution is based on NP-programmable architecture, which protects network investment. Existing hardware can be upgraded to support SRv6 series features, so an SRv6-ready network can be implemented, helping operators to smoothly evolve from IP/MPLS networks to SRv6 networks.

New O&M: Telecom cloud and SRv6 have enabled some network functions to be centralized at the control layer and automated network configuration to be implemented through an open and programmable centralized control plane. Meanwhile, the use of big data and AI has optimized network intelligence.

Huawei's innovative NCE is the first in the industry to integrate management, control, and analysis functions. It comprises four engines – intent, automation, intelligence, and analysis – which form an automated, smart full-lifecycle system. By collecting and aggregating massive

Thanks to telecom cloud sharing and powerful computing capabilities, the architecture can pool network resources, improving resource utilization by 50 percent.

Through in-depth collaboration with operators using the NetCity mechanism, Huawei has already developed high-value use cases in the 5G bearer domain.

network data using telemetry and deep learning and analysis based on AI algorithms, big data analysis can be performed on network capacity, loads, faults, and alarms. This enables global traffic engineering and fault location and ultimately supports congestion-free, fault-free self-healing networks.

Through in-depth collaboration with operators using the NetCity mechanism, Huawei has already developed high-value use cases in the 5G bearer domain, including automated site addition, automated clock management, alarm correlation analysis, and group management.

Exploring new IP networks with partners

In the process of moving towards congestion-free, high-availability IP networks, Huawei is also working with upstream and downstream players to drive industry maturity. This includes industry standards, joint innovation, and commercial pilots. The aim is to build a comprehensive new IP network for the 5G and telecom cloud era.

In the IP interface domain, together with the industry, Huawei is promoting the standardization of new PAM4-based IP interfaces. Huawei is the chair of three of the four standards working groups for 50G PAM4 technology, set up by the IEEE (IEEE 802.3bs, IEEE 802.3cn, and IEEE 802.3ct), and the editor of one (IEEE 802.3cd).

To build up the industry chain, Huawei has organized three 50GE PAM4 technical and industry forums and released a 50G PAM4 technical white paper to foster the maturity of the PAM4 industry chain. Today, the industrial chain is complete, with chips, optical modules, and test instruments.

In commercial deployment, Huawei became the first to pass China Mobile Research Institute testing of 50 GE in September 2017. By the end of 2018, Huawei had completed more than ten 50 GE commercial deployments around the world.

In the sphere of IP protocols, Huawei has over 20 top experts engaged in research in fields relating to SRv6. Many hold key positions in the IETF in sub-fields relating to SRv6, including chamber and chair positions, and have produced dozens of related IETF standards and drafts. Huawei is a main contributor to SRv6 standards and drafts. Huawei also spearheaded the establishment of an SRv6 global industry alliance, and helped organize the first SRv6 industry forum to bring together industry expertise, create consensus, and accelerate the commercial adoption of SRv6.

Looking to the future, Huawei has partnered with leading operators to explore IP network service scenarios based on new interfaces, new architecture, new protocols, and new O&M through the NetCity joint innovation mechanism. By the end of 2018, Huawei had carried out joint innovation on 5G bearing with more than 20 operators across the world. Huawei is also helping to build 5G bearer solutions for more than 10 operators globally. Huawei will work with operators and industry partners around the world to implement a new IP era and together build a fully connected, intelligent world.

Telcos need to prioritize 5G value operations to take back control of the telecoms industry

In the 4G era, telcos expended major resources and time in building networks. However, they soon discovered that the true beneficiaries, both in revenue and reputation, were OTT Internet companies. In the fast-approaching 5G era, will the communications industry be able to regain control of industry development?

By Ning Yu
Chief Strategy Expert, Huawei Software

Transforming business models

As telecommunications involve national security, operators require a government-issued operating license. In the early days, governments strictly controlled access to the communications market, and licenses were a scarce resource.

It wasn't necessary for operators to carry out numerous innovations in terms of network capabilities monetization – voice, SMS, traffic, and private lines could be provided simply by encapsulating communications and networks. Along with the corresponding tariffs, these comprised operators' range of services and products for customers.

Later, the communications market gradually opened up and competition between different operators in the same country or region began to occur. Regardless of the number of permutations of products, packages, or marketing, the basic product provided by operators for customers was simple communication capabilities. But these were built on standards and supported by the same suppliers, so over time network quality and service types became homogenized.

Technology continued to advance, communication channels increased in diversity, and network speeds became faster. But despite this, operators carried out homogeneous competition, with price ultimately becoming the main focus of competition. Industry insiders believe that if the traditional development model continued, operators would find it difficult to increase revenues as service volumes grew.

Today, the world's operators are "reducing costs and increasing efficiency". Leveraging vast customer bases and networks, they're streamlining package tariffs and reducing internal operating costs. Even if revenue growth is small, they're able to maintain high profitability. But if operators keep to this kind of development strategy, what benefits will they be able to extract from 5G packages that include more content and faster user speeds?

Operators must harness the opportunity 5G will provide to transform their position in the industry. The most important task will be to seek a different communication industry business model and a path that supports growth and monetization. Then it will be possible to increase the business value of 5G and encourage the industry to unite and collaborate to develop it.

5G offers conditions for value operations

5G doesn't simply refer to upgrading wireless communication networks.

It's also a general term for a large number of technological innovations. "Value operations", for example, utilizes 5G technologies to package communication resources and capabilities into new products with a better customer experience to achieve higher business value.

In the 5G era, the evolution of the core network to NFV will encourage the further "IT-ization" of CT resources, meaning the further opening of underlying infrastructure and thus free combination and orchestration. The goal of evolving the communication network is orchestratable resources, invokable capabilities, network automation, and O&M smartification. This will accelerate industry innovation and stimulate vast social resources, accelerating digital transformation.

The aim of combining basic technological improvements, such as independently orchestratable resources and freely invokable capabilities is to implement network resources as a capability; that is, combining different network elements and communication units to provide personalized, open services for upper-layer applications. Upper-layer application developers will no longer be constrained by communication network specializations and borders. They will be able to flexibly invoke and combine underlying resources conveniently and freely based on their own needs.

In the 4G era, the mobile Internet has developed rapidly and solved the problem of digitalization for individuals. The basis of this success has been, first, the major development of communication infrastructure, and, second, the openness of communication networks to upper-layer applications. In regard to moving from digitalization for individuals to digitalization of industries, 5G's openness question is an important factor: if 5G is driven only by communication equipment manufacturers and operators, it will be difficult to meet different industries' needs for communication infrastructure.

It will be necessary to support flexible invocation, combine underlying resources, and lower technological barriers to entry. Opening 5G networks will have to be based on the platform, to attract more resources to take part in joint innovation. The main role of the platform will be twofold: one, to eliminate communication specialization, so that partners can easily invoke capabilities; and, two, to accumulate shared capabilities and form digital assets within the telco.

Another important factor is cost. If communication resources are combined into communication capabilities with long cycle times, high costs, and complex operations, the large-scale implementation of even a theoretically achievable function will be difficult to carry out. As such, the question of the implementation cost and ease of use of network resources as a capability must also be considered.

Technological evolution, open platforms, and cost reduction are all issues that need to be addressed when carrying out network resources as a capability. It also involves standardized 5G capabilities, which also creates room for device manufacturers and operators to innovate. Therefore, 5G brings opportunities to change business models, and the possibility of differentiated competitive strengths, which defines a new starting point for operators.

Combining communication capabilities into products

Carriers operate based on basic communication capabilities. Even if they propose optimization, requirements are constrained by CT control models. It's difficult to push equipment manufacturers to complete R&D quickly or quickly adjust communication networks. They carry out development based on communication standards. This involves long cycle times and changes come at high cost. There are also stability requirements. This makes it impossible for them to execute R&D in an iterative trial-and-error manner as Internet companies do.

But in front of customers, these excuses look increasingly feeble. To meet customers' needs and experience demands, changes and adjustments must be made faster. In the mobile Internet era, one of the key things operators were accused of was ignoring customer experience, especially compared to Internet companies. In the 5G era, operators will need to improve how they meet the demands and usage scenarios of customers. They will have to provide products and services in a way that customers can perceive, so that they can receive a better experience. Then operators will be better placed to sell products even at premium prices.

Zero-rated data acceleration packages for mobile games that have come onto the market recently are a good example. With the popularity of unlimited data packages, users have gradually stopped complaining about tariffs. Instead they now grumble about communication quality. Wireless resources are limited, and network congestion is likely to occur in areas with large numbers of users, so customers who are sensitive to network quality will want to purchase high-quality traffic packets. And heavy mobile game users are more than willing to dip into their pockets to buy custom game acceleration packages, which can improve their gaming experience and their scores.

This makes the importance of using network resources as a capability abundantly clear: when underlying resources and capabilities are opened up, upper-layer applications can flexibly combine communication products based on customer needs, so that they can be quickly adjusted according to customers' experiences and perception. Building on increasing network resource capacity to implement experience-based communication capabilities, integrating and packaging communication capabilities in a way that better meets customer requirements, and carrying out marketing in specific scenarios and experiences will be an important means of value operations in the future.

Of the three core 5G scenarios, large-capacity mMTC and low-latency uRLLC have been well received by many customers in the industry, as both will bring a qualitative change in communication technology and connectivity and open the door to digitalization in the industry.

In terms of low-latency application scenarios and in addition to the much-hyped self-driving technology, "digital twins" could also offer a vast range of possibilities. Using this technology to digitally map physical models, sensors, and operating history in virtual space using their data, digital models or twins can be recreated in different locations. This integrated multidisciplinary, multiscale, multi-probabilistic simulation process, combined with low-latency communication, makes remote disassembly and the repair of components possible. Digital twins technology has a high level of commercial value.

In the view of many industry insiders, 5G will enable the Industrial Internet to succeed, optimally integrating communications technology with industry applications to form a "1 + 1 > 2" effect. Technology is only part of the means of turning dreams into reality – business operations and industry cooperation are also key. In this kind of scenario, the winners will be the ones that can integrate communications, operators, industry customers, and industry applications, and maximize value.

The arrival of 5G is inevitable and the decoupling and transformation of underlying communications technology is accelerating. Value operations based on 5G are drawing nearer and nearer. But what we're not sure of is who the main players in 5G-based value operations will be. Will it be the operators blazing the trail, or a new leader standing on their shoulders?

Compared to industry customers and industry solution providers, operators have a first-mover advantage in the 5G field at the moment. And there's no reason why they can't leverage their advantageous position to gain a head start. But if they adopt a wait-and-see attitude or hold on to traditional business models, they may not easily have another opportunity for transformation in the future.

By Lu Hongju
General Manager of Huawei NCE Domain

Driving autonomy with the Network Cloud Engine

5G and cloud will bring a wealth of exciting new services such as VR, AR, live streaming, and autonomous driving, leading to a boom time for the entire ICT industry. These new services will also generate huge amounts of traffic: Huawei's Global Industry Vision (GIV) 2025 predicts that the data generated in 2025 will hit 180 ZB.

The dynamic complexity of services will greatly increase network complexity. That's why reducing OPEX is one of the biggest challenges for operators today, alongside improving user experience and increasing agility.

What's causing these challenges?

The main source is existing network systems. Network complexity is growing exponentially, but legacy problems in current networks still remain. While the device-centric, manual O&M approach is over, dynamic network scheduling is beyond human capability. Thus, the only solution is a high degree of automation.

5G networks will need to support not only high-speed and enhanced mobile broadband services, but also ultra-reliable and low-latency machine-like communication for applications like autonomous vehicles and smart medicine. New, far higher requirements will have far outstripped the capabilities of passive O&M, which rely on user complaints and equipment failure alarms for service guarantees.

New business models for operators

The proliferation of cloud services will enable operators and enterprises to migrate the focus of their business

development to a broad range of vertical markets. Business models will shift from B2C to B2B and B2B2X. The main requirements for implementing enterprise/industry digital IT and network agile integration will be network openness and the ease of integrating capabilities.

Based on its ongoing development of network end-to-end (E2E) industry chain links, Huawei has released the industry's first automated network platform, which integrates management, control, analysis, and smart AI functions into the Network Cloud Engine (NCE). Serving as a unified network brain, on the downstream side the NCE enables centralized management, control, and analysis of the global network. Business and service intent supports resource cloudification, full lifecycle automation, and intelligent closed-loop data-driven analysis. And upstream, it provides open network APIs and rapid IT integration, supporting B2C and B2B e-commerce services and multi-tenant management. The NCE will fully enable operators and enterprises to build user experience-centric automated, intelligent networks.

Connecting physical networks and business intent

As the brain of the entire network, the NCE connects the physical network with business intent, and supports the full implementation of Huawei's Intent-Driven Network (IDN). NCE includes four key capabilities: ultra-capacity cloud-based platform; full-lifecycle automation; intelligent closed-loop based on big data and AI; and, an open, programmable enabling app ecosystem based on scenarios.

Ultra-capacity cloud-based platform: Based on Cloud Native cloud architecture, the NCE operates on private and public clouds, and also supports an on-premise deployment model. Its high capacity and flexible scalability deliver the largest system and user access capacities in the world, allowing networks to transform from the offline model of scattered data and multi-level O&M to an online model of data sharing and open processes.

Full-lifecycle automation: Based on unified resource modelling and data sharing services, the NCE enables serialized solutions for different service scenarios, including home broadband, enterprise interconnections, cloud interconnections, enterprise cloud, and mobile bearer. This allows full-lifecycle automation across multiple network technology domains, enabling device plug-and-play, network switch-and-run, business self-service, fault self-healing, and risk alerts.

Intelligent closed loop based on big data and AI: The NCE consists of four engines: intent, automation, analysis, and intelligence. These form a complete, intelligent closed-loop system. The NCE uses telemetry to collect and aggregate massive amounts of network data, enabling real-time situational awareness of the network. Unified data modelling builds in big data analytics and insights from the entire network. The NCE also uses algorithms based on Huawei's 30 years of experience in the telecommunications field to execute automated closed-loop analysis, predictions, and decision-making on user intent. Problems

The NCE's high-capacity and flexible scalability deliver the largest system and user access capacities in the world.

can thus be solved before customer complaints occur, reducing service interruptions and ensuring customer satisfaction.

Open and programmable for a scenario-based app ecosystem: The NCE includes the programmable integrated development environment Design Studio and a developer community for customers. Design Studio supports southbound connections to third-party network controllers and network devices, and northbound integration with the cloud and AI training platform and IT applications. Customers can also use it to purchase Huawei-native apps, and innovate and develop apps by themselves or with the support of third-party system integrators.

The NCE's four main capabilities can fully support service innovation for operators, enterprises, developers, and partners and maximize network business value.

Smart networks for smart business

Joint innovation between Huawei and leading operators and enterprise customers has applied the NCE to a range of use cases to achieve smart and automated networks. As of the end of 2018, Huawei had collaborated with leading customers on 25 NetCity innovation projects and launched over 60 commercial use cases.

In the area of 5G service scenarios, Huawei NCE launched four key capabilities for 5G bearer scenarios in 2019: rapid 5G base station service provisioning; active and precise fault location; service smartification and optimization; and intelligent fragmentation. These capabilities will help operators achieve E2E automation for 4G/5G hybrid networks and build future-ready smart mobile bearer networks that support rapid deployment, proactive prevention, and optimal experience. It will also help carriers expand in the vertical industry market.

In cloud service scenarios, the Huawei NCE fully enables innovation in service scenario-based solutions for application in, for example, data centers, enterprise campuses, and SD-WAN. Today, Huawei is a leader in the domain of cloud data center networks. Huawei's CloudFabric data center network solutions have been adopted commercially by over 6,400 enterprises worldwide, turning data centers into commercial value creation centers.

In 2018, Huawei's Cloud Managed Network and SD-WAN cloud services were officially deployed in its public cloud. Enterprise users can now purchase convenient, fast, and cost-effective cloud services on Huawei Cloud's official website. Huawei Cloud's campus management solution included collaborations with over 100 managed service providers worldwide to provide quality services to corporate customers worldwide.

Network automation and smartification is set to be a gradual process of evolution. Therefore, Huawei is working with upstream and downstream industries to build an open industrial ecosystem. Huawei's NCE has passed integration certification or interoperability testing with over 40 industry partners and industry players, including services for coordinators, public cloud, cloud platforms, and network value-added services.

To achieve open network capabilities, the NCE solution includes a developer enablement platform, DevZone. It provides a comprehensive learning, development, and verification environment for application innovation for partners, developers, and customers. By the ` of 2018, the NCE solution had provided over 400 APIs; underpinned collaboration with third-party certification bodies like EANTC, IOL, and SDNCTC; and interfaced with mainstream equipment vendors' controllers and transponders. Together, a flourishing ecosystem has been built.

The network industry has entered the IDN era, a key stage in network evolution from automation to smartification. As the intelligent brain of the network, the NCE will fully accelerate this process, speeding up the arrival of the era of autonomous driving networks.

Cutting OPEX and building managed service capabilities with CloudCampus

Driven by the global trend towards enterprise digital transformation, the enterprise campus market continues to expand. According to IDC and Huawei, the global market for campus networks is set to reach US$24 billion by 2021. Enterprise campus networks will be an attractive new area of opportunity for B2B services for operators.

By Wei Lei, Zhao Shumin

A tough market to crack

Currently, the bulk of operators' revenues in the enterprise market comes from reselling private line services and network equipment. From this position, operators will find it difficult to venture into the field of managed LAN network services. The reasons are obvious.

LAN networks and the services they carry target the massive enterprise market, especially SMEs, but are very complicated. When a network failure occurs, specialist engineers are needed to locate and troubleshoot the fault, and issues can take up to three days to solve. Network engineers are also required on-site to assist with fault location and demarcation in the case of service layer failures. This approach is both labor intensive and damaging to customer satisfaction.

Given the market space, labor, and time involved, the managed LAN market offers low ROI and tends to be a frustrating market for operators to succeed in.

One example is the largest private line operator in a particular region. With dedicated line revenues accounting for 70 percent of its total revenues and a focus on the enterprise network market, the operator was seeking specialist partners to explore opportunities in the campus network segment. However, constrained by limited personnel resources, it was unable to develop LAN networking services to a significant scale, only gaining 10 or so

customers by the end of 2018. An all too common eventuality for many operators, as in this case, is that they're forced to abandon this market due to limited overall investment.

The cloud managed network

Therefore, the main obstacles preventing operators from entering the managed LAN market are the large number of fragmented enterprise campus networks as well as O&M methods that require on-premise trained personnel.

In 2017, Huawei launched its cloud managed network solution CloudCampus, which enables operators to purchase a cloud managed platform and operate it independently. The one platform allows them to manage tens of thousands of enterprise campus networks simultaneously and exclusively enjoy service revenues.

A series of network management tools integrated into Huawei's cloud managed platform provides enterprise customers with full-lifecycle cloud managed services, including network planning, deployment, O&M, and inspection. Without having to go on-site, network engineers can carry out wireless network planning and network pre-configuration remotely.

At the same time, network data can be synched to mobile devices to guide on-site engineers installing and deploying equipment. After equipment is powered on, configurations are automatically sent from the cloud to equipment without the need for on-site commissioning by specialists. This cloud deployment method can cut the network deployment cycle from months to weeks or days.

O&M personnel can also perform monitoring and O&M remotely anytime, anywhere without having to be on-site, using troubleshooting tools such as cloud-based user, device and site monitoring reports, and reset package capture. This can reduce OPEX costs by up to 80 percent. Since its release, CloudCampus has been adopted by over ten operators worldwide, which have used it to provision more than 50,000 cloud boxes.

CampusInsight enhances network auto-maintenance

At Mobile World Congress 2018, Huawei launched its Intent-Driven Network (IDN) solution. A standout feature of IDN is that it enables the network to carry out predictive analytics, so network faults can be identified in advance using big data and artificial intelligence (AI), enabling proactive optimization and fault repairs.

CloudCampus integrates CampusInsight's smart campus network analyzer, which can reduce carriers' network O&M labor costs on the basis of full-lifecycle cloud management.

Huawei's CampusInsight enhances automated network maintenance in three stages: network visualization, analysis, and

healing. First, CampusInsight collects data on user dimension access, wireless roaming, throughput experience, and application experience in seconds using telemetry. This enables instant visibility on each user's experience to discover individual network problems.

Then, CampusInsight learns network behavior using machine learning algorithms to analyze big data relating to experience metrics, helping to establish the network dynamic baseline and identify 20 types of failure models in four main categories, including access class and performance class.

CampusInsight can also quickly locate and demarcate group faults based on the integrated analysis of wired and wireless network topology, helping O&M personnel to discover 85 percent of network problems. It can also provide predictive maintenance suggestions by analyzing network trends, preventing problems before they occur.

For example, a traditional network management system cannot actively perceive the quality of typical audio and video service applications, instead relying on manual troubleshooting without an effective means to locate and demarcate problems. CampusInsight can actively perceive audio and video conversations, analyze quality in real time, and then identify and locate the fault point of poor-quality audio and video streams refined to device port level to quickly demarcate faults and close the loop on problems.

On the campus networks of Huawei's Shenzhen headquarters and in over 10 research institutes around the world, CampusInsight has been active since 2015, training AI algorithms, performing iterative verification, generating rapid feedback, and gradually updating to cover the whole network environment. Currently, CampusInsight manages 60,000 pieces of network infrastructure globally, driving the transformation of dozens of networks for dozens of companies around the world.

Harnessing CampusInsight's smart O&M tools, operators can locate and demarcate network problems in minutes and quickly optimize the network, thereby reducing user complaints and improving customer satisfaction, as well as enhancing O&M efficiency and lowering O&M costs.

CloudCampus will continue to integrate new features, such as SD-WAN, to help operators further boost revenues and create a better connected, intelligent world.

New platforms, new business

According to their business needs, operators can opt to rent Huawei's self-built public cloud managed platform. The platform provides network SaaS services for enterprise customers, or operators can purchase a cloud managed platform and operate it independently. They can also take advantage of Huawei's operations experience to quickly develop team and partner capabilities, gain market development experience, and reduce risk.

CampusInsight learns network behavior using machine learning algorithms to analyze big data relating to experience metrics.

As an MSP, operators can offer network construction and O&M services for SMEs and quickly expand the size of the market.

Early stage: multi-branch, large-scale projects

In the initial stage of platform operations before personnel capability and service processes have been honed, operators can focus on two types of customers.

The first are customers with large-scale projects. By delivering and maintaining large project, the carrier can quickly increase labor resources and establish service processes. Examples of large projects in the past two years include a campus network for 500 primary and secondary schools in Latin America, and a Wi-Fi network project for more than 200 clinics for the health ministry in the Middle East. By focusing on one project, operators can quickly establish internal processes, develop personnel capabilities, and build confidence in the managed LAN market.

The second type consists of small and micro enterprise customers. The networks of such customers are generally comparatively simple, consisting of no more than 10 pieces of network equipment. Operators can quickly deliver and pilot operations for this type of customers. One operator in Western Europe adopted this strategy for its cloud platform, focusing on private line customers and targeting scenarios with less than five access points per branch, which quickly developed its team's operational capability. Then, it gradually expanded to the SME market after perfecting its team's operational capabilities.

Development stage: MSP enablement and expanding market size

After the initial pilot operation phase, operators can develop their own partners and become managed service providers (MSPs). And by integrating the cloud managed platform's simplified O&M capabilities, they can provide MSP enablement services. As an MSP, operators can offer network construction and O&M services for SMEs and quickly expand the size of the market. Huawei's cloud platform supports MSP-to-tenant multi-level decentralized and domain-based account permissions, which meets the needs of most scenarios.

Industry MSP Aihui Health, for example, delivered medical SaaS services for 292 hospitals in 20 months leveraging Huawei's public cloud platform in China. The current network covers over 10,000 pieces of equipment.

Huawei has established a comprehensive support platform covering more than 170 countries, with service experts providing uninterrupted services around the globe. Huawei has also configured a cloud management platform for operations and network O&M, setting up courses to help operators quickly establish operations and O&M capabilities.

Huawei's CloudCampus provides operators with high ROI and low-risk campus network service platforms to help them tap into in the enterprise market.

By Chen Jinzhu
Vice President of Huawei Router & Carrier Ethernet Product Line

Building a 400GE backbone network for the smart era

Huawei's Global Industry Vision 2025 predicts that there will be 40 billion smart devices and 100 billion connections globally by 2025. Massive traffic and high-value connections will become ubiquitous. Ubiquitous connections will inevitably lead to a constant rise in network bandwidth, in particular on backbone networks – as the core of the network – and traffic will rise at a CAGR of over 45 percent. In addition to this rapid growth in traffic, new services, such as 5G and cloud, will bring unprecedented challenges to IP backbone networks.

Service and traffic uncertainty: By 2025, 85 percent of enterprise applications will be deployed on the cloud. Service types will number in the thousands and network traffic flows will be more dynamic and disordered. This will lead to a high level of uncertainty in services and traffic. Mass online shopping days rich with discounts such as Black Friday in the UK and 11.11 in China or Chinese New Year tend to cause sudden surges in network traffic. In addition, the development of new technologies, such as cloud computing, VR, 5G, and AI, mean that operators will be faced with a larger number of uncertain service forms and different network service quality requirements. However, existing networks are unable to sense user needs in real time and thus dynamically configure network resources.

User experience will be difficult to guarantee: Interactive services like smart telemedicine, distance learning, and Cloud VR are all experience-sensitive services. The traditional IP network principle of "nearby forwarding" leads to uneven network loads and low overall utilization, resulting in wasted investment. And the "best effort" mechanism of IP networks makes the network vulnerable to congestion and packet loss, resulting in a poor user experience.

O&M challenges are getting worse: In the future, the form, quantity, and service diversity of network elements will increase network complexity at least tenfold. As such, O&M expenditure will remain operators' biggest challenge. Today, OPEX for operators is three times as high as CAPEX, 80 percent of configurations are done manually, 90 percent of issues are handled after user complaints, and O&M efficiency is incredibly low compared with OTT companies.

To overcome these challenges, Huawei's backbone network solution represents a new generation that

According to Moore's Law, to maintain optimal forwarding per-bit costs, it's necessary to continuously increase the port rate, board capacity, and device capacity of routers.

will meet the needs of upcoming services in the smart era through ultra-broadband, simplification, and smart capabilities.

Ultra-broadband for massive traffic growth

According to Moore's Law, to maintain optimal forwarding per-bit costs, it's necessary to continuously increase the port rate, board capacity, and device capacity of routers.

With standardization completed in 2017, 400GE is the industry's latest Ethernet port technology. In 2017, Huawei released the first 400GE port and 4 Tbps board in the industry. In December 2018, Huawei won the world's first 400GE commercial contract, marking the official arrival of the 400GE ultra-broadband era.

Board capacity is determined by chips, and Huawei offers industry-leading chip technology. Huawei's backbone router 4-Tbps board is based on the industry's first 1T NP chip (Solar 5.0) and is fully programmable. New software features are supported through software upgrades, protecting customer investment.

Maximum rack capacity depends on the rack's backplane capabilities. With Huawei's cable backplane, racks can support 20 slots with a 14.4 Tbps single-slot capability. Huawei's backbone routers have an industry-leading capacity of 288 Tbps, which is enough to support operators' traffic growth requirements over the next 10 years.

Multi-network convergence, unified protocols

Huawei's backbone solution simplifies network architecture and network protocols.

In terms of network architecture, Huawei's backbone routers can virtualize one physical system into multiple MDSs (multi-domain systems). The control plane, management plane, and service plane of each MDS are completely isolated, enabling multiple services to be carried in a unified way and isolated from each other. At the same time, Huawei's backbone routers support complete P and PE functions, allowing operators to reduce network levels and flatten the network through P&PE integrated configuration.

LDP/RSVP-TE/GRE/L2TP protocols are replaced with the end-to-end (E2E) SRv6 protocol on the live network, enabling the unification of bearer network protocols and seamless network connections, which can reduce configuration workloads by 60 percent.

Congestion-free, zero service interruptions

The intelligent world will have two defining characteristics. The first is that AI acts as a general-purpose technology. The second is that the intelligence provided by ICT will lay the foundation upon which all industries innovate.

Huawei has designed its +Intelligence smart capabilities for backbone network solutions to help operators improve O&M efficiency, optimize user experience, and run networks that are congestion-free, self-healing, and automated.

Congestion-free: AI-based traffic predictions

and real-time tuning can boost network bandwidth utilization to 80 percent. Huawei's backbone network solution is based on machine learning and neural networks. It can predict traffic patterns with 90 percent accuracy, helping operators to carry out traffic management. Real-time traffic adjustments can be performed using real-time network O&M data acquisition and Huawei's self-developed ROAM (Routing Optimization Algorithm based on Matrix) algorithm, enabling network-wide load balancing, no congestion, and zero packet loss – maximizing resource utilization and enhancing user experience.

Self-healing: Active O&M enables fault location and recovery in minutes so that services are not interrupted. The Network Cloud Engine (NCE) senses network status in real time and performs predictive maintenance. The NCE can generate visualized reports on link status and equipment operating states. When network status is abnormal, the NCE issues an SR policy to the device to specify a new SRv6 forwarding path for traffic. This allows traffic to avoid faulty nodes and links, so that the network automatically recovers from faults, and services are not interrupted.

Automation: Cross-domain collaboration improves network O&M efficiency. Planning and O&M in both the IP layer and the optical layer had in the past always been layered, reducing network-wide O&M efficiency and lengthening new service provision. The NCE enables unified management on IP devices and transmission devices, IP and optical cross-layer network planning, cross-layer service distribution, cross-layer network indicator visibility, cross-layer issue detection, and network end-to-end automated O&M, significantly improving efficiency. In addition, Huawei's backbone network solution also supports cross-WAN and DC domain collaboration for minute-level service provisioning.

Huawei continues to lead industry development

Today, Huawei leads the development of the backbone router industry thanks to its continuous investment in R&D and technical innovation. In addition, Huawei works with its industry partners in standardization work and continues to promote and lead the development of the backbone network industry.

Huawei is a leading contributor to 400GE standardization. As early as 2011, Huawei launched research into 400GE technology and contributed to the IEEE 802.3 400GE standard proposal, submitting more than 50 technical papers as chair of the 400GE standard working group. Huawei has also taken the lead in R&D of PAM4 (four-level pulse amplitude modulation) physical layer optical transceiver system. The system enables optical modules to achieve 400G transmission without increasing the bandwidth of existing optical devices while minimizing the number of optical paths, serving as one of the fundamental technologies of the 400GE standard.

Huawei is also promoting the development of the SRv6 industry. As a next-gen network protocol technology, SRv6 has become the preferred choice for future network architecture. Huawei contributed to SRv6 standardization, leading and participating in 35 IETF SRv6 contributions, 85 percent of the total number. Huawei is working on joint innovation projects in this area with a number of operators, including China Telecom. Huawei offers the most complete SRv6 capabilities in the industry, and is accelerating the simplification and smartification of the backbone network.

In the future, connectivity and intelligence will be ubiquitous. With its backbone network solutions, Huawei will keep leading the development of the IP backbone. Leveraging the mix of technological innovation and customer demand, Huawei will continue to upgrade backbone network ultra-broadband, simplification, and intelligence capabilities, helping operators to maximize network value and sustain business success in the 5G and cloud era.

How China Mobile Zhejiang overcame 3 major problems in its 5G bearer network

By Zhou Ping, Wu Xiaofeng, Wang Xiaoyi, China Mobile Zhejiang

China Mobile Zhejiang has been at the forefront of mobile bearer networks in China since the inception of 4G. In response to the challenges 5G service development place on bearer networks, the China Mobile subsidiary established a joint project team with Huawei in 2016 to research 5G bearer networks. The team went on to construct the largest 5G test bearer network in China in 2018.

Making the 5G bearer smart

IDC predicts that by 2021, at least 50 percent of the world's GDP will derive from digitalized sources and that China's digital economy will account for 55 percent of its total economic output. Digital products, operations, and partnerships will promote growth in all industries. A Gartner survey revealed that 83 percent of respondents are set to complete digital transformation in 2019.

Digital transformation of the global industry has undoubtedly entered the fast lane. And operator networks are the cornerstone of this transformation, in particular 5G networks.

5G will see a far wider range of services than 4G and industry verticals will have much higher demands, which will in turn increase

the requirements on network deployment, adjustment, and O&M. Traditional device-centric network architecture and the 4G O&M model, which is reliant on manual operations, are unsustainable for 5G. Smart and automated O&M that improves the efficiency of network deployment and O&M are essential.

China Mobile Zhejiang and Huawei launched a NetCity project in 3Q 2018 to explore a 5G bearer smartification solution that could give China Mobile Zhejiang an early edge in 5G bearer networks.

NetCity is a future city construction project jointly initiated by Huawei and global operators. It provides broadband-based, cloudified, smart network infrastructure to help people develop smart societies. The main idea behind NetCity matched China Mobile Zhejiang's strategic development demands for 5G bearer smartification.

At the heart of the IDN is the Network Cloud Engine (NCE), which comprises four engines: intent, automation, analysis, and intelligence. The intent engine translates business intent into a web language and simulates network design and planning. The automation engine turns network design and planning into concrete network commands that automate network devices through standard interfaces. The analysis engine mainly collects and analyzes user network data including bearer delays, jitter, packet loss rates, and so on, using real-time telemetry and other technologies. Building on the work of the analysis engine, the intelligent engine provides risk prediction and processing suggestions by using AI algorithms and continuously upgrading the experience database.

The IDN builds a data-driven digital twin network using the four engines, which supports intent-driven auto-configuration and data-driven, real-time situational awareness and global insight into network O&M across the full lifecycle, as well as predictive operations that are customer- and service-experience-centric. IDN is China Mobile Zhejiang's preferred tool for exploring 5G bearer smartification.

Intent-driven bearing

China Mobile Zhejiang and Huawei set up a work group to solve the network problems encountered during the construction of the 5G bearer network, including the long base station deployment cycle, difficult fault location, and insufficient network reliability. Initial results have been achieved so far.

Long deployment cycles of base stations: The team found that the main contributing factors were decentralized management across departments, manual operations for all processes, excessive configuration steps, high skill requirements, and susceptibility to errors.

They planned and introduced a smart platform to support automated and online full-process management of resource planning, network design, the configuration of new network elements, service configuration provisioning, and service verification.

The automation engine turns network design and planning into concrete network commands that automate network devices through standard interfaces.

Completing hardware instillation could then automatically trigger service configuration, reducing personnel skill requirements, improving base station deployment efficiency, and shortening the base station deployment cycle.

Fault location: The mainly difficulties were found to be the separate presentation of hardware information, a lack of detailed base station paths, zero bearer network awareness when base station services deteriorated, a passive response to complaints from adjacent departments, multiple teams performing fault location, low fault location efficiency, and the inability of the network to self-verify that faults have been cleared.

The project team implemented end-to-end path/quality visibility on base station services using a service-layer flow performance monitoring mechanism. Faults can now be detected in seconds and quickly demarcated and located within minutes, so problems can be solved before customers complain. At the same time, when preset network KPI threshold values such as delay, jitter, and packet loss rate are exceeded, warning alarms are reported automatically, preventing faults and avoiding passively responding to work orders.

The project team analyzed and designed an intelligent clock solution to solve the problem of long planning and deployment cycles involving the 1588 clock and the requirement to take sites offline to measure fiber symmetry. The solution allows clock path planning and configuration to be completed in one click. It works with the base station to automatically compensate fiber asymmetry, enabling the deployment of the clock without having to take sites offline, which greatly improves the efficiency of 1588 clock deployment. Functions like monitoring the health of the network clock, performance history playback, and automatic fault tracing allow 90 percent of faults to be automatically located in minutes, making clock O&M simpler.

Insufficient network reliability: The project team discovered that the main factor affecting reliability was that services couldn't accurately detect multiple points of failure or correctly switch to available paths, leading to service interruptions. In response, they designed a better network protection mechanism that enables the fast perception of multiple faults to ensure permanent 1:1 service protection and rapid recovery following faults, thus ensuring services are always online. The team is continuing to carry out analysis and research on issues such as difficulties in analyzing large numbers of equipment alarms and impact assessments on new services on the network.

Thanks to the NetCity project, China Mobile Zhejiang 5G bearer network's deployment and operations efficiency has been significantly enhanced. As the level of intelligence of the whole 5G bearer network continues to improve, O&M efficiency will continue to be optimized, supporting China Mobile Zhejiang's 5G service innovation and commercial success.

TIM and Huawei provide advanced SD-WAN services for Italian enterprises

By Yang Xinfeng, Marketing Director of Huawei Enterprise Gateway Domain

TIM is the leading information and communications service provider in Italy and one of the largest integrated telecom carriers in Europe. As an industry leader in ultra-broadband infrastructure for optical fiber, Digital Subscriber Line (DSL), and Long Term Evolution (LTE), as well as upcoming 5G networks, TIM places high importance on innovation and providing high-quality services for more than 50 million customers in Italy.

As we enter the cloud and digital era, we're seeing the rapid growth of a large number of new enterprise services that are based on technologies such as 4K, Voice over Internet Protocol (VoIP), Artificial Intelligence (AI), and Internet of Things (IoT). These services are also becoming closely intertwined with cloud computing. The rapid development of these technologies is causing enterprises to rethink how they operate. It's also causing enterprises to place new demands on network services. "Today, more than ever, companies need networks that can adapt to different business needs over time, in particular to enable cloud and VoIP services," says Luigi Zabatta, Head of Fixed Offers, TIM's Chief Business & Top Clients Office.

TIM's B2B Division is focusing on providing end-to-end professional services based on connection services and one-stop, converged Information and Communications Technology (ICT) service experience for enterprise customers, including quality Wide Area Networks (WANs) and Value-Added Services (VASs).

TIM is proactive in enterprise-oriented SD-WAN service transformation

Based on TIM's ultra-broadband infrastructure covering optical fiber, DSL, and LTE, as well as the upcoming 5G networks, Software-Defined WAN (SD-WAN) technology will enable TIM's solutions to balance and optimize applications across different virtual private lines and the networks of multiple sites or data centers, improving the reliability, flexibility, and O&M efficiency of enterprise WANs.

The complexity and large scale of carrier networks has led to a few challenges in the implementation of enterprise-oriented SD-WAN service transformation.

First, implementing interworking and the migration of existing customers and building future-proof networks that are cloud-ready. As a growing number of enterprise services are moving to the cloud, the requirements of enterprise customers are changing. In most cases, enterprises need to connect to multiple networks (including optical fiber, DSL, LTE, and upcoming 5G networks), as well as requiring multi-cloud connections and adaptability to a range of service requirements (such as branch communication and isolation and group security management and control). Implementing large-scale networking and building future-proof networks that are cloud-ready is the basis for TIM to consolidate its leadership and further improve its operating results.

Second, optimizing network performance at a reasonable cost and providing first-class application experience for enterprises. TIM aims to strengthen network quality and improve its leading position when it comes to customer satisfaction. Generally, traditional enterprise network services cannot monitor the traffic direction of enterprise applications. During traffic bursts at peak hours, the traffic of key services may become congested, affecting an enterprise's business. In this case, enabling enterprises to select hybrid links at reasonable cost as well as balancing and optimizing applications (especially key applications) on different virtual private lines and networks, will be critical for TIM to win over enterprise customers.

Third, automated management tools are required to reduce network deployment and O&M costs and shorten the network service provisioning time to improve customer satisfaction.

TIM works with Huawei to provide advanced SD-WAN services for enterprises

Having worked with Huawei in the WAN edge sector, TIM chose Huawei's SD-WAN Solution to build cloud-ready network solutions for enterprise customers. TIM integrates the Huawei SD-WAN solution into its cloud infrastructure and provides Italian enterprises with innovative services based on SD-WAN technology, improving reliability, flexibility, and the O&M efficiency of enterprise networks.

The strong ever-evolving networking capability of Huawei's SD-WAN solution is the basis for SD-WAN construction.

In October 2018, Gartner released its inaugural Magic Quadrant for WAN

Edge Infrastructure. Huawei was positioned as a Challenger in this Magic Quadrant in recognition of its SD-WAN capabilities in terms of Customer Premises Equipment (CPEs) and large-scale networking, which are the foundation of TIM's SD-WAN construction.

The CPEs can seamlessly integrate with TIM's ultra-broadband infrastructure to provide hybrid link access and optimize link costs for different enterprises. In addition, Huawei's SD-WAN solution can customize different network topologies. Moreover, networks can be smoothly expanded to support large-scale multi-tenant network services and, more importantly, legacy CPEs can be smoothly migrated to SD-WAN networks through a simple software upgrade.

High-performance CPEs will become the key to improving network performance and optimizing application experience.

Huawei's next-generation SD-WAN CPEs contribute hugely to network performance improvements and application experience optimization, instead of simply forwarding traffic. The intelligent identification engine embedded in SDN-WAN CPEs can quickly identify a vast number of enterprise applications such as Software as a Service (SaaS), VoIP, and video applications. Enterprises can fully leverage hybrid links to optimize application experience, thus offering high-quality interconnection experiences for business-critical applications.

In addition, high-performance CPEs are not only the key to improving network experience, but are also key for TIM to enable VAS such as Virtualized Network Functions (VNFs), virtual firewalls (vFWs), and virtual WAN Optimization Controllers (vWOCs).

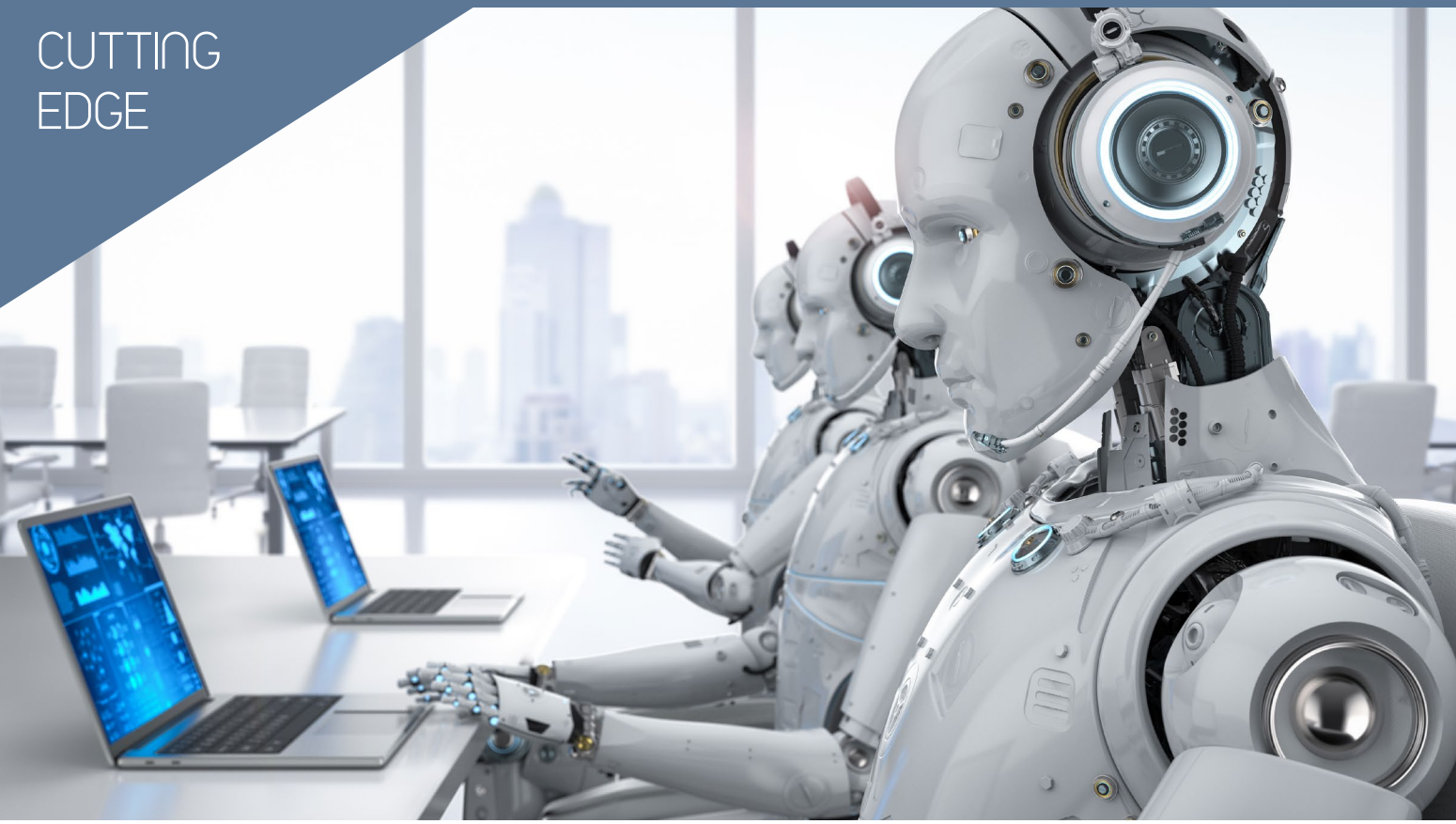
"Thanks to the advanced technologies, these networks can be managed both jointly and by customers themselves through simple tools," says Zabatta. "The partnership with Huawei allows us to expand our value proposition for companies and to enrich our offerings through the adoption of a technological model that is increasingly and rapidly emerging in the ICT industry."

The entire process is automated to optimize network services.

With the technical support and expertise of TIM's National Assistance Center, the new service model of TIM will allow customers to manage their networks through a single control platform. Of the solutions provided by TIM, Huawei's SD-WAN technology will be the first to be integrated into this control platform, enabling end-to-end, full-process automation. TIM is able to fully optimize their network service process and further improve enterprise customer satisfaction by leveraging a centralized and automated platform, plug-and-play network service provisioning capability, complete application and network policy configuration tools, and multi-dimensional visualized reports based on links, applications, users, sites, and devices.

Huawei's SD-WAN Solution assists TIM in providing on-demand branch-to-branch, branch-to-DC, and branch-to-cloud interconnection, and delivering an outstanding experience in enterprise interconnection. The solution also flexibly provides differentiated, customizable network services based on enterprises' application requirements, ensuring high-quality interconnection experience and the full autonomy of enterprises.

Huawei's SD-WAN solution has already successfully helped TIM win the first commercial SD-WAN project in Europe and expand the SD-WAN market in Italy. By 2020, SD-WAN, as an important innovative technology and based on local networks, will be used on Multiprotocol Label Switching (MPLS) networks, the Internet, and LTE networks to implement multi-cloud and multi-network on-demand interconnection, helping TIM increase the penetration rate of its ultra-broadband infrastructure and win over more enterprise customers.



How virtual assistants can cut OPEX for telcos

By Sachin Dutta

Much like we're seeing with AI now, emerging technologies seem to follow a predictable cycle: wonderful promises of endless new possibilities coupled with a lack of business cases that proves a given technology is mature, ROI is assured, and implementation strategies are clear.

There are two choices: either wait for the dust to settle and learn from others' mistakes before moving in; or jump in, be an innovator, do POCs, and take the lead. Both strategies have pros and cons.

A simpler strategy is to start with a use case where technology has reached a sufficient degree of maturity, business benefits are evident, and ROI is assured.

For AI, one such clear use case is Virtual Assistants.

AI in customer services makes sense

Globally, telcos continue to spend huge amounts of OPEX. It's not surprising that half of the world's operators set bringing down the cost of current operations as a target for 2018, with 20 percent making it their top priority.

As customer services account for 7 percent of telcos' total OPEX, there's considerable room for AI to cut the OPEX incurred by telcos from customer services and, at the same time, make customers more engaged and satisfied.

However, do efficiency improvements from virtual assistants come at the expense of people? To answer that we need to look at AI-based Chatbots as a solution to augment agents rather than as a replacement for agents. These solutions free up agents from repetitive tasks like understanding

customer queries and looking at different systems to provide customers with updates. They allow agents to develop more meaningful relationships with customers based on empathy and truly understanding what customers need. In turn, organizations can develop deeper bonds with customers and improve organizational NPS.

Advantages of virtual assistants in customer services

Advances in NLP (natural language processing) and neural network technology have facilitated the rise of virtual assistants and chatbots in daily life.

In call centers, the shift from manual agents to self-services for customers is gathering momentum. Calls to direct agents are expected to account for only 47 percent of calls in 2019, down from the current figure of 64 percent. By 2020, it's predicted that 25 percent of all B2C first-level engagements will be handled by virtual assistants.

Now that voice recognition technology can more easily differentiate between different dialects and languages, the advantages of virtual assistants are becoming more evident. They're always available and they eliminate waiting times. Unlike real agents, virtual assistants don't have to log on to different systems, query information, and then inform the customer. They can call different enterprise APIs directly to provide information updates to customers in real time.

If we look at current self-service channels like IVR, it's become much too frustrating for customers to traverse complex IVR nodes to reach the final node to complete a given query.

Virtual assistants can complete customer requests based on a single voice command. Multi-round dialogue engines can respond to multiple queries to greatly increase response time and customer satisfaction.

Going forward, virtual assistants can offer much more value when the whole AI ecosystem improves. Multiple AI systems will be able to interact with each other, creating a mesh and a larger AI system that's capable of handling more complex customer engagements.

Huawei solutions for AI based virtual assistants

Huawei's AI strategy and product portfolio is helping Huawei to set the pace in various industries with a series of powerful products and solutions. In customer services, Huawei is exploring how AI can help minimize costs, make customer service operations more efficient, and increase customer satisfaction.

In Huawei's solution when a call is received by the system, ASR (Automatic Speech Recognition) and TTS (Text to speech) technologies provide speech recognition and speech synthesis capabilities. The customer's voice query is transferred to the bot, the bot understands the customer's intent, and engages the customer in dialogue. If the bot is unable to understand what the customer says, it can seek help from a human agent.

The Huawei solution offers three major advantages:

- Huawei's strong in-house AI capabilities include different NLP models, a very strong contextual intent management system for dialogue flow, sequence recognition models, and online error correction.
- Multiple open APIs can connect to existing billing systems, BSS systems, and all other enterprise applications.
- Multiple OOTB templates accelerate rollout and meet the requirements of telco-based call centers.

Huawei launched the solution in 2018. Since its inception, it has achieved 90-percent FCR (First Call Resolution) and a satisfaction level of 88 percent, which we're confident will continue to rise. Going forward, we're planning to expand AI to cover all our customer service operations, which will further boost experience by making customer interactions more meaningful and insightful.

Making data centers AI-ready with an industry-leading cloud engine

By Leon Wang, General Manager of Huawei Data Center Network Domain

As part of its full-stack, all-scenario AI strategy, Huawei has embedded artificial intelligence into its network products and solutions to create a fully connected, intelligent future. What are the key solutions for realizing this future?

A cloudy history

On August 8, 2012, Huawei launched CloudEngine 12800, a data center switch built for the cloud computing era. It led the world in design and technological trends for high-density 100G platform data center switches, enjoying the fastest growth for six consecutive years with a CAGR of 82 percent.

On January 9, 2019, Huawei defined three characteristics of data center switches for the AI era: embedded AI chips, 48 x 400GE high-density ports per slot, and the capability to evolve to an Autonomous Driving Network. Huawei also unveiled the industry's first data center switch built for the AI era, CloudEngine 16800, once again setting a new benchmark for the industry.

Data centers face challenges with AI

Driven by AI, the fourth industrial revolution is leading us into a new era where everything senses, everything is connected, and everything is intelligent. According to Huawei's *Global Industry Vision (GIV)*, the amount of global data will rise to 180 ZB by 2025. Moreover, 95 percent of unstructured data, such as voice and video, will depend on AI processing. And enterprises will begin harnessing AI for decision-making, reshaping business models and ecosystems, and rebuilding the customer experience, with 86 percent of organizations having adopted AI.

However, while the evolution of data centers from the cloud era to the AI era is inevitable, current data centers face three major challenges:

A packet loss of 0.1 percent on traditional Ethernet limits AI computing power to 50 percent: To boost AI's operating efficiency, AI systems will use flash storage to reduce latency by

more than 100 times. They'll also use GPUs and even dedicated AI chips for computing to increase data processing ability again by the same amount. In this context, network communication latency has emerged as a critical weakness. AI computing power affected by the performance of data center networks is now a worrying bottleneck for the commercial application of AI. High-performance data center clusters are extremely sensitive to network packet loss.

Existing 100GE networks will be unable to handle the data flood over the next five years: The amount of global data is predicted to surge from 10 ZB in 2018 to 180 ZB in 2025. Existing 100GE-based data center networks will be unable to support this data flood. New services, such as enterprise AI, are driving the evolution of data center servers from 10G to 25G and even 100G, which necessitates switches that can support 400G interfaces.

With the deep integration of computing and storage networks, manually locating network problems takes several hours. In recent years, data center architecture has changed dramatically, with the number of servers per data center increasing from dozens to tens of thousands. Moreover, computing, storage, and data networks are converging, and the amount of analyzed traffic has increased many thousands of times.

Locating service faults takes several hours using traditional manual troubleshooting O&M methods, which is no longer viable.

Data center switches in the AI era

To tackle these challenges, data centers will require autonomous high-performance networks to improve AI computing power and help customers speed up AI service operations. Therefore, Huawei's three characteristics for data center switches in the AI era responds to this.

The industry's first data center switch with an embedded AI chip for 100 percent AI computing power

CloudEngine 16800 is the first data center switch in the industry to harness the power of an embedded high-performance AI chip. It uses the iLossless algorithm for auto-sensing and auto-optimization on the traffic model, thereby realizing lower latency and higher throughput based on zero packet loss. CloudEngine 16800 overcomes computing power limitations caused by packet loss on traditional Ethernet, boosting AI computing power from 50 percent to 100 percent and improving data storage IOPS by 30 percent.

The industry's highest density 48 x 400GE ports per slot, meeting requirements for traffic growth in the AI era

CloudEngine 16800 boasts an upgraded hardware switching platform. Its orthogonal architecture solves multiple technical challenges, including high-speed signal transmission, heat dissipation, and efficient power supply. These advantages enable it to provide the industry's highest density 48-port 400GE line card per slot and largest 768-port 400GE switching capacity (five times the industry average), meeting traffic multiplication requirements in the AI era. In addition, its power consumption per bit is reduced by 50 percent.

Enables autonomous driving network, identifies faults in seconds, and automatically locates faults in minutes

The CloudEngine 16800 is embedded with an AI chip, substantially enhancing the intelligence of devices deployed at the network edge and enabling the switch to implement local inference and rapid decision-making in real time. With CloudEngine 16800's local intelligence and the centralized network analyzer FabricInsight, the distributed AI O&M architecture identifies faults in seconds and automatically locates them in minutes, helping to accelerate evolution to autonomous driving networks. Additionally, it provides root cause analysis of more than 72 types of typical faults in seconds using the iNetOps smart O&M algorithm, boosting the automatic fault location

rate to 90 percent. Furthermore, the distributed AI O&M architecture dramatically enhances the flexibility and deployability of O&M systems.

3 major breakthroughs for the hardware exchange platform

CloudEngine 16800 supports the high-speed smooth evolution of high-density ports from 10GE to 40GE, 100GE, 400GE, and even 800GE. It slashes the number of core layer devices, simplifies the network, and improves management efficiency. CloudEngine 16800 delivers revolutionary technological breakthroughs in three areas:

SuperFast: Ultra-high-speed interconnection

When evolving from 100GE to high-density 400GE, the first challenge is implementing the high-speed intra-switch signal transmission capability. Each time the signal frequency doubles, the signal attenuation of the PCB increases by more than 20 percent. As traditional PCBs are made from copper foil using traditional manufacturing techniques, transmission loss and high-frequency interference become more severe when the signal transmission rate increases. This is the main bottleneck limiting the switch capacity of switches. Huawei employs techniques like sub-micron lossless materials and polymer bonding to improve signal transmission efficiency by 30 percent, thus supporting full-lifecycle compatibility and evolution from 100GE to 400GE and even higher port speeds.

SuperPower: Efficient power supply

Based on a traditional design, a high-density 400GE interface core switch like CloudEngine 16800 would require 40 power modules, which would take up over one-third of the entire chassis alone. Huawei has developed the industry's first power module with independent dual inputs and intelligent switching. It utilizes magnetic blowout and large exciter technology to realize fast switching in milliseconds and ensure high reliability. As such, 21 of these new power modules can achieve the same power supply capability and reliability as 40 single-input regular power modules, using 50 percent less space. Line cards use a magnetic matrix and high-frequency magnetic technologies to provide 1600 W power supply capabilities in a space the size of two thumbs, improving power supply efficiency in the space of a single unit by 90 percent.

SuperCooling: Powerful heat dissipation

For an ultra-high-density switch, heat dissipation is an important reflection of the engineering capability of the entire system. The CloudEngine 16800 switch's cooling system provides both card-level and system-level heat dissipation for true energy efficiency.

When it comes to card-level heat dissipation design, evenly exporting the chip-generated heat out of the card and dissipating it is key. CloudEngine 16800 leverages a unique carbon nanotube thermal pad and VC phase-change radiator technology for 4x better cooling capability than the industry average, improving the entire system's reliability by 20 percent.

In terms of system-level cooling, Huawei uses mixed-flow fans, an industry first, to achieve the best heat dissipation efficiency of an entire system in the industry. The average power consumption of each bit of data is 50 percent lower than the industry average, producing savings equivalent to 320,000 kWh and reducing carbon emissions by more than 250 tons per year per switch. The unique magnetic permeability motor and the mute defector ring reduce noise by 6 dB, making the data center quieter.

Equipped with a high-performance AI chip and featuring the industry's highest switching capacity, CloudEngine 16800 will enable the switch over from cloud-era to AI-era data center switches, lead data centers into the AI era, and help customers succeed in the new AI future.

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The image showing a Mobile Phone's screen is a Mate 20 whilst the remaining images are all Mate 20 Pro.
*40W Super Charge refers to a High-Voltage variant of HUAWEI SuperCharge Technology which only applies to HUAWEI Mate 20 Pro and is only supported by a 40W HUAWEI Charger.

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