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Unfolding the map to a fully connected, intelligent world

In 1968 scientists and scholars met in New York to predict what the world would be like in 2018. Some predictions were wild, others surprisingly accurate. But one that was consistently on the mark was connectivity: a "universality of telephony" supported by massive information networks comprising fiber optics and satellite communication and accessed through pocket devices.

Enabled by ICT and AI, the fourth industrial revolution will take connectivity to the next level, leading society into an intelligent world where everything senses, everything is connected, and everything is smart.

In this new world, AI will be a general-purpose technology and ICT will create the rich soil in which industries can continually innovate. The convergence of 5G, cloud, data intelligence, IoT, AI, and video will create enormous value for individuals, home life, and business.

In 2025, 40 billion smart devices that sense and 100 billion connections will shatter information silos, enabling the faster, more secure, and smarter exchange of data.

The integration of the physical and digital worlds means that the experiences of individuals and households will change. Organizations will adopt data-driven growth models and cities will discover new springboards for leapfrog development. But the future is unknown: How should upstream and downstream ICT industries seize the opportunities of the intelligent world?

Huawei will bring digital to every person, home, and organization to build a fully connected, intelligent world. By focusing on ICT infrastructure and smart devices, the soil we provide will be rich with information-based, automated, and intelligent potential. Our partners and customers will be able to grow the content, applications, and clouds that serve individuals, homes, and organizations.

Better connections: More connections and bigger pipes will harness the advantages of 5G and cloud-and-network synergy and enable the digital transformation of every industry.

Better business growth: Maximizing network value plus video and IoT services will create new business growth.

Better experiences: Business agility for smart and efficient operations through digital O&M will provide a ROADS experience for users.

But, we need to unfold the map now to avoid heading in the wrong direction. Together, we can walk farther. Together, we can reach the fully connected, intelligent world.

William Xu,
Director of the Board & Chief Strategy
Marketing Officer, Huawei

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COVER STORY

SoftCOM AI
Hard on the competition with zero faults

By Zhu Guangping
Huawei Fellow

Huawei's SoftCOM AI solution introduces AI to All Cloud Networks. Designed to create self-driving network architecture, SoftCOM AI is a transformative solution that can help operators compete with OTT companies by using predictive AI to minimize network faults.

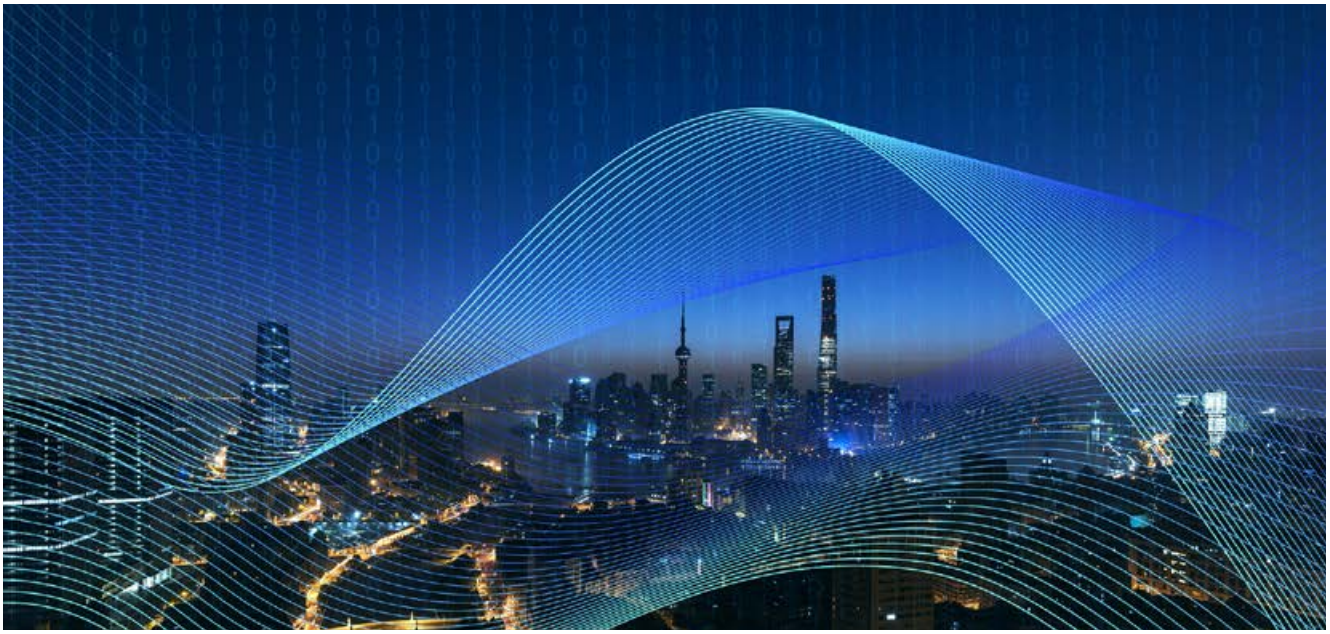
Competition drives innovation

Telecom services are divided into three tiers: device, network and IT infrastructure, and upper-layer applications. However, in today's telecoms landscape, cross-sector competition is threatening telco revenue models. Thanks to dramatic increases in network speeds, IT and Internet companies are offering cloud services in traditional telco territory: backbone networks, some MANs, IT infrastructure, and IT applications. If operators can provide top-tier cloud services, they can compete with the likes of AWS in the trillion-dollar cloud service market. If not, they will lose many of their traditional services, in particular data center leased lines.

Operators also face efficiency and cost challenges. OPEX for maintaining telecom equipment is about three times higher than the original CAPEX. Moreover, higher network complexity often means that engineers lack specialist knowledge and capabilities, resulting in 70 percent of major network faults being attributable to human error.

As Frank Qing, Chief Wireless Architect for Canada's TELUS, puts it, "We're using 21st century 4G networks, but network O&M is somehow like being stuck in the 18th century. Machine manufacturing has become automated but the telco industry is still using manual labor."

Product innovation alone isn't enough to overcome the challenges facing operators.



Boosting competitiveness requires innovations in system architecture, products, and business models.

What is system architecture innovation?

In cloud computing, it isn't a breakthrough in a server or storage product. Instead, it's system-level innovation based on new distributed systems that increase resource utilization. Innovations in **products**, **system architecture**, and **business models** are mutually reinforcing. To meet customer needs in the new era, Huawei has designed an innovation system covering these three areas.

On the product side, the principle behind Huawei's network equipment design is "Olympic Spirit": high capacity and low latency. For system architecture, Huawei is looking at self-driving networks that are agile, automated, and smart. And we have two goals for business model innovation: one, for operators and Huawei to form one of five major clouds, and, two, to build an Online Smart Service model.

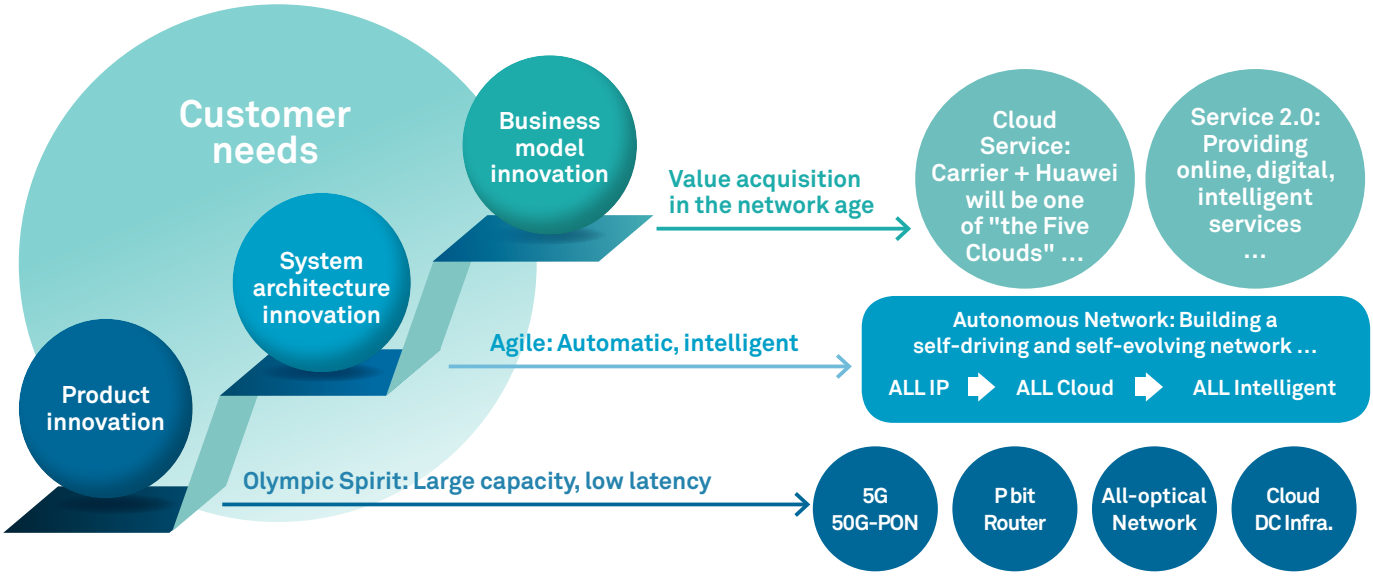
Self-driving

The aim of AI-driven autonomous networks is to create a self-driving network model with three features: agile devices, intelligent control, and intelligent analysis.

In telecom networks, the lower layer is network equipment and the upper layer is the control layer. For network-wide control and O&M, AI and segmented autonomous functions can achieve E2E functionality through the upper-layer operating system, thus enabling the entire network to become autonomous.

The biggest change realized by autonomous networks is that maintenance personnel are no longer involved in the service process. The entire network is self-driving in that it's automated, self-optimizing, and self-healing.

The growth of the Industrial Internet has changed the business models of industrial giants such as Boeing, which now provides digital services like predictive maintenance, fuel management, and flight management. A similar service concept can be applied to telecommunications. Future networks will be fully automated at the operator side with Huawei



providing fully automated AI-based online services. These services will be underpinned by a continuous iterative AI model that's available as a continually improving Model-as-a-Service.

Introducing AI to networks will bring new value from predictability. Telecom network management and the control center are based on southbound interfaces for devices and data collection. Various strategies and rules enable network-wide management and scheduling to fulfill three conditions for network automation: network reachability, SLA requirements, and resource efficiency.

However, as networks become increasingly complex, this isn't enough. Online AI reasoning and data analysis are required to predict traffic, quality, and faults. Scheduling networks based on predictions of future conditions avoids faults before they occur, optimizes quality before it deteriorates, and adjusts traffic before congestion occurs. Thus, the core value offered by AI is zero faults.

Five phases, three areas

Developing a self-driving network is a long-term process that we've divided into five phases:

One: AI knows "what happened."

Two: AI can determine "why it happened."

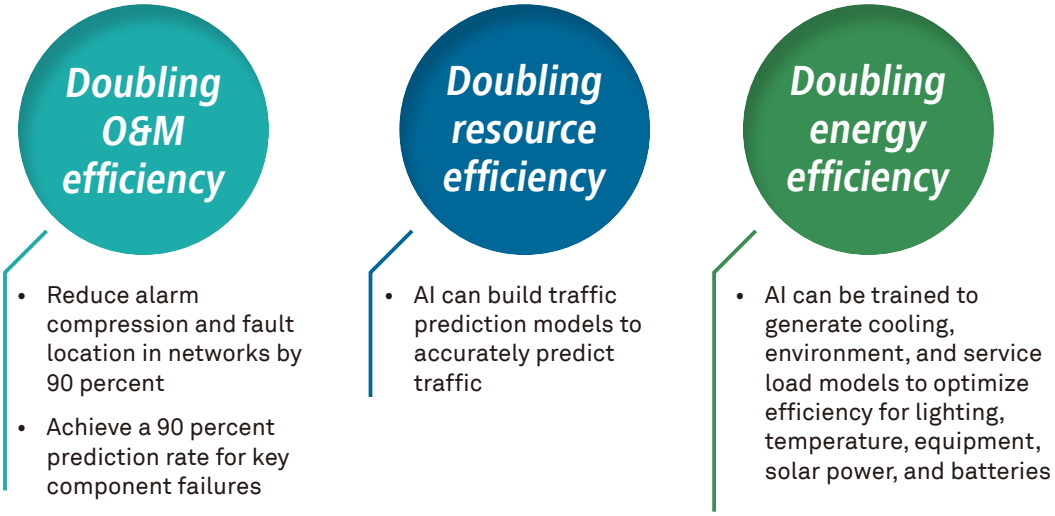
Three: AI can predict "what will happen" and is supported by manual judgments and decisions.

Four: AI judges "what measures need to be taken", which are then carried out manually.

Five: Full automation enables self-healing.

Autonomous networks and Model-as-a-

The aim of AI-driven autonomous networks is to create a self-driving network model with three features: agile devices, intelligent control, and intelligent analysis.



Service will provide end users with a minute-level ROADS experience, optimal network connections at all times, and networks with zero downtime. Operators will benefit from doubling efficiency in three areas: O&M, resources, and energy.

Doubling O&M efficiency: There are three levels of development in O&M. The first is Run-to-Failure (R2F). With R2F, O&M personnel rush to fix sudden faults when they occur in network operations. This is the lowest level of O&M. The second stage is Preventive Maintenance (PvM). This involves routine inspections. Each item of equipment is checked to prevent failures. This method is extremely inefficient. The third level is Predictive Maintenance (PdM), where the probability that a certain device will fail in the future can be predicted and targeted maintenance carried out.

With PdM, we hope to reduce alarm compression and fault location in networks by 90 percent and achieve a 90 percent prediction rate for key component failures and deterioration, taking a further step towards network self-healing.

With more than 70 percent of network faults caused by passive equipment, for example, fiber bends, device aging, and loose ports, AI can learn the characteristics of signal changes when problems like this occur and drive predictive maintenance.

Doubling resource efficiency: Currently, networks are constructed before data traffic begins to flow, sometimes leading to poor resource utilization. If the problem is approached from the other way round, with network scheduling based on flow direction, resource utilization would be much higher.

AI can build traffic prediction models to accurately predict traffic, and thus reveal the best network topologies where network paths are determined by traffic direction rather than physical connections.

Doubling energy efficiency: To achieve this, bits can manage watts; that is, network

traffic can determine energy consumption. In equipment rooms and base stations, each system has dozens of parameters. AI can be trained to generate cooling, environment, and service load models to optimize efficiency for lighting, temperature, equipment generators, solar power, and batteries.

At the equipment level, dynamic energy delivery can be based on service loads. When there's no traffic, methods such as timeslot shutoff, RF deep sleep, and carrier frequency shutoff can reduce power consumption, coupled with dynamic energy-saving management for data center servers and other equipment.

On the network system side, accurate service load prediction models can optimize all network traffic for optimal energy efficiency.

Building and training autonomy

SoftCOM AI is Huawei's target architecture for self-driving networks based on introducing AI tech and capabilities in three layers: device and cloud infrastructure; the network management and control center; and the network O&M system. These three layers will achieve the E2E smartification and automation of network planning, deployment, operation, maintenance, optimization, and business operations.

Huawei is also planning an AI training platform for operators that can train AI using data from network equipment that's sent to the platform. Models will be continuously updated and optimized to help improve the level of automation in the network system.

Example: SoftCOM AI in an optical network

SoftCOM AI can enable the whole service development process. The first requirement is the data foundation, which determines what kind of data is needed. For an optical network, this includes fiber optic data, optical signal data, and optical routing data. The next requirement is enabling technology, or AI algorithms, including algorithms for data cleansing, integrating information, machine learning modeling, and deep learning.

A large number of models also need to be built to enable a "self-driving" optical network. These include fiber optic and filter models.

The final requirement is service application scenarios. These include the initial automated inspection of optical fiber, service provisioning, network optimization, fault location, and automated resource scheduling. Models will be able to find optimal approaches, enabling fast provisioning, simpler O&M, and smart operations. Smartification will improve network scheduling efficiency. With zero-wait, zero-touch, and zero-experience, people won't even feel the network is there.

The future is intelligence. But, network smartification won't be achieved overnight. SoftCOM AI is a part of Huawei's All Intelligence strategy in the telecoms sector to help operators create automated networks that never fail and act as a springboard for digital transformation.

Operators will benefit from a doubling in efficiency in three areas: O&M, resources, and energy efficiency.

Embracing the intelligent era with Intent-Driven Networks

In an intelligent world, all things will be connected. Connections have infinite potential value and will ultimately deliver a vast new range of user experiences. ICT is the foundation of a fully connected society. However, universal and reliable connectivity is necessary to ensure a premium user experience. This is where Intent-Driven Networks come into play.

By Kevin Hu
President of Huawei Network Product Line

A premium user experience will enable new technologies to develop, endowing our networks with greater vitality. Cutting-edge technologies, such as cloud, big data, and artificial intelligence (AI), are already making an impact beyond just the Internet. They are transforming new IT and will go on to revolutionize communications, driving fundamental changes to the communications industry.

Huawei's Global Industry Vision (GIV) predicts that by 2025, there will be 100 billion connections worldwide. The Internet will be available to 77 percent of the world's population, 75 percent of homes will enjoy broadband connections, and 80 percent of people will have mobile phones. This enhanced connectivity will be the foundation for the intelligent world.

Towards intelligent networks

The popularity of broadband over the next decade will increase global GDP by about 4.5 percent, and erode the constraints distance has on economic activities. Today, fiber, copper, cable, and microwave technologies mean that networks can grow even faster. We already have the core of a global network, which is gradually being extended to every corner of the earth. The expansion of broadband coverage has been a major factor driving the incredible development of the ICT industry over the past 20 years. As one of the world's leading ICT companies, Huawei's mission is to build links between people and between things. Today, half the world's population uses Huawei equipment in some form or another and benefits from the broadband services that our networks make possible.

The pursuit to give users a better service experience is also the pursuit of autonomous networks – the ultimate goal of network development.

During the rapid growth of broadband networks, cloud-based technologies led by SDN were deployed, first in enterprise networks and then in telecom networks. Doing so achieved central network control and management, and accelerated carriers' digital transformation. The core principles of network cloudification are automation coupled with vertically extending the value of network connectivity, so new services like 5G can be vertically extended. Huawei launched its all-cloud network strategy in April 2016, and proposed the transformation of carriers' ROADS experience by cloudifying devices, networks, services, and operations. By the end of 2017, Huawei had deployed more than 380 SDN networks for carriers and enterprises worldwide, covering data centers, campuses, and WANs, helping customers solve some of the challenges with digital transformation.

The pursuit to give users better service experiences is also the pursuit of autonomous networks – the ultimate goal of network development. However, there's still a huge gap between SDN and autonomous networks, which prompted our intelligent network concept.

Intent-Driven Networks: For users

Carriers now understand how crucial network intelligence is for service operations.

In the home broadband service field, carriers have limited awareness of the entire network, and network faults cannot be handled quickly. As a result, the quality of the broadband user experience cannot be guaranteed over the long-term. Increasing service quality requirements for enterprises and governments greatly increases the challenges to carriers' networks, which is compounded by scattered resources. In the mobile service field, sudden traffic spikes affect mobile transport networks, which can be adjusted only after user complaints have been received.

All challenges for carriers with core service operations boil down to equipment-centric network O&M. Executives from leading carriers around the world recognize that their networks are not designed to revolve around users or services. Carriers must build an intelligent network that can sense user requirements in real time and dynamically configure network resources based on service operations.

At MWC 2018, Huawei launched its Intent-Driven Network solution. The solution enables digital twins to connect physical infrastructure to business needs. The network is driven by customers' business intent and service policies. Huawei will help build a network that puts user experience front and center based on the following features: intelligence, simplicity, ultra-broadband capabilities, security, and openness.

Seeing the future

The Intent-Driven Network has five major features:

One, predictive analysis: Using big

data and AI, the network can predict network issues, optimize network performance, and perform troubleshooting in advance. The network can also perceive the service experience of every user in real time. With self-learning capabilities, it can continuously improve its intelligence and ability to perceive issues with the network and with user experience.

Two, simplicity: The architecture, protocols, sites, and O&M are simple and able to achieve full lifecycle automation so the network is more agile and efficient. This helps improve the utilization of network resources and the flexibility of services.

Three, ultra-broadband: New UBB technologies can achieve massive numbers of connections, ultra-low latency, and ultra-high bandwidth.

Four, openness: The network can interconnect with various third-party platforms to build an open industry ecosystem.

Five, security: By identifying security threats in advance, the benefits of network intelligence and automation can be fully realized.

The Intent-Driven Network will be integrated into various service scenarios and help carriers build solutions for future business scenarios. At MWC 2018, Huawei launched a series of innovative solutions for agile private lines, 5G transport, premium broadband, and enterprise campuses. These new options will help carriers reshape their business models.

Huawei believes that enterprises and carriers will walk together into the Intent-Driven Network era and develop in parallel, driven by the ICT industry.

Partnerships and openness

Huawei is committed to bringing digital to every person, home and organization for a fully connected, intelligent world.

We work with our partners to build an open, collaborative, and win-win industry ecosystem. In the field of network innovation, Huawei works with upstream and downstream partners to promote innovation in the Intent-Driven Network industry. Huawei has established R&D organizations in eight countries and established more than ten network innovation centers with multiple carriers, including Vodafone, Deutsche Telekom, SK Telecom, China Mobile, British Telecom, and Telefonica.

We actively participate in formulating mainstream international standards. In the network field, Huawei has held nearly 40 high-end standard positions in standards organizations, including IETF, ITU, ETSI, BBF, OIF, and IEEE. We now lead industry standards in the access and transport domains, entered the first camp of IP technology standards, and we're the main contributor to SDN/NFV technology standards.

To help construct the SDN/NFV ecosystem, we have built more than 10 SDN/NFV open labs. By the end of 2017, we had more than 40 partners in the SDN field and completed integration and test certification with more than 20 industry partners.

Huawei is seeking to build alliances to establish an industry cooperation platform. The Edge Computing Consortium initiated by Huawei and its partners has more than 150 members. Through open collaboration between the OT and the ICT industry, Huawei promotes sustainable development in the edge computing industry.

In the future, Huawei will work with its global partners to leverage strategic development opportunities that will be delivered when everything is connected. By building intelligent, simple, and secure Intent-Driven Networks that are open and feature UBB capabilities, Huawei will enable global carriers to build user-centric intelligent networks for the benefit of all.

Cloud data centers in the 5G era

By Dennis Gu
Chief Architect of Huawei Cloud

The 5G ecosystem chain covers cloud, pipe, device, and everything in between. Innovative and cross-generation evolutionary wireless terminals, air interfaces in base stations, and network transmission technologies are accelerating the evolution of device and pipe architectures. However, cloud data centers are the core hub of the 5G digital ecosystem and will play a pivotal role in 5G's evolution. What kind of cloud data center will be able to meet the network and service requirements of 5G?

The answer is simple: A distributed full-stack cloud data center that is open, efficient, flexible, and intelligent.

Open: Open architecture means that cloud services at different layers aren't locked by a single vendor. Instead, cloud data centers in the 5G era adopt mainstream open-source northbound service APIs and applications in compliance with industry standards.

The infrastructure layer adopts mature OpenStack elastic computing, storage, and network service APIs. The data layer uses APIs for data operations and queries based on big data and database standards such as Hadoop, Spark, MySQL, and Redis. The platform layer uses Kubernetes container service APIs, which are now a mainstream solution for application deployment and the microservices framework.

Huawei cloud data centers employ standard service APIs on artificial intelligence (AI) platforms such as TensorFlow and MXNet, both of which represent benchmarks in machine learning and deep learning.

Efficient: 5G networks require 100 times higher transmission rates and bandwidth than 4G networks. 5G networks also demand much more in terms of reliability and latency for applications such as virtual reality (VR), ultra-HD video, intelligent manufacturing, and auto-pilot

functionality. However, delivering ultra-high throughput and ultra-low latency capabilities is challenging for 5G cloud data center platforms when faced with network-intensive workloads, such as vEPC, and storage-intensive workloads such as CDN and 4K/8K Video On Demand.

The Huawei solution delivers optimized energy and cost efficiency for compute-intensive workloads such as machine learning, deep learning, and 3D rendering. Obviously, general x86 architectures no longer meet these requirements. Data center vendors need to introduce heterogeneous computing architectures such as ARM, SoC-based intelligent network adapter, GPU/FPGA, and neural-network processing unit (NPU) chips, to ensure businesses can run at the highest energy efficiency ratio and cost-effectiveness.

Network elements (NEs) on the data plane of 5G networks, such as virtualized evolved packet core (vEPC) and CloudRAN base stations, normally require the throughput of a single NE or single server to jump from 10 Gbps to 100 Gbps. But, the conventional, software-only overlay cloud networks based on x86 CPUs face severe performance bottlenecks. Therefore, it's necessary to deploy SR-IOV direct pass-through or the DPDK user space mechanism to offload overlay networking functions, such as OVS, vRouter, and vFW, from X86 to heterogeneous hardware, for example, Intelligent NIC or FPGAs with 100 Gbps port speed.

For 5G Internet of Things (IoT) scenarios, massive volumes of data collected from distributed IoT terminals and edge nodes in various industries need to be aggregated, stored, processed, analyzed, and managed in a centralized cloud data center based on the object storage service and Hadoop/Spark/Stream Big Data Pipeline services.

Huge amounts of machine learning and deep learning processing tasks require extensive resources for the following parallel computing operations: convolution, derivatives, logarithms, and matrix multiplication with floating numbers. These operations extract valuable business insights and train prediction models based on inputted raw data.

Offloading these computing capabilities to heterogeneous hardware, such as GPU/FPGA clusters or even the NPUs, improves the cost effectiveness of the high-density computing and energy efficiency ratio by 5 to 10 times. More customers require data interconnections between heterogeneous computing GPUs, FPGAs, and NPUs in massive parallel computing scenarios, which has prompted huge advancements in ultra-high-speed link connection technologies such as RDMA over converged Ethernet and NVLink. This ensures that the performance advantages of heterogeneous computing clusters are fully brought into play.

For ultra-high performance IOPS in storage-intensive scenarios, the next-generation storage-class memory (SCM) is increasingly used as the default flash storage medium with an acceptable unit capacity price, while providing read and write speed and latency comparable to memory solutions. SCM-based storage nodes with RDMA/RoCE link connection to compute nodes are now more widely used in the distributed storage architecture, typically delivering sub-100 ms shared storage latency and storage bandwidth that's even higher than the local disk's PCI speed.

Flexible: Another challenge for 5G networks is to flexibly orchestrate and reassemble network slices. Network slicing requires the evolution of NEs for 5G services and protocols, as well as streamlining on the 5G IoT application data layer, core network layer, and wireless access layer of a cloud data center. These advancements will help implement end-to-end network functions on the management, control, and forwarding layers, as well as support dynamic on-demand isolation of capacity and QoS.

Based on the specific requirements of vertical service scenarios, flexible 5G network slicing requires that

Dynamic orchestration helps simplify and shorten 5G network construction from several months to one-click, automated construction in minutes.

deployment, including capacity, service configuration, network elements, service applications, and the in-between networking link, is completed as quickly as possible. Template-based orchestration services are introduced here to enable 5G networking elements and applications. Dependency can be automatically provisioned and configured based on the heterogeneous resource flavors of virtual machines, and physical machines with pre-defined topology dependency. In addition to static resource topology, PaaS requires dynamic orchestration capabilities such as sequential, conditional, and loop service logic control for orchestrated services with ensured transaction integrity. Dynamic orchestration helps simplify and shorten 5G network construction from several months to one-click, automated construction in minutes.

Distributed: In the 5G era, the majority of physical network access and routing network functions and applications, such as IoT core services, big data, and deep learning, will be deployed in centralized large-scale cloud data centers based on geo-redundant VMs. This will enable 5G IoT device access and corresponding application platforms, as well as diverse third-party applications located in distributed sites. The data centers in this layout can support tens of thousands of hosts. The access devices on the 5G data plane, such as vEPC gateways, are generally deployed near the metro aggregation access Points of Presence (POPs). This ensures that cloud services, like backup, disaster recovery (DR), video storage uploads, and other typical low-latency interactive services, can be accessed with ensured QoS/SLA over non-blocking dark-fiber/MPLS bandwidth. These services can run on hundreds of small-scale satellite cloud sites configured as a one-stop cloud in box mode.

The ubiquitous access and coverage of 5G networks require ultra-low latency and ultra-high bandwidth. Functions that should be moved to the satellite cloud include radio air interface protocol processing; baseband control; wireless resource management and scheduling; network data tunnels; route forwarding, aggregation, and processing; and service processing.

In synergy with the centralized cloud region and in addition to the satellite cloud located around local city PoP, we still need large numbers of edge nodes beneath the satellite cloud, which is designed to better support IoT services. For example, predefined AI-enabled recognition of surveillance videos, stream processing filtering of raw IoT data, 3D content rendering of VR/AR games, and real-time user operations, can be migrated from the centralized data center to the access network edge. By doing so, centralized intelligent analysis, agile development iteration, and local and real-time access processing capabilities can complement each other.

Moreover, edge nodes can convert a large amount of high-bandwidth, unstructured, or multimedia data on the terminal side to high-value and low-bandwidth structured data that can be uploaded to the cloud data center for centralized analysis and processing. The edge nodes deliver control commands for the edge and terminals. This improves the overall throughput of E2E 5G networks and cloud service applications, which in turn will improve user experience. The seamless integration of edge computing services with full-stack cloud services, such as the cloud PaaS platform, big

data, and AI services, accelerates the development and rollout of innovative services such as IoT, video AI, and AR/VR games with ubiquitous access.

Typical reference architecture for edge clouds can be implemented by the reference architecture of centralized Kubernetes master nodes plus the remote minion node with Kublet agent. With northbound K8S APIs, the edge cloud is compatible with the edge computing services in the Kubernetes ecosystem. It supports access registration and security certificate management for tens of thousands of distributed edge nodes. Edge nodes also need to support parallel batch container instances, serverless instance deployment, and lifecycle management

Intelligent: Enabling IoT applications is one of the main objectives of 5G network construction. IoT applications generate massive amounts of data, so data centers in the 5G era need to provide ultra-large elastic storage capacity and computing capabilities. In addition, an intelligent, highly efficient engine that's easy to configure and use, combined with diverse domain knowledge and data models, is needed to quickly learn and extract targeted valuable information and strategies from this data. This facilitates closed-loop control on IoT terminals and edge devices.

Typical application scenarios include:

- Image and video recognition in wireless video surveillance scenarios
- Vehicle GPS location tracking and driving behavior preference analysis for the Internet of Vehicles
- Traffic congestion and violation detection in intelligent traffic scenarios
- Population density and mobility prediction in smart city scenarios
- Power use distribution and peak predictions in smart grid scenarios

The intelligent engine previously introduced in the IoT scenario requires that the cloud data center relies on IoT data lakes on the big data platform. This enables the cloud data center to provide rich platform services and APIs with pre-integrated machine learning, deep learning, a graphics engine, search capabilities, AI services, and APIs in common fields such as visual, voice, natural language, and optical character recognition (OCR). These platforms and general AI/machine learning service capabilities work closely with heterogeneous computing hardware, including GPUs, FPGAs, and NPUs and the scheduling system's 5G cloud platforms, to implement deep software optimization.

As 5G cloud data centers will be deployed over multiple distributed geo-locations with support for multi-tenant network slices and millions of resource nodes, features such as maximum cloud region size must be supported and a truly intelligent and self-healing maintenance mechanism is urgently required.

Moreover, traditional local O&M and fault management needs to be replaced by proactive, predictive O&M and management based on powerful big data and AI services as part of a 5G full stack cloud. AI/ML algorithms deployed on the basic platform with supervised learning, semi-supervised learning, and unsupervised learning can help analyze the massive amounts of log information collected from software and hardware subsystems. These algorithms support the root cause analysis of failures, automatic identification of abnormal behavior patterns, and the prediction of network and hard disk faults, greatly improving hardware and software O&M efficiency, with a single O&M staff member able to maintain more than 1,000 servers.

Both equipment providers and carriers have great expectations for 5G. In some countries, 5G commercial deployment may be accelerated by government policy. So, carriers must plan ahead to build an open, efficient, flexible, and intelligent distributed full-stack cloud data center that ensures the openness and flatness of the 5G network. Then, 5G industrial applications can be quickly commercialized.

5G On the verge of a smart future

At Mobile World Congress (MWC) 2018, Huawei released the industry's only 5G end-to-end (E2E) product and solution based on the 3GPP standard. Focusing on enhanced mobile broadband (eMBB) services, we completed the world's first interoperability test of 3GPP R15-based commercial products and we've been working with world-leading operators on large-scale 5G verification tests in commercial environments – Huawei is ready for large-scale 5G rollout.

By Zhou Yan

E2E and all-scenario

Our 5G E2E products and solutions cover the core network, bearer network, base stations, and terminals. Huawei's 5G core network solution is designed with all-cloud architecture, with software architecture based on microservices. The solution can simultaneously support 2G, 3G, 4G, and 5G, and enable smooth evolution in non-standalone (NSA) and standalone (SA) scenarios. Its flexible, distributed network architecture applies control plane and user plane separation (CUPS), helping operators deploy the control plane in a central data center and flexibly choose the deployment location for the user plane according to the service scenario.

The all-cloud 5G core network provides the basis of network slicing, which will enable operators to offer various services on a single network and transform their businesses from the mass market to the vertical industry market.

Huawei's X-Haul 5G bearer solution supports multiple technologies, including IPRAN, PTN, OTN, and microwave, covering active to passive and 5G microwave to IP bearer networks. To meet 5G network capacity requirements and help operators solve the challenges large-scale 5G deployment will bring for mobile bearer networks, Huawei has launched a 5G bearer product portfolio that suits various scenarios, media, and forms. The portfolio includes a series of 5G microwave products for backhaul scenarios that can provide 10-Gbps bandwidth and 25-ms latency on traditional microwave frequency bands; a 50 GE/100 GE adaptive slicing solution that supports smooth evolution from 10 GE to 50 GE and 100 GE for on-demand gradual deployment; an active FO OTN fronthaul solution that supports up to 15 channels of service access, lossless switching, and integrated access for multiple services; and a centralized WDM fronthaul solution that uses a colorless optical module to simplify site delivery and O&M.

Huawei provides a range of base station products covering all site forms, including tower sites, pole sites, and small cells. Diverse site forms are required to meet the needs of complex deployment scenarios, provide continuous coverage, and satisfy capacity requirements for indoor and outdoor hotspots.

The first wave of 5G deployment will take place in buildings and densely populated urban areas. Huawei's C-band 64T64R and 32T32R Massive MIMO AAU both support 200 MHz large bandwidth and 3D beamforming. This allows for the flexible and accurate control of cell coverage radius. The vertical plane improves coverage for tall buildings, while the horizontal plane enhances coverage at near points and far points horizontally in buildings, enhancing cell capacity and user experience.

Huawei's mmWave products support 1 GHz bandwidth, with

5G LampSite is the industry's first multi-frequency integrated indoor small base station that supports both 5G and LTE.

antenna port equivalent isotropically radiated power (EIRP) hitting 65 dBm, the highest in the industry.

Huawei's wireless products are integrated, compact, and light. They slash space requirements on the antenna installation platform and reduce installation complexity. The fronthaul optical interface speed for the hardware is less than 25 Gbps, reducing transmission requirements, which is ideal for large-scale 5G deployment.

Huawei's base station products support both distributed and centralized deployment. BBU5900, which is for distributed sites, is the most integrated site solution currently available in the industry. It supports all RATs (2G, 3G, 4G, and 5G) and all frequency bands, and offers 50 Gbps backhaul capabilities, which meets the long-term development needs of 5G services. CBU5900, which is for centralized sites, requires many BBUs to support C-RAN (Centralized RAN) architecture, simplifying remote sites, reducing the need for equipment rooms, and contributing to quick satellite clock synchronization across the entire network. This approach reduces the number of site visits during maintenance and installation, allowing sites to be added on demand, greatly reducing future site construction and maintenance costs. Centralized site deployment also enhances the edge user experience and the performance of the entire network through large-scale site coordination.

Huawei's new compact 5G Massive MIMO 5G C-band and mmWave products can be deployed on streetlamp poles to fill coverage holes and boost hotspot capacity. Huawei has also launched 5G LampSite, an indoor 5G small base station product. The solution is backwards-compatible with 4G and harnesses existing CAT6A network wires or optical cables to achieve indoor 4G and 5G co-deployment with zero cable adjustment or site addition. 5G LampSite is the industry's first multi-frequency integrated indoor small base station that supports both 5G and LTE.

On the device side, Huawei has invested heavily in developing 5G chipsets and customer premise equipment (CPE) to help operators achieve first-mover advantages in the 5G market. Huawei released its Balong 5G01 5G chipset, the industry's first commercial 5G device chipset that supports the 3GPP standard. It supports all the main 5G frequency bands, including sub-6 GHz and mmWave, provides Gbps-level data downlink speeds, and supports NSA and SA networking.

Huawei's 5G CPE is based on 3GPP standards and chipset architecture. Compact with low power demands, it's currently the only miniaturized 5G commercial terminal. In Seoul and Canada, we've seen the first batch of users of 5G CPE. In 2019, Huawei plans to launch 5G mobile phone chips and a 5G smartphone.

Following the advancement of standards in addition to the completion of key technologies and system verifications, Huawei has carried out large-scale engineering and performance verifications in real-world field environments to prepare for

5G commercial application. Using its leading 5G products and solutions, Huawei has already deployed large-scale 5G networks in more than 10 countries, including China, South Korea, Canada, Germany, the UK, and Italy. In typical densely populated urban areas, these products and solutions provide ubiquitous Gbps-level access rates, indoor access rates of hundreds of Mbps, and over 20 Gbps of user peak rates.

Partnerships, innovation, ecosystem

Huawei has deepened collaboration with industry leaders in device ecosystem, technological innovation, and network verification.

In early 2018, Huawei worked with Deutsche Telekom and Intel to complete the first ever 5G interoperability and development test in a carrier network environment using a commercial 5G site based on the 3GPP R15 Standard, carrying out 5G interoperability testing based on the 3GPP standards with Qualcomm.

At the 2017 Global Mobile Broadband Forum, Huawei and the BT subsidiary EE conducted the first field demonstration of 5G uplink and downlink decoupling technology, achieving a 70 percent increase in cell radius coverage. The technology flexibly shares the 1.8 GHz uplink frequency band with 5G without affecting user experience on the existing LTE 1.8 GHz band. 5G downlink continues to operate on the 3.5 GHz band. The solution compensates for insufficient uplink coverage due to factors like high penetration loss and propagation loss in the 3.5 GHz band. Not only is cell coverage uplink improved, but the downlink performance of 3.5 GHz Massive MIMO is also maximized. Achieving C-Band and 1.8 GHz co-site deployment with the same coverage can greatly reduce requirements for new sites during 5G network construction, lowering operator investment in site construction and leasing.

Huawei and Bouygues Telecom have signed a 5G agreement to carry out the first 5G trial in Bordeaux. Huawei and Vodafone joined forces recently to complete the world's first 5G call and dual-connectivity test on a 5G commercial system. Huawei partnered with TELUS to conduct the first user friendly test of 5G CPE in North America, taking 5G from the lab toward the end user. Huawei, Telecom Italia, and Fastweb completed 5G verification achieving a single-user downlink rate of 3 Gbps. Huawei teamed up with Telefonica to demonstrate the first interactive virtual reality (VR) service using 5G E2E network slicing. Working with Deutsche Telekom, Huawei carried out the first high-level mmWave (73 GHz) field verification. Huawei and Vodafone jointly completed the world's first 5G microwave proof-of-concept (PoC) test, demonstrating a capacity of 2.7 Gbps on a single microwave link and single-hop latency of 50 microseconds. This will be able to fully meet the demands of 5G bearer networks for large bandwidth and low latency. Huawei became the first company to perform third-phase 5G validation tests in

China, as organized by the IMT-2020 (5G) Promotion Group.

Huawei is committed to promoting 5G in vertical industries and plans to set up a 5G slicing alliance with industry partners. Huawei and Telefonica achieved the world's first PoC of 5G ultra-reliable and low-latency communication (URLLC) for connected vehicles.

Huawei is committed to promoting 5G in vertical industries and plans to set up a 5G slicing alliance with industry partners.

From eMBB to fully connected and intelligent

The widespread adoption of Ultra HD video will be a defining feature of the 5G era. Interactive live broadcasts will become a new social entertainment experience that will exponentially increase requirements on network bandwidth. To drive the commercial adoption of 3GPP R15-based eMBB services, Huawei has been exploring services such as multi-channel Ultra HD video, VR, and 360-degree live broadcasts over a 5G network, and carried out a number of on-site demonstrations of these services at MWC 2018. We're actively seeking to innovate in areas that integrate technology, industry, and services for the 3GPP R16 standards for 5G.

Huawei and TPCAST performed the first PoC of CG Cloud VR. Huawei Wireless X Labs set up the Cloud VR/AR special interest group (SIG) with a number of partners to jointly conduct 5G pre-commercial field testing to promote the development of the 5G Cloud VR industry and transform concept into commercial reality.

Huawei's Digital Sky Initiative has now moved a step closer to implementation. Huawei and the Civil Aviation Administration of China have completed low-altitude network testing and are promoting safety standards for connected drones.

On the smart factory side, Huawei has conducted several 5G verifications and demonstrations. Cloud and wireless connectivity are key technologies for smart factories. The increasing wireless nature of manufacturing equipment will make modularized production and flexible manufacturing in factories possible and slash maintenance costs. High uplink rates will help industrial vision systems analyze and locate issues in real time. The high-reliability and low-latency capabilities of 5G networks will enable high-precision synchronization between robots so they can work and coordinate seamlessly.

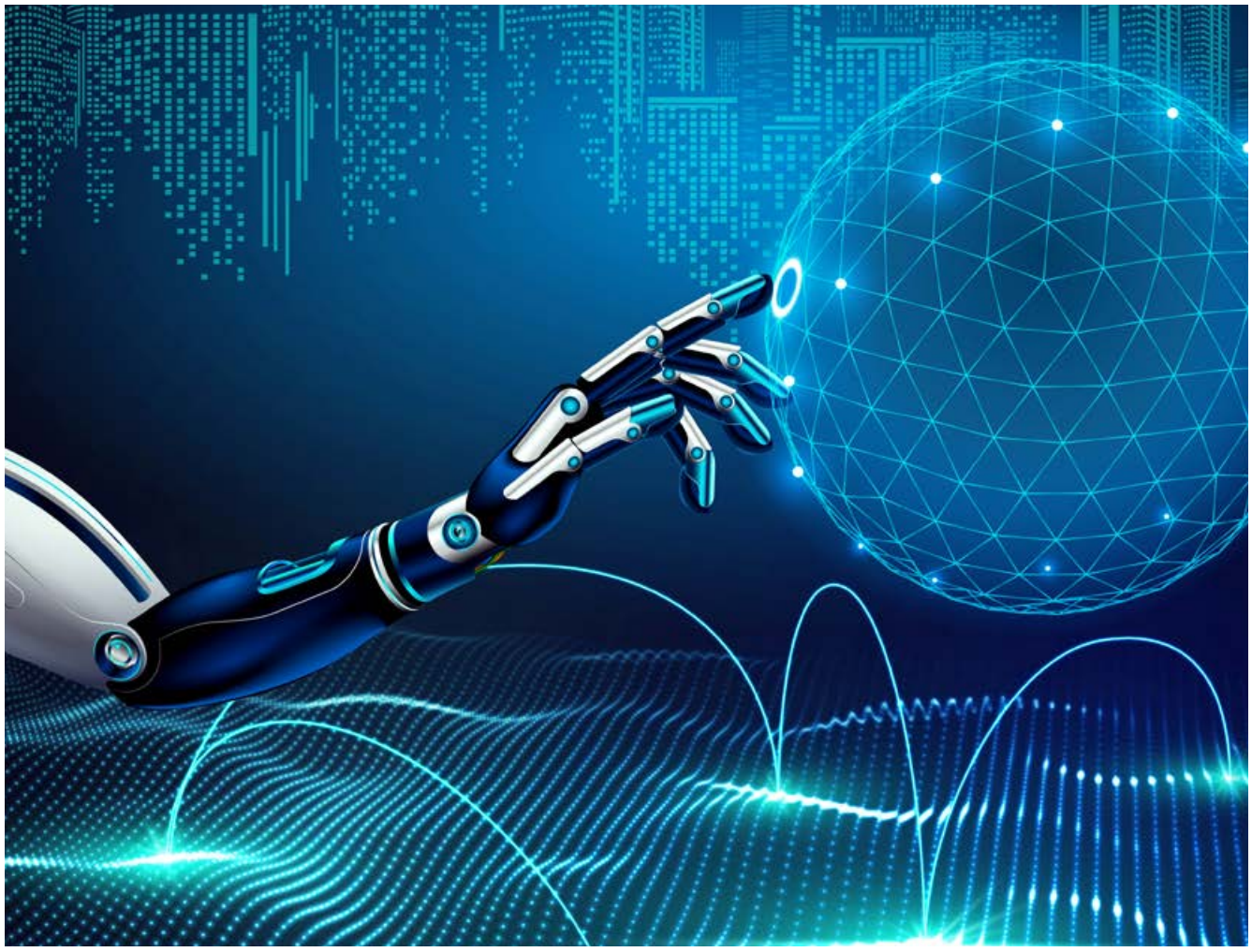
Huawei was a major member in setting up a special interest group for wireless connected healthcare, jointly publishing a white paper on the topic, a first in the industry. Huawei has worked with industry partners to build remote B-scan ultrasonography robots, providing real-time, reliable wireless connections for remote control, image acquisition, and diagnostic data for the robots.

Huawei is leading the way to 5G. We're not only dedicated to helping operators build the best 5G networks, but we will also work with industry partners around the globe to help operators achieve commercial success in 5G, explore innovative applications, and work together towards a fully connected, intelligent world.

Wireless AI for networks that understand you

The annual Mobile World Congress (MWC) in Barcelona is a weather vane for the mobile and ICT industries. At the CTO Roundtable hosted by Huawei at MWC 2018, network automation was one of the hottest topics – no surprise given that the exploration and application of artificial intelligence (AI) in mobile networks has been picking up pace in recent years. It's likely that a sharp rise in network complexity in the 5G era will lead to stronger demand for network automation and AI in mobile networks.

By Ding Jiangbo



Network automation

In the 5G era, networks will be larger, contain more frequency bands and channels, and offer a greater variety of base station types and scenarios, features that will sharply increase network O&M complexity. Moreover, the complexity of network systems will lead to a continual fall in the utilization efficiency of wireless resources.

At the service level, there's been a dramatic increase and diversification in the types of services carried by the same physical mobile networks, from traditional MBB services, such as voice and data, to mobile IoT services that enable industry digitalization. Safeguarding service experience has become a prerequisite for service development. At the same time, the use of network slicing has made real-time resource orchestration involving multiple services more difficult.

With future networks set to be 100 times more complex than current mobile networks, how will the industry deal with the challenges arising from complex network O&M, wireless resource management, and service experience assurance? Traditional methods and tools won't be able to meet the service development needs of the new 5G era, and so adopting AI to accelerate network automation is the only answer.

Wireless AI

At the Global Mobile Broadband Forum in London in November 2017, the President of Huawei Wireless Solutions, Edward Deng, made the first announcement of Wireless AI, which is set to become a core element of future networks, lighting the spark for the democratization of AI in the wireless domain.

Huawei debuted its Wireless AI solution at MWC 2018, positioning it as the way to solve three major challenges in the 5G era: O&M complexity, declining resource utilization efficiency, and service experience assurance. There are three major benefits of AI in the wireless domain: simplifying O&M, breaking through performance limitations, and enabling new business.

Deng showed how introducing Wireless AI in three scenarios – Massive MIMO, multi-band/multi-system, and wireless fingerprint positioning – could increase O&M efficiency by up to ten times, improve experience by 20 percent, and increase positioning accuracy by between three and ten times.

Massive MIMO 5G base stations provide high-capacity coverage and greatly improve spectral efficiency. With current 4.5G, there are nearly 300 broadcast beam combinations for improved cell coverage, but with 5G, there will be over 10,000. It will be impossible to flexibly adapt to particular scenarios and traffic models using traditional manual methods. However, enhanced learning-based automated optimization will automatically adapt to specific scenarios. The resulting dynamic traffic models will make it possible to automatically batch fast-lock optimal patterns and double O&M efficiency, which will improve overall cell performance. A joint innovation test that Huawei conducted with an operator in Japan revealed a potential

20 percent increase in cell throughput and number of connected users.

Moreover, with the rise of mobile IoT and in particular the proliferation of NB-IoT applications, demand will increase for positioning capabilities that meet the needs of massive numbers of IoT terminals, for example, bike-sharing services. GPS-based positioning solutions offer meter-level positioning capabilities, but problems include high chip costs and high energy consumption. NB-IoT-based positioning accuracy is currently inadequate to meet the needs of applications. Using Wireless AI, multi-dimensional structured data can be entered to form a network fingerprint, enabling a positioning accuracy of approximately 30 meters. This meets the positioning requirements of bike-sharing services. In the future, sub-meter level positioning is hoped for, alongside the expansion of network fingerprint dimensions and more innovative applications.

Creating the DreamWorks of Wireless AI applications

The development of Wireless AI isn't something that can be achieved overnight. Capabilities must be built in data, intelligent algorithms, and architecture.

Increasing mobile big data to make it more valuable: Mobile networks generate huge quantities of data every day, but much real-time data is "read and burn", and structured storage is lacking. Wireless AI in the mobile domain will lead to three data expansions and transformations: real-time to historical, single-dimension to multi-dimensional, and fragmented to structured. Over the longer term, mobile base stations will become mobile big data awareness systems, including the data generated within the mobile communication system and sensing data from mobile stations' external environments. It will be possible to analyze the characteristics of big data and accurately profile cells, grids, and users, creating a digital twin mobile network.

Building a dedicated automated machine learning (AutoML) platform for the mobile domain: Wireless network systems have their own unique characteristics. Huawei has built a library of AI/ML algorithms for wireless networks based on its experience in mobile communications. The algorithm library integrates various industry- and Huawei-developed AI algorithms that generate various data models that match mobile network application scenarios, with 90 percent of mobile scenarios covered. At the same time, Huawei is also partnering with universities on AI research and exploring new algorithm models. Huawei has developed the industry's first AutoML for mobile communications and reduced the data modeling cycle from months to days, accelerating the incubation of Wireless AI applications.

We're at the very start of integrating mobile networks and AI. As we prepare to enter the 5G era, we believe that continual interaction, understanding, and integration between Wireless AI and mobile networks will lead to mobile networks that understand you, networks that are dedicated to you, and networks that work for you.

In the future, sub-meter level positioning is hoped for, alongside the expansion of network fingerprint dimensions and more innovative applications.

The power of 5G core networks

Operators set to lead digital transformation in all industries

5G services and applications bring new challenges to existing networks, including core networks. At Mobile World Congress 2018, Huawei demonstrated its 5G core network solution for all-service enablement to help operators support fast service development in the future and enable digital transformation in all industries.

By Zhao Wei

Fully connected, full-service

"4G changed lifestyles but 5G will change society" is a well-known industry maxim. During past generations of mobile communications, connectivity was human-centric, but in the 5G era everything will be connected. 5G will foster a fully digitalized society and change the way the whole world operates at a fundamental level.

Over the past decade, mobile broadband services drove the widespread growth of 3G and 4G networks, introducing greater variety and diversity into our day-to-day lives and entertainment. Basically, it changed the way we live. But over the next ten years, telecommunications networks will go from providing people-to-people connections to people-to-things and things-to-things connections, which will provide a wealth of

information services for all different sectors and industries.

5G networks will give rise to new services, such as smart offices, home entertainment, augmented/virtual reality (AR/VR), autonomous driving, industrial control, and IoT. These new services will impose harsher requirements on network capabilities. Autonomous driving and industrial control, for example, will require networks to support ultra-low latency of under 5 ms and industrial-grade reliability guarantees in mobile scenarios. Services like multi-service broadband for homes, high-def video surveillance, and 360° VR live-streaming will need networks that support 5 Gbps or more for a single user plus a network throughput of 20 Tbps or more per square kilometer.

5G will also enable new business. In the 5G era, operators' business scopes will expand beyond the mass market to include industry verticals, generating significant socioeconomic value and new business opportunities for operators. Yet due to the vast variety of service requirements in different verticals, operators need to build highly agile operational capabilities to respond to fast-changing market demands.

5G will open the door to a fully connected, full-service era. Core networks will play a crucial role, acting as the enablement center for all access types and all services. First, it will transform the current network-centric service model into a user-centric service model by eliminating differences in network access. Second, it will enable 5G networks to provide different services on demand for different industries through network slicing.

With the new opportunities and challenges 5G will bring, it will be crucial to reconstruct existing core networks. In June 2017, 3GPP officially confirmed that the 5G core network will adopt service-based architecture (SBA), which has been proposed by 26 companies, including China Mobile and Huawei, as a unified infrastructure. This means that 5G networks will be truly open, service-oriented, and software-oriented, facilitating the integrated development of 5G and vertical industries.

New business, new operations, and new experiences

At MWC 2018, Huawei launched and demonstrated a 5G end-to-end product solution based on the 3GPP standard. As the core component for managing differentiated services and ensuring user experience in operator networks, Huawei's 5G core network helps operators extend the value of their networks to all industries, enabling new businesses and operations and providing a great new service experiences for users.

New business: product slices

Network slicing is the pillar technology for enabling 5G to digitalize all industries. It's also the key to new business models. Slices will become a commodity, with operators able to generate revenue by selling network slices to provide services for different industries. Huawei's 5G core network is

In the 5G era, operators' business scopes will expand beyond the mass market to include industry verticals, generating significant socioeconomic value and new business opportunities for operators.

The 5G era will be defined by fast-changing market demand. Operators will need to build agile operational capabilities to quickly seize market opportunities and succeed commercially.

based on microservice-centric architecture (MCA), which simplifies network slice management through integrated lightweight management, enabling closed-loop business segmentation. It also simplifies network deployment through unified access functionality, permitting the closed-loop deployment of network slices and helping operators to quickly offer slices as products.

Operators will be able to first deploy core networks to launch business operations such as eMBB, voice, and WTTx, which will maximize network-resource efficiency through the free orchestration of microservices and guarantee the E2E SLA of services through definable networks. A network slice for voice services, for instance, can guarantee five 9s reliability and allow O&M to be independent of other services. An eMBB slice enables high bandwidth of over 20 Gbps for a single user and fast updates of new functions. And a slice for FWA services can save large amounts of network resources through a simplified user plane that doesn't have functions such as billing or SA.

In the future, operators will be able to slowly expand their network slicing operations to include slices for smart grids, industrial control, and autonomous driving, providing differentiated services for multiple industries and enabling digital transformation and commercial success for all.

New business: agility

The 5G era will be defined by fast-changing market demand. Operators will need to build agile operational capabilities to quickly seize market opportunities and succeed commercially. However, they're constrained by the architecture and technology of their current networks. For example, new service deployment typically takes over six months, making it difficult to compete for new market opportunities. Huawei's MCA-based 5G core network supports automated, self-managing, and smart operating models, enabling lifecycle management and the smart operation of microservices, shortening new service deployment to weeks or even minutes, and boosting fault location accuracy and efficiency by more than tenfold. Traditionally, to update a particular function of the core network, the whole version needs to be updated. But, with Huawei's 5G core network, only the specific function needs to be updated, significantly cutting down on the workload. Functions can be updated in real time, and the updates have no effect on other functions, because different functions are completely decoupled.

New experience: ultra-high bandwidth

Single-user ultra-high bandwidth is one of the key capabilities of 5G networks. Leveraging multi-core coordination, Huawei's 5G core network allows for ultra-high bandwidth of over 20 Gbps for a single user, ensuring an outstanding experience for eMBB applications such as AR and VR. Through distributed network architecture, the user plane can be flexibly deployed at the network edge by separating the control and user planes, ensuring ultra-low latency anywhere. Huawei's 5G core network simultaneously

supports 2G, 3G, 4G, and 5G, ensuring the best user experience when there are multiple coexisting networks through integrated control plane management and a distributed user plane.

Huawei's 5G core network helps operators smoothly evolve their networks from how they are today to how they need to be in the future, so that operators can protect existing investment and simplify network operations. Operators can increase network capacity through the cloud-based expansion of core networks and support 5G non-standalone (NSA) scenarios using the mixed pool of traditional networks with updated software and cloud-based core networks with increased network capacity. Software upgrades make 5G and traditional network orchestration possible, supporting network-level convergence and 5G standalone (SA) scenarios.

On the road to commercialization

With the most proposals made and accepted for 5G architecture, Huawei has been working with its industry partners to encourage the development and maturity of 5G standards, technologies, and industries. It has led and promoted the standardization of key architectures, including SBA, multi-access edge computing (MEC), and network slicing.

At the same time, Huawei and globally leading operators, such as China Mobile, Vodafone, and Deutsche Telekom, continue to carry out technical and commercial verification for 5G core networks to accelerate the pace of 5G commercial adoption. As of the end of 2017, Huawei had built 15 pre-commercial networks around the world for its 5G core network. In 2017, Huawei's 5G core network was named Best 5G Core Development at the 5G World Summit 2017 and Best Vertical Application in 5G at the SDN NFV World Congress. The solution also picked up the Best Network Software Breakthrough award from GSMA at MWC 2018, reflecting Huawei's leading capabilities and outstanding performance in 5G core network standards, technologies, and commercialization, and the fact that its industrial practices are highly regarded by the industry.

Huawei has also launched 5G Slice Mall, a world first comprising a series of joint innovation projects with operators such as China Telecom, Deutsche Telekom, Telefonica, and industry partners such as State Grid and LETINVR. Of these ventures, Huawei, China Telecom and State Grid cooperated on 5G network slicing in the electric power industry, publishing a joint report on the topic, launching research, and carrying out technical and pre-commercial verification. At MWC 2018, Huawei demonstrated a network slicing-based telemedicine service developed with Deutsche Telekom and showcased a VR game using 5G network slicing created in partnership with Telefonica. In the future, Huawei will continue to use innovative projects and platforms, such as 5G Slice Mall, to spur 5G innovation and commercial adoption and drive its sustainable development.

Building fully connected, intelligent emerging markets

Emerging markets now underpin the global economy. Home to between 80 and 85 percent of the world's population, they contribute almost three-quarters of global GDP growth. In 2017, global economic growth reached 3 percent, up from 2.6 percent in 2016. What are the right solutions for operators to maximize opportunities?

By Dang Xin

A macroeconomic perspective

The digital economy is expanding in several ways. The global production of ICT products and services accounts for an estimated 6.5 percent of global GDP, and some 100 million people are employed in the ICT services sector alone. The digital spillover effects are changing all parts of the economy.

Connectivity is developing fast globally. In 2017, more than 450 million people were connected to the mobile Internet and more than 30 million households were connected to home broadband. However, there are still 3 billion people in the world who still don't have mobile Internet, 870 million of whom lack mobile phones, while 1.1 billion households are without home broadband.

However, due to inadequate infrastructure and a weak business foundation in emerging markets, the ICT sector faces challenges. Operators frequently find it difficult to acquire site infrastructure and

fiber optic resources, and spectrum resources are extremely costly. To grow, operators require more revenue streams from data, such as video, music, and gaming content, that grows their user bases.

An emerging market ecosystem

At the Unlocking New Economic Value Summit at Mobile World Congress 2018, the Chief of Strategic Planning and Membership Dept for ITU, Doreen Bogdan-Martin, said that, "Infrastructure, investment, innovation, and inclusivity are the 4 'I's put forth by the ITU to guide our work toward the 2030 Agenda." And Doyle Gallegos, Global Lead of Broadband Access for All Global Solutions Group, the World Bank, commented that, "To make sure the digital economy works for everyone, we must build it on four foundations: digital infrastructure, basic E-payments, digital entrepreneurship, and usage."

A strong ecosystem ensures the rapid growth of the ICT industry. The ecosystem includes infrastructure supply, regulatory environments, industry sector participation, business operations, and system and device provisioning. A healthy ecosystem for energizing business isn't built by a single stakeholder – it needs collaboration from regulators, stakeholders, industry partners, operators, and suppliers.

Infrastructure providers from all industries need to open up and help develop supply utilities such as transportation, power grids, and facilities. For example, Italy's utility Enel and state lender CDP established OpEn Fiber to deploy fiber optic networks throughout the country.

Regulators need to orchestrate regulations to ensure spectrum availability, service authorization, telecom taxation, and demand for digital social awareness. For example, Malaysia has initiated High Speed Broadband (HSBB), a government program to make high-speed Internet accessible and affordable to every citizen. The Indonesian government is working on the Indonesia Broadband Plan (IBP) to ensure high-speed fixed-line connectivity across the country, alongside mobile data services offered by mobile operators. In Ghana, the government worked with the Alliance for Affordable Internet (A4AI) to cut mobile phone taxes, which led to the rapid penetration of mobile broadband.

Operators need to provide affordable, valuable, and convenient digital services that offer the best user experience and improve the quality of digital life. For example, Safaricom M-Pesa has lifted 2 percent of Kenyan households out of extreme poverty. The economic impact of M-Pesa is mostly seen through its 1.8 percent contribution to GDP.

Stakeholders and partners from all industries need to develop profitable business models and encourage investment by providing demand. In Ghana, MTN has implemented rural coverage through the Ghana Infrastructure Fund for Electronic Communications (GIFEC), extending mobile

Operators need to provide affordable, valuable, and convenient digital services that offer the best user experience and improve the quality of digital life.

coverage across the country.

System and device suppliers need to keep innovating and providing agile solutions and affordable devices optimized for every scenario.

The obstacles to unlocking opportunities include resource availability, operating efficiency, and lengthy ROI. It takes a combined effort to remove these stumbling blocks and build a fully connected, intelligent world together.

Huawei's ICT vision and strategy

To enable operators and partners to seize opportunities in emerging digital economies, Huawei's strategic approach has three pillars: support national ICT policies, build a healthy ecosystem, and create end-to-end business solutions.

Zhou Jianjun, Vice President of Huawei Carrier BG, believes that, "To capitalize on the vast opportunities in emerging markets, operators need to deliver a better scenario-based service and accelerate their ROI. Huawei focuses on three core areas to help operators meet the burgeoning demands on their networks. We're engaging with industry partners to build open, cooperative, and win-win industry ecosystems for ICT infrastructure, and creating business solutions to help operators deliver services that generate new revenue streams, while simultaneously improving the quality of life in emerging markets."

Huawei works proactively with countries to develop their national ICT plans as well as define a roadmap that's relevant to the market and to society over both the short and long term.

Another core strategy centers on building a sustainable ecosystem to facilitate the digital transformation of the telecom industry. Huawei's expertise has supported operators in leveraging market resources to benefit all stakeholders and industry partners. Huawei has achieved significant progress in site, device, and FTTx alliances, and bridged the gap between affordable devices and content providers.

Huawei aims to maximize business value for operators and unleash business potential through innovative solutions that leverage the most valuable operator assets, like spectrum, site facilities, subscribers, and services. Huawei's business methodology improves investment efficiency by facilitating spectrum utilization and agile site deployment, and brings revenue growth by maximizing user value and innovative digital services.

Huawei CloudAIR2.0, nTnR, and massive MIMO solutions enable spectrum efficiency improvements. CloudAIR uses cloud technology to centrally schedule and utilize air interface resources, including spectrum, power, and channels. Carriers can increase efficiency, flexibly deploy services, and deliver a better user experience. At MWC 2018, CloudAIR won GSMA's awards for Best Mobile Technology Breakthrough and CTO's Choice in recognition of the innovations it offers mobile broadband networks.

Huawei's agile site solutions, including PoleStar, TubeStar, RuralStar2.0, and Indoor Coverage Digitalization Solution are adapted to all deployment scenarios to optimize overall site TCO and ROI.

Huawei's TubeStar solution features E2E system-level site design. The BBU, RRU, power supply module, battery, and transmission equipment are integrated into a tube, eliminating the need for equipment rooms and cabinets. TubeStar satisfies current network requirements, while also allowing for future evolution. A single site supports five to seven bands for multiple RATs (GSM/UMTS/LTE). TubeStar won the Green Mobile award at MWC 2018 for communications infrastructure and progress at reducing emissions, boosting energy efficiency, and lowering O&M costs.

Huawei has been working to connect the unconnected and promote mobile broadband in emerging markets through healthy business models. Huawei's RuralStar won the GSMA's Best Mobile Innovation for Emerging Markets award for its role in promoting rural network construction. According to the judges, the solution ticks all the boxes for benefiting emerging markets, including low power consumption and a choice of sources, low TCO, easy installation with minimal site preparation, new battery technology, and security features.

To lower site OPEX and prepare sites for the 5G era, Huawei provides L.I.V.E Site for site transformation, with "LIVE" being an acronym for on-Line, Intelligent, Visible, and Evolved. It automates O&M and modernizes sites to cut site OPEX and prepare for massive site construction to accommodate 5G.

By using big data to identify potential customers and high-value users, Huawei's innovative DSP and SmartCare solutions help operators attract new customers and migrate existing ones to new services. By offering an outstanding global experience, Huawei can help operators accelerate revenue growth.

The home broadband solutions WTTx and FTTx enable operators to rapidly deploy home broadband services, provide seamless connections with household Wi-Fi, and lay the foundation for services such as smart home solutions.

Huawei provides business and network consulting services to address operators' business needs, while putting processes in place to ensure well-managed product offerings. With highly efficient and innovative products and solutions, Huawei helps operators deploy and maintain affordable networks.

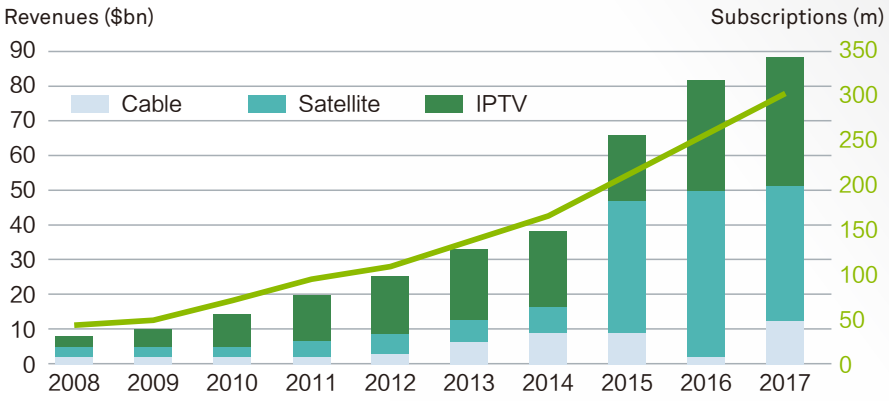
Huawei's RuralStar won the GSMA Best Mobile Innovation for Emerging Markets award for its role in promoting rural network construction.

Making video work for telcos

*At Mobile World Congress 2018, Huawei and the information analysts IHS Markit released the white paper **Video as a Core Service for Telcos – Analysis of 50 Leading Operators in Achieving Video Business Success**. What are the report's findings and how can telcos develop a successful video strategy?*

By He Jing

Video subscriptions by platform for the 50 largest telco video operators



Source: IHS Markit

Analysis of the 50 Leading Operators in Achieving Video Business Success

Challenges and opportunities

In recent years, growth in traditional operator services and revenues has slowed. From 2012 to 2017, the average annual growth rate was just 1.3 percent, with ARPU declining 2.2 percent year on year. At the same time, video grew to account for more than 60 percent of traffic on telco networks, becoming the most important service type and the key service for telcos to avoid pipefication. Users have grown accustomed to video anytime, anywhere, and experience is now a major factor for many when it comes to choosing an operator.

As a result, telcos have been investing in infrastructure. But, they cannot recover their investment through network monetization alone, and are thus forced to rethink the positioning and monetization of video services.

At the end of 2002, a handful of operators worldwide were providing IPTV services for less than 100,000 users. But by 2017, 130 operators were offering video services, with IPTV subscribers alone numbering over 200 million. The rapid growth in operator video services over 16 years shows us how telco video has developed from VAS into a core service that can enable business success. At the end of 2017, the top 50 telcos by video subscribers accounted for more than 300 million video subscriptions and generated US$89.3 billion in video revenue, up 8 percent over 2016.

Not only does video directly generate revenue for operators, it also grows subscriber numbers, revenue, and profits, and increases subscriber stickiness.

Real-world cases

Video as a Core Service for Telcos analyzes the strategies and real-world practices of the top 50 fixed-network telcos. The results reveal that fixed-line operators use video as a major value proposition, treating it as a core service to drive the growth of overall telecom services. Crucial to this is the inclusion of video services in basic service packages that aim to open new markets and drive growth. The five main strategies operators use to deliver video services are package bundling, premium content, aggregating multiple content

By working with content providers, telcos can aggregate various types of content to provide users with integrated, high-quality video experiences.

sources, providing innovative service experiences, and providing their own video services.

Aggressive bundling: Bundling video with broadband, mobile, and fixed-line services lowers the barriers to entry for video services. However, this strategy is at the expense of ARPU, with the contribution video makes to the operator typically becoming less direct. In the early stages of developing video services, operators tended to use this kind of strategy to rapidly grow video subscribers or to respond to market competition and prevent customer churn. China Telecom bundled video with broadband and mobile services, driving the growth of both. At the end of 2017, its video service had achieved a market revenue share of 28 percent. In France, the big four operators started offering packages with video services to broadband subscribers in 2003, which helped France become the world's largest IPTV market after China. IPTV became the leading pay-TV platform in France in 2007, and today there are close to 18 million subscribers.

Premium content disruption: Premium or even exclusive content can create brand differentiation by helping carriers stand out from the competition. However, this is a very expensive approach and the loss of key content rights can lead to customer churn. This strategy is often used in mature, high-end video markets. A classic example is BT's purchase of the Premier League's broadcasting rights to counter the threat of its competitor, the well-established cable TV operator Sky TV. BT's sports offering successfully snatched broadband subscribers away from Sky TV, but the strategy didn't come cheap – the UK operator invested £5.09 billion to secure rights from 2013 to 2019. At first, BT adopted a bundling strategy, with broadband subscribers able to watch exclusive sports programs at no extra cost. At financial year-end 2017, BT's consumer division, which includes BT Sport and BT TV, reported an increase in revenue of 7.1 percent to £4.93 billion. But this wasn't enough to offset BT's investment in premium content, so the operator introduced a direct content monetization strategy, launching a monthly charge of £3.50 in April 2017. Monetizing premium content places higher requirements on a telco's operating capabilities, but it shows how operators have shifted from a focus on network monetization to content monetization when it comes to video.

Multisource aggregation: Most operators prefer to use content aggregation strategies rather than buy expensive premium content. By working with content providers, telcos can aggregate various types of content to provide users with integrated, high-quality video experiences. The content aggregation model offers limited revenue generation opportunities as operators only take a share of subscription fees when customers sign up to a service on their platform. But, few customers do – most instead choose to use their existing third-party accounts.

Netflix is the world's most popular paid video application. Netflix's surging subscriber numbers have led to closer

partnerships between the streaming service and operators. For operators, providing end-users with Netflix content through set-top boxes keeps users on their platforms, helping to reduce customer churn and increase customer satisfaction. It's worth noting that this approach doesn't offer a strong source of revenue. Operators typically get a 5 to 15 percent share of monthly subscription fees, but most subscribers will already have a Netflix account. From a cost perspective, telcos need to ensure that their CDN infrastructure meets Netflix's QoS standards. However, adding Netflix to an operator's video content library has a positive impact on operator KPIs and promotes the growth of ARPU as a whole without compromising operators' performance. Going forward, carriers adopting the content aggregation business model should explore how to monetize user assets through integrated data analysis.

TV UX and multiscreen innovation: Operators can provide users with cross-platform, feature-rich video services through experience innovation. The provision of multiscreen services is an important part of this service innovation strategy. Multiscreen allows users to experience video services anytime, anywhere. Direct monetization of the multiscreen strategy has proven difficult, however, and obtaining the required additional content rights drives up costs for operators. But enhanced user experience through techniques such as better recommendations can increase subscriber spend on paid video, so experience can be monetized this way.

Deutsche Telekom (DT) launched Entertain TV 2.0 in May 2016, touting experience as its core competitive strength. A consistent focus on user experience has helped DT maintain the appeal of its service. It doesn't hold rights to the most popular sports programs, but instead focuses on distributing Sky TV's premium sports channels. DT also brings together Netflix and local content, turning itself into a super content aggregator.

TV unbundling and cross-border expansion: A new trend in video strategies among leading operators is to use OTT video to quickly expand into new markets and drive growth. Through streamlined packages, operators can offer end users greater choice and flexibility. This strategy of using lightweight OTT services to capture the young subscriber demographic is a direct response from operators to competition from OTT services.

America Movil is Latin America's largest pay-TV operator. In the face of competition from Netflix, America Movil acquired DLA (Digital Latin America), a company with VoD credentials and close ties with Hollywood studios and content providers, and launched its own service – Claro Video. Claro Video applies several business models, including subscription, pay-per-view, and free-to-view content, and is either offered as a supplement to pay-TV or sold separately.

Factors for business success in telco video

In many cases, the video strategies we've talked about can supplement each other, as long as telcos consider local market conditions, network strengths, content strategies, and experience.

Telcos can use their core strengths to deliver superior video experiences anytime, anywhere, develop content investment strategies, and embrace aggregation. In terms of product strategy, they can consider bundling existing services or launch their own standalone video services. If they have a strong content offering, either bought or aggregated, they can quickly expand into new markets via OTT video offerings to attract young subscribers.

But, when calculating ROI, it's crucial to consider both the direct and indirect value that video services generate.

CloudAIR 2.0 unleashes all-spectrum potential

At Mobile World Congress 2018, Huawei's CloudAIR solution won two awards: GSMA's Best Mobile Technology Breakthrough and CTO's Choice for Outstanding Mobile Technology. These were in recognition of Huawei's innovations in the field of radio air interfaces, a critical technology for mobile broadband networks. According to one judge, "Cloudification of the RAN is still in its early stages, but the actual benefits in commercial deployment helped to separate CloudAIR 2.0 from other solutions."

By Hao Fei

30 commercial deployment cases

Future networks will be deployed on multiple frequency bands, accommodate multiple Radio Access Technologies (RATs), and have greater requirements on power. To address these demands, CloudAIR allocates air interface resources on-demand, including spectrum, channel, and power, according to traffic demands or mobile user location. Mobile operators can then optimize network spectral efficiency, capacity, and user experience.

Huawei introduced CloudAIR at the 7th annual Mobile Broadband Forum (MBBF) in November 2016 and showcased the solution at MWC 2017. The early version of CloudAIR, which included sharing GSM and UMTS spectrum and also GSM and LTE spectrum, has been deployed widely by operators across the world.

Vodafone Turkey and Huawei achieved unparalleled overlap by using 900 MHz for GSM (2G) and LTE (4G) services. Huawei's solution enabled greater flexibility in the way

that blocks of 900 MHz spectrum could carry both 4G and 2G traffic and assign spectrum dynamically between 4G and 2G services based on customer demand. GL spectrum sharing raised average downlink user throughput by 58 percent and uplink user throughput by 44 percent over a standard 5 MHz block of LTE bandwidth.

CloudAIR has been widely commercially deployed across Turkey. India's Bharti Airtel implemented CloudAIR to deploy LTE within the same 900 MHz band as GSM and UMTS, significantly improving LTE coverage and the mobile user experience. Compared with an alternative approach for deploying LTE in a higher frequency such as 1800 MHz, 900 MHz LTE required 30 percent fewer sites to achieve the same coverage and enabled Airtel to increase network traffic by 20 percent.

CloudAIR has proven to be a valuable solution allowing different RATs to share spectrum resources dynamically, instead of using traditional spectrum refarming solutions. The solution has been deployed in over 30 commercial networks, including in Thailand, Turkey, Indonesia, Uganda, and Bulgaria. It has enabled operators to improve mobile network quality and user experience and save network investment.

How it works

CloudAIR 2.0 features new technologies that dramatically increase spectrum sharing and support LTE and 5G NR on the same spectrum.

Deeper spectrum sharing for dynamic allocation and adjusting spectrum resources: To deploy new radio technologies such as 5G or LTE, mobile operators need to release blocks of spectrum from legacy radio technologies such as UMTS and GSM. However, releasing blocks of spectrum can reduce capacity and worsen user experience. But, if operators wait for traffic to decrease on existing radio technologies to unlock spectrum, they risk hindering network development, which will in turn stifle new growth opportunities.

Another approach is to acquire entirely new spectrum, but this involves buying more spectrum at hugely expensive auctions. For example, in 2015 Bharti Airtel paid US$236.3 million for a band 1 (2.1 GHz) 5 MHz spectrum covering 110 million people. In the same year in Thailand, True paid US$2.16 billion for a 10 MHz paired spectrum in 900 MHz.

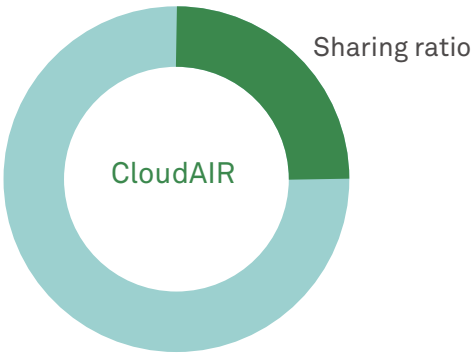
The spectrum sharing capabilities of CloudAIR 2.0 enable the deployment of different RATs in the same spectrum. This solution can dynamically allocate and adjust spectrum resources according to changes in mobile traffic and avoid legacy RATs taking up prime spectrum, improving spectrum efficiency.

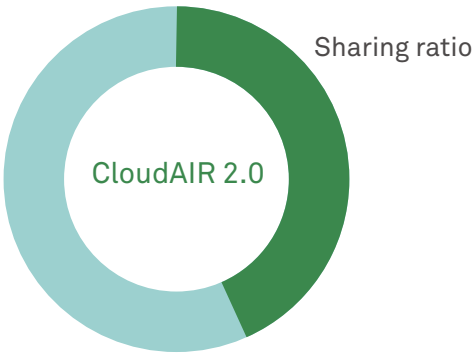
Doubling the spectrum sharing ratio enhances network performance: Compared with Huawei's first release, CloudAIR 2.0 doubles the spectrum sharing ratio, which greatly improves network performance.

Without CloudAIR 2.0, an operator can typically deploy three GSM carriers and LTE 5 MHz within 10 MHz of spectrum. With CloudAIR 2.0, the operator can deploy the same three

CloudAIR 2.0 features new technologies that dramatically increase spectrum sharing and support LTE and 5G NR on the same spectrum.

Cellular IoT represents important growth opportunities for mobile operators looking to expand their business beyond traditional voice and data services.





GSM carriers and LTE 10 MHz simultaneously with a 4.4 MHz sharing spectrum block between both technologies. Compared with a 5 MHz LTE carrier, a 10 MHz LTE carrier with sharing spectrum offers a network capacity gain of around 90 percent, saving 4.4 MHz of spectrum for the operator.

Full coverage for all services on a low frequency: Spectrum sharing is not limited to two coexisting radio technologies. CloudAIR 2.0 supports spectrum sharing with multiple RATs in the same frequency. This solution is ideal for operators looking to extend LTE and cellular IoT coverage on a low frequency.

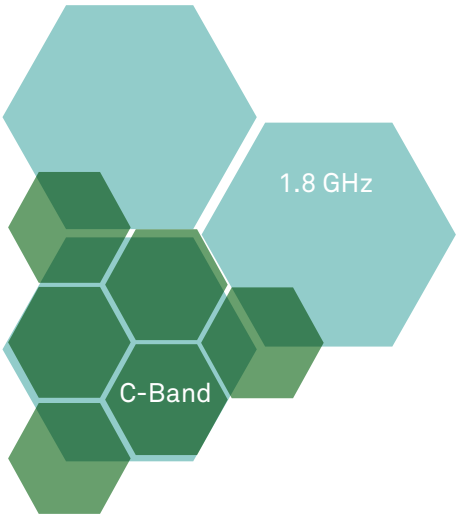
Cellular IoT represents important growth opportunities for mobile operators looking to expand their business beyond traditional voice and data services. At the same time, VoLTE is a next-generation voice solution that offers better call quality than 3G or 2G. As users migrate to the new service, the spectrum used for 2G can potentially be repurposed to increase the capacity of LTE networks.

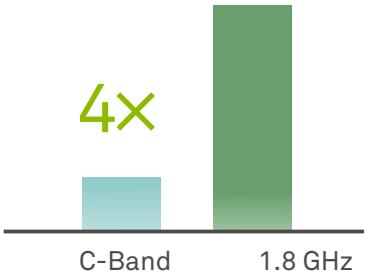
However, most operators have limited spectrum bandwidth in low frequencies, such as 900 MHz, which is currently used by legacy technology such as GSM and UMTS. Therefore, operators cannot deploy VoLTE and cellular IoT on a low frequency until the spectrum is released or they acquire more dedicated spectrum.

With CloudAIR 2.0, both VoLTE and cellular IoT can be deployed on limited bandwidth coexisting with GSM and UMTS, which allows a low frequency to become a fundamental network layer to support all services. A typical lower frequency coverage layer requires 30 percent fewer sites than a higher frequency, saving operators a significant amount of investment.

Spectrum sharing for full network coverage by LTE and 5G: The deployment of a nationwide 5G NR network with dedicated infrastructure and frequency is a costly investment, both in infrastructure and resources. Furthermore, low 5G mobile penetration in the early phases will result in light network loads that lengthen the ROI period.

C-Band, a globally harmonized frequency allocation for communications satellites operating between 3.4 and 4.2 GHz, will





be the key spectrum for 5G. However, its coverage radius is less than the popular LTE frequency 1.8 GHz.

In December 2017, the first 3GPP 5G NR standard was finalized. According to the 3GPP standard, many 5G NR frequencies have been defined which are the same frequencies as for LTE, making it possible for operators to deploy LTE and 5G NR in the same frequency.

With the joint efforts of leading operators and ecosystem partners, LTE and 5G NR spectrum-sharing has already been accepted in 3GPP, and will be supported in 3GPP R15. Both LTE and 5G use Orthogonal Frequency Division Multiplexing (OFDM) or a variant scheme that defines frequency and time-domain resource blocks.

Therefore, LTE and NR spectrum sharing allows for the flexible sharing of more frequency and time-domain resource blocks, deepening the spectrum sharing ratio and increasing spectrum efficiency. Theoretically, with proper system design, the allocation interval for spectrum resources between 5G NR and LTE can be implemented in a millisecond.

Accelerating 5G deployment and monetize spectrum assets with LTE and 5G spectrum sharing: In many countries, C-Band has already been deployed for LTE. With LTE and 5G NR spectrum sharing, 5G NR can be activated instantly by sharing spectrum dynamically. This will help operators accelerate 5G deployment and shorten TTM for 5G services.

Conversely, operators that have deployed 5G NR using dedicated spectrum need to improve network efficiency, which will have low utilization rates due to lower 5G penetration in the early adoption phase.

With LTE and 5G spectrum sharing, 5G and 4G traffic can share the same frequency, enabling operators to monetize spectrum assets and improve network ROI.

Extend C-Band coverage by decoupling uplink and downlink: C-Band is expected to be one of the most popular frequencies for deploying 5G in many countries, including Japan, South Korea, China, and some European nations. C-Band gives operators abundant spectrum resources; however the shorter coverage in uplink remains a

As mobile networks evolve toward All Cloud, they will go beyond current boundaries and create unlimited possibilities.

significant issue. If an operator wants to use C-Band to ensure seamless coverage, site requirements could be three to four times higher than for 1.8 GHz.

Using paired spectrum for both downlink and uplink, FDD LTE is a popular approach for radio technology in many countries. Most mobile applications generate more downlink traffic, leaving uplink spectrum in the network idle.

Spectrum sharing combines the advantages of the larger downlink bandwidth of high bands and better uplink coverage of low bands. By multiplexing LTE and 5G NR in an existing LTE uplink frequency and using C-Band's abundant spectrum resources for 5G NR downlink frequency for uplink and downlink decoupling, operators can significantly extend C-Band coverage.

Huawei's joint field test showed that C-Band coverage has been extended by around 73 percent, which is equal to 1.8 GHz LTE coverage. Thus operators can reuse the existing 1.8 GHz LTE site resource to deploy C-Band as a seamless network, instead of undertaking costly new site acquisition.

Multi-band power sharing improves network connectivity: Most modern radio networks reduce TCO by using SingleRAN or similar solutions. The multi-carrier and multi-mode features of SingleRAN radio units enable operators to share transmit power in a single radio unit at the same frequency.

In addition to intra-band transmit power sharing, Huawei CloudAIR 2.0 features a new multi-band radio unit that can support inter-band power sharing to improve network connection speed at the cell edge, as well as cell throughput.

Mobile networks evolve toward All Cloud

CloudAIR schedules and utilizes air interface resources, including spectrum, power, and channels, to more efficiently deploy services and improve the mobile user experience.

CloudAIR 2.0 enables spectrum sharing for most of the popular radio technology combinations between GSM, UMTS, LTE, and 5G NR. It can dynamically allocate and adjust spectrum resources according to changes in traffic, helping operators enhance spectrum efficiency.

LTE and 5G NR spectrum sharing can accelerate 5G deployment and shorten 5G service TTM. Unlike deploying 5G NR on a dedicated frequency, operators can monetize spectrum assets. The uplink and downlink decoupling scheme extends C-Band coverage to equal 1.8 GHz, which can slash network investment.

Power sharing and on-demand power allocation across multiple carriers, RATs, and frequency bands represent breakthroughs in OPEX.

As mobile networks evolve towards All Cloud Networks, they will go beyond current boundaries and create unlimited possibilities, becoming the basic architecture for digitalization across all industries and creating new business opportunities in the mobile industry.

Cloud and network synergy for B2B services

As digital transformation continues to advance across industries, more companies are migrating their custom-built, legacy enterprise IT systems to cloud platforms. Huawei predicts that by 2025, all businesses will be on the cloud and 85 percent of enterprise applications will run on cloud platforms. And that means huge growth potential in the IoT space.

By Ronald Chung, Liang Feng

When an enterprise starts using cloud services, LANs that interconnect company departments become WANs that connect each department to cloud services, placing new demands on connectivity.

First, more types of connections are required, such as traditional private lines, Internet private lines, and private lines for enterprise cloud. Moreover, different types of connections are required for different kinds of enterprises. For example, governments and banks need

In the near future, the growth and number of IoT connections will far exceed traditional connections.

secure, high-quality private lines with low-latency, while SMEs might want more cost-effective private lines.

Second, more connections are needed, not just traditional corporate private lines but also IoT connections, given that in the near future, the growth and number of IoT connections will far exceed traditional connections.

Third, as enterprises invariably adopt cloud or hybrid cloud strategies for digital transformation, high requirements are imposed on connection bandwidth, latency, and security.

Thanks to these new demands, there are new growth opportunities for operators in offering B2B services. But at the same time, telcos face a serious challenge from over-the-top (OTT) cloud service providers in the B2B sector.

Amazon Web Services (AWS) is perhaps the leading example. The company delivers services over a cloud platform and supports Amazon's e-commerce business, demonstrating how cloud is a key infrastructure in industry digital transformation. AWS actively works with operators and other IXP service providers to make up for what it lacks in communications and dedicated line services.

Alibaba announced at Mobile World Congress 2018 that it aims to become the world's largest cloud communications service provider within three years. Alibaba has already launched enterprise networking services over the cloud backbone network it recently built. The likes of AWS and Alibaba have significantly impacted operators' B2B private line services, especially cross-regional and national.

In the face of new opportunities and challenges brought by the digital transformation of vertical industries, operators should redefine their B2B service strategies. They should leverage their strengths in connectivity to meet customer needs through cloud-and-network synergy, which will in turn ensure differentiation.

Operators with the willingness, ability, and foundation should use the cloud as a unified platform and portal for B2B services to serve government and enterprise customers.

In addition to delivering basic services, such as computing, storage, and networking, operators can leverage their current strengths to develop cloud services. There are three

steps to achieving this: 1) Migrate existing communications capabilities to the cloud to provide faster and more flexible services. Examples of capabilities are DCI, private line, CDN, enterprise network management, and enterprise communications. 2) Build innovative services like IoT on cloud platforms to provide a broader range of service categories. 3) Leverage cloud platform and network capabilities to develop ecosystem partners, focusing on popular industry scenarios, such as distance education, industry video, and enterprise office, to provide flexible solutions that help government and enterprise customers implement digital transformation.

Operators that mainly offer connectivity should focus on networking and build agile, high-quality, dedicated line services that adapt to the changes in enterprise customers' expectations on private line performance and purchase models.

With enterprises quickly moving to the cloud, demand for cloud private lines has increased dramatically. To successfully grow cloud private line services, operators will need to develop high-performance networks in terms of bandwidth, latency, and security; minute-level service provisioning capabilities; an online retail-like purchase experience; and network intelligence. They will also need to harness their existing network assets to build a competitive advantage over OTT cloud service providers.

As the solution provider with a full understanding of carrier networks and services, Huawei can help operators build complete B2B business solutions. Huawei offers the following services:

Strategic planning: helps operators to establish strategic positioning, identify target customers, and design reasonable packages.

Solution implementation: provides a variety of cloud network solutions such as agile private line, CloudCampus, SD-WAN, cloud services, and IoT.

Operations and maintenance: sorts and integrates telco operations processes into a cloud-based operations and management system and processes.

Ecosystem development: extends the global ecosystem chain based on Huawei's experience in cloud service provision. Ecosystem partners can help operators to expand their upper-layer services.

We believe that by reconstructing connection services and leveraging cloud services to position themselves in the B2B market, operators can make networks more agile and communications simpler. They can then meet the new demands of industry digital transformation with cloud services and networks and find new growth opportunities.

RingShow stacks up micro-video wins for carriers

The development of network technologies means that an increasing number of carriers have deployed 4G networks and that global VoLTE network construction has accelerated. According to GSMA, 127 global carriers had commercially launched VoLTE HD voice service in 63 countries as of March 2018. How can carriers generate new revenue streams from this trend?

By Liu Meiyuan, Guo Jun

The commercial use of VoLTE is a good opportunity for carriers to add to their VAS repertoire, with now being the right time to innovate services to drive VoLTE penetration and monetize the value they add.

Based on native VoLTE communication, Huawei's video ring back tone RingShow is the evolution of audio RBT. Before answering a voice or video call on a VoLTE network, a video will play, which then disappears when the call is answered, delivering a new video experience for users and adding monetization capabilities to VoLTE.

RingShow users can select videos from the carrier's video library, create their own, or upload videos from their own libraries. Different RingShow video content can be

played for different calling parties during different time segments.

Usage scenarios

Individual service: For individual users, RingShow provides a personal entertainment media platform that gives users more room for self-expression and the chance to spread positive vibes. Carriers can aggregate rich video content, DIY video tools, and OTT channels to provide users with a personal display platform and seamless sharing experience.

Enterprise and advertising services: RingShow's digital media platform provides a marketing and advertising platform for enterprises to get their message out. During work hours companies can set videos with core messaging like brand culture, marketing events, customer care, and service navigation content, and thus create brand ambassadors.

For advertisers, RingShow is a highly efficient advertising platform that supports wide coverage and precise push mechanics. There are multiple RingShow ad modes, including floating, inserted, and full. Advertisers can use the RingShow platform for brand and product promotions, while carriers can obtain advertising revenue in a reverse business mode. RingShow ad users can receive call fees or data traffic from carriers as a reward.

By raising the VoLTE experience, RingShow can help drive VoLTE penetration and, for carriers, create the impetus to develop mobile video under a VoLTE and video strategy.

What's new?

New experience: delivers a fresh and innovative experience. RingShow is a distinctive service with a differentiated experience that boosts communication, loyalty, and carriers' digital brand image.

New revenue: applies carriers' native communication capabilities to fill mobile communication pipes. The information transmission rate is 100 percent, making full use of the golden 15 seconds before a call and monetizing data traffic. The service expands the revenue of new markets created for individuals, enterprises, ads, and micro-video communication.

New ecosystem: represents a unique distribution and monetization channel for the video industry, a core control point, and important foothold for carriers to integrate the video ecosystem. It's also an excellent opportunity for a large number of partners to build a carrier-owned micro-video ecosystem.

Case study: China Mobile

Over 10 years, China Mobile's audio RBT service has attracted 400 million RBT users and is now its main VAS, allowing the operator to introduce music into the industry chain. With VoLTE running in 29 provinces, China mobile had 200 million VoLTE users as of 2017. On the VoLTE network, China Mobile upgraded its RBT service to provide the Video RBT service.

China Mobile and Huawei jointly established the operator's Video RBT service standards, designed the technical solution design, built the platform, and provisioned services.

In June 2017, China Mobile released *China Mobile 4G+ Mobile Phone White Paper*, specifying that China Mobile 4G+ mobile phones would support the Video RBT service from October 1, 2017.

In July 2017, China Mobile Yunnan partnered with Huawei to launch the Video RBT service, resulting in the world's first commercial Video RBT service use trial.

In March 2018, China Mobile's Video RBT service was launched in 29 provinces, with Migu Music app, H5, and WWW providing the Video RBT experience zone.

In the near future, Video RBT will be as widely used as audio RBT – and China Mobile will be running the world's largest micro-video ecosystem.

AUTIN: Helping you go digital

The first organizations to identify the opportunities afforded by digitalization and smartification weren't traditional IT or ICT vendors – they were Internet firms like Amazon, Google, Baidu, Alibaba, and Tencent. Despite having the strongest infrastructures and most subscribers, telcos have been comparatively slow to get in on the act. Why?

By Yuan Dieping, Guo Min

As easy as ABC

Having developed as B2C businesses characterized by fast-changing tech, the big Internet players are stepping into enterprise and industrial markets by the ABC route: AI, big data, and cloud computing. In contrast, telcos remain constrained by complex services, siloed systems, and scattered data.

The increasing digitalization of the telecoms industry coupled with higher user expectations on services has meant that traditional operations models are struggling to keep pace and severely limiting the benefits of transformation. The telecoms industry urgently requires future-proof operations models and platforms, ones that can meet the requirements of managing current physical networks and that are suited to network architecture transformation for hybrid virtual networks.

Smart digital

The traditional telecoms industry

is at a major crossroads. With the challenges brought by NFV/SDN, IoT, and 5G, current operations models are unable to support operators' strategic transformation into digital service providers. Operators have realized that they need to build new future-proof, software-defined operations models if they hope to meet the operational requirements of both existing physical networks and continually evolve hybrid and virtual network architectures of the future.

We've seen increasing diversification in operator services, with the proliferation of new services like video, games, and IoT. These new services have extremely demanding requirements when it comes to TTM and quality. Meanwhile, operator ICT infrastructure has grown more complex, with both traditional networks and virtualized and cloudified hybrid ICT infrastructure. With the market shifting from investment-driven to value-driven, telcos are focusing on ROI, with user experience and greater value emerging as new criteria for network evaluation.

Unlike the Internet sector, traditional telecoms operations are still manual, with operations support software based on rigid and closed software architecture. Deployed on scattered IT operation silos in each domain, these architectures make it difficult to control software change cycles and lead to delays in new service TTM. Operations personnel are forced to integrate scattered operations systems to integrate end-to-end (E2E) operations processes. As a result, the degree of automation is low, leading to longer average times for resolving resource and service failures and lower QoS. Moreover, personnel require software training, and the traditional model doesn't suit emerging hybrid virtual infrastructures because it was developed for physical infrastructure.

The successes of companies like Amazon, Uber, and GE demonstrate that digitalization and smartification are the only ways to improve operating efficiency and maintain a company's competitiveness. Today, more than 60 percent of operators maintain a large number of isolated OSSs, a huge obstacle to evolving to digital operations. Moreover, 70 percent lack centralized data sources, while 60 percent of telco operations are black box with no E2E visibility. Change is urgently needed.

AUTIN steps in

A portmanteau of "automation" and "intelligence", AUTIN is Huawei's digital operations service solution that's designed to consider customer business goals and help telcos carry out digital transformation.

AUTIN helps carriers to build visualized, automated, and intelligent capabilities for operations. It improves efficiency and quality through the Operation Web Services (OWS) digital operations platform, creates empowered staff through re-skilling and a change in mindset, and provides an open ecosystem to learn from other industries. Automation refers to rules based on operations standardization and summarized expert experience, with simple and recurring tasks handed over to machines. Intelligence refers to big data analysis and machine learning, which enable constant improvements and the enrichment of rules, increasing automation efficiency. Moreover, complex operations that cannot be handled manually are handed over to machines, reducing reliance on experts and enabling fault and risk prediction and prevention.

AUTIN's Digitized Operations Services solution include Operation Consulting (OC) Services and Operation Web Services. They comprise Huawei's mature operations capabilities, which are delivered as open cloud services, helping telcos transform their operations. The OC services leverage Huawei's ten-plus years of experience in operations and the successful management of over 160 networks worldwide. For customers, the service provides customized paths for transforming operations and personnel skills. It also enables the system design and integration of digital operations. Operations Web Services uses software

as a service (SaaS) to provide backbone applications and APP self-development, allowing customers to quickly deploy applications.

Five main scenarios

Field operations: helps operators solve the last-mile issue for managing field operations. It provides real-time, online, and visualized status information about resources, including people, vehicles, sites, materials, and work orders. Operations managers are able to get an accurate, real-time understanding of the specific status of each link, helping them to execute command and management quickly and accurately. Intelligent analysis reports help operations managers to analyze and thus optimize service and staff efficiency in multiple dimensions, so operations can be continually refined.

NOC operations: helps operators solve low automation and high human error rates in all aspects of operations. Automated rule deployment and intelligent applications are employed in areas such as fault management, change management, and preventive maintenance. AUTIN enables automated alarm association/ compression, automated fault diagnosis and recovery, automated creation and the intelligent scheduling of work orders, change automation, and automated and accurate data logging. Replacing repetitive manual tasks with machines speeds up operations, improving operations standardization and quality.

Fixed operations – home and enterprise: helps operators solve operations issues found in FTTH networks and HFC networks for enterprise customers such as low efficiency, slow fault recovery, and the lack of unified fault management. It includes almost 20 operations for optimizing process efficiency and, by deploying automated tools, improves the efficiency of network maintenance centers and field engineers.

IT operations – billing service guarantee: helps operators solve billing service issues such as high numbers of order errors, slow issue handling, and high end-user complaint rates. Anomalous orders are reduced at the source, resulting in 10 to 30 percent fewer complaints and 10 to 50 percent higher issue detection and demarcation efficiency, which improves user satisfaction and reduces revenue losses.

Key and high-risk operations: provides a complete set of solutions to manage high-risk operations such as major cutovers, emergency recovery after major accidents, key event assurance, and post-mortem analysis. With a one-click application, the solution coordinates operations and information sharing by organizing personnel, collecting information, and enabling multi-media functionality, including screen interaction.

Three key facets of AUTIN's features

Digital platform OWS: Based on public cloud platforms (AWS and Huawei enterprise cloud), OWS can be quickly deployed, has big data and AI capabilities, and can quickly adapt to evolutions in technology and services. It provides open APIs to enable staff to develop operations applications based on service scenarios. OWS is AUTIN's foundation and enablement platform. It features all-online capabilities, full automation, real-time data analysis, and a DevOps ecosystem to support digital operations transformation. OWS's intelligent self-learning platform engine captures structured and unstructured data, analyzes this data using algorithms, provides real-time insights to operations teams, and automatically recovers live network resources.

OWS employs microservice architecture to decouple IT and services. Its unique service orchestration capabilities enable engineers who don't have strong IT skills to flexibly develop operations applications. Personnel can then quickly and easily build and deploy service components and establish a global developer ecosystem. Our data shows that so far over 6,000 DevOps engineers have collaborated on the platform, building an open, shared developer ecosystem, developing and releasing over 900 APPs, and replicating

the best practices of operators from different parts of the world.

Digital workforce: Huawei continues to build the digital capabilities of operations teams globally, enabling operations engineers to use the digital platform to develop automated operations APPs based on specific service scenarios, thereby improving operations efficiency. Huawei has also explored a set of incentivisation mechanisms to encourage operations engineers to transform into automation engineers and algorithm engineers. Huawei has also looked at creating flat agile operations teams through organizational transformation to eliminate siloes.

Digital capabilities: This involves building all-online, automated, and intelligent capabilities by employing a DevOps model. All-online is the foundation of this. First, all operations resources, activities, and data are entered into a unified online database, and current operations targets, resources, and quality are displayed as reports. This enables the visibility of operations, establishes standards, and allows for continuous improvement. With the data, automation and intelligence capabilities can be built on this foundation.

Successful examples from around the world

Digital transformation isn't easy or quick. It involves a high level of risk and uncertainty. Most operators will need partners to provide consulting services, process reengineering, software programming, cloud computing virtualization technology, big data architecture, and data science and machine learning skills. Huawei understands both CT and IT. We can provide specific tools based on our full understanding of operators' pain points. We can solve technical problems as well as meet business needs, and that's why multiple operators have selected us as a partner.

In 2016 and 2017, nine subsidiaries of MTN Group deployed OWS, realizing fully online, visualized, and manageable services, and intelligent scheduling that maximizes operational efficiency. OWS has enabled lean and refined management and accelerated MTN's digital transformation.

In January 2017, Kuwait's VIVA launched a digital operations and maintenance project, deploying Huawei's OWS. VIVA then launched a number of functions including online fault management automation, change management automation, intelligent scheduling, and precision data logging. Through this, the telco achieved a 20 percent increase in operations efficiency, a 36 percent rise in network quality, and 25 percent fewer complaints. In 2017, VIVA won the 2017 Speedtest Awards and was named Kuwait's fastest mobile network.

As of March 2018, Huawei has deployed the OWS platform in over 130 networks to automate processes, including work orders for network faults and the intelligent dispatch of field maintenance engineers. To further optimize O&M, Huawei plans to automate fault management, change management, and intelligence on 34 networks this year.

Huawei's digital operations service capabilities and contributions have been widely endorsed. In 2016, Huawei won the Cloud Innovation of the Year award at the Telecoms Awards Ceremony for OWS. And in November 2017, Huawei's OWS received Cloud Security Alliance (CSA) STAR and Information Security Certification from the British Standards Institution. The certification covers solution development, delivery, operations, and APP management in Huawei's OWS cloud services, reflecting how Huawei's operations services have now received the highest international security certification.

AUTIN is an opportunity for global operators and partners to build an ecosystem that contains the latest industry advancements. This community will work together to innovate new services that will accelerate operators' transformation journey and help them evolve into digital service providers.

Ready for the future with Cloud Core Networks

With the increasing maturity of Network Functions Virtualization (NFV) technology, the world's leading operators have already begun rolling out All Cloud Networks. Many also started formulating roadmaps for commercial 5G deployment after the first 3GPP 5G standards were fixed, setting the wheels of 5G network construction in motion. And it all starts with the core.

By Yuan Gang

Transforming the core network is the first step on the path to full cloudification. Huawei believes that to meet the needs of existing services and smoothly evolve to 5G, fully cloudified core networks need to be flexible, robust, and agile. Control plane and user plane separation (CUPS) is a must for constructing distributed networks with lower latency. And DevOps is required to improve deployment and O&M efficiency to meet the needs of more industries and achieve network transformation.

"Cloud Native" flexibility

Building 5G-ready core networks

and All Cloud Networks that are elastic, robust, and agile requires the reconstruction and optimization of software architecture for virtual network functions (VNF).

Huawei's Cloud Core Network is based on Cloud Native architecture and key technologies such as stateless design, service-based decomposition, and lightweight virtualization (containers). To meet the requirements of different applications, the solution can be used to construct flexible networks with service awareness, on-demand resource allocation, a service capacity that's unconstrained by single pieces of physical hardware, and network functions that can be dynamically generated and deployed on-demand.

Stateless design: Service status and session data are separated from service processing units and stored in a separate distributed database. This creates a stateless design for service processing units that enables on-demand elastic scalability and ensures that services remain unaffected even when single or multiple service processing units fail, greatly enhancing the flexibility and robustness of virtual software.

Service decomposition: The microservices decomposition of virtualized software can be realized according to the service application scenario and network model. When it comes to decomposition granularity, smaller is not necessarily better. Instead, the focus should be on independent upgradability, independent scalability, and reusability. The size of post-decomposition microservices will differ markedly between applications that change rapidly and have a high number of customized requirements, such as IoT and enterprise communications, and those where functions are comparatively stable, like IMS and EPC.

Lightweight virtualization (containers): Containers are a lightweight virtualization technology that greatly benefit resource efficiency, performance, deployment, startup speed, and mobility. Virtual machines (VMs) are a heavyweight virtualization technology with clear advantages in security and resource isolation. In the future, the two types of virtualization technologies will coexist, so operators can select the one that best suits a particular application.

Distributed networks lower latency and boost user experience

Emerging services such as AR and VR have higher requirements on network latency, bandwidth, and security. Core network CUPS enables the construction of distributed networks, where the user plane is moved down to the network edge nearer the service. This significantly reduces network latency and improves user experience. Local data processing also guarantees enterprise users' data security, helping operators to enter the enterprise market.

Huawei's MEC@CloudEdge is based on Cloud Native architecture and is 5G-ready. The solution harnesses new technologies based on CUPS to optimize the edge user

Containers are a lightweight virtualization technology that greatly benefit resource efficiency, performance, deployment, startup speed, and mobility.

Huawei will continue to work with industry partners to explore more MEC application scenarios to create a prosperous MEC ecosystem and boost business value for the entire industry.

experience. It enables local traffic offloading; reduces latency; supports local service charges, management and control; opens pipeline capabilities; and can integrate third-party applications.

Huawei has worked with world-leading operators like China Telecom, China Mobile, and Vodafone to deploy MEC@CloudEdge commercially in various scenarios, including private networks for governments and enterprises, smart factories, smart venues, and IPTV over WTTx.

Over the past couple of years, Huawei's MEC@CloudEdge solution has picked up numerous awards for its outstanding technical and commercial contributions to the industry, including Best Edge Computing Technology award at MEC Congress 2016 and Best Commercial Deployment of MEC at MEC Congress in September 2017. At this event, China Telecom Ningbo also won the Operator Award for MEC Development for its joint Smart Factory project, Zhenhai Refinery, with Huawei, marking the first award for commercial MEC deployment received by a carrier. Huawei's MEC@CloudEdge also won the Annual Technology Architecture Excellence Award for MEC and Annual Scenario Excellence Award for MEC at the 2017 China International Information and Communication Exhibition. These awards reflect the strong industry recognition for Huawei's MEC@CloudEdge architecture, technology, and successful commercial deployment.

Huawei has deployed MEC@CloudEdge solutions in more than 10 scenarios for multiple operators worldwide, including carriers in China, UAE, Portugal, and Thailand. Huawei will continue to work with industry partners to explore more MEC application scenarios to create a prosperous MEC ecosystem and boost business value for the entire industry.

Acceleration with DevOps

Operators are facing competitive homogeneity in telecom services and fierce competition from OTTs. However, quickly developing new, innovative services to compete increases the pressure to deploy network resources rapidly, share capabilities and resources, and implement flexible management and scheduling.

DevOps can be used to integrate equipment vendors and operators' development and operations processes, enabling rapid network deployment, gray upgrades, and service innovations that boost operational efficiency and accelerate

service provisioning. Gray upgrades are one of the most important DevOps practices. Due to the outstanding business value they offer, operators are starting to notice this key feature.

The advantages of gray upgrades include lossless service upgrades using the least backup resources. Moreover, the whole upgrade process is fully automated, and designated services can be easily upgraded, accelerating service provisioning from months to weeks.

Evolving to the 5G core

Huawei's Cloud Core Network supports smooth evolution to 5G core networks. It can also integrate 2G, 3G, 4G, and 5G services to protect operators' legacy investments.

Huawei is the first manufacturer in the industry to offer Cloud Native with three-tier architecture. Huawei has worked with the world's top operators to test the technology and commercially deploy CUPS, where it continues to lead the way. Huawei's Cloud Core Network solution features Cloud Native software architecture capabilities and CUPS distributed cloud network architecture. It supports lightweight virtualization technologies, including virtualized software-based microservice decomposition, core network static slicing, and containers. When it comes to O&M, the solution allows operators to build telco DevOps platforms and smart O&M systems based on big data, helping them implement organizational transformation and boost the flexibility of existing networks. This guarantees carrier-grade reliability and lays the foundation for the smooth introduction of 5G services.

The initial 5G NSA phase focuses on deploying eMBB. Service requirements on networks include ultra-high bandwidth for individual users and 5G charging and networking, which in turn requires verifying 5G eMBB deployment and building up experience at operating networks. In 2018, Huawei will provide a commercial version of its Cloud Core Network for eMBB services as part of the NSA stage.

In the later 5G SA stage, we will see the commercial adoption of multiple services. Here, service-based architecture (SBA) will support 5G commercial slicing products and services. Of more than 30 SBA PoCs and pre-commercial deployment cases, Huawei's 5G core network has a significant lead in both architecture and performance. Huawei is a major contributor to SBA and has already demonstrated a 5G slicing prototype.

As of 1Q 2018, Huawei's 5G core network has been deployed in over 100 commercial sites. Step by step, we can go far. Huawei will join forces with operators, jointly promote All Cloud, and accelerate the arrival of the 5G era.

X-Haul for 5G Leadership

As the foundation of 5G, transport networks must be constructed to truly enter the 5G era. And with the first 5G transport networks set to be commercialized in 2018, Huawei is ready to lead deployment. We've developed the industry's first 5G E2E commercial solution capable of supporting the commercial deployment of 5G by carriers around the world: Meet X-Haul.

By Zhao Guanglei

Driven by joint innovation

In 2017, Huawei launched its 5G transport solution, X-Haul, to help carriers build E2E 5G networks. Over the past year, Huawei has collaborated with multiple leading carriers around the world in the area of 5G transport.

Asia

In Japan and South Korea, two nations with the highest network deployment requirements and fastest 5G deployment speeds, Huawei has worked with multiple top carriers to carry out 5G transport tests, covering multiple KPIs. In China, Huawei makes full use of carriers' network scale advantages to jointly carry out 5G transport tests. Huawei was the first vendor to pass China Mobile's 5G transport test, demonstrating the position of Huawei's 5G transport solution as a leader in multi-service transport, OAM, protection, and multi-vendor interworking. This also highlighted the key capabilities of Huawei's FlexE-based 50GE line cards: zero packet loss and the longest transmission distance in the industry – 40km. In China's first 5G Fronthaul test organized by China Telecom, Huawei's 5G OTN Fronthaul solution set an industry record with a transmission latency of less than 1 μs and a jitter of less than 1 ns.

Europe

In Europe, network scenarios are

more diverse, with multiple carriers carrying out transnational services. Huawei and Telefonica verified multiple key X-Haul technologies in a lab environment, including PAM4-based 50 Gbps ports for reducing 5G network construction costs; FlexE bundling for smoothly evolving bandwidth; and SR+EVPN to unify network protocols, unify service bearing, and make network connections simpler, more flexible, and more efficient. Huawei 5G transport helped Telefonica demonstrate the industry's first 5G slicing-based interactive VR service.

In addition, Vodafone and Huawei tested the applicability of IP microwave backhaul for 5G. According to the test results, it's possible to deliver up to 2.7 Gbps capacity from a single IP microwave link and a single-hop latency of 50 μs. In a 5G E2E network slicing demo performed by Deutsche Telekom and Huawei, a cloud transport network achieved data plane isolation over IP+Optical Infrastructure, maintaining different network topologies and SLAs for the respective control plane.

Huawei's 5G transport solutions have been well received by many leading carriers, which are now expanding collaboration with Huawei to accelerate commercialization.

"We're very happy to demonstrate this VR service with Huawei at MWC. Telefonica is committed to becoming a pioneer in the 5G era and will work with Huawei through joint innovation to promote 5G commercial use," said Javier Gavilan, Planning and Technology Director of Core Network, Platforms and Transport, Telefonica Global CTIO Unit.

Eva Rossi, Head of Transport Products for Vodafone Group, commented on his blog that Vodafone and Huawei will continue to work on microwave technology to increase the transmit distance by Multi-Band and E-band links.

Li Junjie, Director of the Optical Communication Research Center at the China Telecom Beijing Research Institute, remarked that, "Huawei's OTN Fronthaul solution obtained excellent test results, creating confidence for China Telecom in its potential for future commercial deployment. I hope Huawei can continue this joint innovation and long-term cooperation with China Telecom to enable China Telecom to become a pioneer in global 5G network services."

Competitiveness through differentiation

Transport networks differ greatly around the world from carrier to carrier, creating great diversity in 5G transport scenarios and increasing the requirements for 5G transport solutions.

Huawei's X-Haul 5G transport solution supports various technologies, including IPRAN, OTN, and microwave technologies. The solution can apply to multiple service scenarios and help carriers smoothly evolve live networks to 5G transport networks.

In February 2017, Huawei launched the industry's first 50GE/100GE adaptive slicing router to meet mobile backhaul service requirements. 50GE interfaces were introduced on the access layer, reducing TCO by 30 percent and supporting seamless upgrades to 100GE interfaces. SR and EVPN provide elastic connection architecture for a large number of 5G services, helping carriers to deliver 5G slicing services.

In February 2018, Huawei launched the industry's first 5G microwave equipment, with transmission bandwidth reaching 10 Gbps and single-hop latency cut to tens of microseconds. This equipment supports 5G-oriented smooth evolution and smart network O&M.

In February 2018, Huawei also launched a 5G Fronthaul transport solution to support services such as mobile transport, private line cloud access, and wide home bandwidth

Huawei will continue to work with upstream and downstream partners to jointly promote sustainable development in the 5G transport industry and share industry dividends in the 5G era.

coverage. It enables carriers to deploy a network for multiple purposes, greatly reducing network construction costs, shortening site construction timeframes, and maximizing network value.

At the same time, the emergence of these innovative 5G services imposes increased requirements on network intelligence. With this in mind, Huawei has launched the Intent-Driven Network solution that features intelligence, simplicity, ultra-broadband, openness and security. This solution helps carriers build networks centered on user experience. At MWC 2018, Huawei also launched an Intent-Driven Network solution for 5G transport scenarios, helping carriers reshape their 5G business models.

Thus, Huawei is helping carriers build leading 5G transport networks with differentiated competitiveness.

Key solutions

The competitiveness of Huawei's X-Haul 5G transport solution can be attributed to Huawei's long-term accumulation of expertise in core technical fields. Huawei's contribution to international 5G transport standards is also accelerating the commercial use of 5G transport.

FlexE is a core technical standard for 5G transport that has been widely accepted by international standards organizations. Huawei participated in the formulation of the FlexE standards and continues to be a key contributor, with Huawei's FlexE2.0 solution well received in the industry.

50GE is an important Ethernet interface technology in the 5G transport field. It has a mature technical background and wide market applicability. In 2016, Huawei took the iniatitive, proposing a 50GE/200GE 10 km standard for the Institute of Electrical and Electronics Engineers (IEEE), eventually resulting in the 50GE standard. Currently, carriers around the world, including China Mobile, are actively promoting the standardization of 50GE. The whole industry is enthusiastically pushing for 50GE commercial deployment. In March 2018, Huawei and Ethernet Alliance worked with industry partners to complete 50GE multi-vendor interoperability tests at the Optical Fiber Communication Conference & Exposition (OFC) 2018, showcasing the development of the 50GE industry and supporting subsequent applications on live networks.

OTN Lite is a key standard for 5G Fronthaul scenarios. It meets low-latency and cost reduction requirements based on simplified OTN frame structures and protocols. In February 2016, Huawei introduced the idea for OTN Lite at the IITU-T SG15 plenary meeting.

A prosperous industry ecosystem requires the participation of all stakeholders, because fragmented development hampers industry development. Huawei actively lobbies international standards organizations and industrial organizations to build unified 5G transport standards and a complete 5G business environment. In the future, Huawei will continue to work with upstream and downstream partners to jointly promote sustainable development in the 5G transport industry and share industry dividends in the 5G era.

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