Building a Fully Connected, Intelligent World

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Leading the Intelligent IP Era

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We look forward to hearing from you.

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Leading the Intelligent IP Era

By David Wang, Executive Director of the Board, Huawei Technologies Co., Ltd.

Huawei's vision and mission are to bring digital to every person, home and organization for a fully connected, intelligent world. Inspired by this goal, we believe that data communications networks are the foundation on which everything can be connected.

We can think of data communications networks as a series of waterbodies. As such, IP transport for 5G and fiber broadband networks can be analogized as brooks and streams, with numerous small tributaries finally converging into a parent river. Furthering this analogy, enterprise campus networks are comparable to ponds, with diversified services and varied connections, while IP Metropolitan Area Networks (MANs) and backbone networks are like huge, gushing rivers. Data Center Networks (DCNs) can be imagined as lakes, with some super DCNs like oceans, to underpin the connectivity, computing, and storage of vast volumes of data. Just as rivers, lakes, and oceans are endless, so will network connectivity be boundless and the intelligent world be limitless.

In the earliest days after inception, data communications networks mainly served applications such as email and bulletin boards. At that time, service experience of Internet users was deemed to have been fulfilled as long as there was network connectivity.

As enterprises deepen their digital transformations, their networks undergo new changes, such as a growing number of applications, ever-increasing network scale and complexity, higher network bandwidth demand, and increased network traffic. These changes bring unprecedented challenges to network planning, deployment, maintenance, and optimization.

So, how should we address these new challenges? A viable solution is to introduce digital transformation into the networks and leverage the technology bonus to cope with the challenges. To this end, Huawei takes the lead in introducing big data, AI, and next-generation protocols into data communications networks, bringing data analytics and closed-loop feedback for optimization. This is a giant leap forward from traditional IP networks to intelligent IP networks. In 2019, Huawei officially released its intelligent IP network architecture and next-generation data communications products powered by AI Turbo technologies, leading data communications networks into the intelligent IP era.

Three Characteristics of Intelligent IP Networks

- **Super capacity**

The network bandwidth demand keeps increasing with surging traffic. Accordingly, campus networks are upgrading to Wi-Fi 6 and 100GE switches, while data center networks and IP backbone networks are moving towards 400GE interfaces. Huawei's data communications network products and solutions constantly set new industry benchmarks in bandwidth and performance, capitalize on engineering breakthroughs in material and system engineering innovations as a result of long-term R&D investment.

For example, the flagship data center switch CloudEngine 16800 comes with the industry's highest density 48-port 400GE line card, while the AirEngine Wi-Fi 6 AP stands out with an

all-time high bandwidth of 10.75 Gbps. Huawei's NetEngine 8000 high-end routers provide the industry's highest-density line card (36 x 400GE).

To deliver greater flexibility and efficiency in bandwidth usage, Huawei is the first vendor in the industry to propose and develop the FlexE-based network slicing solution. Similar to dedicated bus lanes on a road, this solution implements strict bandwidth isolation between different types of service traffic on the ultra-broadband network. In this way, this solution provides 100 percent committed bandwidth for critical services of vertical industries (such as 5G telemedicine), production networks in enterprises, and carrier IP private lines, and allows flexible adjustment of slice bandwidth to cater for service changes.

- **Intelligent experience**

Services and applications have varied requirements for network connections. Typically, video conferences require real-time connection services, production control systems call for highly reliable connection services, and data backup needs cost-effective connection services. Users often complain about poor service experience, while overlooking a very important fact: To obtain good service experience, the network must first understand service intents. Only then can the network provide the desired experiences of connection services in line with service intents.

But how does the network obtain service intents? With traditional networks, this is not possible. With AI inference capabilities and service models from previous AI training, the intelligent IP networks will analyze packet header sequences of various service flows in real time, identify service types and finally derive service intents from service types. For example, in an AI computing data center, AI training traffic flows can be recognized by analytics because packet header sequences of AI training traffic flows have distinct characteristics. The network then knows that zero packet loss is expected by those traffic flows.

How can we better serve the known service intentions? On traditional networks, service provisioning is static and therefore unable to configure network resources in real time based on service intents, let alone quickly adjust network resources upon network status changes. In this context, insisting on traditional approaches cannot realize service intents or ensure service connection experience. This is where intelligent IP networks come in. By using telemetry and AI technologies, intelligent IP networks make it easy to analyze and predict the network status in real time and adjust network resource configurations accordingly to continuously realize service intents and ensure connection experience.

For example, to ensure optimal connection experience in site-to-cloud connectivity scenarios, quick network adjustment upon cloud changes is required so that WAN resources can be configured and adjusted in real time based on the network connection requirements of cloud services. In the past, routes were statically selected based on network topologies for WAN connections, making it impossible to perform intelligent traffic steering according to real-time congestion status. Huawei is the first to provide an SRv6-based solution that allows optimal paths to be intelligently selected and adjusted in real time based on service intents, network topologies, and network congestion status to continuously provide optimal connection experience.

When it comes to DCNs, where lossless network connections should be provided for AI training traffic flows, despite frequent traffic fluctuation, Huawei's data center switches can dynamically adjust the buffer thresholds of the forwarding line cards in real time, based on

By using Telemetry and AI technologies, intelligent IP networks make it easy to analyze and predict the network status in real time and adjust network resource configurations accordingly to continuously realize service intents and ensure connection experience. ››

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service intents and AI-powered prediction, continuously providing lossless connection services.

- **Autonomous driving**

The ever-growing network scale and complexity bring great challenges to today's complaint-driven "post mortem" style network O&M, where the network O&M department is often the last department to know that a network fault occurred. So, how can we quickly rectify faults or perform predictive O&M? An ideal solution is to introduce the autonomous driving system, a key differentiator in intelligent IP networks. This new system can detect the network status in real time, quickly identify network faults or potential issues, accurately identify root causes through fault model matching, and automatically rectify faults or issues. In this way, the impact on user experience is minimized or even eliminated, network faults are greatly reduced, and network O&M efficiency is increased dramatically.

Working together with customers, Huawei has actively engaged in and explored autonomous driving networks. In particular, Huawei has proposed a five-level autonomous driving network evolution standard that helps ecosystem partners jointly explore the evolution path toward autonomous driving networks.

For example, in the DCN domain, Huawei and leading customers have made great strides in joint innovations—detecting 75 types of typical faults within one minute, locating them within three minutes, and rectifying them within five minutes. This groundbreaking milestone marks Huawei as the first to achieve Level-3 autonomous driving networks in the DCN domain.

Joint Innovation with Customer Pioneers to Lead the Intelligent IP Era

Together with industry pioneers, Huawei has carried out a series of joint innovations on intelligent IP networks. These concerted efforts have paid off, achieving numerous productive innovation outcomes.

Huawei's CloudCampus solution, ideal for campus networks of all sizes, stands out with Wi-Fi 6 products powered by Huawei 5G and the industry's highest-density 100GE campus switches, delivering gigabit ultrafast connection experience. This feature-rich solution also uses AI technology to realize intelligent O&M, troubleshooting 85 percent of typical faults in minutes and greatly improving the reliability of campus networks. Furthering this, intelligent prediction of terminal trajectories enables lossless Wi-Fi roaming and improves service experience. All these differentiators help lead campus networks into the intelligent gigabit-wireless era.

Huawei's CloudFabric solution transforms DCNs to take on three new features: ultra-broadband, lossless, and full intelligence. This future-proof solution fully supports high-density 400GE line cards and uses iLossless — the innovative intelligent lossless algorithm — to fully unleash AI computing power. So far, Huawei is the only vendor in the industry to implement Level-3 autonomous driving networks, leading DCNs into the intelligence era.

Huawei's CloudWAN solution implements strict isolation of office and production services through network slicing and enables real-time, dynamic adjustment of service paths via SRv6. This ensures converged transport of all services, including office and production services, and delivers guaranteed experience, leading WANs into the all-service intelligence era.

In 2019, Huawei took the lead in unveiling the one-of-a-kind HiSecEngine series AI firewalls. Equipped with a threat detection engine based on AI chips, these firewalls can detect unknown threats at an accuracy of up to 99 percent while delivering five times the industry average performance. These innovative AI firewalls lead network security into the intelligent defense era.

Because of the public health crisis in 2020, we are becoming accustomed to new application scenarios such as video conferencing, collaborative office, wireless projection, and robot services. New infrastructure deployments, covering 5G, artificial intelligence, cloud computing, and industrial Internet, are also getting into full swing. These new changes are posing higher requirements on data communications networks. Against this backdrop, intelligent IP networks are becoming the natural choice in the new era and will also be an inevitable trend for data communications networks for the next 10 years. We firmly believe that 2020 will be the first year for large-scale commercial use of intelligent IP networks.

Huawei stays customer-centric and keeps innovating to create greater value for customers. We join forces with industry players to accelerate the in-depth integration of AI into networks and jointly build intelligent IP networks, leading the intelligent IP era. ▲

News Express

Jan

Huawei's Dr. Liu Shucheng Elected Vice Chairman of ETSI ISG IP6

On January 8, 2020, ETSI Industry Specification Group (ISG) IPv6 Integration (IP6) held the 34th conference. At the conference, ETSI ISG IP6 announced new management, with Professor Latif Ladid from Luxembourg University as the chairman and Huawei Liu Shucheng as a vice chairman. This change shows ETSI's high regard for Huawei's continuous contribution to the data communications field.

Established in 2014, ETSI ISG IP6 aims to promote IPv6 deployment in various fields and guide the IPv4-to-IPv6 transition. It is one of the most important platforms for promoting the development of the global data communications industry. Huawei is excited to work with global industry partners to accelerate continuous innovation in the IPv6+ field and open a new chapter for the development of the data communications industry.

Feb

Huawei Launches AirEngine Wi-Fi 6 Products

On February 20, Huawei unveiled the AirEngine Wi-Fi 6 series products, including ten new Wi-Fi 6 Access Point (AP) models in three series for outdoor and indoor deployments, at the 2020 product and solution launch event in London. These all-new products stand out with unmatched performance and are ideally suited to help enterprises step into the fully wireless campus era. Powered by these new additions, enterprises will build fully connected, fully wireless campus networks with unprecedented levels of experience for offices, production lines, and services, accelerating digital transformation.

Of these new offerings, the flagship AirEngine 8760 AP delivers an air-interface data rate of up to 10.75 Gbps, twice the industry average. This AP achieves an air-interface data rate of over 10 Gbps, setting a new benchmark for Wi-Fi 6 products.

Mar

Huawei's Full Lineup of IP Products Recognized as Gartner Peer Insights Customers' Choice

In both April and October 2019, Huawei was twice the recipient of the title of Gartner Peer Insights Customers' Choice for Data Center Networking. Shortly after, in January 2020, Huawei was named the Customers' Choice for Wired and Wireless LAN Access Infrastructure, coming out on top among 26 vendors with an overall rating of 4.7 out of 5. Recently, Huawei was once again singled out with the Customers' Choice accolade for its WAN edge infrastructure, with a high overall rating of 4.8 out of 5. Huawei is the only vendor outside of North America to be honored with these distinctions.

Huawei CloudEngine 16800 Wins Frost & Sullivan 2020 Global Data Center Switch Technology Leadership Award with Highest Score

Huawei's CloudEngine 16800 data center switch won Frost & Sullivan 2020 Global Data Center Switch Technology Leadership Award, receiving 9.6 points for its technology leverage and 9.2 points for customer impact (10 points in total). It is the first 400GE switch in the industry to win this award.

Huawei Routers Take Top Spot in 2019 Global Carrier Market

Huawei routers took top spot in the global carrier market in 2019 according a recent report by Omdia (formerly IHS Markit), an authoritative international research institute.

Huawei routers rose to the top of the carrier market in 2018 and maintained their leading position throughout 2019. Huawei routers have maintained their top position for three consecutive years in the backbone router market. This is the first time that Huawei routers took top spot in the metro router market.

Huawei Launches the Intelligent IP Network Solution for the 5G and Cloud Era

At an online launch event themed of "5G, Bring New Value", Huawei showcased its intelligent IP network solution for the 5G and cloud era. This launch event comprehensively upgraded the intelligent IP network strategy, covering the industry's first end-to-end 400GE solution, SLA-committed solution, and Think it is missing a word here "AI-based management, control, and analysis integrated platform".

Huawei Hosts the 107th IETF Meeting

The 107th IETF meeting was held on 23 March, 2020. Due to the spread of the coronavirus around the globe, the meeting was held online for the first time ever. The IETF plenary meeting and a number of working group meetings were held in March. All other working group meetings were held successively and completed in early May.

Huawei has been actively supporting IETF standardization and is one of the enterprises with the largest number of IETF participants. The number of RFCs compiled by Huawei experts ranks top, and a total of 464 RFCs were released by Huawei experts in the IETF. In this meeting, Huawei worked with industry experts to promote standardization in SRv6, telemetry, 5G transport, YANG, and cyber security.

This is the 4th IETF meeting hosted by Huawei.

Apr

Huawei Launches the All-Video "Online Datacom" Column on Its Official Website

To provide customers with the latest digital updates on Huawei IP networks fast, securely, and vividly, Huawei has recently launched the video "Online Datacom" column on its official website. This column comprises three sections:

- "Online Release": Subscribe to and watch the launch of new products live.
- "Online Exhibition": Experts take you through the exhibition and each exhibition hall.
- "Online Solution": Watch videos from experts to learn about the latest solutions and technologies.

May

Huawei Launches the Industry's First 5G AR Enterprise Routers

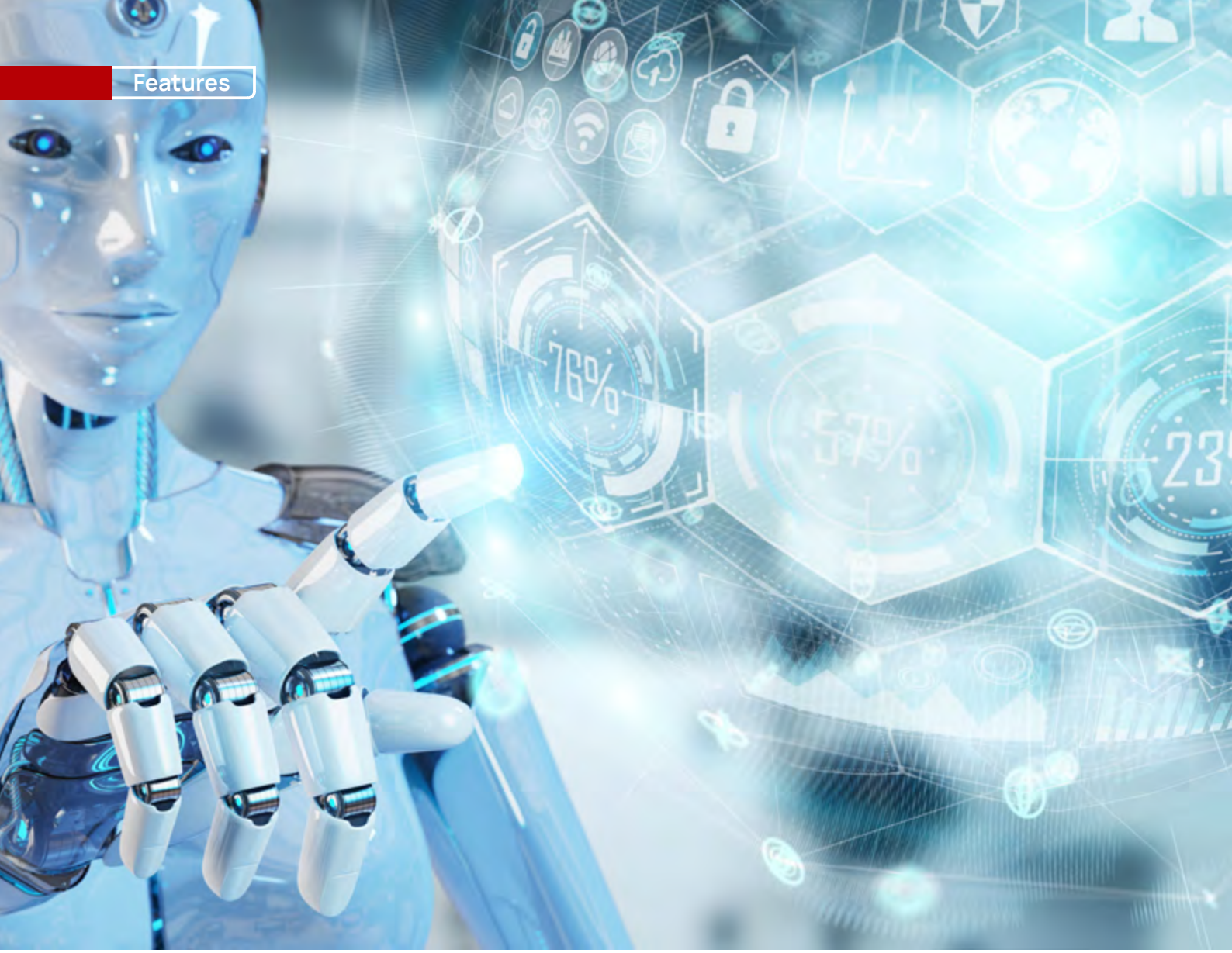
On May 14, Huawei launched a full lineup of NetEngine AR routers, the first-of-its-kind 5G enterprise routers. These future-proof products leverage Huawei's high-performance 5G cards to provide powerful 5G access capabilities. Standing out with differentiators such as 5G ultra-broadband, always-on services, and secure interconnection, NetEngine 5G AR routers are ideal for building high-speed, stable, and secure WANs to help enterprises accelerate their digital transformation.

Jun

Huawei IP Products Grab headlines at the Interop Tokyo 2020

Three coveted top awards which Huawei have won at Interop Tokyo 2020, Japan's largest ICT exhibition:

- CloudEngine 16800: Best of Show Award Grand Prize
- AR502H: Best of Show Award Grand Prize
- NetEngine AR6000: Best of Show Award Special Prize



Artificial Intelligence to Transform The Future Network Industry

By ***Liu Yunjie, Academician of the Chinese Academy of Engineering***

More than four decades of development has led to the Internet exerting significant influence across everyday consumption. Internet applications are now expanding from consumption to the production field, deeply integrating with real economy sectors such as manufacturing and energy. This poses higher requirements on the real-timeliness, security and reliability, service level classification, massive data processing, and resource scheduling of network communication. In this context, the sustainable development of networks has gradually become the focus of global attention. The fundamental transformation following industry digitalization and intelligentization calls for multi-level and multi-dimensional research on new basic theories and technical methods. These include designing a new network architecture free of existing Internet defects, exploring key technologies suitable for future network application innovation, developing core devices and systems for future networks, and performing large-scale networking verification.

At present, research has been conducted on future network architecture and key technologies both inside and outside China, and Software-Defined Networking (SDN) has attracted worldwide attention. Thanks to the centralized control mechanism, SDN can greatly improve the controllability, manageability, and flexibility of existing networks while effectively reducing Capital Expenditure (CAPEX) and Operating Expenditure (OPEX) of network service providers. In addition, SDN is capable of collecting an extensive amount of network data on the data plane in real time.

However, new application scenarios such as the Internet of Things (IoT) will render human-compiled centralized control programs — such as SDN — incapable of effectively dealing with future network complexity and unexpected network events.

Big data — collected by mechanisms such as network telemetry — can be analyzed by big data analytics and AI technologies in real time. This way, computers with AI capabilities may be able to detect 90 percent of network faults and security risks and suggest solutions to fix them. As a result, experts could solely focus on the remaining 10 percent of problems that machines cannot solve. Machines can also acquire increasingly stronger capabilities to handle complex network problems through continuously iterative AI training. In terms of path planning and traffic scheduling, future networks need to meet the high throughput and low latency requirements of applications. It is very difficult to provide an optimal traffic scheduling solution in real time based on the dynamic status of link loads if traditional path planning algorithms are used. Nevertheless, AI technologies are expected to make proactive prediction and effective scheduling of link traffic possible by using the massive amount of historical traffic data accumulated. AI has great potential to improve network management, fault detection, network security, path planning, traffic scheduling, and many other operations. The intelligence of the "network brain" is becoming a key enabler to address the continuous increase of network scale and complexity.

Introducing new concepts such as AI, to future networks brings technical challenges, one especially worth mentioning is how to improve the reliability of AI decision-making. Path planning and traffic scheduling on networks differ greatly from consumer-oriented services such as voice recognition. The AI-trained deep learning model can allow for certain errors during speech recognition, but errors are usually not permitted on networks. Path planning errors may lead to large-scale network breakdown, causing great loss.

This means, the introduction of AI technologies to future networks must be carried out in phases. The first breakthrough should be using AI technologies to implement network fault detection and network security diagnosis based on big data analytics. In this phase, AI will independently solve simple network problems and merely assist human experts with the more complex issues. As AI gradually matures and the network brain becomes more reliable, proactive planning of network paths will be conducted by the brain, which delivers an optimization efficiency of highly dynamic networks better than that achieved using traditional network algorithms.

We believe that AI technologies will revolutionize the network industry as they mature, providing an unprecedented opportunity for China to build self-sufficient, controllable, and secure new networks. ▲

Liu Yunjie, Academician of the Chinese Academy of Engineering

Editor's note: This article describes the significance of AI technologies for the development of future networks, and proposes typical application scenarios of AI analysis and AI training on networks. This article is a pioneering work about intelligent networks.

[This article, originally published in the Chinese Association for Artificial Intelligence Communications, is now republished after being revised by the author.]

AIOps and Beyond: Promoting Rapid Development of Enterprise ICT

By Peter Ye, Data Communication Product Line, Huawei Technologies Co., Ltd.

"Strategic technology trends have the potential to both create opportunity and drive significant disruption," said Andrew Lerner, Vice President of Gartner Research. "Enterprise architecture and technology innovation leaders must evaluate these top trends and find the best combination for powering their innovation strategy." As one of Gartner's top analysts in enterprise networking, Andrew Lerner has successfully predicted the application trends of SDN and intent-driven networks. This has led to him garnering immense popularity in the industry, winning recognition from customers and vendors alike.

Recently, Andrew Lerner led his team to propose key technologies that will promote enterprise Infrastructure and Operations (I&O) in the future. Specifically, he believes that these technologies will have a transformative impact on enterprise I&O, presenting significant disruptive potential over the next five years. The following sections will provide more details on the technologies, before analyzing their impact on enterprise network development.

Technology No. 1: Artificial Intelligence for IT Operations (AIOps) Platforms

AIOps is the application of AI in ICT operations. It is the future of ITOps. To be more specific, it uses AI to provide full visibility into the status and performance of IT systems on which enterprises depend. The AIOps platform combines big data and machine learning to analyze a large amount of data from multiple data sources and provide multiple analytical and presentation technologies.

Gartner predicts that, by 2022, at least 25 percent of large enterprises will be using AIOps platforms, up from 2 percent in 2018.

We believe that there is no time to waste when it comes to building AIOps platforms for enterprise network O&M. AIOps can go deeper than automatic O&M, solving more problems and providing a more intelligent basis for ICT O&M decision-making. It can even predict trends that will occur, thereby providing better assurance for stable operation and growth of enterprise services. Such capabilities mean that, sooner or later, all businesses will have to adopt AIOps.

Technology No. 2: Compute Accelerators

Compute accelerators offer outstanding performance and power efficiency. The mainstream compute accelerators are:

- **Graphics Processing Unit (GPU)** accelerators accelerate highly parallel compute-intensive portions of workloads. They are usually used for High Performance Computing (HPC), and Deep Neural Network (DNN) training and inferencing. GPU computing is also available as a cloud service and may be economical for applications where utilization is low but time to market is a priority.
- **DNN Application-Specific Integrated Circuits (ASICs)**

accelerate DNN computations. Use cases that can benefit from DNNs include speech-to-text, image recognition, and natural-language processing.

- **Field-Programmable Gate Array (FPGA)** accelerators deliver outstanding performance by enabling programmable hardware-level application acceleration. They are well suited to AI inference workloads due to their excellent low-precision processing capabilities in energy-efficient footprints.

Gartner predicts that, by 2022, computational resources used in AI will be four times more than in 2018, making AI the number one workload factor driving infrastructure decisions.

We believe that compute accelerators are able to greatly improve the computing performance. However, if there is packet loss on a traditional computing network, it will not be able to reach its full potential in terms of computing power. As such, it has become the bottleneck for improving computing power in the AI era. To fully unleash the computing power of data centers, enterprises urgently need to introduce the zero-packet-loss network.

Technology No. 3: Edge Computing

Edge computing is a distributed computing paradigm that places information processing close to the things or people that produce or consume that information. It keeps traffic and processing local to reduce latency and unnecessary traffic. Additionally, it establishes a hub for the data thinning of complex media types or computationally heavy loads. Edge computing solves many pressing issues, such as excessive latency, insufficient bandwidth, and high costs, helping to cope with the massive increase in edge-located data as positioning applications become increasingly popular.

Gartner predicts that, by 2022, more than 50 percent of enterprise-generated data will be created and processed at the network edge, up from 10 percent in 2018.

We believe that edge computing poses new requirements on network intelligence, latency, bandwidth, and access, which will transform edge computing network technologies from lossy to lossless, from "best-effort" to "deterministic", from dumb traffic pipes to intelligent computing networks, and from limited access to access anytime, anywhere.

Technology No. 4: Intent-Based Networking

An intent-based networking system (IBNS) provides:

- **Translation and validation:** It can take a higher-level business policy as input from end users and convert it to the required network configuration.
- **Automation:** It can configure appropriate network changes across existing network infrastructure.
- **State awareness:** The system ingests real-time network status for systems that it controls.
- **Assurance and dynamic optimization:** The system continuously validates that business intent is being met and can take corrective action when it isn't.

Intent-based networking can transform network operations. IBNSs improve network agility and availability and support unified intent and policy across heterogeneous infrastructures. When the technology matures, a full IBNS implementation will reduce the time to deliver network infrastructure services to business leaders by 50 percent to 90 percent. It will also reduce the number and duration of outages by at least 50 percent. In addition, IBNSs reduce operating expenditure, optimize performance, cut dedicated tooling costs, enhance documentation, and improve compliance.

Gartner predicts that, by 2022, more than 1500 large enterprises will use intent-based networking systems in production, up from less than 15 today.

We believe that networks will inevitably evolve to be intent-based and finally to autonomous driving. To help realize this, Huawei is exploring this aspect and actively carrying out joint innovation practices with customers. In 2018, Huawei released the Intent-Driven Network (IDN) solution with the aim of building a digital world that connects physical networks with business intents. Such a digital world is driven by users' business logic and business strategy intents, enabling customers to evolve from the live network to the target network architecture centered on user experience.

Summary

Various innovative technologies are emerging, and digital transformation requirements of various industries impose increasingly strict requirements on networks. Users need more secure, intelligent, and agile networks. Huawei's IDN solution helps customers to build ubiquitous ultimate connection experience and accelerates enterprise digital transformation. Driven by technology and customer requirements, Huawei continuously invests in and innovates to build better ICT solutions, maximize customers' business value, and lead the intelligent IP era. ▲

(The Gartner report cited in this article is excerpted from the ICT-related content of Andrew Lerner's Top 10 Technologies That Will Drive the Future of Infrastructure and Operations. For the original report, visit https://www.gartner.com/document/97084?ref=solrResearch&refval=24926222.)

Building AI-boosted Intelligent IP Networks

By ***Kevin Hu, President of Data Communication Product Line, Huawei Technologies Co., Ltd.***

After more than 30 years of development, IP networks have laid a solid foundation for network connectivity, and they're critical to realizing the ubiquitous connectivity that will power an intelligent world. According to Huawei's Global Industry Vision (GIV) 2025, 6.2 billion people will have access to the Internet and 100 billion connections will exist worldwide by 2025. Moreover, all enterprises will use cloud services and 85 percent of enterprise applications will be cloud-based. To achieve this, IP networks are required to carry more critical services, which in turn poses higher requirements on IP networks.

Detecting Usage Fluctuations and Diversity

A campus Wi-Fi network typically serves scenarios like office buildings, large stadiums, and large shopping malls. In these environments, the number of people in different areas fluctuates frequently and people use a variety of applications and services at the same time. O&M personnel have traditionally adjusted network resources manually. But to ensure service experience for different users, this approach is inefficient because it cannot cope with the rapid movement of people and assure user experience.

Can Wi-Fi networks become intelligent enough to detect fluctuations and multiple service types, and then automatically adjust resources to meet different service requirements? AI-boosted campus networks can intelligently detect changes in the number of terminals, access locations, bandwidth requirements, and service experience requirements of Wi-Fi users. It can also predict trends and dynamically adjust Wi-Fi network resources to optimize network performance.

Huawei has collaborated with leading customers to jointly develop Intelligent IP Networks, with test results showing that our AI-powered Wi-Fi solution can:

- Improve the throughput of wireless air interfaces by 58 percent over the industry average.
- Reduce Wi-Fi channel interference rate by 49 percent over the industry average. In addition, AI can be used for intelligent O&M on campus networks.
- Rectify about 85 percent of faults within 10 minutes.

What will Intelligent IP Networks Look Like?

Huawei believes that Intelligent IP Networks have the following characteristics:

- **Super Capacity** is the basis of the Intelligent IP Network architecture. At present, applications such as video, remote office, cloud computing, and AI are driving a new round of growth in network bandwidth. Campus networks are being upgraded with Wi-Fi 6 and 100GE switches, and data center networks and IP backbone networks are being upgraded to support 400GE. Advances in physical-layer performance and the emergence of network slicing networks like FlexE allow businesses to use bandwidths more flexibly and efficiently to simultaneously support multiple services, including office work, production, and computing, with a single physical

Huawei's full series of network devices are embedded with AI Turbo acceleration engines, extending the AI inference capability to edge nodes and achieving real-time perception, inference, and optimization of network service quality.In addition, the AI cloud service model is used to deliver inclusive AI, enabling customers and Huawei to achieve more service innovations and speed up the advent of autonomous driving networks.

— Kevin Hu, President of Huawei Data Communication Product Line

network. Hard bandwidth isolation for traffic of different services enables 100 percent committed bandwidth to support verticals' key services, businesses' production networks, and operators' IP private lines. The ability to intelligently adjust the bandwidth of different slices allows ultra-broadband networks to be flexibly adjusted for service changes, better addressing service needs.

• **Intelligent Experience** is the ultimate goal of an intelligent IP network. Many uncertainties exist with IP networks such as inadequate or non-existent negotiation on SLA between the service layer and the network layer. As a result, the expectations (the service intent) of the service layer are unclear at the network layer, creating uncertainty on the demand side. IP networks are statistically multiplexed, meaning that the resource usage level at the network layer constantly changes with service and traffic. That creates uncertainty on the supply side.

To eliminate these uncertainties, it's necessary to accurately sense service intent. For example, the service layer could notify the network layer of service requirements, or the network layer could analyze service traffic characteristics (service models); proactively detect terminals, users, and service types; and infer the expectations of the service layer. These approaches can help eliminate demand-side uncertainty. Furthermore, a unified platform for network management, analysis, and control can use algorithms, such as neural networks, to establish network models, detect and analyze network status in real time, and learn about network resource usage. These capabilities help eliminate uncertainty on the supply side. Intelligent experience is also a process of matching service intent with network resources to continuously provide the desired connectivity services at minimum cost, thus achieving an application-driven experience.

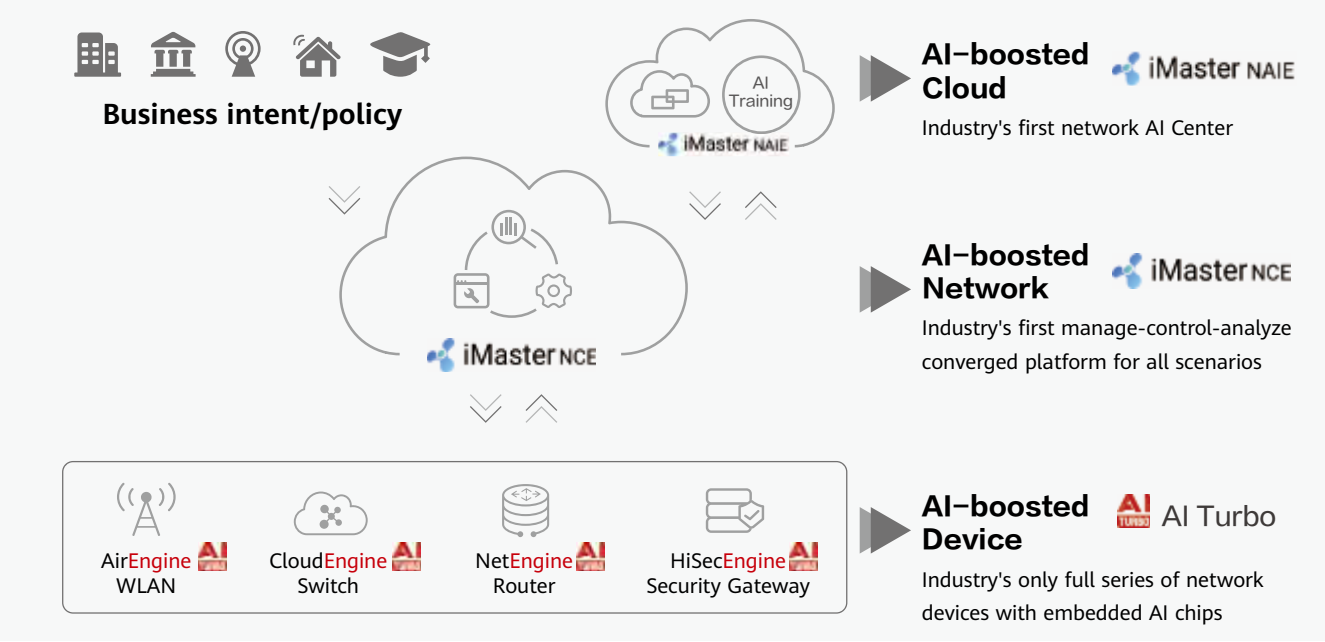
• **Autonomous driving** is the key to improving user experience. Complaint-driven troubleshooting has brought significant challenges to network O&M, with the network O&M department often the last to know that a problem has occurred on the network. Proactive O&M is essential for improving user experience. First, network status should be monitored in real time to check whether an issue or potential risk exists on the network. If an issue or risk is discovered, AI can accurately identify the root cause by matching fault patterns and then automatically fix the fault before services and user experience are affected.

3-layer AI Architecture to Build Intelligent IP Networks

At HUAWEI CONNECT 2019, Huawei launched AI-boosted Intelligent IP Networks with three layers enhanced by AI:

• **AI-boosted devices:** Huawei provides a comprehensive range of AI Turbo products in NetEngine routers, CloudEngine switches, AirEngine WLAN products, and HiSecEngine security gateways products. These offerings deliver edge inference and real-time decision-making, and adjust IP packet forwarding policies based on service intent to ensure optimal service experience in real time.

• **AI-boosted network management:** Huawei iMaster NCE can identify the intent of the service layer, automatically generate and deploy network configurations, and ensure that the network meets service intent. It can also detect the health status of the physical network in real time, detect anomalies,



3-layer AI Architecture for Intelligent IP Networks

provide alerts, and quickly offer handling suggestions. Its built-in expert system database enables the Huawei iMaster NCE to quickly troubleshoot and optimize against network anomalies. Huawei iMaster NCE also delivers real-time visibility of SLAs and enables predictive maintenance based on AI technologies. In addition, this system provides various viewgraphs of AI-powered network capabilities, enabling partners across various industries to perform customized development.

- **Cloud-based AI Training:** The Huawei iMaster NAIE comprises a cloud platform that provides a data lake, model and training capabilities, an open ecosystem, and developer services. The solution brings the following benefits: 1) It helps businesses develop AI algorithm experts and helps developers build AI algorithm capabilities. 2) It provides training services, so that developers don't need to invest as much in computing power resources. 3) It provides a platform for sharing resource data that has undergone desensitization, which developers can use for model training. 4) It provides federated learning and transfer learning capabilities to tackle problems in model generalization and achieve model sharing.

AI training is the foundation of smart connectivity and smart O&M. In turn, building service, network, and fault models rely on training with big data and analytics. AI training can continuously evolve, enabling the entire system to become smarter, so that it adapts to rapid changes in services and networks to boost service quality and experience.

Practices and Experiences of Intelligent IP Networks

Intelligent IP networks not only vastly improve campus networks, they also deliver breakthroughs in Data Center Network (DCN), Wide Area Networks (WAN), and security firewall fields.

- **DCN + AI:** The arrival of the AI era poses higher requirements on DCNs. According to related tests, a packet loss rate of 0.1 percent in a DCN can reduce the computing power of AI training by 50 percent. To combat this problem, Huawei launched the industry's first AI Fabric DCN solution, which achieves zero packet loss and fully unleashes the AI computing power on a DCN. This solution uses AI technologies to implement predictive traffic scheduling, achieving zero packet loss on the network and improving data computing and storage efficiency by approximately 30 percent. In addition, Huawei and leading customers have made great progress in joint innovation by applying AI technologies to autonomous driving of DCNs. Huawei's solution can detect

75 types of frequent faults within one minute, locate them within three minutes, and rectify them within five minutes. Huawei's AI-powered DCN solution can implement intelligence in understanding service intent, selecting the optimal network path, evaluating change risks, and detecting fault and the rapid location of fault root-cause. With these achievements, Huawei has taken the lead in creating an L3 autonomous driving network in the DCN field.

- **WAN + AI:** In today's new era, a combination of 5G, cloud, and AI is powering all industries. 5G provides unprecedented capabilities for wireless access, while cloud and AI offer almost unlimited scalability for intelligent computing (for single tenants). The bonding between 5G, cloud, and AI—the DCN and WAN networks—shouldn't be overlooked. The AI-powered DCN is the catalyst for adding AI to cloud, while the AI-powered WAN is the catalyst for joining the dots between 5G and cloud. We will use AI to advance autonomous driving networks in WAN networks and thus unleash the full potential of 5G, cloud, and AI, enabling millions of enterprises to migrate to cloud and bringing the benefits of 5G to all industries.

So, how can we make this reality?

Much like the DCN scenario, WAN networks can use AI to develop autonomous driving networks. Specifically, the AI-powered WAN can intelligently match network resources and intelligently select the optimal routes based on SLA requirements such as service latency. However, unlike the DCN scenario, WAN networks need to resolve how to quickly provision WAN networks to meet the different SLA requirements of various industries, for example, 5G telemedicine, where E2E latency must be less than 15 ms. Enabling the physical forwarding plane "body" to keep pace with the AI-powered "brain" for management, control, and analysis is a new challenge for WAN networks.

Millions of enterprises are now migrating to cloud. Traditional WAN networks need to be manually provisioned hop by hop and so deployment efficiency is very poor. As virtual machines and containers can be provisioned much faster, WAN network deployment is the bottleneck. The source routing mechanism of Segment Routing IPv6 (SRv6), a next-generation routing protocol, shifts away from traditional E2E, hop-by-hop provisioning to source node provisioning only. SRv6 greatly simplifies WAN deployment and enables the body to keep up with the brain, realizing automatic and fast deployment in WAN networks.

5G-powered industries have varied SLAs, especially in terms of latency requirements. To address this, the WAN uses the SRv6 protocol to program the network forwarding route based on the optimal path calculated by the management, control, and analysis system. A route with a deterministic node, route, and latency can be quickly configured to meet the requirements of the service layer.

Therefore, SRv6 is a crucial forwarding plane capability of next-generation AI-powered WAN networks. SRv6 enables the WAN to intelligently recommend the optimal route, quickly deploy the optimal connections, and optimize service SLAs in real time. Together with 5G and cloud technologies, SRv6 can enable millions of enterprises to move to cloud.

- **Network security firewall + AI:** Malware has many variants and is difficult to detect, especially by today's firewalls that use signature matching. Huawei confirmed its leadership in the industry by launching the industry's first T-level AI firewall series, HiSecEngine USG12000. It handles threats that traditional firewalls cannot detect and uses a unique threat detection AI Engine (AIE) to identify, for example, compromised hosts and communication with external Command and Control (C&C) servers—at network borders in real time. Achieving a detection accuracy of more than 99 percent and powered by the AI chip, HiSecEngine USG12000 improves threat detection performance five-fold. By applying intelligent security event analysis and intelligent security policy optimization technologies, HiSecEngine USG12000 achieves service rollout in minutes and implements service-driven policy deployment and change, reducing OPEX for security O&M by 80 percent. The next-generation AI firewall will provide intelligent network border protection and build impenetrable high security for enterprises.

Summary

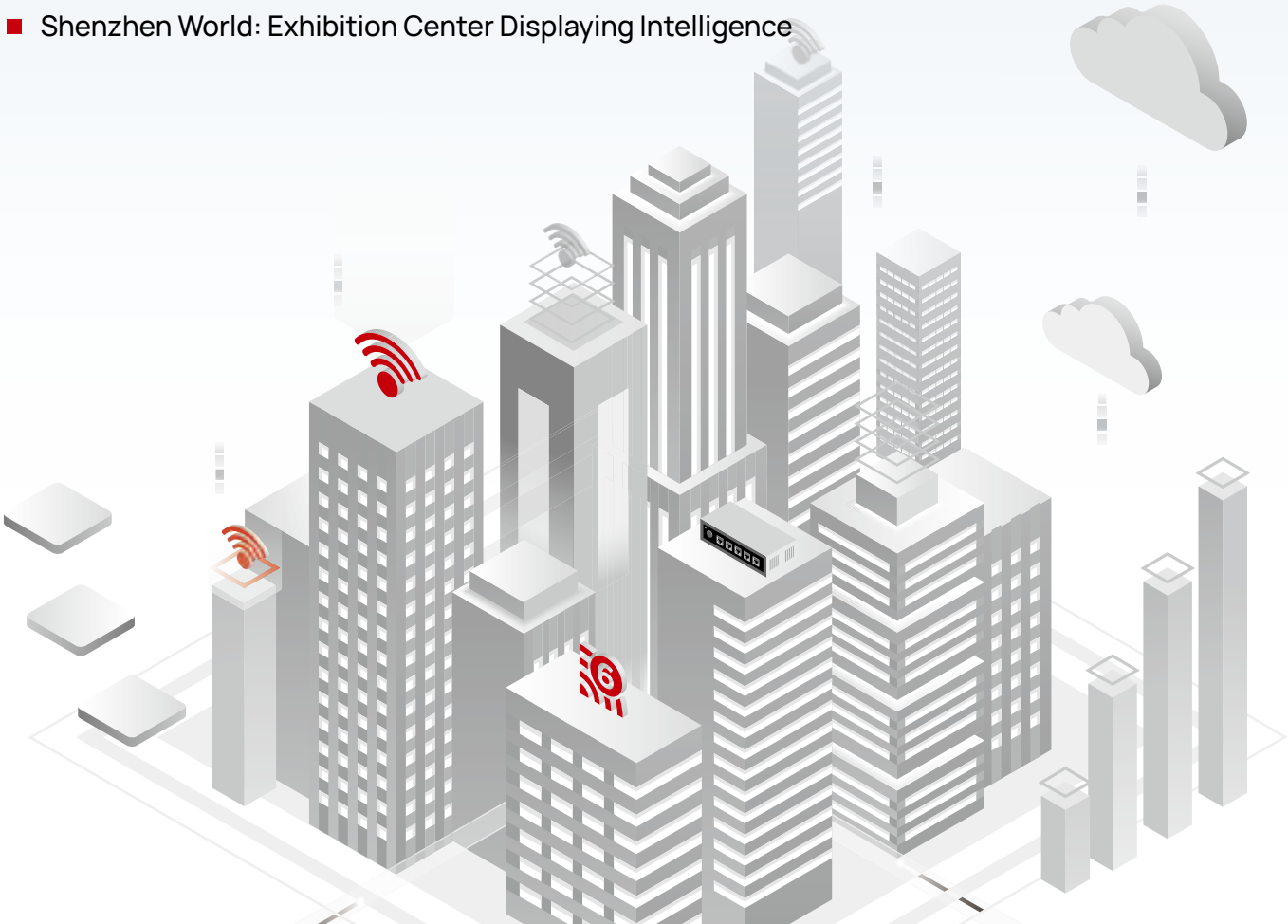
Customer-centricity is Huawei's core philosophy. Customer needs are always the driving force behind Huawei's development. Through the NetCity joint innovation program, Huawei combines the requirements of leading customers with its own R&D capabilities to develop leading IP network solutions and shape the future of IP networks with its influence in the IP standards community. Huawei will continue to work with customers and partners worldwide to continuously incubate cutting-edge products and solutions and lead the way in intelligent IP networks. ▲

Leading Campus Networks into the Intelligent Gigabit-Wireless Era

It is clear that network connection resources are becoming increasingly cloud-based and service-oriented. Imagine the future of networks, where network access will be available anytime, anywhere and "network access" itself will become an unperceivable necessity like sunshine and air. Such ubiquitous network access will be especially beneficial for enterprises, as it will greatly improve the efficiency and quality of enterprise office work, production, and services.

The prerequisite to realizing this future lies in fully-wireless, experience-assured network connections. Nowadays, wireless gradually replaces wired connections, becoming the mainstream for enterprise network access. Further, wireless connection technologies represented by Wi-Fi and Bluetooth are rapidly penetrating more application scenarios.

- Enterprise Transforms: Building new Foundation for Digitalization By Wi-Fi 6
- Leading Campus Networks into the Intelligent Gigabit-Wireless Era to Power Digitalization
- Industry-Leading Wi-Fi 6: New Engine for Enterprise Digital Transformation
- Building High-Quality Campus Network with CloudEngine Switches
- St. Jakob-Park Stadium: Embracing the Smart Era with Wi-Fi 6
- Shenzhen World: Exhibition Center Displaying Intelligence



Building a Fully Connected, Intelligent World

HUAWEI

AirEngine Wi-Fi 6

Powered by Huawei 5G

Wins Best of Show Award Grand Prize at Interop Tokyo 2019

- **Lightning-fast speed:** 1.6 Gbit/s for a single user, and 10.75 Gbit/s for a single AP
- **Always-on lossless experience:** 50% lower latency and 20% greater coverage than industry Wi-Fi 6
- **Continuous self-organizing networking:** 100 Mbit/s anytime, anywhere

Leading Intelligent IP Networks

Learn more about AirEngine Wi-Fi 6

Enterprise Transforms: **Building new Foundation for Digitalization By Wi-Fi 6**

By ***Jiang Junmu, C114 News Feature***

Beginning with a stroke of genius that connected two bank machines wirelessly, Wi-Fi has undergone over 20 years of development and penetrated into all aspects of society, occupying almost half of the device networking market. PCs, laptops, and almost all hand-held devices nowadays support Wi-Fi, even if they do not necessarily support cellular communication. With the continuous increase in application scenarios and digital requirements, Wi-Fi has also evolved to the next generation—802.11ax. This latest technology system, which has been renamed "Wi-Fi 6", has gained favor within the business community over the past year due to its game-changing performance. It has become the preferred support network for more enterprises to promote transformation and redefine their competitiveness.

According to the latest report on global Wi-Fi 6 indoor Access Point (AP) market share from 2018 Q3 to 2019 Q3 by Dell'Oro Group, a renowned analyst organization, overall global Wi-Fi 6 market revenue surged over the first three quarters of 2019, amounting to 30 times that of 2018. Further estimates indicate that Wi-Fi 6 devices will account for one third of the global Wi-Fi market by 2020.

"5G changes society, and Wi-Fi 6 transforms enterprises." In the future, this may be the impression you get when you look back at 2019, the first year of Wi-Fi 6 commercial use.

Enterprise Networks Usher in the Wi-Fi 6 Era

The booming digital economy and explosion of emerging digital technologies have led to the world developing faster than anticipated. It is possible that more development will occur in one year than the last 100 years. For enterprises, new opportunities and blue oceans are on the verge of reality, while industry disruption as well as shuffling are prevalent. Whether enterprises proactively embrace opportunities to stimulate innovation or passively react so as not to be left behind, digital transformation has already become the norm.

According to research by the Massachusetts Institute of Technology (MIT), digital transformation can be classified into two types: digitized and digital. The digitized process aims to achieve higher efficiency, higher reliability, and lower costs, while the digital process focuses on rapid innovation, revenue

generation, and growth. According to a report by the International Data Corporation (IDC), digital transformation has become the core strategy of most enterprises. Direct investment in digital transformation is growing at a Compound Annual Growth Rate (CAGR) of 17.5 percent and is expected to attain US$7.4 trillion by 2020 to 2023.

This sweeping trend will affect network transformation first. In the future, enterprise networks will face unprecedented challenges due to factors such as 86 percent of enterprises using AI, collaboration between hundreds of billions of production and office terminals, "cloudification" requirements for 100 percent of enterprise services, the popularization of new applications with high interactivity, as well as various security issues. A network that is ubiquitous like water and air, on-demand, as well as easy to manage is key to successful digital transformation.

Therefore, it is not difficult to understand how 2019 became the first year for the commercial use of Wi-Fi 6. Wi-Fi has fundamentally been transformed by Wi-Fi 6, which incorporates numerous key 5G technologies. That is, breakthroughs have been achieved in various aspects such as bandwidth, concurrency, latency, transmission range, and battery life. For example, the maximum bandwidth of each terminal and number of concurrent network terminals have both increased more than four times. Furthermore, latency has reduced by more than two thirds. All these improvements create an entirely new user experience. Another advantage that cannot be ignored is the lower deployment and usage costs of Wi-Fi compared to other connection methods.

Wi-Fi 6 will be deployed in 90 percent of enterprises by 2023 according to the Unleashing the Power of Wi-Fi, Enterprise-Grade Wi-Fi 6 Forecast 2019–2023 white paper that was released during the 2019 Mobile World Congress (MWC), as well as the opinions of industry standards organizations and analysts.

How Does Wi-Fi 6 Change Enterprises?

Looking ahead, we may understand the benefits of Wi-Fi 6 better by interpreting some typical scenarios.

For example, in enterprise office scenarios, 4K video conferences anytime and anywhere require a stable bandwidth of at least 40 Mbit/s for each user. Wi-Fi 6 can meet this expectation well because its 1024-QAM technology improves overall network bandwidth and ensures Ultra-HD (UHD) video experience for each user. Another example lies in the industrial production environment that has high requirements on network stability. However, in ultra-high density concurrency scenarios, the data transmission rate and network stability of terminals decrease sharply. To address these pain points, Wi-Fi 6 technologies, such as uplink and downlink Multi-User Multiple-Input Multiple-Output (MU-MIMO) and Orthogonal Frequency Division Multiple Access (OFDMA), improve concurrent capacity and transmission efficiency, ensuring industrial production terminals with continuous and stable operations. Internet of Things (IoT) applications will also gain additional value-added features through Wi-Fi 6. For example, Target Wake Time (TWT) can reduce UE power consumption and save battery life.

"Now is a good time to start planning for Wi-Fi 6. According to the digital transformation strategy and impact of Wi-Fi 6 on ICT infrastructure changes, CIOs and IT leaders need to consider future Wi-Fi 6 upgrades to achieve smoother migration," said Dr. Osama Aboul-Magd, Chairman of the IEEE 802.11ax standard task group. He also pointed out that with user numbers and coverage being constant, Wi-Fi 6 requires significantly fewer APs than the previous Wi-Fi generations, saving capital expenditure considerably.

To truly use Wi-Fi 6 to enable digital transformation, field-proven and leading

More than 700 cities and 228 Fortune Global 500 companies had chosen Huawei as their digital transformation partner. Wi-Fi 6's large-scale deployment on enterprise networks has just begun, and it is expected to truly become a basic network technology supplying endless power to enterprise production and service digitalization. ››

commercial Wi-Fi 6 products are essential. As a leading ICT vendor, Huawei is a leader in 5G and a frontrunner of the Wi-Fi 6 industry. The company has been participating in the establishment of next-generation Wi-Fi standards since 2014. It released the industry's first Wi-Fi 6 AP in 2017, and helped deploy Shanghai's first enterprise-class Wi-Fi 6 network in 2018. This shows that Huawei plays a key role in end-to-end processes ranging from standard formulation to product development and commercial applications. Integrating the advantages of Huawei's own 5G technologies, AirEngine Wi-Fi 6 series products use innovative smart antennas and algorithms to build Wi-Fi 6 networks with "zero coverage holes, zero waiting time, and zero packet loss during roaming" for enterprises of all sizes. This allows various industries to accelerate toward a fully connected, intelligent world.

According to the report on global Wi-Fi 6 indoor AP market share from 2018 Q3 to 2019 Q3 by Dell'Oro Group, Huawei ranks first in both the global (excluding North America) and Chinese markets. Huawei Wi-Fi 6 APs have been deployed in five regions worldwide, serving fields such as government, education, finance, energy, airports, and manufacturing. These success cases provide immense demonstration and reference value.

A financial center in the Middle East houses more than 2000 financial companies, as well as ultra-modern office spaces, retail stores, restaurants, art galleries, public green spaces, and hotels. Huawei AirEngine Wi-Fi 6 has helped the financial center build ubiquitous and ultra-broadband digital workspaces. The single-carrier peak rate of Huawei's Wi-Fi 6 APs attain 3.8 Gbit/s, which is the highest throughput in the industry as verified by Tolly Group, an international authoritative evaluation organization. This all-time high throughput meets the requirements of ultra-broadband service applications, such as 4K/8K HD video. Each AP supports over 200 concurrent connections, ideally suited to guest access requirements in high-density scenarios, including office spaces,

public green spaces, and art galleries.

Mondragon University, a renowned university in Spain, has been committed to innovating and developing new education paradigms based on ICT technologies. However, its existing campus network is plagued by poor Wi-Fi roaming experience and frequent signal interruption, which have become the biggest bottlenecks. Huawei AirEngine Wi-Fi 6 utilizes unparalleled four-element smart antennas to enable wireless signals that "move with people," expanding coverage distance by 20 percent. Huawei's agile distributed Wi-Fi solution provides high-performance network experience for students in dormitories, improving management efficiency by 90 percent. In addition, the AirEngine-based Dynamic Turbo (an intelligent application acceleration technology) reduces Wi-Fi network latency to 10 ms, meeting requirement for VR/AR teaching without dizziness over long periods.

Airports, stadiums, coffee shops, and other public locations are traditional Wi-Fi deployment scenarios. However, in the past, experience sharply declined as the number of connections increased. A large airport in Asia is one of the busiest in the world, with passenger traffic reaching new heights every year. Huawei AirEngine Wi-Fi 6 is powered by the industry's fastest Wi-Fi 6 APs that support high concurrency, meeting the wireless access requirements of densely populated airports and ensuring smooth HD video playback. In addition, Huawei AirEngine Wi-Fi 6 supports IoT extension modules, ensuring value-added services, such as asset management as well as positioning and navigation, are effectively deployed in airports.

AirEngine Wi-Fi 6 Network That Goes Beyond Wi-Fi 6

Compared with other Wi-Fi vendors, Huawei is not only the first company to invest in and promote the development of commercial Wi-Fi 6 products, but more importantly, it provides real-world end-to-end Wi-Fi 6 enterprise network solutions. In addition to ubiquitous wireless access with service continuity, Huawei's solutions also include ultra-broadband, intelligent transmission, as well as intelligent, simplified management and O&M.

In terms of network transmission, CloudEngine (switches) are part of Huawei's "four-engine" product portfolios. In June 2019, Huawei launched the all-new CloudEngine S series campus switches that are tailored for enterprise digitalization in the Wi-Fi 6 and cloud native era. These switches are available in 16 models in several series: CloudEngine S5700 series (intelligent GE access switches), CloudEngine S6700 series (10GE routing aggregation switches), and CloudEngine S12700E series (industry's highest-performance core switches).

According to Tolly Group's test report, the switching capacity of the CloudEngine S12700E is six times that of the industry average. Furthermore, these campus core switches have the highest single-slot bandwidth, highest 100GE port density, and largest system switching capacity. In addition, the CloudEngine S series is one-of-a-kind in the industry with wired and wireless convergence capabilities, a threat deception engine, and the telemetry technology. Based on the new Solar chips, as well as well-trained and optimized network AI algorithms, CloudEngine S series switches can provide zero packet loss and non-blocking services in high concurrency, large capacity, and heavy load scenarios, ensuring the quality of data center-level networks and services.

In terms of network management, the popularization of mobile offices and cloud applications is leading to increasingly intricate network policy management. Built on the Intent-Driven Network (IDN), Huawei's CloudCampus solution is capable of intent-driven and proactive O&M, delivering "zero-touch" management and O&M.

As an embodiment of the AI-powered network layer, iMaster NCE is the industry's first network automation and intelligence platform that integrates management, control, analysis, and AI functions. It features full-lifecycle automated management and intelligent O&M of networks. Tailored for campus networks, iMaster NCE-Campus provides unmatched provisioning capabilities such as one-stop network planning, deployment, and policy automation based on service intent. Using big data analytics and AI technologies, iMaster NCE-Campus also proactively identifies and analyzes network faults to implement intelligent closed-loop management.

Eric Xu, Huawei's Rotating Chairman, revealed in his New Year message that as of 2019, more than 700 cities and 228 Fortune Global 500 companies had chosen Huawei as their digital transformation partner. Wi-Fi 6's large-scale deployment on enterprise networks has just begun. Driven by vendors such as Huawei, Wi-Fi 6 is expected to truly become a basic network technology with quality assurance that supplies endless power to enterprise production and service digitalization. In the future, we will undoubtedly hear an increasing number of success stories of how Wi-Fi 6 transforms enterprises. ▲

Leading Campus Networks into the Intelligent Gigabit-Wireless Era to Power Digitalization

By Jason Ding, Data Communication Product Line, Huawei Technologies Co., Ltd.

Digital Services Transform Campus Networks

Driven by technologies such as cloud, Internet of Things (IoT), and edge computing, ultra-fast reliable network connections available anytime and anywhere have become one of core competitive strengths for enterprises, society, and even countries.

Today, Chief Information Officers (CIOs) in almost every enterprise are re-thinking about how to apply the new connection technologies, such as 5G, power-efficient short-range IoT, and Wi-Fi 6, to improve collaboration, production, and operational efficiency, as well as accelerate innovations.

Although digital scenarios vary in different sectors, digital transformation is required in all sectors to achieve the following objectives: improve enterprise office and operational efficiency, reconstruct enterprise production environments, and streamline communication with customers. Digital transformation takes place not only in enterprise headquarters, but also in global branches, and even in their global manufacturing or logistics partners.

Every enterprise knows that high efficiency is beneficial. The email-based non-real-time communication services on traditional enterprise office networks can no longer meet today's requirements for efficiency in communication. The current enterprise communication market is seeing a large number of instant communication applications to realize real-time communication, video interaction, collaboration, and project management. Such a change in applications increases the required average bandwidth per user from 3–5 Mbps to 100 Mbps. To meet the requirements of today's Virtual Reality (VR) and Augmented Reality (AR) training and design as well as the requirements of 4K telepresence video conferencing systems, the peak wireless rate of each user needs to reach 100 Mbps to 1.5 Gbps.

For enterprises with many branches globally, emerging digital applications are redefining their production efficiency. Here are a few examples of digital applications in different sectors.

In the warehousing sector, Automated Guided Vehicles (AGVs) are being used more extensively for automated warehouse management, as they can improve the efficiency of warehousing 100-fold. However, this requires wireless networks to ensure zero packet loss during roaming.

In the education sector, teachers use remote or VR classrooms to provide classes for students from multiple locations at the same time, improving the quality of learning. However, the latency of VR applications must be less than 10 ms to ensure a high-quality learning experience.

In the retail sector, Electronic Shelf Labels (ESLs) are widely used in stores to enable prices to dynamically change based on the shelf life of commodities and climate change. However, integrated deployment and management of Wi-Fi and IoT networks must be achieved to make full use of this application.

Wireless connections are the basis of digital applications. However, different applications have strict, or even harsh, requirements on wireless networks. This raises concerns for many enterprise CIOs as IT personnel are worried about deploying wireless networks in production scenarios and being unable to monitor the quality of applications on networks or quickly resolve issues.

Many CIOs may ask their IT department directors: "Is our network ready for digital transformation? What kind of network do we need?"

Huawei CloudCampus Solution Builds an Intelligent Gigabit-Wireless Campus Network for Enterprises

We believe that the future campus network has three unique features:

- **Super capacity:** gigabit speeds and beyond

Since early 2020, the COVID-19 virus has swept the world, affecting 210 countries and regions. For this reason, enterprises, schools, and other organizations during the lockdown have to continue business through working remotely. This shows that the enterprises' work and production are becoming remote and mobile. As such, the requirement for high-quality wireless networks has increased to new heights.

- **Intelligent experience: Continuous Self-Organizing Networking (CSON)**
- **Autonomous driving: service provisioning and troubleshooting in minutes**

Such a network is ready to support enterprises' digital services for the next 10 years. In addition, we believe that the current network architecture should not be abandoned. Rather, we need to evolve the current network architecture to a gigabit fully-wireless network architecture in phases.

Super Capacity: Gigabit Speeds and Beyond

In the new era, the campus network architecture will undergo three key changes to meet the future requirements of fully-wireless access for offices to production services and provide ultra-high-speed connections exceeding one Gbps for each user. The first is implementing fully-wireless access. Wi-Fi 6 has already been put into commercial use in a small number of enterprises since 2019. By 2024, 80 percent of enterprises will be using Wi-Fi 6. Huawei's brand-new AirEngine Wi-Fi 6 series APs are unique in the industry with 16 smart antennas embedded. They provide full coverage for each user and offer a throughput of up to 10.75 Gbps. The second change is in the port rate. With the upgrade of Wi-Fi networks, wired access switches need to support the new IEEE 802.3bz standard, which requires multi-GE switches. These switches provide multiple port rates, including 2.5 Gbps, 5 Gbps, and 10 Gbps. The third change is that one network for multiple purposes is required to support all-round connections. The fully-wireless access of IoT terminals requires a wireless network to provide access, authentication, authorization, access control, and device management for short-range IoT terminals of various types, such as Bluetooth Low Energy (BLE), Radio Frequency Identification (RFID), ZigBee, and thread terminals.

Intelligent Experience: Continuous Self-Organizing Networking (CSON)

As an increasing number of key services are carried on campus networks, network experience directly affects user collaboration efficiency and service operational efficiency. Service- and user-oriented End-To-End (E2E) experience assurance is the key to measuring the quality of campus networks. To provide an optimal network experience, a campus network must cope with the following three core challenges:

First, it needs to reduce radio interference. Wi-Fi networks are easy to obtain and deploy, but use the limited unlicensed 2.4 GHz and 5 GHz frequency bands. Therefore, co-channel interference is still an issue for Wi-Fi networks. Based on the Basic Service Set (BSS) coloring feature, Huawei AirEngine Wi-Fi 6 APs use Artificial Intelligence (AI) technology to proactively learn network traffic behavior and radio information and greatly reduce interference, improving network-wide performance by 58 percent.

Second, it needs to reduce the packet loss rate during station (STA) roaming. Service interruption during STA roaming can occur for a number of reasons. For example, STAs stick to the previous AP due to having different

requirements on signal strength. In some other cases, services are interrupted due to STAs failing to set up links with the target AP during roaming. To prevent packet loss during STA roaming, Huawei AirEngine Wi-Fi 6 APs use AI technology to dynamically detect and predict the roaming characteristics and paths of STAs. With the help of the optimized 802.11k/v/r fast roaming protocols, the APs can increase the roaming success rate of STAs to 100 percent and reduce the service packet loss rate to nearly zero.

Third, it needs to increase the usage of network resources. A fully-wireless campus network differs from a traditional campus network in two major aspects, which may cause bottlenecks in network performance. First, due to the swarm effect of STAs, burst high-density access may occur anywhere in a fully-wireless campus. Second, as cloud applications produce large north-south traffic on the campus network, burst traffic may cause congestion on the ports of aggregation and core switches, affecting the quality of applications. In addition, the occurrence of these issues is highly unpredictable. Huawei provides two innovative technologies to effectively solve issues. Firstly, Huawei innovatively integrates both Orthogonal Frequency Division Multiple Access (OFDMA) and Multi-User Multiple-Input Multiple-Output (MU-MIMO) into AirEngine Wi-Fi 6 products for joint scheduling. This prevents traffic congestion on the wireless side in the case of service concurrency. The second innovative technology is user- and application-based intelligent Hierarchical Quality of Service (HQoS). This technology ensures a satisfactory experience for VIP users using key applications when the wired network is congested due to traffic bursts.

Autonomous Driving: Service Provisioning and Troubleshooting in Minutes

The management of networks was not originally a major challenge for campus networks. However, as the number of branch networks increases and wireless coverage applies more widely, simplifying network management, O&M, as well as management of user experience becomes a new challenge. Different networks may have different management requirements, but all require simplified management and O&M regardless of the size of the network. Against this backdrop, Huawei CloudCampus Solution introduces iMaster NCE, a one-of-a-kind Network Management System (NMS) that can centrally manage and maintain LANs, WANs, WLANs, and networks at enterprise headquarters as well as their branches. Huawei also provides customers with much flexibility in networking. iMaster NCE can be flexibly deployed in on-premises, public cloud, or MSP-owned cloud mode. With the help of iMaster NCE, customers can roll out networks and services within minutes. Furthermore, the CloudCampus Solution uses the industry-leading AI-powered intelligent O&M system — CampusInsight. It has been widely proven at Huawei and global customers across industries. At Huawei, CampusInsight can evaluate and analyze the network experience of up to 190,000 employees in real time and proactively detect potential network faults, helping IT managers quickly locate and rectify these faults. With CampusInsight, enterprise O&M personnel can gain full visibility of the network quality for the first time.

Enterprises Accelerate Digital Transformation with Huawei CloudCampus Solution

Campus networks are main venues for digital service innovation of enterprises. Since initiation of its commercial use in 2017, Huawei CloudCampus Solution has been serving customers across various industries in more than 100 countries and regions. Huawei is recognized as a mainstream provider of differentiated campus network solutions and services by analyst organizations such as Gartner, IDC, Forrester, and Dell'Oro Group. Huawei is also a leading vendor in the campus switch and WLAN fields.

In the past few years, Huawei CloudCampus Solution has been applied in various sectors to build digital-ready networks. Typical examples include fully-wireless office environments for enterprises and governments; unstaffed retail stores for retailers; VR multimedia classrooms for educational institutions; digital production lines and flexible manufacturing for manufacturers; and fully-wireless 24/7 business branches for financial service institutions. We also help ISPs and MSPs provide cloud-managed network services for their customers. We believe that the next-generation gigabit-wireless intelligent campus networks — built with Huawei CloudCampus Solution by adopting disruptive IT technologies such as Wi-Fi 6, short-range IoT, AI, automation, and Autonomous Driving Network (ADN) — will be the cornerstone for the digital transformation of enterprises for the next 10 years. ▲

Industry-Leading Wi-Fi 6: **New Engine for Enterprise Digital Transformation**

By Dr. Li Xing, President of Campus Network Domain, Data Communication Product Line, Huawei Technologies Co., Ltd.

Wi-Fi, with a history of more than 20 years, has always been driven by the pursuit for ever higher bandwidth. In fact, there have been major upgrades to Wi-Fi almost every four to five years, with bandwidth increasing each time. The latest standard, Wi-Fi 6, is a game changer for enterprises. By introducing new technologies, such as uplink/downlink (UL/DL) 8x8 Multi-User Multiple-Input Multiple-Output (MU-MIMO), Orthogonal Frequency Division Multiple Access (OFDMA), and 1024-state Quadrature Amplitude Modulation (1024-QAM), Wi-Fi 6 delivers a four-fold increase in throughput and user access capacity while reducing latency by 50 percent compared with Wi-Fi 5. With these vastly improved capabilities, Wi-Fi 6 opens up opportunities for enterprises to replace wired networks with wireless ones. Going wireless frees employees from the constraints of cables, allowing them to work and communicate anywhere and anytime. Meanwhile, all-wireless accelerates the sharing of innovative ideas, improves production and operational efficiency, and strengthens overall competitiveness. However, pursuing a fully wireless campus in the Wi-Fi 6 era requires more than just high bandwidths and large capacities. There is also a need for stable, continuous signal coverage, low-latency service assurance, and lossless roaming to deliver fiber-like speeds and performance that is on par with wired networks.

Huawei AirEngine Wi-Fi 6 Helps Enterprise Digital Transformation

- **16 spatial streams, 10.75 Gbit/s speeds, twice the industry average throughput**

Throughput is the biggest difference between Wi-Fi 6 and previous Wi-Fi generations, but not all Wi-Fi 6 products can deliver ultra-high throughput. The number of spatial streams and the effective operating frequency bandwidth are the key factors that determine throughput. Huawei AirEngine Wi-Fi 6 boasts the industry's largest number of spatial streams, 16 in total, and supports the industry's widest 160 MHz channels on 5 GHz, delivering air-interface throughput of up to 10.75 Gbit/s, twice that of the Wi-Fi 6 standard.

- **Built-in Smart Antennas at dual bands ensure stable network coverage without blind spots.**

Radio frequency and antenna are the key factors that affect the performance of Wi-Fi products. Huawei AirEngine Wi-Fi 6 APs feature 16 Smart Antennas — the most in the industry — and a unique dual-band dual-polarized co-planar antenna design, with Artificial Magnetic Conductor (AMC) antenna materials. Additionally, Smart Antennas are supported on both 2.4 GHz and 5 GHz without increasing the size of the AP. Performance is further enhanced by Huawei's unique four-element electronic switchgear and dynamic coverage direction adjustment algorithms, as well as beamforming technology. Packed with all these features, AirEngine Wi-Fi 6 APs enable signals to move with users, double signal strength at the same location, and increase coverage distance by 20 percent.

- **Unique SmartRadio lossless roaming technology ensures stable roaming with zero packet loss.**

Roaming on a Wi-Fi network is different from that on a cellular mobile network, because roaming is initiated by a terminal (sometimes referred to as a station or STA). Specifically, the terminal usually triggers roaming by detecting

an idle channel and the signal quality based on a carrier sense technology called Clear Channel Assessment (CCA). As a result, Wi-Fi terminals always scan for an idle channel before roaming, which takes up more than 80 percent of the handover time. A long roaming handover time causes an increase in the packet loss rate, which, in turn, adversely impacts services sensitive to in-roaming packet loss, such as voice and production network instruction delivery.

Huawei AirEngine Wi-Fi 6 tailors to customers' actual service requirements and applies the roaming processing algorithms and practices on cellular mobile networks. Specifically, AirEngine Wi-Fi 6 APs identify and notify terminals of available idle channels before roaming. In this way, terminals do not need to scan all channels during roaming, greatly reducing the roaming handover time. When Huawei devices are used, the roaming handover time is reduced to as low as 10 ms, ensuring no interruptions for mobile voice calls. In addition, Huawei has set up a "connectivity" alliance with partners, where multiple types of mobile terminals deliver optimal mobile experiences with low roaming handover latency and uninterrupted services.

When it comes to Automated Guided Vehicle (AGV) terminals in industrial production, Huawei AirEngine Wi-Fi 6 uses a device-pipe synergy mechanism to proactively steer AGV roaming and back up service data during roaming handovers. The data is then sent back to the AGVs after successful roaming handovers, eliminating packet loss. Such design ensures the stable running of AGVs without interruptions, improving efficiency by more than 40 percent.

- **Unique SmartRadio Dynamic Turbo technology delivers 10 ms ultra-low latency for application experience assurance, improving stability for applications.**

Wi-Fi 6 uses OFDMA technology to concurrently transmit different services of different users over more subcarriers. This approach greatly reduces the transmission latency for a vastly superior experience. However, there are no technical specifications for the classification of different services, and subcarrier allocation is random. Consequently, some key users and latency-sensitive services still encounter delayed data transmission issues caused by untimely scheduling or insufficient subcarrier allocation, affecting the service experience. For example, high latency may cause users to feel dizzy after prolonged usage of real-time interactive services such as wireless Virtual Reality (VR) and Augmented Reality (AR).

To tackle this issue, Huawei AirEngine Wi-Fi 6 is looking beyond OFDMA technology. For example, a hardware-based multi-queue mechanism efficiently groups users, while air-interface slicing technology slices wireless air interface resources based on service requirements. With these innovations, Hierarchical QoS (HQoS) assurance for data forwarding and scheduling as well as air-interface resource scheduling is achieved, slashing the latency for key services to as low as 10 ms, 50 percent lower than that of the Wi-Fi 6 standard.

Wi-Fi 6: Wait and See or Act Today?

- **AirEngine Wi-Fi 6 transforms enterprise offices, improves collaboration, and accelerates innovations.**

AirEngine Wi-Fi 6 uses industry-leading Smart Antenna technology to enable wireless signals to move with users. At the edge of a Wi-Fi network, AirEngine Wi-Fi 6 automatically enhances signals and suppresses interference based on user locations, improving user experience.

In dense environments, AirEngine Wi-Fi 6 flexibly adjusts the coverage direction based on the number of access terminals to ensure consistent signal quality for users. Unique to Huawei CSON continuous networking technology, enabling applications on wireless networks to be as stable as those on wired networks, and delivering speeds comparable to optical fiber networks. In this way, enterprises are one step closer to going all-wireless for their campus networks.

AirEngine Wi-Fi 6 has the power to transform the way enterprises work. Traditional office cubicles that rely on phones and emails for communication may be disrupted with new ways to communicate and collaborate, such as real-time mobile HD videos and wireless multi-screen interactions in meetings, improving work efficiency and driving innovation.

- **AirEngine Wi-Fi 6 transforms the teaching experience and improves students' learning interests.**

According to the joint research from Stanford University and a Danish university, students' learning outcomes are improved by 76 percent after wireless VR/AR is introduced to the curriculum. And with the ability to create virtual anatomy labs, wireless VR/AR is revolutionizing the medical teaching field. For instance, training for medical professionals is often hindered by the limited number of donated bodies, which can't be reused. Additionally, the traditional methods to teach anatomy based on 2D contents, where students have to rely on their imagination for graphs and organ structures, have become dated. None of these problems exist in virtual anatomy labs.

AirEngine Wi-Fi 6 delivers a wireless throughput of over 10 Gbit/s, fully meeting the requirements for various bandwidth-hungry services. By introducing one-of-a-kind Software-Defined Radio (SDR) technology, AirEngine Wi-Fi 6 allows 50 percent more concurrent users without compromising bandwidth per terminal. On top of that, unique SmartRadio Dynamic Turbo technology reduces the latency for wireless AR/VR services of multiple users to as low as 10 ms — only half the industry average — so users don't feel dizzy after prolonged use. By making VR/AR a reality in the classrooms, students can have a more immersive learning experience, enriching teacher-student interactions, and inspiring greater engagement in learning.

- **AirEngine Wi-Fi 6 transforms production and manufacturing for higher operational efficiency.**

Continuous and stable running of the production line is paramount in production and manufacturing scenarios. AirEngine Wi-Fi 6 uses industry-unique SmartRadio lossless roaming technology to ensure production services are uninterrupted. For example, Automated Guided Vehicles (AGVs) operate consistently 24/7, even in large-scale high-speed scenarios such as material feeding at logistics and production lines.

With a throughput of over 10 Gbit/s, AirEngine Wi-Fi 6 enables employees to cost-effectively participate in simulation training sessions online in real time through VR. Elsewhere, technicians can implement repairs at any time through AR and call remote experts to provide guidance in real time when needed, making repairs faster, more accurate, and more efficient. With the help of AirEngine Wi-Fi 6, production components can be detected by using ultra-HD cameras in real time, improving the efficiency and accuracy by dozens of times.

With all these capabilities, industrial production is becoming less labor-intensive as automation increases. Meanwhile, the production process is transforming from one that is characterized by rigidity to one with flexibility and resilience. These changes greatly reduce production costs, while doubling efficiency, and enhancing competitiveness.

Act Today for More Productive Tomorrow

Wi-Fi 6 is bringing substantial changes to enterprises' ongoing digital transformation. Compared to previous Wi-Fi generations, Wi-Fi 6 delivers unprecedented levels of throughput and capacity needed for an optimal user experience and superb service stability.

Huawei is leading the Wi-Fi 6 standard as well as the Wi-Fi 6 market. Armed with Huawei's exclusive cutting-edge technologies, Huawei Wi-Fi 6 products are well-received by enterprise customers and take the largest market share in the industry.

High-quality fully wireless campus networks built using Wi-Fi 6 can truly help enterprises accelerate digital transformation in their offices, production lines, and services, with improved efficiency and experience. In the future, we will continue to carry out joint innovations with customers and capitalize on Wi-Fi 6 upgrade opportunities to build fully connected, intent-driven campus networks with AirEngine Wi-Fi 6. With this network, enterprises can reduce operating costs, improve competitiveness, and enter the fully wireless campus era. ▲

Building High-Quality Campus **Network with CloudEngine Switches**

By ***Wei Yupeng, Data Communication Product Line, Huawei Technologies Co., Ltd.***

In recent years, emerging technologies represented by Wi-Fi 6, the Internet of Things (IoT), cloud computing, and Artificial Intelligence (AI) are maturing, accelerating the transition of campus services toward all-wireless, cloud, and intelligence. As a growing number of key services are carried on Wi-Fi networks, the focus has shifted to user experience and future network evolution, instead of just bandwidth and security of campus networks.

Wi-Fi 6, a game-changing technology, provides unprecedented levels of bandwidth and latency to ensure optimal wireless experience, accelerating digital transformation of enterprises. As Wi-Fi 6 becomes the preferred choice for enterprises, what will happen to wired switching networks?

In the Wi-Fi 6 Era, Campus Access Network Speeds Surge

The theoretical maximum rate of a Wi-Fi 6 Access Point (AP) is higher than 10 Gbit/s — with up to 1.15 Gbit/s on 2.4 GHz and 9.6 Gbit/s on 5 GHz — while actual test results show that the maximum throughput is higher than 7 Gbit/s. Undoubtedly, Wi-Fi 6 APs have achieved a record high bandwidth over the air interface, but if no corresponding wired network is available, the performance of Wi-Fi 6 APs is wasted. To prevent the uplink ports on Wi-Fi 6 APs from becoming network bandwidth bottlenecks, device vendors have upgraded uplink ports from gigabit Ethernet to multi-gigabit Ethernet (multi-GE) that supports 2.5 Gbit/s, 5 Gbit/s, or even 10 Gbit/s.

According to the current Wi-Fi 6 AP specifications, most Wi-Fi 6 APs deliver 5 Gbit/s on uplink ports, with high-end models offering as high as 10 Gbit/s uplink speeds. Therefore, to support 5 Gbit/s and 10 Gbit/s simultaneously, the campus access switches connected to Wi-Fi 6 APs must be multi-GE capable and are recommended to provide 40 Gbit/s uplink speeds. In addition, access switches must have 802.3bt PoE capabilities to supply power to IoT devices such as wireless APs and cameras.

In fact, deploying Wi-Fi 6 APs doesn't necessarily require a large-scale upgrade of access switches. If the current network bandwidth requirements aren't demanding and access switches don't result in network bottlenecks, enterprises can still use legacy access switches without the need for upgrades. Instead, they can decide on an upgrade schedule that suits their actual requirements and future service development.

In the "Experience First" Era, Campus Networks Should Ensure Non-Blocking and High-Speed Forwarding at the Core Layer

Traditional campus switches use packet switching technology, where packets are switched according to the following process. First, upon receiving service flows, an inbound line card randomly selects a switching fabric to which it then sends data packets based on a hashing algorithm. Then, the switching fabric forwards the data packets to an outbound line card, which then delivers these packets to the target end user.

This conventional approach is workable in a network with a light load. However, with the growth of user concurrency and single-user bandwidth, two significant problems emerge. First, the switching fabric is randomly selected based on the hashing algorithm, which can easily cause unbalanced loads among switch fabrics and therefore affect the overall performance. Second, when multiple inbound line cards select

the same switching fabric, this switching fabric becomes overloaded with concurrent traffic, resulting in the loss of data packets. As illustrated in the following figure, the switching fabric is congested when users A and B send service flows simultaneously to user C.

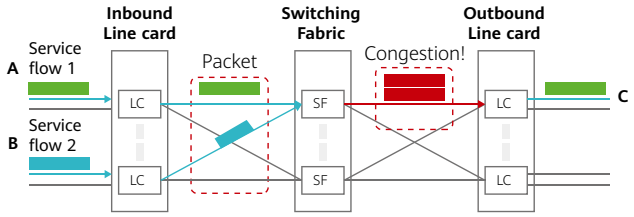


Figure 1: Data forwarding process

Featuring an innovative Next-Gen Switch Fabric (NGSF) switching architecture, Huawei's next-generation flagship core switch, CloudEngine S12700E is unlike any other. This switch is the first of its kind to introduce cell switching and dynamic load balancing algorithms, achieving non-blocking, lossless ultra-fast traffic forwarding at the campus core. In addition, CloudEngine S12700E, resolves the congestion and packet loss problems caused by packet switching and static hashing algorithms when traditional core switches are heavily loaded.

Huawei NGSF architecture innovatively processes service flows as follows. First, upon receiving the service flows sent by users A and B, an inbound line card slices data packets into cells, selects a switching fabric dynamically based on loads, and sends the cells to the optimal switching fabric. Then, the switching fabric forwards the cells to an outbound line card, which then assembles cells into data packets and sends

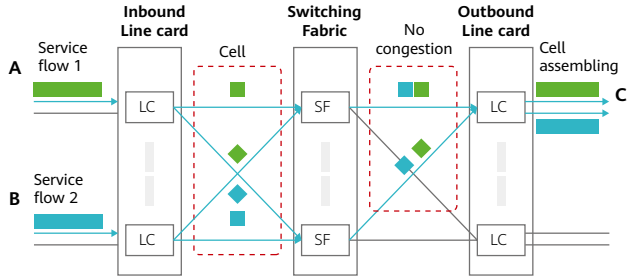


Figure 2: Data forwarding process

them to the target end user. This innovative cell switching mechanism achieves dynamic load balancing among switching fabrics, and maximizes the switching performance. In addition, multipath transmission of cells prevents network congestion and service loss caused by overload of a single switching fabric, providing better Quality of Service (QoS) assurance.

Huawei CloudEngine S12700E has been tested and verified by Tolly, a leading provider of third-party testing and validation services. The test report shows that Huawei CloudEngine S12700E-12 supports up to 288 100GE ports, providing 57.6 Tbit/s switching capacity in total and offering 4.8 Tbit/s bandwidth per card, six times that of the industry average performance.

A Broad Range of Features and Full Programmability Facilitate Smooth Evolution

CloudEngine S series switches are equipped with Huawei's next-generation programmable chips. These latest chips outperform previous generations by significantly improving data exchange performance, data analysis and processing, and application identification assurance. Built on Huawei's Versatile Routing Platform (VRP), CloudEngine S series switches provide numerous advanced features, including wired and wireless convergence (integrated WLAN AC), free mobility, horizontal virtualization, vertical virtualization (Super Virtual Fabric, or SVF), network virtualization (VXLAN), deployment automation (NETCONF/YANG), intelligent O&M (Telemetry), and advanced security protection (NetStream and Encrypted Communications Analytics, or ECA). With a fully programmable architecture, CloudEngine S series switches accelerate the provisioning of new services and features through programming without the need for hardware upgrades, fully protecting customer investments.

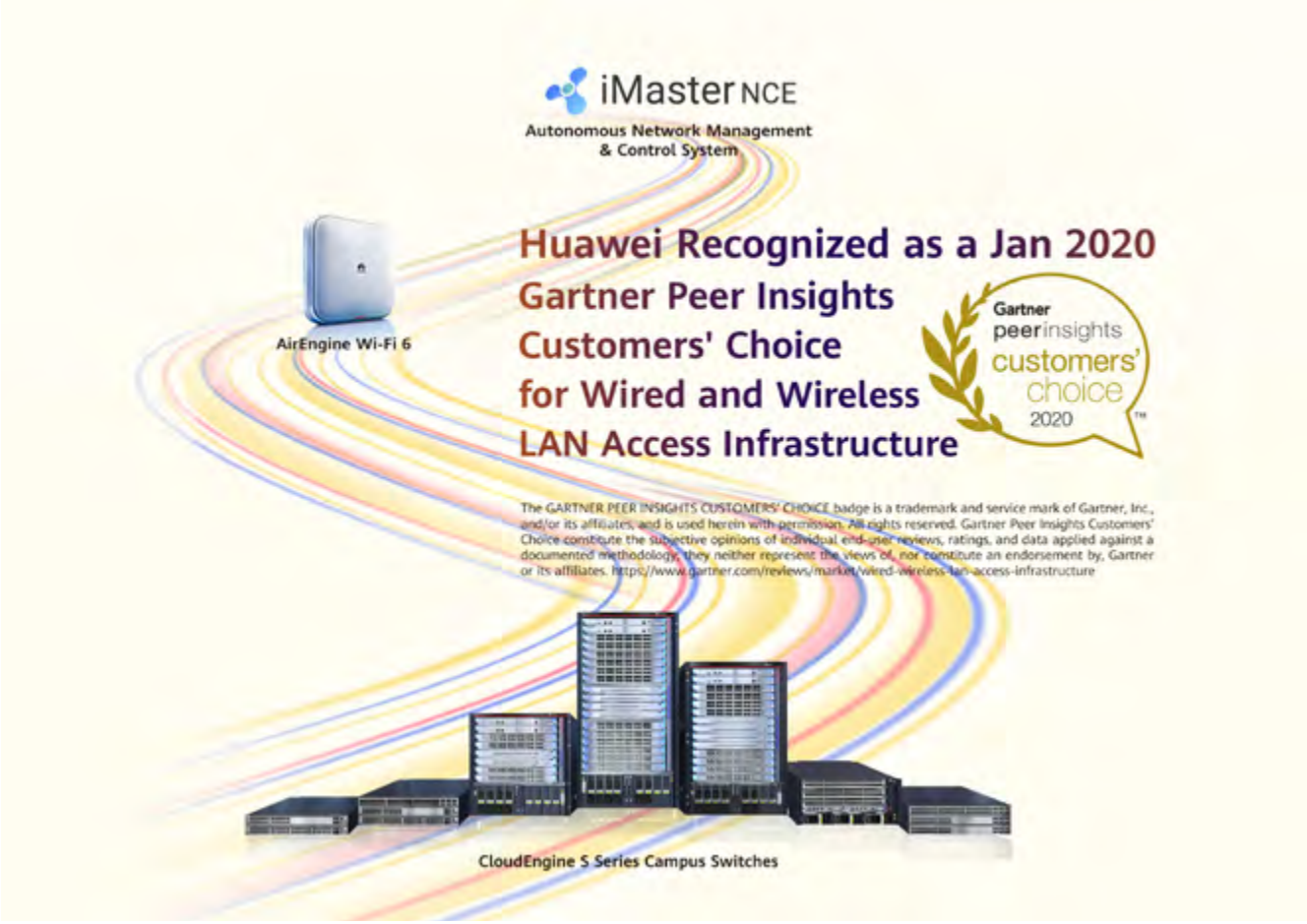
Huawei is the first vendor in the industry to propose and launch wired and wireless convergence features and solutions that, to date, have been widely used and proven in medium- and large-sized networks in world-renowned universities, governments, enterprises, stadiums, as well as primary and secondary schools. Huawei CloudEngine S12700E integrates the WLAN AC function based on programmable chips to manage up to 10,000 WLAN APs and allow concurrent access of 50,000 wireless users. In contrast with the traditional separate management of wired and wireless networks, CloudEngine S12700E achieves true wired and

wireless convergence, including centralized service forwarding, unified device management, and converged policy control. This convergence saves a considerable amount of network construction and operating costs compared with a standalone WLAN AC or WLAN AC cards (used with modular switches). Customers only need to deploy one switch to manage devices, users, and policies in a unified manner.

Award-Winning Products and Solutions Accelerate Digital Transformation of Enterprises

Huawei CloudEngine S series campus switches are purpose-built for the Wi-Fi 6 era by providing wired network assurance for high-bandwidth application experience. In particular, the flagship campus core switch, CloudEngine S12700E, delivers six times the industry average performance, meeting the network evolution needs of large enterprises and campuses for the next ten years.

Huawei's intent-driven campus network solution — CloudCampus — consists of Huawei CloudEngine S series switches, AirEngine series Wi-Fi 6 products, and iMaster NCE (a brand-new one-stop management and control system). This future-proof solution was named a Gartner Peer Insights Customers' Choice for Wired and Wireless LAN Access Infrastructure in 2020, signifying its recognition within the industry. Huawei's CloudCampus Solution will continue to build a superfast, intelligent, and open campus network centered on service experience, helping enterprises achieve their digital transformation goals. ▲



St. Jakob-Park Stadium: **Embracing the Smart Era with Wi-Fi 6**

By ***Lu Bingtuan, Data Communication Product Line, Huawei Technologies Co., Ltd.***

Digital transformation is sweeping across nearly all industries and changing the way we live. In particular, digital transformation is innovating the sport industry. Riding the wave of digital transformation, the sport pioneer St. Jacobs Park is embracing a revolution of smart sports.

The St. Jakob-Park — located in Basel, along the Rhine River — is the largest soccer venue in Switzerland. With excellent infrastructure, it has been awarded four stars by the Union of European Football Associations (UEFA), and has hosted international soccer events such as European Cup Winners' Cup finals, Europa League games, and European Football Championship games, gaining a good reputation in the soccer industry.

With over 40,000 seats and numerous stores, this stadium is at the forefront of digital transformation, and its network supports access of a maximum of 60,000 terminals.

The Wi-Fi network in the St. Jakob-Park brings many benefits, including the following:

- Ubiquitous Wi-Fi connects the stadium and spectators. Before a match begins, spectators can easily view match information through the Wi-Fi network. In the stadium, Wi-Fi-based indoor navigation helps spectators to easily find parking spaces and their seats. During the halftime break, they can buy food and drinks from their seat using mobile apps.
- The mobile Wi-Fi network connects spectators inside and outside the stadium. During the match, spectators can replay highlights of the match at any time and share

their favorite moments with friends on social media. They can also view real-time information and match statistics as well as share their views through posting comments on mobile apps.

- Soccer clubs can innovate the business model with Wi-Fi. The Wi-Fi network provides more Value-Added Services (VASs) for the stadium. Football clubs can push value-added information, such as sports events and advertisements, on the Portal page of the stadium network and apps, to create more revenue.
- Wi-Fi improves the efficiency of the stadium's office services. Stadium staff benefit from mobile offices through Wi-Fi, security staff use Wi-Fi for voice communication, and sports organization staff coordinate through Wi-Fi.

High-speed mobile Wi-Fi is the key to digital transformation of the stadium. In such high-density scenarios, ensuring a high-quality Internet access experience of tens of thousands of terminals also brings unprecedented challenges to Wi-Fi.

Wi-Fi deployment in stadiums is different from that in offices in that it requires high density, large capacity, and serviceability, and poses many challenges. The first challenge comes to the high user density. The St. Jakob-Park accommodates over 40,000 spectators and more than 60,000 access terminals. The user density is far higher than that in common offices. Second, the bandwidth requirement increases by tens of times to meet the demands for web browsing, instant messaging, High Definition (HD) video calls, and blu-ray video playback. Third, the user and service types vary greatly. It is critical to effectively identify users and services, implement differentiated control, and ensure the experience of key services and VIP users.

Based on the characteristics of St. Jakob-Park, Huawei provides a high-density Wi-Fi 6 solution that meets the stadium's requirements, offering full coverage, high-density multi-user access, high bandwidth, and simplified O&M, to improve Wi-Fi coverage in the stadium. Considering the Wi-Fi characteristics and difficulties of deployment in the stadium, Huawei designed the Wi-Fi network to provide high-density access, ensure key service experience of VIP users by using differentiated policies, and simplify network management and O&M.

High-Density Access Provided by Huawei's Powerful Wi-Fi 6

To support high-density access, the Wi-Fi network is designed in an end-to-end manner, ranging from product capability, network planning, and deployment to configuration optimization. Key requirements for the network design are that the products must support high-density access and large bandwidth, and the high-density wireless network must be planned based on the stadium's structure and access scenarios.

In high-density scenarios, such as stadiums, signal coverage issues become a thing of the past. The key to Wi-Fi deployment is to minimize interference while maximizing network capacity through proper network planning. Because St. Jakob-Park has a complex structure, AP deployment and interference reduction are difficult. Huawei's unique 3D network planning tool quickly provides a network planning scheme based on the stadium's structure, and performs 3D

coverage simulation and interference rendering to offer an optimal Wi-Fi deployment scheme.

Huawei AP706DN, the industry's first Wi-Fi 6 AP, provides high-density coverage for the stadium. Huawei's leading Wi-Fi technologies not only ensure high-quality access in terms of signal coverage, access density, and stability, but also meets the quality requirements of bandwidth-hungry services such as HD videos, offering an excellent wireless experience for users.

Cutting-Edge Wi-Fi 6 Technologies, Ensuring User Experience

St. Jakob-Park has both common stands and VIP rooms. The Wi-Fi users include ordinary spectators, VIP users, and staff, so the network needs to provide high-performing Internet access for spectators as well as key services such as match coordination and live streaming. When network congestion occurs, key services of VIP users must be ensured. Huawei's exclusive VIP air interface assurance technology reserves some dedicated spectrum resources for VIP users, ensuring that VIP users can obtain desired spectrum resources as needed and enjoy the VIP user experience. In addition, this technology is associated with Huawei's exclusive 5G-powered Dynamic Turbo technology (air interface slicing technology) to determine the spectrum allocation preference and quantity for different users based on service priorities. This ensures the experience of VIP users and key services, such as sports event coordination and live streaming.

Cloud Management, Implementing Device Plug-and-Play and Efficient O&M

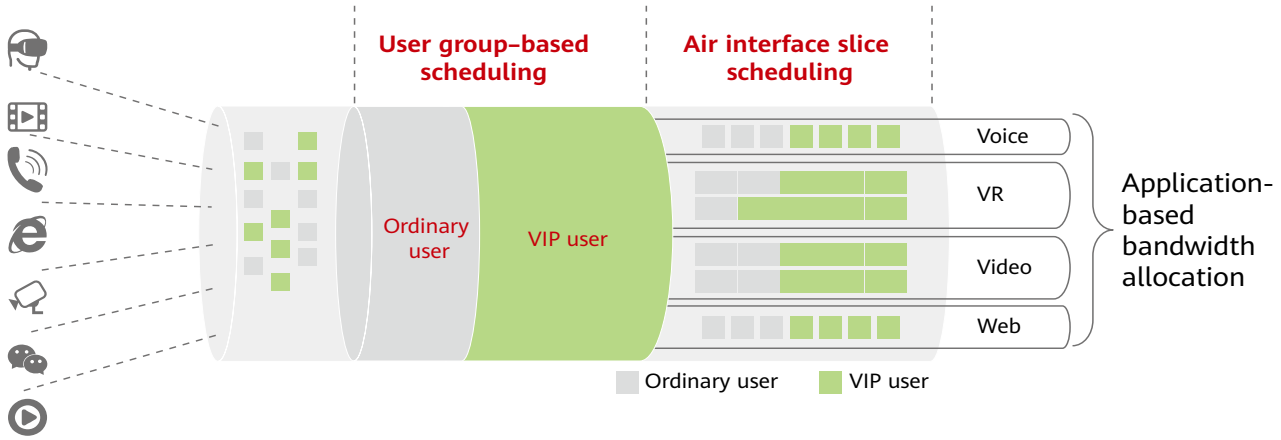
As an increasing number of terminals access the network and service scenarios become increasingly complex, low network deployment and O&M efficiency become challenges for high-density stadium networks. Simplified network deployment and management, network autonomy and self-healing, improved user experience are also the requirements raised by St. Jakob-Park for Huawei.

Huawei CloudCampus solution redefines network management and O&M in stadiums. This feature-rich solution provides end-to-end cloud management services throughout the entire network life cycle, including cloud-based network planning, deployment, O&M, and optimization, to deliver automated, self-service, and simplified network management, greatly reducing network O&M costs.

With exclusive Wi-Fi 6 technologies, Huawei builds a fast, stable, and efficient wireless network for St. Jakob-Park. This wireless network brings benefits to the stadium, spectators, and football clubs. Spectators can enjoy more convenient services and a more exciting experience during the match. Football clubs can use the Wi-Fi network in branding and precision marketing. The stadium not only improves the management and operational efficiency, but also makes football fans want to return for the exciting experience.

This is just the beginning of the smart stadium era.

With the continuous development of 5G, Wi-Fi 6, and AI technologies, science and technology will bring the next level of intelligence into the sport industry. ▲



Dynamic Turbo Technology, Powered by Huawei 5G

Shenzhen World: Exhibition Center Displaying Intelligence

By Zhang Shengbing and Monica Zhang, Data Communication Product Line, Huawei Technologies Co., Ltd.

On September 28, 2019, the Phase I inauguration ceremony of the Shenzhen World Exhibition & Convention Center (Shenzhen World) was held in Shenzhen's West Coast Great Airport Area. Shenzhen World's completion demonstrates Shenzhen's rapid development and highlights Huawei's capabilities in building intelligent ICT systems.

Shenzhen World — Shenzhen's New Showpiece

Shenzhen World is located at the top of the Guangdong-Hong Kong-Macao Greater Bay Area, the center of the Guangzhou-Shenzhen-Hong Kong Economic Zone and Guangdong Free Trade Zone, and the convergence point of three megalopolis As a landmark project invested by the Shenzhen government, the project will play an important role in the future development of Shenzhen. When completed, Shenzhen World will become the world's largest exhibition center with an indoor area of 500,000 m2 and will be Shenzhen's new showpiece.

How Do We Build a World Leading Digital Exhibition Center?

"Shenzhen World is not just an exhibition center with another name, another design, and another contour. It is revolutionary in terms of functionality, positioning, and technology application. Therefore, our objective is to build an exhibition center that leads the world not only in terms of area and traffic, but also in the level of digitalization and industrial innovation," said Ren Chunlei, the IT System Head of Shenzhen World. World-class first-generation smart exhibition halls entail industry-leading ICT networks,

however, there are immense challenges in planning and designing the ICT network architecture. This is because of the diversified and complex requirements of the exhibition halls and the tidal traffic.

- **How do we provide self-service minute-level network provisioning services for exhibitors?**

Exhibitors have different requirements for service networks, and time is short for booth construction. If the networks are deployed manually, the services may not be provisioned on time. Therefore, self-service network provisioning services should be provided so that exhibitors can provision network services just by purchasing bandwidth services based on the scenarios.

- **How do we quickly deploy and manage the network of the exhibition center?**

As the world's largest exhibition center, Shenzhen World will have over 40,000 information access points. This allows for the provisioning of diversified services such as IP phone, video conferences, Wi-Fi access, video surveillance, and Virtual Reality (VR). Thousands of network devices are required to provide network access for these services, and deploying and managing this large number of devices is a significant challenge.

- **How do we provide high-quality Wi-Fi services for 120,000 concurrent users in the exhibition halls?**

Once opened, Shenzhen World is expected to receive a maximum of 400,000 people a day. The network should be designed to provide Wi-Fi access for 120,000 concurrent users (30 percent of maximum traffic), which poses significant challenges to WLAN construction.

- **How do we achieve intelligent operation of the exhibition halls?**

Diversified and complex service requirements bring the exhibition halls numerous challenges. These include difficulties in unusual visitors, inefficient handling of security protection issues, ill-informed exhibition analysis and evaluation, lack of visibility into device status and refine management measures, high operation and labor costs, and unstable service quality.

Intent-Driven Network — Digitally Linking 400,000 People

Bringing optimal digital experiences to every spectator and exhibitor pose extremely high requirements for the digital construction of Shenzhen World. Based on its substantial level of experience in digital transformation and ICT, Huawei uses technologies including big data, AI, and cloud computing to build an Intent-Driven Network (IDN) solution. This features intelligent on-demand network, plug-and-play automatic deployment, and industry's unique intelligent high-density Wi-Fi. Overall, this solution meets the requirements for the digital construction of Shenzhen World.

- **Intelligent on-demand campus network**

Exhibitors need to purchase different network bandwidth services from operators for different scenarios. The operators use Huawei's free mobility network technology to implement intelligent network selection for all exhibitors and spectators based on their identity information. This is done to achieve fast network provisioning and diversified value-added bandwidth operations. Huawei's free mobility solution also provides network access control and good access experience for users, and uses innovative software and hardware designs to completely decouple network service policies from network locations. Exhibitors log in to the official platforms of Shenzhen World, such as the portal website and WeChat official account, register and apply for booths and network bandwidth services, and pay for the services. Then, the operation system of the exhibition center and the iMaster NCE controller of the campus network are used to provision network and diversified VIP bandwidth services for exhibitors in real time. Huawei IDN solution digitizes user experiences and applications on campus networks to bridge the gap between the business intent of the exhibition center and the physical network of the campus.

- **Plug-and-play automatic deployment**

It is impossible to manually configure and deploy thousands of network devices one by one in the exhibition center. In the Huawei Intent-Driven CloudCampus Solution, IT administrators plan network resources and configurations on the iMaster NCE GUI. After network devices are installed, powered on, and connected in the exhibition halls, they are automatically registered on the iMaster NCE platform. Network configurations are automatically obtained and delivered without local configuration. The plug-and-play automatic deployment solution shortens the deployment time of network devices from three months to less than one week. This greatly improves the efficiency and in addition, this solution considerably reduces the

subsequent maintenance workload for IT administrators. It also betters the O&M efficiency of the entire network, so fewer IT network O&M workers are needed in the exhibition center.

- **Industry's Unique Intelligent High-Density Wi-Fi Solution**

More than 8000 wireless APs are deployed based on the structure of each functional area in the exhibition center. This is done so that 120,000 people can enjoy high-quality Wi-Fi access at the same time. The most appropriate Wi-Fi coverage solutions are adopted for different areas. If the omnidirectional coverage is used, especially in standard exhibition halls with massive traffic, it is difficult to control the signal coverage area and the interference is severe. The traditional solution (APs plus external antennas) is complex and costly. In contrast, Huawei's industry-leading wireless AP coverage solution with built-in 30-degree directional antennas achieves targeted coverage. This improves the overall user access concurrent rate by 50 percent in the standard exhibition halls. Both exhibitors and spectators can access the Wi-Fi network and enjoy optimal digital experiences, such as 4K video, VR, AR navigation, live broadcasts, and conference video uploading, anytime and anywhere the moment they enter the halls.

Intelligent Operations: Building the Next Generation Eco-Friendly Exhibition Center

Huawei's HiCampus Solution integrates the converged communications system with the Intelligent Operation Center (IOC) to build an all-in-one application platform, based on the Huawei Horizon Digital Platform. This streamlines the entire exhibition process, from planning to removing exhibits, with the unified and platform-based operation management greatly improving the end-to-end operations efficiency of exhibition activities. In addition, Huawei has provided an exhibition command room that generates insights, assists resource utilization, and predicts problems. The command room enables intelligent operation monitoring, as well as intelligent command and dispatch. This ensures optimal routine operations and decision making for the exhibition halls. Indeed, the data plays a key role in eco-friendly operations, efficient decision-making, and sustainable development for the exhibition halls. "The IOC can not only manage data, but also dynamically adjusts the water, electricity, and gas supply. It can also configure equipment, monitor network connectivity, control the indoor environment, manage waste disposal, all based on crowd flow in the exhibition halls," Ren Chunlei said. "We are striving to build an intelligent exhibition center with eco-friendly operations."

Ren Chunlei said, "Shenzhen World stunned the world with its massive size and extremely short project time. Huawei is not only an end-to-end digital system provider, but also a reliable, trustworthy friend. Huawei has earned both our admiration and appreciation." ▲

Leading Data Center Networks into **the Intelligence Era**

Network AI has become a key driving force for enterprises to reshape business models, improve customer experience, and build a more prosperous future. Enterprise digitalization has entered a new era of intelligent upgrade. For example, just five years ago, taking out a loan required at least one week, involving: preparation of various materials, queuing to submit applications at the counter, and waiting for manual risk assessment from the bank to notify the drawdown. Now, only a cellphone is needed to perform a facial recognition check and an AI-based review. It may take less than ten minutes for the money to be received. This is all made possible by the change in data center's roles. Data centers have become the smart brain and a strategic high ground for enterprises, enabling them to enter the intelligence era.

Efficiency is the core and computing power is the foundation in the intelligence era. If the computing power of a single server depends on the processor, then the computing power of the entire data center depends on the data center network. What type of data center networks can improve the running efficiency of data centers, unleash the full computing power potential, and accelerate the intelligent transformation of enterprises?

- How Will Data Center Networks Evolve in the Intelligence Era?
- CloudFabric: Leading DCNs into the Intelligence Era
- CMB: Promoting Network Transformation, Creating the New Future of Financial AI
- Unveiling Technologies of Atlas 900 — The World's Fastest AI Cluster

How Will Data Center Networks Evolve in the Intelligence Era?

By Pan Haotao, Chief System Architect of the Data Center Network Domain, Data Communication Product Line, Huawei Technologies Co., Ltd.

As the Chinese saying goes, "a flower cannot grow to be beautiful without its leaves." In a data center, computing is the "flower" and the data center network (DCN) is undoubtedly the "leaf". According to Amazon, 57 percent of its data center investment is in computing, yet only 8 percent is in DCN. Today's data centers are evolving from the cloud era to the intelligence era where computing power is the foundation. Against this backdrop, optimizing DCN performance to improve computing efficiency can bring huge savings on computing investment, and therefore has become the main driving force for DCN evolution.

Computing is the main driver for DCN evolution. As such, any changes to computing directly drive the progress of DCNs. In recent years, the data center computing field has undergone three major changes:

- **Change 1: High-speed computing interfaces**

According to Amdahl's lesser known law, each 1 MHz CPU can generate a maximum of 1 Mbit/s I/O in parallel computing. So, to unleash the full computing performance of a server with 32-core 2.5 GHz CPU, we would need to install a 100 Gb/s Network Interface Card (NIC). Nowadays, servers connecting upstream to 100GE access switches and then to 400GE core switches is an increasingly common network architecture.

- **Change 2: Parallel computing**

Parallelization is a successful practice for expanding application performance. As the number of users and the scale of data increase, the degree of parallelization becomes higher than ever. According to Facebook, when a user likes someone's post, an HTTP request of 1 KB is sent to the data center. In the data center, this request is amplified to 930 KB in parallel operations, including 88 cache queries (648 KB), 35 database queries (25.6 KB), and 392 Remote Procedure Calls (RPCs) (257 KB). Parallel computing leads to thousands of times larger DCN internal traffic (east-west traffic), as well as aggravating network congestion, increasing communications time, and reducing computing efficiency. To address this, intelligent and lossless networks are emerging.

- **Change 3: Virtualization of compute resources**

In 1998, pioneers including Diane Greene, the founder of VMware, created server virtualization technology that virtualizes a physical server into multiple Virtual Machines (VMs). This helped to improve the average usage of compute resources from 10 percent to 30 percent. In recent years, emerging container technologies (such as Docker, Kata, and Unikernel) have further improved the usage of compute resources by employing more lightweight virtualization technologies. The dynamics brought by computing virtualization completely change the way we manage

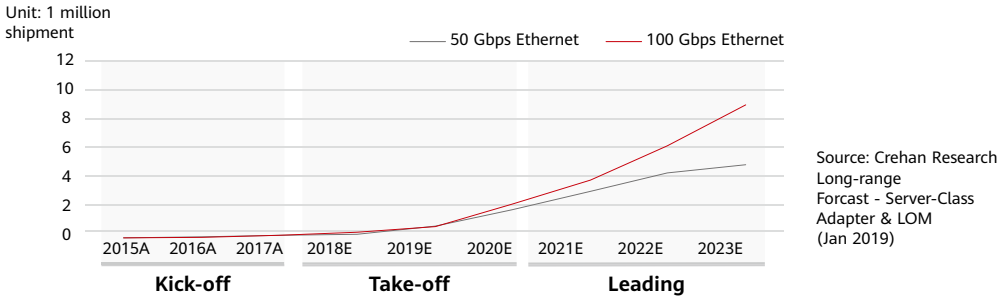


Figure 1: Shipment Forecast of 50GE-NIC-server and 100GE-NIC-server

networks, paving the way towards autonomous driving networks.

These three distinct changes in the computing field are leading DCN development. In particular, the increasingly widespread use of Artificial Intelligence (AI) technologies has the potential to shake things up dramatically. AI computing brings about tens of millions of iterations, a high level of parallelization, and massive parameter transmission, which is increasingly straining the network. Meanwhile, the use of AI for achieving network self-evolution and meeting computing virtualization requirements is opening a new road for DCN development as well as a new round of transformation.

400GE DCN: A Must for Embracing the Trend of 100GE-NIC-Servers

The pervasive use of multi-core processors and AI processors significantly increases demands on I/O bandwidth. Such demands can be met in part thanks to advances in bus technology. One example is PCIe 4.0 (16 GT/s), which will be rolled out commercially in 2020, by which point the I/O bandwidth will reach 50 Gb/s to 100 Gb/s and even to 200 Gb/s. PCIe 5.0 (32 GT/s) chips will be released in 2021, reaching I/O bandwidths of 100 Gb/s to 400 Gb/s.

The NIC rate is another key to improving the I/O capability. NICs have evolved from 10GE to 25GE, and then finally to 100GE, with 100GE expected to rapidly become the mainstream in 2020. According to Crehan Research Inc., a leading market research and consulting firm, the shipment of 100GE NICs will exceed that of 50GE NICs in 2020, making them more widespread in the industry.

Considering factors such as the cost, power consumption, and ecosystem, DCNs may skip 200GE and directly evolve to 400GE. This can be best explained by referring to historical practices, according to which the ratio of server NICs to network rates is 1:4. That is, 25GE NICs correspond to 100GE networks, while 100GE NICs correspond to 400GE networks. In terms of the optical module architecture, both 200GE and 400GE use the 4-lane architecture and 4-level pulse amplitude modulation (PAM4) mode, so their costs and power consumption are similar. As a result, the cost per bit of 400GE is half that of 200GE. What's more, from the perspective of the optical module ecosystem, 400GE modules are more diversified, providing greater choices for customers. To be specific, there are currently five types of 400GE modules (covering 100 m, 500 m, and 2 km), compared to just two types of 200GE modules (100 m SR4 and 2 km FR4).

Parallel Computing Capabilities Drive DCNs Towards Intelligent and Lossless Networks

As the computing scale grows, communications takes up an increasingly large proportion of total task processing time. This, in turn, offsets the benefits brought by the scale increase and causes negative impacts

Huawei's AI-powered CloudFabric the industry's first intelligent lossless DCN Solution, based on the built-in AI chip and iLossless scheduling algorithm redefines the traffic control technology and unleashes 100% of the computing power potential. ››

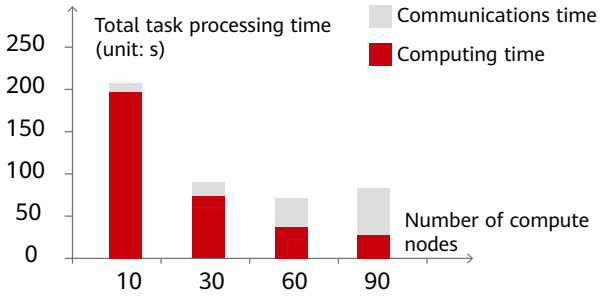


Figure 2: The relationship between parallel computing performance and compute node quantity

on cluster performance. For example, when the number of compute nodes in Netflix's distributed movie rating and recommendation system reaches 90, the computing efficiency decreases, as shown in the following figure.

A lossless network would be the best way to reduce the proportion of time occupied by communications, reduce the application waiting time, and expand the network scale.

- **A lossless network is paramount to maximizing the transmission efficiency of 25GE/100GE high-speed interfaces.**

It is generally accepted that communications between applications need to be lossless. Achieving this normally requires either of the following two methods:

- Lossless protocol + lossy network: This combination is generally used in the 10GE NIC era. In this method, packets may be lost when congestion occurs on the network, but can be remedied at the protocol layer. For example, the TCP retransmission mechanism allows packets to be retransmitted after packet loss is detected on the network.
- Lossy protocol + lossless network: In the 25GE/100GE NIC era, the protocol stack processing is offloaded onto NIC hardware to resolve the issue of excessively high CPU consumption (it is estimated that the full throughput of 25 Gb/s to 100 Gb/s bandwidth consumes about 30 percent CPU resources of a server) and achieve high performance. To do so, the protocol must be simplified and therefore a lossless network is required. The industry uses Remote Direct Memory Access (RDMA) to replace the complex TCP protocol, facilitating the offloading of protocol stack processing onto NIC hardware. However, the downside of RDMA is that it is sensitive to packet loss. According to a test in Microsoft labs, 2 percent packet loss on the network causes the effective network throughput to decrease to 0. Therefore, "lossless" becomes a necessary feature of a DCN.

Intelligent congestion control + Intelligent traffic scheduling = A lossless network

- Lossless networks redefine the congestion control mechanism. Congestion control is the mechanism by which the rate of incoming traffic is controlled through the collaboration between the network and endpoints. Its aim is to ensure that the incoming traffic matches the network bandwidth and does not overflow. For optimal network usage, it is vital that congestion control is performed at exactly the right time. If a congestion notification is sent too early, the computing side slows down too much, resulting in low network utilization. On the other hand, delayed congestion notification causes network overload and then packet loss. In this case, an AI algorithm is used to predict the traffic model, achieving timely notification and controlling the incoming traffic. Furthermore, the network allocates a proper rate to each flow based on accurate active flow statistics, thereby avoiding probe-mode transmission between compute nodes, reducing burst traffic, and decreasing network jitter. This credit-based congestion control mechanism is especially suitable for low-jitter networks such as storage networks.
- Lossless networks redefine traffic scheduling. A bucket can only fill with the volume of water the shortest plank allows. Likewise, in parallel computing, the completion time of the entire task is determined by the flow that takes the longest time to complete. To overcome this restriction, differentiated scheduling is performed for different flows, thereby reducing the time required for completing the entire task. It is widely recognized that AI algorithms play an important role in identifying key flows or co-flows.

Advances in Computing Virtualization Drives DCN Evolution Towards Autonomous Driving

Computing virtualization tears down the physical boundaries originally defined by servers and allows compute resources to be dynamically scaled on demand. Likewise, networks need to be able to keep up with these changes to computing, and this is where SDN comes in. It uses the SDN controller to dynamically construct a logical network for compute resources based on their changing locations. This is called deployment automation.

- **SDN-based deployment automation greatly improves service provisioning efficiency.**

In the deployment automation phase, man-machine interfaces evolve to machine-machine interfaces, improving the configuration efficiency from hours to minutes.

The first step of deployment automation is simplification. Deployment automation in a complex network environment can be counterproductive and make things more complex. In terms of SDN practices, the industry has also gone on many detours. Finally, the industry finalized a "simplicity first" principle. This refers to the simplification of the network topology into a

leaf-spine structure, forwarding plane into VXLAN, protocol into BGP EVPN, and gateway into all-active gateways, laying a solid foundation for automation.

The second step of deployment automation is standardization. Specifically, the standardization of SDN Northbound Interfaces (NBIs) enables networks to be integrated into the cloud computing ecosystem. In particular, as the OpenStack cloud platform has become the mainstream, Neutron has become a de facto standard, which, in turn, accelerates the maturity of the SDN ecosystem.

- **Autonomous driving implements full-lifecycle autonomy and self-healing.**

Automated deployment can cause these side effects:

- Frequent changes magnify the impact of configuration errors. On traditional networks, changes occur on a daily basis, giving administrators sufficient time to check the network. However, in the SDN era, changes occur by the minute, significantly magnifying the impact of a small configuration error. Consequently, such errors can then become a potential risk. According to Google, 68 percent of faults on DCNs are caused by network changes. To overcome this problem, a network verification technology is introduced to eliminate configuration risks before faults occur. To be more specific, it verifies errors and conflicts on the configuration plane, as well as loops and black holes on the data plane, before the configuration takes effect.
- Frequent changes mean that O&M must be quickly completed within minutes. As networks change rapidly, traditional static network O&M becomes ineffective. A solution is urgently needed that can detect, locate, and rectify faults within several minutes. Intelligent O&M is a viable solution to address this requirement. Based on massive data collection and AI prediction algorithms, some faults can be detected and rectified before they occur. Even if a fault does occur, we can combine knowledge graphs and expertise to quickly locate the root cause of the fault and provide a basis for fault recovery. In addition to deployment and O&M automation, an autonomous driving network also achieves full-lifecycle automation across network planning, construction, and optimization.

AI as an Enabler Drives DCNs Towards Intelligent, Lossless, and Autonomous Driving Networks

The implementation of intelligent and lossless networks as well as autonomous driving networks can only materialize with the use of AI technologies. Otherwise, such networks would be nothing more than a distant fantasy.

AI algorithms have achieved great success in voice, language processing, and image fields. The further integration of AI technologies into networks will supply endless power to networks.

As shown in the following figure, both academia and the industry have invested much research in AI-powered identification, prediction, optimization, and quality evaluation, making many achievements in these areas.

Huawei is working with academia and the industry to continuously explore AI possibilities and fully integrate AI with network technologies to continuously improve computing efficiency and move toward a new DCN era together. ▲

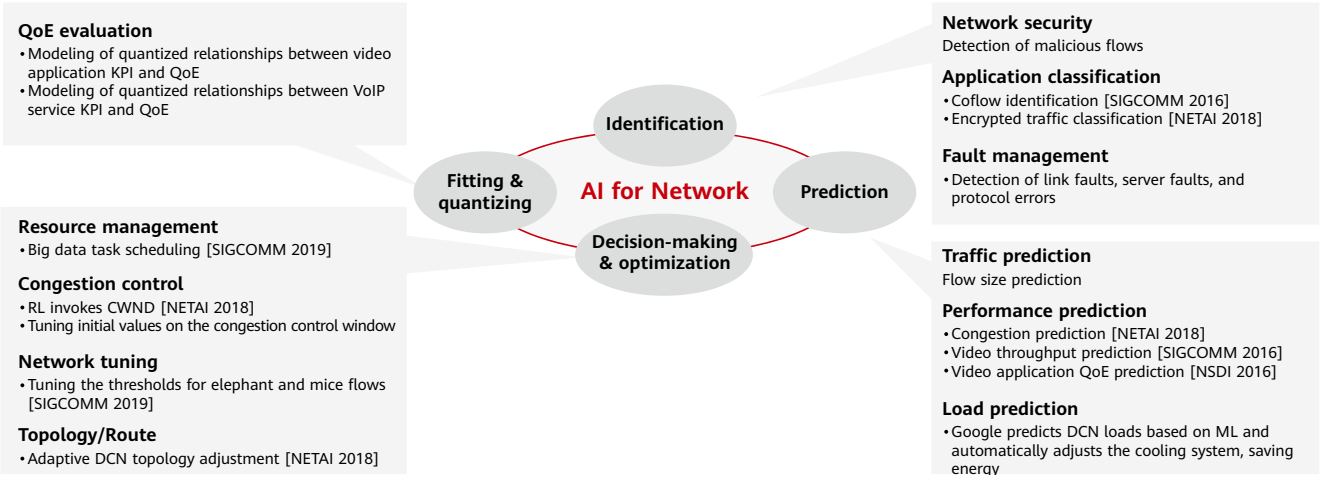


Figure 3: Research and use of AI in DCNs

CloudFabric: Leading **DCNs into the Intelligence Era**

By Leon Wang, President of Data Center Network Domain, Data Communication Product Line, Huawei Technologies Co., Ltd.

Having experienced the agricultural and industrial eras, the world is now entering the digital economy era, which is emerging due to the rapid development of Information and Communications Technology (ICT). According to a survey conducted by Gartner, 75 percent of large enterprises have already transferred their strategic focuses to digital transformation. While the most critical production elements were land and labor in the agricultural era and capital and technology in the industrial era, data and intelligence have taken their place in the digital economy era. A deluge of data is generated during digital transformation, which has become part of enterprises' core assets. However, data is not an end in and of itself: rather, it is knowledge and wisdom that remain our true pursuits. In this context, the focus of enterprise digital transformation is how to harness the power of Artificial Intelligence (AI) to gain genuine insight from transient data, and ultimately monetize such data. As such, AI has become the key driving force for enterprises to reshape their business models, improve their customer experience, and redefine their futures. +AI signifies a key milestone for enterprise digital transformation in the intelligence era.

AI is driving Data Center (DC) reconstruction as Data Center Networks (DCNs) face new challenges. Intelligent upgrades of enterprises drive DCs to transition from the cloud era into the AI era. Compared with traditional DCs, cloud DCs are more like service support centers, with applications at the core, and can quickly provision IT resources through a cloud platform. From this foundation, the AI DC goes further still, evolving into a business value center that focuses on how to

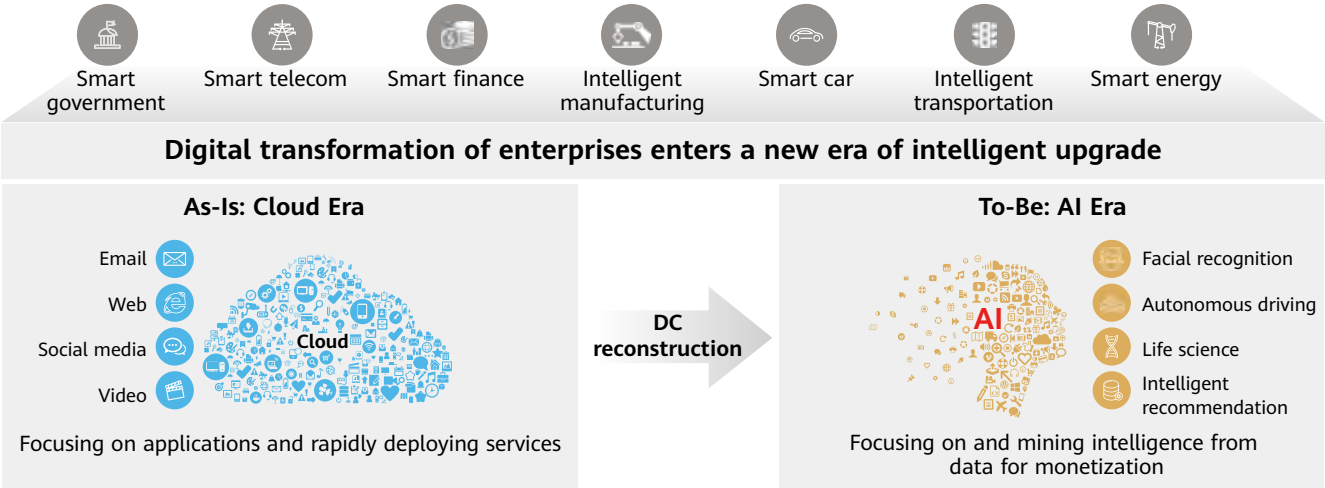


Figure 1: AI-powered Data Center Reconstruction

Data has been becoming the core production factor in driving economic growth, and "Data Infrastructure" is the key to gain a competitive edge. As a strategic highland for the digital economy, it's a top priority to optimize data center operation efficiency to unleash the computing power and the value of data.

efficiently process data using AI.

Without a doubt, running AI efficiently requires an enormous amount of computing power. For example, a common AI training for speech recognition involves 20E (1E = 10^{18}) floating-point operations. Even if the world's most powerful supercomputer is used, it would take an extended period of time. Such stringent requirements for AI computing power are the driving force behind the evolution of DC architecture. The emerging DC architecture in the intelligence era is characterized by all-flash storage data lakes serving as the core, with GPU/AI diversified computing as the computing base. Additionally, storage and computing facilities are both undergoing drastic changes. All-flash storage, for instance, has improved storage performance 100 fold while GPU/AI intelligent computing has also improved computing performance 100-fold.

If the running efficiency of a single server is accelerated by improving the performance of the processor and storage medium, the running efficiency of the entire DC can also be improved by enhancing the performance of the DCN. Indeed, DCNs have become the impetus for unleashing the DC computing power and monetizing data value in the intelligence era. As an enabling technology in the intelligence era, AI presents both new opportunities and challenges for DCNs seeking to complete intelligent upgrades and improve deployment and O&M efficiency.

CloudFabric Upgrade for the AI-Powered Intelligence Era

As the key to unlocking the gold mine that is data, AI is essential to the success of enterprises' digital transformation and intelligent upgrade. The pervasive use of AI technologies has driven disruptive changes in the mission of enterprise DCs. As AI technologies are widely used in DCs, Huawei has upgraded the CloudFabric solution to help enterprises overcome the new challenges.

World's Highest-Density 400GE DCN, Connecting Enterprises to the Intelligence Era

Enterprise digitalization has led to an exponential increase in global data volume every year. Huawei GIV predicts that the data volume will reach 180 ZB by 2025, a 20-fold increase in a span of just 10 years. Currently, 100GE DCNs cannot cope with the challenges posed by the surge in data volume expected over the next few years. In addition, from the perspective of mainstream AI service servers in the industry, 100GE NIC interfaces have become standard configurations, indicating that the 400GE era has arrived.

In 2019, Huawei launched the industry's first DC switch, CloudEngine 16800, which is designed for the AI era. The CloudEngine 16800 has upgraded the hardware switching platform and made breakthroughs in multiple fields, achieving ultra-high-speed signal transmission, super heat dissipation, and efficient power supply based on the orthogonal architecture. It provides the industry's highest-density 48-port 400GE line card in a single slot and the industry's largest 768-port 400GE switching capacity. With five times the industry average switching capacity, CloudEngine 16800 easily satisfies the traffic multiplication requirements in the AI era.

Digital business transformation has to be focused on a company's core business. The overarching idea is to develop a new business model, one based on the results of digitization and digitalization. ››

Industry's First Zero-Packet-Loss Ethernet, Unleashing the Full Computing Power Potential in the Intelligence Era

The core of the intelligence era is to introduce AI to mine data value. AI computing, characterized by deep learning, depends on the input of massive data, and the data access speed directly affects the computing power. Improvements in both computing and storage performance, however, further deteriorate the congestion and packet loss issues on the traditional network. In the AI era, even 0.1 percent packet loss will directly cause the computing power to decrease by nearly 50 percent. Even worse, packet loss will become more serious as the service load and distributed computing traffic increase. Moreover, because computing power of AI DCs is so expensive, insufficient computing power has become a major challenge. Even when computing power is available, it cannot be fully used due to network bottlenecks. Building a lossless DCN, therefore, has become a priority for many in the AI era.

Figure 2: CloudEngine 16800 data center switches

Huawei CloudEngine 16800 is the industry's first DC switch equipped with high-performance AI chips and features an innovative iLossless algorithm that implements adaptive traffic model optimization. Intelligent and lossless DCNs built based on CloudEngine switches implement zero packet loss on the Ethernet, fully unleashing the potential of AI computing power. As verified by Tolly, Huawei's intelligent and lossless DCN achieves 27 percent higher AI training efficiency than other networks in the industry when the same GPU cluster is used.

Huawei's intelligent and lossless DCN has been applied to the Atlas 900 AI training cluster, which boasts the world's highest computing power. Indeed, the intelligent lossless DCN was the key to enabling Huawei to break through the performance bottleneck to set a new world record. Besides being a high-performance network oriented to AI training clusters, Huawei's intelligent and lossless DCN is also a next-generation network architecture oriented to DCs in the intelligence era.

The autonomous driving DC, which first implements full intelligence of the network before advancing towards autonomy and self-healing, is constantly growing in scale, and its structure is becoming increasingly complex. The Operating Expenditure (OPEX) of some DCs may even be three times higher than the Capital Expenditure (CAPEX), and the efficiency and cost of DCs face structural challenges. Even if the mainstream SDN is used to implement automatic network deployment, administrators still need to understand service intents, perform routine network inspections, and locate and rectify faults.

Huawei was the first to propose the autonomous driving network concept. Based on the SDN network architecture, Huawei introduced AI technologies in the end-to-end process of planning, deployment, running, maintenance, optimization, and operation for network devices, network management and control, and upper-layer service orchestration systems. Through AI technology, networks have evolved: automated service deployment and action execution are replaced with intelligent fault self-healing, network self-optimization,

Huawei CloudFabric is the first to offer full intelligence for DCNs and implement the industry's first L3 autonomous driving network.
› ›

Figure 3: Huawei AI-powered CloudFabric Solution

network autonomy, and self-healing, free from any manual interventions.

The fully intelligent AI-powered CloudFabric solution can preliminarily implement intelligent understanding of service intents, intelligent selection of the optimal network path, intelligent evaluation of change risks, intelligent fault detection, and quick location of root causes. For 75 types of common faults, the solution can detect faults within one minute, locate them within three minutes, and rectify them within five minutes. The solution is the first to implement the industry's first L3 autonomous driving network in the DCN field as certified by Tolly.

New CloudFabric, Leading DCNs into the Intelligence Era

Around the year 2000, with the development of enterprise informatization strategies, real enterprise DCs were born.

In 2010, Huawei proposed the enterprise digitalization strategy. As cloud computing boomed, Huawei took the lead in releasing the industry's first cloud DCN, CloudFabric, leading DCs into the cloud era, realizing the elastic scaling and automatic provisioning of IT resources.

Enterprise digital transformation has entered a new phase of intelligent upgrade. As AI is widely adopted in DCs, Huawei has upgraded the CloudFabric solution. Huawei CloudFabric is the first solution to offer full intelligence for DCNs and implement the industry's first L3 autonomous driving network. In addition, Huawei CloudFabric uses the world's highest-density 400GE CloudEngine switches with embedded AI chips and an innovative iLossless algorithm. The solution also uses the industry's only intelligent and lossless DCN with zero packet loss, which unleashes the full computing power potential for AI. It enables AI services to run more efficiently while fully monetizing the value of data, leading DCNs into the era of intelligence.

Data has become the core factor of production in driving economic growth, and whoever has the leading "data infrastructure" can gain an edge. DCs have become a strategic high ground for the digital economy. To that end, enterprises are prioritizing the optimization of DCs to more effectively unlock the computing power potential and data value. ▲

CMB: Promoting Network **Transformation, Creating the New Future of Financial AI**

By Li Yunlong, Manager of Data Center Network Division, Information Technology Department, China Merchants Bank

China Merchants Bank (CMB) was founded in 1987 in Shenzhen, the city at the forefront of the reform and opening-up of China. It is the first share-holding commercial bank to be wholly owned by corporate legal entities in China. CMB is innovative in providing thoughtful services to customers. For example, CMB was the first Chinese bank to hold umbrellas for customers coming in and out of the bank on rainy days, introduce queue management systems, and provide milk to customers. Over the past 30 years, CMB has developed rapidly and was ranked No. 213 in the Fortune Global 500 list in 2018. Among the top 1000 global banks released by italicize an authoritative financial magazine in the UK, it was ranked No. 20 by capital, No. 12 by profit, No. 7 by Return On Equity (ROE), and No. 3 by revenue. CMB was ranked No. 1 by business performance indicators among all banks in China.

Evolving from the Card Era to the App Era and Promoting Retail Finance 3.0

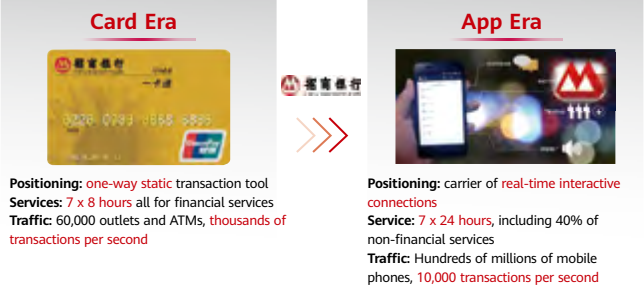


Figure 1: CMB's strategic transformation from the card era to the app era

The above achievements are due to CMB's continuous strategic transformation over the years. In terms of digital transformation, CMB specified its strategic direction and positioning of "Light Bank" and "One body with Two Wings", retail finance as the main body and corporate finance and interbank finance as two wings, in 2014. In 2015, CMB outlined its mobile-first strategy and developed two apps, Mobile Banking and Handheld Life, taking CMB into the app era. In 2017, CMB proposed to use financial technology as the driving force for future transformation. This allowed CMB to change from a "customer thinking" to "user thinking" strategy. It also enabled the company to change from a "card business" to "app operation" direction, and from a "transaction thinking" to a "user journey thinking" approach. The company has been dedicated to promoting Retail Finance 3.0 and transforming from operating static transaction products to building a dynamic service ecosystem.

Presently, the main operation field of CMB has changed from branches to apps. The two apps, Mobile Banking and Handheld Life, have become the most important carriers for connecting customers to CMB and the most important platform for CMB to provide retail services. By the end of 2019, the number of Monthly Active Users (MAU) of the two apps reached 102 million. In 2018, CMB proposed to use the MAU as the "North Star Metric" to guide retail financial transformation. In the Retail Finance 3.0 era, CMB will continue executing its mobile-first strategy and to promote digital transformation of retail finance. The company will do this by building platforms, extending application scenarios, and traffic operations. It will also build a service system covering all

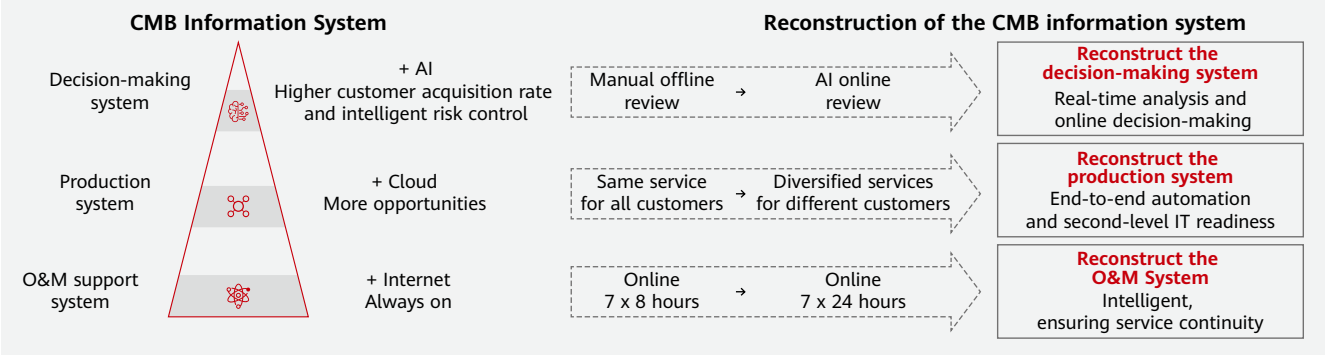


Figure 2: Reconstruction in three layers of CMB's information system

products, channels, and customer groups to provide customers with the optimal experience.

Three Challenges and Transformations of Networks to Reconstruct Digital Operation

The financial technology transformation centered on app operation requires transformation and planning in different areas. These include customer service, operation mode, and organization architecture using financial technologies. It also requires a vast transformation and reconstruction to IT infrastructure, which brings severe challenges to networks.

Firstly, in the decision-making system, real-time and intelligent requirements of services make big data analysis increasingly popular in the service chain. Prompt big data analysis is important. The AI is related to both IT computing power and network performance. High throughput, low latency, and zero packet loss are basic requirements for networks. Traditional networks limit the improvement of AI training efficiency. Secondly, financial services require agility. However, with traditional operations, weekly delivery and daily network policy provisioning are far from agile. Thirdly, the O&M support system needs to ensure service continuity and enhance stability and visualization. The system also needs to provide an insight into the network and its data as it is interconnected, scaled-up, and made more complex due to increased traffic.

The following describes CMB's digital transformation practices from three aspects.

Reconstructing the Decision-making System and Using Intelligent Lossless Ethernet to Achieve Efficient Running of AI Data Centers

Service intelligence cannot be achieved without big data. Today's data center can better realize its potential than ever before. The data center contains service, customer, and O&M data, which is increasing explosively. What matters is how to use this data, and CMB has now diversified services, including intelligent customer service, smart marketing, and Machine Gene Investment. The data continuously creating value for CMB. Meanwhile, real-time data analysis is gradually used in CMB's services. Prompt big data analysis is becoming increasingly important. For networks, big data analysis requires not only high bandwidth, but also low latency and zero packet loss capability.

CMB has implemented data analysis in the branch cloud, which is an innovative pilot of CMB's cloud computing strategy, with the company adopting a deployment architecture with separated computing and storage. The IT system department of CMB has introduced the Remote Direct Memory Access (RDMA) to improve the overall network throughput and reduce CPU consumption. This provides users with the same experience as accessing local disks. RDMA is a technology that is extremely sensitive to latency and packet loss and according to the test data of CMB, approximately one thousandth of packet loss results in the loss of half of the network throughput. Therefore, zero packet loss is required on networks.

However, the Ethernet is a less reliable network in a traditional data center network. Fortunately, Huawei CloudFabric data center network provides CMB with an intelligent lossless Ethernet solution. With this solution, CMB has achieved high throughput, zero packet loss, and low latency by using iLossless, an intelligent lossless switching algorithm. According to the AI training test, the throughput of a compute node accessing a storage node in a 25GE NIC reaches 2.8 GByte/s. The throughput of the entire storage

The CMB has changed from outlet-centric to app-centric while financial industry moving from the card era to the app era . The key is to reconstruct digital operation capabilities through digital transformation, including reconstructing the data decision-making system, the production system, and the O&M system. › ›

cluster is increased by at least 20 percent compared with that of a traditional network. This is equivalent to four to five iterations per second. Next, to propel the AI strategy, CMB is planning to introduce the intelligent lossless Ethernet to the Graphics Processing Unit (GPU) cluster with 300 NICs.

Reconstructing the Production System and Building Full-Process Automation Through ADN Joint Innovation

The IT infrastructure of CMB increases exponentially with the digital transformation of financial services and the advancement of technology strategies. These include cloud computing, big data, and artificial intelligence. From the beginning of 2017 to October 2018, the growth of computing and network resources of CMB has exceeded the inventory in the past 10 years. The number of app visits has reached 450 million per day with the peak number reaching up to 15,000 per second.

The rapid growth poses significant challenges to the construction of infrastructure, with the service agility requiring frequent network changes. How can we build a full-process and automatic chain to efficiently implement service intents in network configurations? This is one of the biggest challenges that CMB has faced, and to find solutions to this, CMB and Huawei have made joint innovations and explorations.

In 2017, CMB deployed Huawei's CloudFabric data center network in an availability zone with 2000 nodes in the newly built Xili cloud data center. If a traditional deployment mode was used, it would take at least two weeks to complete the delivery, connection, and verification of the basic network of the same scale. However, using Huawei's iMaster NCE and the Zero-Touch-Provisioning (ZTP) function, CMB implements automatic delivery of overlay configurations. Therefore, service configurations can be delivered in minutes, shortening the delivery of basic networks to three days. Overall, this greatly reduces the pressure in the resource delivery phase.

Although network resources are efficiently delivered, there will still be endless service rollout and auto scaling, and a huge gap exists between the service intent and the final network configuration. For example, network engineers often face the service requirement scenario where service growth is expected to exceed 50 percent. A network engineer may be unable to handle such service requirements, due to the fact that 50 server nodes need to be added, 500 IP addresses need to be allocated, or even 5000 network policies to be enabled. Although automation is implemented in parts of the work for the network engineers, full-process automation is not achieved. It is estimated that capacity expansion of such scale takes approximately one month, with IT engineers facing high communication and rework costs caused by incorrect or missing configurations.

To address this pain point, CMB and Huawei launched a joint innovation project to discover breakthroughs and solutions and to achieve success in the Autonomous Driving Network (ADN). The project aims to identify business intents as network behavior and form a complete closed-loop of policy, verification, delivery, and verification. This can be implemented so that the overall network delivery time, and operation and capacity expansion time can be shortened to just days.

Reconstructing the O&M System and iMaster NCE FabricInsight Achieving Quick Intelligent O&M

O&M usually goes through several phases, where the first phase is to ensure stability and service rollout, as changes may pose risks. Meanwhile, O&M engineers want to achieve high visualization, which means that indicators can be measured and visualized. In the second phase, it is impractical to avoid changes with the development of financial technologies and business needs more agile changes. In this phase, platform automation is the key. However, automation will also bring further problems, with the main challenge being

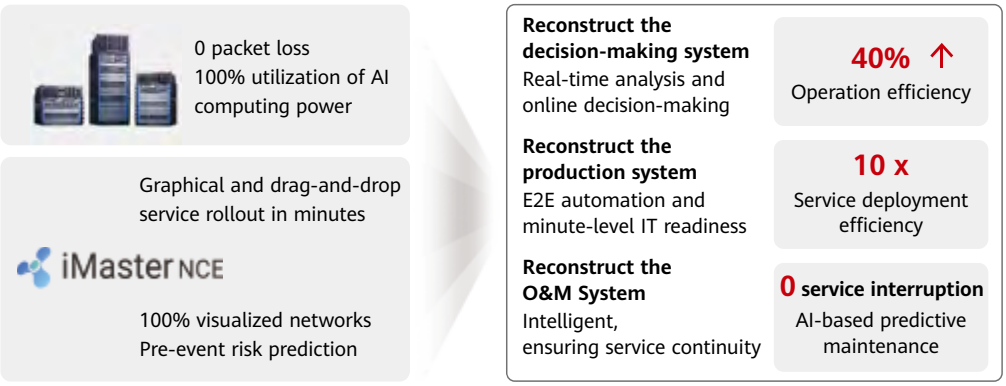


Figure 3: Huawei's CloudFabric builds the best data center network for financial digital transformation

that the network becomes a black box, and traditional O&M cannot meet the requirements. However, massive O&M data also drives intelligent O&M based on big data and AI, leading to the third phase of AIOps.

The CMB cloud data center introduced Huawei's iMaster NCE FabricInsight network intelligent analyzer to implement automatic fault identification. It also introduced the product for intelligent fault locating, and potential risk prediction based on big data and AI algorithms. The major difference between FabricInsight and the traditional O&M is that FabricInsight manages the entire network from the service perspective. Each network device is a probe on the network and can perform full-path O&M management for each service flow. This allows for implementation of fault identification within one minute, fault locating within three minutes, and fault rectification within five minutes.

In July 2018, shortly after FabricInsight went online in the data center of CMB, CMB service personnel discovered a significant number of retransmission alarms were generated between the big data cluster and Kafka cluster of a channel. It was estimated there were 300,000 alarms per hour, but it wasn't possible to instantly determine the cause of the alarms. Nevertheless, the root cause was quickly found with FabricInsight's intelligent analysis. A port of a server in the Kafka cluster responds slowly to syn.ack, causing a vast number of retransmission alarms. Only several minutes were needed to locate the fault's root cause, and after the network engineer notified the service department of the cause it was confirmed by the service department. The fault was then rectified after the application was restarted.

In the traditional O&M process, service personnel discover access is slow and the cause cannot be found, they call the network engineers and ask them to check the network. It usually takes a long time for network engineers to locate faults, which negatively impacts services. As a result, complaints frequently come from the business department about the network department. In the past, the network was not transparent and there have been numerous unclear situations. In contrast, FabricInsight makes networks more visual, which equips network O&M engineers with a greater insight into networks. CMB also has high expectations for FabricInsignt, hoping to further improve intelligent functions including intelligent prediction and automatic verification of changes. Overall, this will help CMB advance toward the ADN.

Huawei's CloudFabric data center network provides powerful support for CMB in digital transformation and digital operation reconstruction. Huawei will continue to partner with CMB to promote Retail Finance 3.0 and shape the future of financial AI. ▲

Huawei's CloudFabric solution provides powerful support for CMB in the digital transformation and digital operation reconstruction. Huawei will continue to partner with CMB to promote Retail Finance 3.0 and create the new future of financial AI. ››

Unveiling Technologies of Atlas 900 — The World's Fastest AI Cluster

By Leo Liu, Data Communication Product Line, Huawei Technologies Co., Ltd.

Atlas 900 is an Artificial Intelligence (AI) training cluster that was released by Huawei at HUAWEI CONNECT 2019. It has the world's fastest computing power of 256 to 1024 petaFLOPS (PFLOPS) FP16, equivalent to that of 500,000 PCs. Atlas 900 shattered the world record by completing the ResNet-50 ImageNet training in just 59.8 seconds. How fast is this? What are the major technological difficulties? How can Huawei possibly achieve this?

How Fast is 59.8s Achieved by the Atlas 900 Training Cluster?

At first, ImageNet was a computer vision system recognition project, but it has now become the world's largest database for image recognition. It contains tens of millions of sample images and provides sample data for numerous image recognition AI algorithms. The ImageNet Large Scale Visual Recognition Challenge (ILSVRC) has been held since 2010 and has become an authoritative arena for the AI industry. Over the seven years, the recognition rate of the winners has increased from 71.8 percent to 97.3 percent, surpassing that of humans. The ILSVRC has significantly promoted the advancement of AI technologies.

ImageNet is an arena for both AI algorithms and for the AI computing power of a substantial number of AI vendors' products. The time required for completing an ImageNet training has now become the gold standard for AI computing power in the industry. Below are key milestones for ImageNet training in the past several years:

- In September 2017, the ImageNet training was completed within 24 minutes, setting a new world record (UC Berkeley).
- In November 2017, the ImageNet training was finished within 11 minutes, with DNN training breaking the record (UC Berkeley).
- August 2018: The ImageNet training was completed within a world record four minutes (Tencent).

Every improvement in ImageNet training and every record broken represents an important breakthrough for AI. An ImageNet training task requires approximately 10 billion floating-point computations and takes a prolonged period of time to finish, even for the world's most powerful supercomputer. Huawei's Atlas 900 training cluster won the Tech of the Future Award for shortening the training time to under a minute.

Why is Improving the Performance of AI Training Clusters so Difficult?

One way to improve the computing power of AI clusters is to use processors with higher performance. This is because the performance of AI processors is the basis for the overall performance of clusters. In recent years, the performance of AI processors has developed explosively. However, a cluster usually involves thousands of AI processors in computing, and how to effectively collaborate the processors is the greatest challenge in the industry.

- **The processors are key to the performance of a single AI server.**

The Atlas 900 AI training cluster uses the Ascend 910 AI processors with the largest computing power in the industry. Each processor integrates 32 built-in Da Vinci AI cores, so the product has twice the computing power (256 TFLOPS FP16) of the industry average. One server can be configured with eight Ascend AI chips, so its peak overall floating-point computing power is expected to reach the petaflop level.

However, this isn't enough to achieve the 10 billion floating-point computations required in an AI training, such as ImageNet training. Therefore, more AI servers are required to form a

After seven years of persistent efforts since 2012, Huawei is committed to building Ethernet networks with zero packet loss and low latency.
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cluster to finish the computations collaboratively. Many have argued that the larger the scale of the AI training cluster, the greater the computing power. This, however is incorrect. Deciding how to deal with this problem is one of the biggest difficulties in improving the AI training cluster's performance.

- **Packet loss restricts the performance AI training clusters.**

Theoretically, the overall performance of an AI cluster made up of two servers is twice that of a single server. However, the performance can only reach less than twice that of a single server due to the collaboration overhead. According to

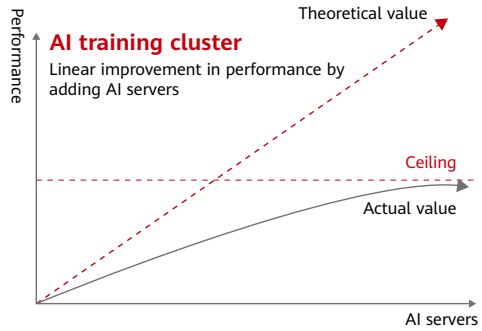


Figure 1: Performance curve of the AI training cluster

industry experience, the maximum performance of an AI cluster made up of 32 nodes can reach only half of the theoretical value. More server nodes may even reduce the overall performance of the cluster, with all AI training clusters having their performance ceilings.

The reason this happens is that a large number of parameters are frequently synchronized between multiple servers when the AI training cluster completes a training. When the number of servers increases, there is more network congestion and packet loss occurs. According to the test data, only one thousandth of packet loss results in the loss of half of the network throughput. The packet loss rate increases with the number of server nodes and if the packet loss rate reaches 2 percent, the network will break down. Therefore, the packet loss on the network restricts the improvement of AI cluster performance.

How Does Huawei Overcome this Challenge?

As the world's fastest AI training cluster, Atlas 900 connects hundreds of server nodes consisting of thousands of Ascend 910 AI processors. How does the Atlas 900 break the performance ceiling and ensure efficient and lossless interconnection between hundreds of service nodes without computing power loss? The answer to this is a network with zero packet loss.

- **Completing the intelligent lossless algorithm after seven years' hard work.**

As early as 2012, Huawei assigned a significant number of scientists to research next-generation lossless networks to solve the issue of future data deluge. Huawei is committed to building Ethernet networks with zero packet loss and low latency. After seven years of persistent efforts, the scientists worked out the iLossless algorithm solution that uses AI technologies to implement network congestion scheduling and network self-optimization. The iLossless algorithm provides intelligent predictions for Ethernet traffic scheduling. It can accurately predict the congestion status at the next moment based on the current traffic status and make accurate preparations. The mechanism is similar to how congestion degree predictions of runways are made. These predictions are based on the frequency of flight take-off and landing at the airport, and then scheduling is performed in advance to improve the traffic rate.

However, as an AI algorithm, the iLossLess algorithm must be trained based on a significant amount of sample data before commercial use. In the past few years, Huawei has worked with hundreds of customers to innovate the iLossLess algorithm. Based on the running scenarios of the customers' live networks and the unique random sample generation technology, Huawei has accumulated substantial amounts of valid sample data. This has been done so the algorithm can

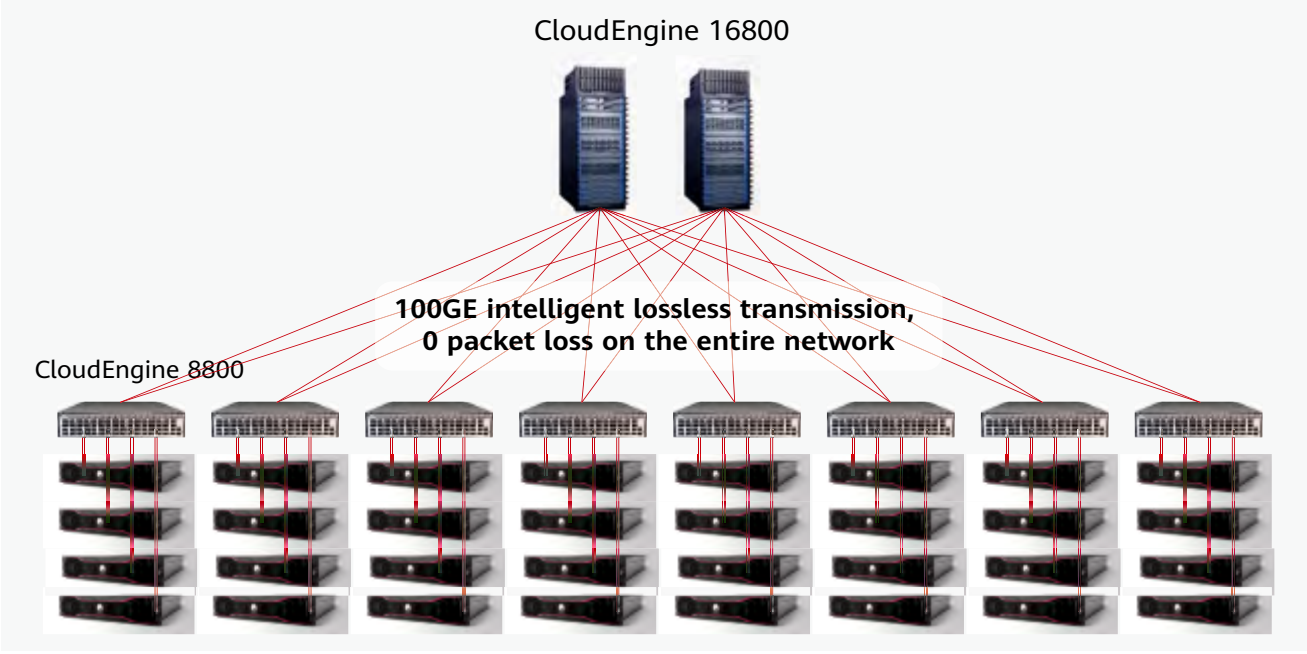


Figure 2: Network connection architecture of the Atlas 900

function optimally, enabling zero packet loss and 100 percent network throughput in any scenario.

With the iLossLess algorithm, the packet loss that's caused by congestion on Ethernet networks is no longer an issue, eliminating a problem that has existed for 40 years. Under Huawei's leadership, the IEEE has set up the IEEE 802 Network Enhancements for the Next Decade Industry Connections Activity (Nendica) working group. The intelligent lossless DCN has become the new trend for Ethernet development.

- **Industry's only Ethernet with zero packet loss, equipping Atlas with the world's greatest computing power.**

At the beginning of 2019, Huawei launched the industry's first CloudEngine data center switch. The embedded AI chips within make this switch a perfect running platform for Huawei's innovative iLossless algorithm. With the three AI elements (algorithms, labeled data, and computing power) available, the CloudEngine switch can be finally used commercially after numerous years of technical research.

CloudEngine series switches are used to build an intelligent lossless Ethernet network with zero packet loss. The Atlas 900 is made up of such Ethernet networks, which provides each AI server in the Atlas cluster with 8 x 100GE access capability. This achieves a 100 Tbit/s full-mesh, non-blocking dedicated parameter synchronization network with zero packet loss. The intelligent lossless DCN built based on the world's highest-density 400G CloudEngine16800 meets the requirement of zero packet loss, and supports large-scale 400GE network evolution. Overall, this ensures linear scale-out performance expansion in the future and continuous peak performance. In short, Huawei's intelligent lossless DCN achieves zero packet loss and equips Atlas 900 with the world's greatest computing power.

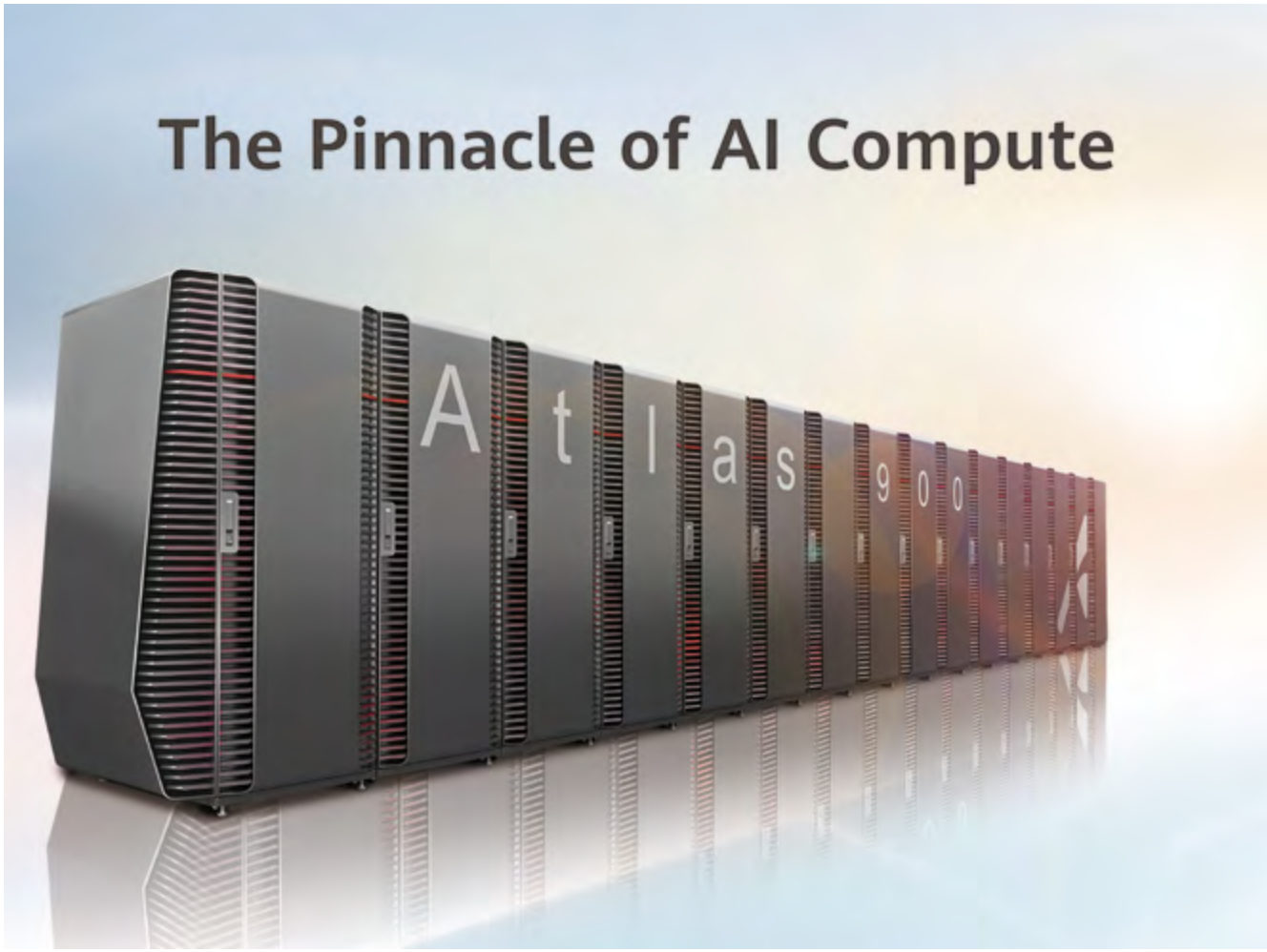
Intelligent and Lossless DCN Achieves the Three-Network Convergence DCN Architecture.

Huawei's intelligent lossless DCN is not only a high-performance network for AI training clusters, but also a next-generation network architecture for cloud and AI data centers. Ethernet networks with zero packet loss have advantageous performance in storage, including all-flash distributed storage and distributed database, high-performance computing, and

big data. Tolly Group tests show that the intelligent lossless DCN with zero packet loss delivers a 30 percent improved service performance compared to the traditional Ethernet, and is comparable to private networks. .

Building a converged data center network has always been a dream for network operators. In the past, traditional Ethernet networks could not meet the requirements of scenarios such as storage due to packet loss. Despite challenges such as closed ecosystems and incompatibility with the live network, network operators couldn't abandon dedicated networks such as Fibre Channel and InfiniBand, and several dedicated networks were deployed on the live network. Huawei's intelligent lossless DCN makes it possible to integrate the three networks of a data center. To date the DCN has been commercially deployed in 47 data centers worldwide, including HUAWEI CLOUD, China Merchants Bank branch cloud, Baidu, and UCloud. This achieves the convergence of the computing network, storage network, and service network. The converged data center network can reduce the total cost of operations by 53 percent, according to estimates.

The intelligent lossless data center network is becoming the cornerstone of the next-generation three-network convergence DCN architecture. ▲



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Leading Intelligent IP Networks

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Leading WAN into **the All-Service Intelligence Era**

In the wave of digital transformation, digital technologies are accelerating the reshaping of enterprise production and operation models. For enterprises, the core of digital transformation is to transform business models, service processes, and organizational structure so that all services can be driven by data, improving customer experience and organizational efficiency while driving business growth.

In the course of digital transformation, big data has become the core competitive advantage of enterprises. An enterprise needs to enable interconnection between the headquarters, branches, and collaborative organizations to allow efficient data transmission within the enterprise.

- IPv6+, IPv6 Enhanced Innovation Promoting the Development of Next-Generation IP Network
- Intelligent IP Network Leads WAN into the All-Service Intelligence Era
- 5G AR Routers: Building Ultra-Broadband and High-Quality Enterprise WANs
- Intelligent WAN Solution Passes the EANTC Test
- Chinese Banking Giant CCB Builds the First '5G+ Intelligent Bank' Offering New Marketing Services
- Agricultural Bank of China: Building a Future-oriented Cloud Interconnection Network in the Digital Era
- Bridging Space and Time with Telemedicine

IPv6+, IPv6 Enhanced Innovation Promoting the Development of Next-Generation IP Network

By Tian Hui, China Academy of Information and Communications Technology (CAICT)

Through continuous breakthrough of information communication technologies represented by integrated circuits, computers, optical communication, and networks, TCP/IP-based Internet technology developed at a rapid pace in the second half of the twentieth century. The Internet has now penetrated all aspects of society and profoundly affected people's lives.

Different services, such as cloud services, mobile transport, industrial Internet, Internet of Vehicles (IoV), telemedicine, and holographic communication, all pose requirements on network transport. Currently, cloud-network synergy and 5G transport are the services that have the most urgent and clear requirements on network transport.

Network Evolution Trend

- **Cloud-Network Synergy Requirements**

With the development of cloud computing technologies and industries, an increasing number of services and amount of data are migrated to the cloud. In addition, a large number of IT infrastructure resources that provide computing and storage capabilities exist on the network. The intra-cloud network, inter-cloud network, and user cloud network of the cloud computing infrastructure can't form an organic whole, and end-to-end resource management and control cannot be implemented. Moreover, fragmented clouds can't serve users as a whole IT resource pool, resulting in difficult incorporation into the ICT infrastructure. For a cloud to work, the cloud must be accessible to users, the key to which lies in the conditions and capabilities of the network between the cloud and users. A network can't provide the IT capabilities required by users if it is non-perceptible, unmanageable, uncontrollable, unable to ensure security, and unable to provide best-effort information transmission. Therefore, promoting the integration of the cloud and network, implementing on-demand allocation of IT resources, and ensuring that IT resources are fully utilized have become a trend.

- **5G Transport Requirements**

5G is the starting point for people to shift their focus from personal entertainment to a fully connected society. 5G applications will further improve communication and provide a more real-world experience. Compared with traditional mobile communications systems, 5G needs to meet the ultra-high performance challenges in diversified application scenarios, which poses new requirements, such as low latency, high mobility, and numerous connections, on transport networks. Changes in the 5G RAN architecture (such as separation of active antenna units, centralized units, and distributed units) also pose requirements for low latency on transport networks.

- **Transport Network Requirements**

In cloud-network synergy and 5G transport scenarios, the transport network must have more convenient service provisioning capabilities and more efficient network operating capabilities, as well as higher service quality. Therefore, transport networks must meet the following requirements:

Network planning capability: Scenario-specific bandwidth

guarantee policies need to be formulated, with end-to-end latency as the triggering mechanism. Many accurate underlying network parameters are used as the basis for determining a transport layer policy. According to the requirements for reliable and unreliable transmission in common scenarios, the transport layer design needs to ensure that the bandwidth guarantee policy for the transport layer meets the requirements of upper-layer applications.

Management and control for numerous connections: With the expansion of network infrastructure, more people will access the Internet and enjoy the convenience of the Internet. The number of global smartphone subscribers is estimated to exceed 6 billion by 2025. Compared with the sharp increase in the number of physical communication devices and machines such as mobile phones and vehicles, global IoT connections are projected to exceed 27 billion by 2025. The number of communication connections will continue to grow rapidly, and we will enter the era of massive connections. The transport network needs to support access management, congestion control, query and retrieval, release and tear-down, and status management on massive numbers of connections.

Network and application status awareness: Network status awareness is the basis of network resource management and control. The network status needs to be monitored accurately and completely in real time, including the network availability, usage, throughput, link or Net Element (NE) congestion status, and actual transmission paths of flows. Based on the real-time, accurate, and complete network status data, the resource management and control system needs to make comprehensive and accurate management and control decisions, including appropriately scheduling and allocating compute, storage, and network resources and formulating security control policies to improve the overall network usage and user experience.

E2E service automation: The intra-cloud, inter-cloud, and cloud access networks face different challenges and use different technologies (for example, VXLAN for intra-cloud networks, MPLS for inter-cloud networks, and MPLS and IPsec for cloud access networks). During service deployment, segment-by-segment interconnection is required. IT resources distributed in different data centers cannot be scheduled centrally, increasing the difficulty of service automation. A technology that is compatible with and unifies live-network technologies is needed to shield technical differences between networks in order to meet the requirements for unified resource management and service provisioning in the cloud era.

IPv6+, IPv6 Enhanced Innovation Promoting the Development of Next-Generation IP Network

The right technology is always developed at the right time. IPv6+, technology based on Segment Routing over IPv6 (SRv6) is introduced to meet the requirements of the 5G and cloud era. After the native IP era (network reachability) and MPLS era (converged multi-service transport), the data communications network will pave the way for the IPv6+ era featuring automation, intelligence, and cloud-network synergy.

- **Segment Routing over IPv6**

Segment Routing over IPv6 (SRv6) allocates a segment to each node or link. The ingress combines these segments into

an ordered list and instructs packet forwarding according to the list.0 SRv6 uses IPv6 addresses as segment IDs (SIDs). Therefore, SRv6 can be seamlessly integrated with IPv6 networks. With SRv6 enabled on key nodes, IP networks support network programming, cross-domain deployment, Traffic Engineering (TE), and fast switching. In this way, SRv6 can be compatible with the overlay network (VXLAN), underlay network (MPLS), and other IP-based networks (IPsec and GRE).

SRv6 has the following advantages:

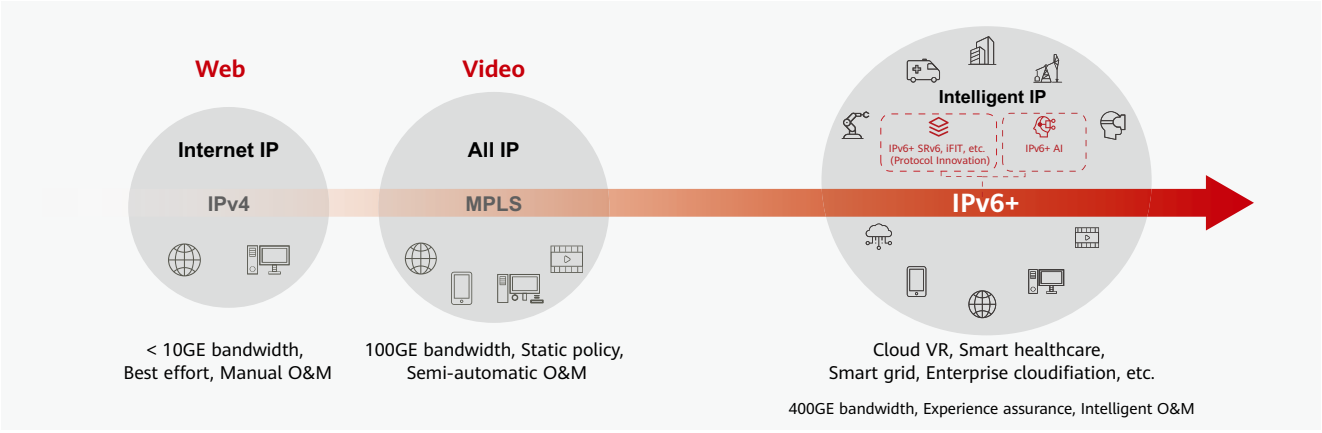
- **Simplified protocol:** Unlike MPLS that requires LDP and RSVP-TE in addition to IGP, SRv6 almost only uses IGP, simplifying O&M.
- **High scalability:** RSVP-TE is typically used to implement TE on the live network and is a soft state protocol. Each node on the network needs to detect the status of each path. The protocol cost is high, which limits the number of TE tunnels and increases the difficulty of deployment and maintenance. SRv6 path programming is performed on the ingress. The ingress only needs to combine the segments of a limited number of links and nodes even when a large number of paths exist.
- **Excellent programmability:** SRv6 segments are similar to computer instructions. They are orchestrated to implement corresponding functions. SRv6 supports flexible establishment of paths to meet different requirements, ensure service latency, and optimize forwarding paths to guarantee SLAs, as well as programming of value-added services to release network values.
- **Reliable protection:** SRv6 provides network-wide Fast Re-Route (FRR) protection, which resolves long-term technical problems on IP networks and provides complete FRR reliability protection while meeting network scalability requirements.
- **High compatibility to achieve end-to-end automation:** SRv6 uses an IPv6-based addressing mode. It can be deployed on any reachable IPv6 network and be compatible with all IPv6 networks without compromising network capabilities. Conventionally, services were deployed segment by segment. SRv6 enables service deployment only on the ingress and egress, achieving service automation.

- **IPv6+, IPv6 Enhanced Innovation Promoting the Development for the Next-Generation IP Network**

IPv6+, the IPv6 Enhanced Innovation represented by protocol innovation such as SRv6, BIERv6 (Bit Indexed Explicit Replication version 6), etc. , combined with AI such as network analysis, intelligent tuning, etc. is introduced to meet requirements, such as flexible networking, on-demand services, differentiated assurance, and network visualization, for 5G transport and cloud-network synergy. This technology system implements unified network deployment, flexible programming, and scalable expansion. It supports network visualization, application awareness, and scalable slicing, therefore IPv6+ is expected to promote the development for the Next-Generation IP Network.

Summary and Prospect

IPv6 is not the whole of the next-generation Internet, but the starting point and platform for innovation of the next-generation Internet. With the large-scale deployment of IPv6, IPv6+, the IPv6 Enhanced Innovation will be widely used on networks to form an automated and committed next-generation network similar to how MPLS formed an era, and promote the rapid development of 5G and cloud services.▲



IP Industry Generation

Intelligent IP Network Leads WAN into the All-Service Intelligence Era

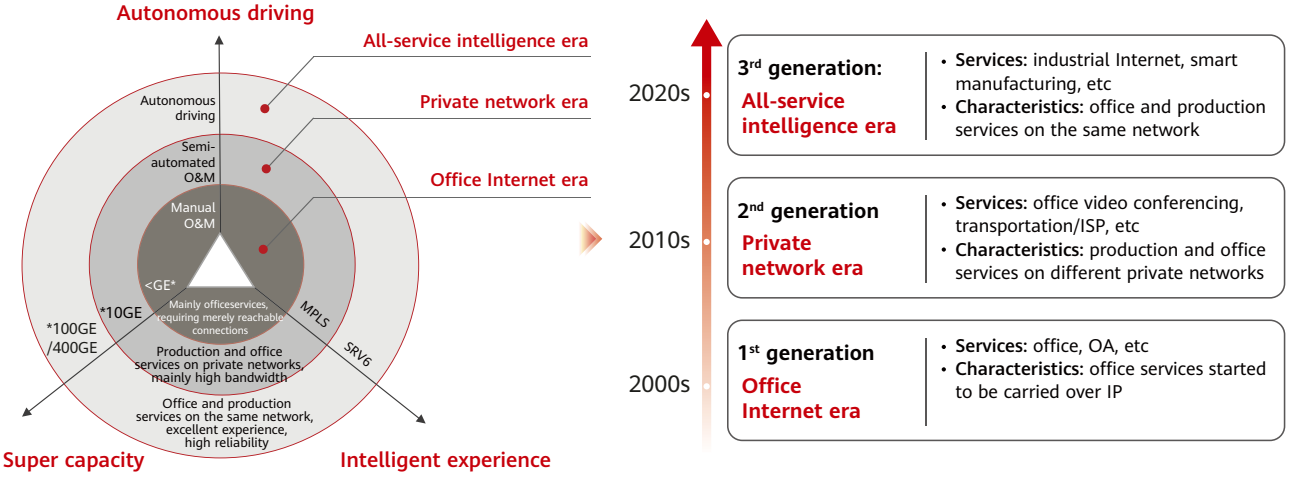
By Hank Chen, President of Service Router Domain, Data Communication Product Line, Huawei Technologies Co., Ltd.

In the digital wave, a wide variety of industries are accelerating digital exploration and transformation. For enterprises, the core of digital transformation is to reshape business models, service processes, and organizational structures so that all services can be driven by data, improving the customer experience and organizational efficiency while driving business growth. The ultimate goal of enterprise digital transformation is to bring digital immersion to enterprises and enable data flows within enterprises.

All technologies that support enterprise digital transformation, such as cloud and Internet of Things (IoT), are network-centric in nature. This means that networks, especially Wide Area Networks (WANs), have a direct impact on the success of digital transformation. For example, during digital transformation of the electric power industry, remote detection and control of power production services are required, making the network that carries the data for detection and control indispensable. Any deterioration in network quality may affect production monitoring and even lead to production accidents.

In this context, WANs are the foundation for enterprise digital transformation. Throughout the digital transformation journey, WANs have experienced three eras: office interconnect, private service network, and all-service intelligence.

- **The first generation, which started in 2000, is known as the office interconnect era.** This era saw the emergence of tools such as Word and Excel, making statistics collection possible for office services. These tools, together with word processing, signaled the transformation of offices from paper to digital information. During this phase, the bandwidth requirements on WANs were low, and E1, STM-1, and FE physical interfaces were primarily used. Service experience could be met as long as the network was reachable, with low SLA requirements. Also, network O&M was mainly command-driven.
- **The second generation, which started in 2010, is known as the private service network era.** ICT gradually entered the production system of enterprises, generating multiple independent private networks for production, office, and other purposes. SDH networks were mainly used for production, which required high-quality transport. The growing need for centralized management and control and the emergence of video services pushed office networks to evolve towards higher bandwidth. Physical interfaces were mainly GE, 2.5G, and 10GE interfaces. Still, SLA requirements were not high, and service quality could be guaranteed through simple QoS. In terms of O&M, simple tools were used to implement preliminary automation.
- **The third generation, which started in 2020, is called**



* Mainstream interface rate of IP backbone and DC networks

Evolution of Wide Area Network

the all-service intelligence era. Oriented toward services such as industrial Internet, IoT, and cloud, ICT has become the core production system of enterprises and requires the consolidation of data from diverse fields (such as R&D, manufacturing, finance, and marketing) for big data analytics and collaboration. The production, decision making, and operation of enterprises are driven by various data. Enterprises require network convergence and big data interworking, and therefore, all services need to intelligently run on one WAN.

Three Challenges WAN Faces in the All-Service Intelligence Era

- **Challenge of bandwidth:** In terms of network access, extensive interfaces must be available to support production services for all-service transport. Such interfaces include E1, POS, and PCM interfaces for the electric power industry and E1 and POS interfaces for the financial industry. In terms of traffic, high-bandwidth services, such as video conferencing, are gaining popularity. Taking 4K video conferencing as an example, a video conference with 20 parties requires a stable bandwidth of about 100 Mbps.
- **Challenge of service experience assurance:** The trend of carrying all services on one network is making experience guarantee, such as latency guarantee, a must-have for production services. Take the financial industry as an example. Services, such as online transactions, require a stable latency. If a stable latency cannot be provided, the transaction may be delayed or even fail.
- **Challenge of intelligent experience:** As the network scale expands and services are migrated to the cloud, automated network deployment, fast fault locating, and intelligent traffic optimization have become increasingly important. Take fault locating as an example. On a large-scale OTT network, services pass through 32 network nodes on average from users to the data center and may traverse thousands of paths, making it difficult to visualize service quality. Network fault locating takes days or even weeks.

Intelligent IP Network Leads WAN into the All-Service Intelligence Era

To meet the requirements of the all-service intelligence era, Huawei has developed the intelligent IP WAN solution based on years of innovation and industry experience. The intelligent IP WAN solution uses NetEngine series intelligent routers to offer super capacity and support all-scenario coverage and on-demand service access. The solution also uses FlexE-based network slicing to guarantee and flexibly allocate bandwidth for critical services, allowing one network to carry both office and production services. SRv6 is used to ensure committed latency, build intelligent connectivity, and

support optimal experience for all services. iMaster NCE — the industry's first intelligent O&M platform that features integrated management, control, and analysis — is used to implement full-lifecycle intelligent O&M and support automated service provisioning, minute-level fault locating, and predictive O&M.

- **Super Capacity: Most Comprehensive Interfaces, with FlexE-Based Slicing for Flexible Bandwidth Adjustment**

Based on NetEngine series products, Huawei's intelligent IP WAN solution supports the most comprehensive interfaces on a single device and applies to both the production and office scenarios. Huawei NetEngine series routers support PCM, E1, SDH, GE, and 10GE interfaces as well as 100GE and 400GE network-side interfaces, meeting the requirements for extensive interfaces and high bandwidth of enterprise services. At the aggregation and core layers, the cost-effective 400GE will become the next-generation networking technology following 100GE. Oriented to the 400GE networking era, Huawei launched the industry's first E2E 400GE solution (from aggregation to core and backbone) to meet the needs of the massive traffic growth that is projected for the future. Huawei is the major contributor to 400GE standardization and the industry's only vendor that can provide full-distance 400GE optical modules covering transmission distances over 10, 40, and 80 km. Huawei helped a carrier deploy the industry's first commercial 400GE network in February 2019.

In the same way that traffic congestion may occur regardless of how wide a road is, the traditional IP network may fail to guarantee the bandwidth of critical services (such as production services) even if the network capacity is high. This is because all services share bandwidth resources and preempt each other in case of traffic bursts. Huawei is the first in the industry to propose and develop FlexE-based network slicing, which is similar to a dedicated lane on the road — it implements hard bandwidth isolation between different service traffic on the ultra-broadband network. This solution provides 100 percent committed bandwidth for services, such as enterprises' production services. The slice bandwidth can be flexibly adjusted to adapt to service changes. Huawei's FlexE-based network slicing technology is also five times more fine-grained than the industry average, supporting more production services and finer bandwidth scheduling.

- **Intelligent Experience: Committed Latency and Optimal Service Experience**

Oriented toward the converged transport of office and production services, Huawei's intelligent IP WAN solution provides SRv6-based latency commitment to ensure the experience of critical services, such as production services. On a traditional IP network, service paths are uncontrollable, and the latency can't be guaranteed. Huawei is the first enterprise in the industry to support SRv6-based intelligent traffic steering. SRv6 allows the optical path to be selected in accordance with service latency requirements, ensuring low latency of critical services, such as production services.

The intelligent IP WAN solution uses SRv6 to speed up service provisioning, implement cloud-network synergy and one-hop access to the cloud, allow service provisioning within minutes, and support 50 ms protection switching in 100 percent of all topology-independent scenarios, ensuring high service reliability. Huawei is committed to promoting the development and large-scale commercial use of SRv6. As the largest contributor to SRv6 standards, Huawei has participated in the formulation of more than 59 percent of SRv6 standards. To date, SRv6 has been commercially deployed by more than 20 carriers worldwide.

- **Autonomous Driving: Full-Lifecycle Intelligent O&M, Moving Toward Autonomous Driving**

With iMaster NCE — the industry's first intelligent O&M platform that integrates management, control, and analysis — Huawei helps customers achieve automated and intelligent O&M throughout the entire lifecycle. iMaster NCE implements centralized coordination and orchestration as well as automated service configuration across network layers and vendors, enabling minute-level E2E service provisioning. Based on big data analytics, iMaster NCE supports visualized and manageable network quality as well as minute-level fault demarcation and locating. Fault locating is a prime example. Huawei is the first in the industry to propose the iFIT technology to implement performance detection per service and per flow, supporting SLA visualization. The combined use of iMaster NCE and iFIT allows fault locating within minutes and ensures high network reliability. Huawei's iFIT won the Best of Show Award Special Prize at Interop Tokyo 2019. To date, iMaster NCE has been put into commercial use on more than 80 networks worldwide, helping customers implement intelligent WANs.

Huawei's intelligent IP WAN solution helps customers build WANs featuring vast capacity, intelligent experience, and autonomous driving — leading WANs into the all-service intelligence era and helping enterprises grow with speed, agility, and efficiency in the digital wave. ▲

5G AR Routers: **Building Ultra-Broadband and High-Quality Enterprise WANs**

By ***David Gu, President of Wide Area Network Domain, Data Communication Product Line, Huawei Technologies Co., Ltd.***

Wide Area Networks (WANs) are crucial for cloud-based enterprise service deployment, cross-regional interconnection, and network interaction with the outside world. With the advent of 5G, enterprises are undergoing comprehensive intelligent service upgrades and accelerated digital transformation. This means that the data volume on enterprise WANs will increase dramatically. As such, enterprise WANs face unprecedented challenges in adapting to network service requirements in the 5G era and translating 5G features into network resource dividends.

In response to such immense challenges, Huawei has launched NetEngine AR series routers — next-generation SD-WAN-capable 5G enterprise routers. With a wide range of features, these routers provide powerful 5G uplink capabilities, deliver three times the industry average forwarding performance, and integrate innovative Adaptive Forward Error Correction (A-FEC) for video optimization. NetEngine AR series will be able to deliver the optimal service experience and transmit ever-increasing amounts of WAN data, as requirements continue to increase over the next three to five years.

5G Super Uplink: Enabling High-Speed Enterprise Interconnection

The 4G era is typified by to-consumer (2C) applications, so most data transmitted over the network is downlink traffic. In the 5G era, where all things are connected, massive amounts of to-business (2B) industry application data will be generated, creating new demands for higher uplink bandwidth and lower latency.

For example, with 5G, banks can deploy interactive robots, smart teller machines, Financial Capsules, and Artificial Intelligence (AI) in customer service, enabling traditional branches to transform into smart marketing- and service-oriented branches. To achieve these innovative services, WANs with higher bandwidth and lower latency are required. However, traditional private lines provide only 2 Mbps to 4 Mbps bandwidth, while 4G links are used only as backup links due to insufficient bandwidth and poor stability.

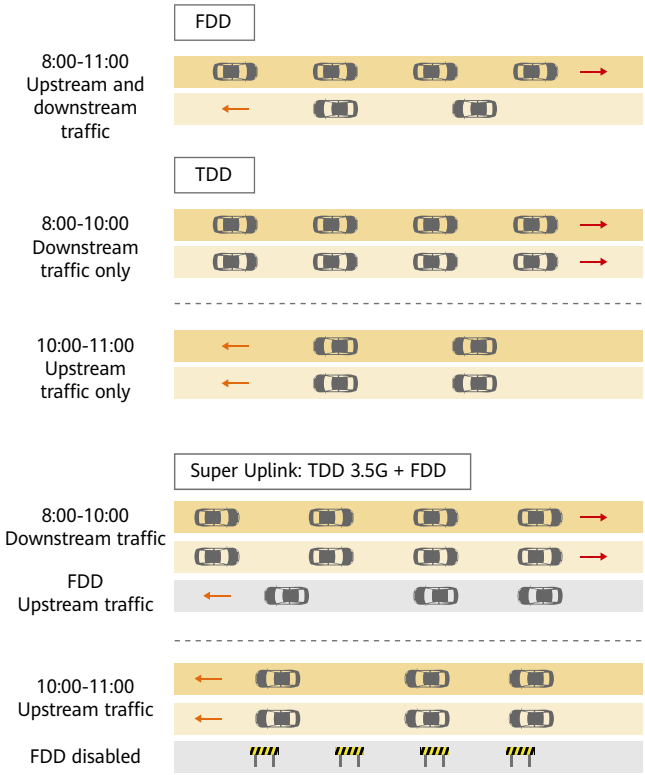


Figure 1: 5G Super Uplink

With the advent of the 5G era, cutting-edge technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Augmented Reality (AR) and Virtual Reality (VR) are gaining momentum. And according to Gartner, enterprise WAN traffic doubles every three years, resulting in ever-increasing bandwidth demands on enterprise WANs. As such, enterprise routers must have powerful service processing capabilities to deliver optimal service experience.

Huawei's 5G AR routers provide a viable solution to make a difference. They use a first-of-its-kind commercial 5G dual-mode chip — Balong 5000 — which incorporates Huawei's futuristic 5G Super Uplink technology. This greatly improves 5G transmission rates and reduces air interface latency.

The routers also use 5G New Radio (NR) to support two duplex modes — Frequency Division Duplex (FDD) and Time Division Duplex (TDD):

- **FDD:** Data is transmitted on two independent and symmetric frequency channels in upstream and downstream directions. Like a two-way road, traffic in both directions doesn't interfere with each other.
- **TDD:** The uplink and downlink data is transmitted on the same frequency channel by assigning transmitted and received signals in separate timeslots. This is like a reversible lane, in which traffic direction is reversed by time segment.

By combining TDD and FDD, Huawei's 5G Super Uplink technology eliminates the need to transmit uplink data according to timeslots. When uplink data is transmitted in the 3.5 GHz TDD frequency band, no data goes over the FDD uplink frequency band. This makes full use of the 100 MHz bandwidth provided by the 3.5 GHz band. Meanwhile, when downlink data is transmitted in the 3.5 GHz band, the FDD frequency band is used to transmit uplink data. This implements timeslot-based traffic diversion between FDD and TDD and ensures that uplink data is transmitted in all timeslots.

5G Super Uplink technology innovatively combines TDD and FDD and increases the 5G uplink rate by 20 percent to 50 percent. This makes it ideal for sectors requiring a high uplink bandwidth, such as smart banking, telemedicine, and smart manufacturing. Huawei's 5G AR routers are also backward compatible with 3G and 4G, and support both non-standalone (NSA) and standalone (SA) networking.

Intelligent Traffic Steering and A-FEC: Offering a High-Quality Application Experience

The number of network terminals connected to enterprise networks sees a ten-fold increase each year. Today, 85 percent of enterprise services can already be deployed on the cloud, while enterprises are evolving toward full cloudification. With the advent of 5G, enterprises may launch new intelligent services or even develop brand-new service systems at any time. The resultant rapid growth in WAN traffic makes WAN links more prone to congestion, failing to guarantee user

Huawei's 5G AR routers provide ultra-broadband 5G channels and ultrahigh service processing capabilities for enterprises. Additionally, SD-WAN provides the ultimate application experience and builds high-speed and super-quality WANs, facilitating the digital transformation of enterprises. ››

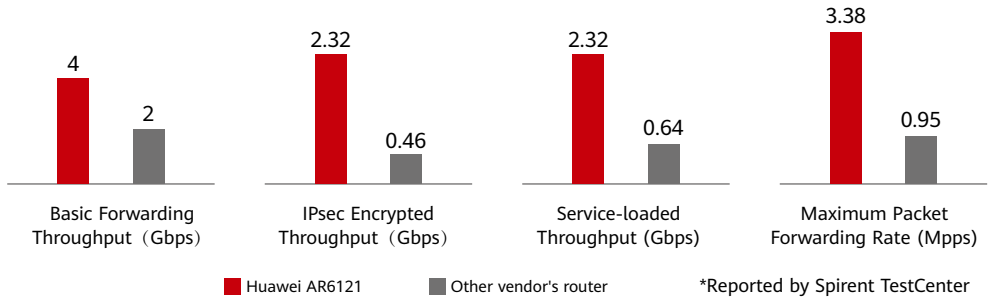


Figure 2：Performance compariosn between Huawei NetEngine AR6000 Series routers and other vendor's routers (mainstream models)

experience of key applications. With Software-Defined Networking (SDN), SD-WAN uses technologies such as application identification, intelligent dynamic traffic steering, Quality of Service (QoS), and WAN optimization to optimize and ensure the service-layer application experience.

The full-series SD-WAN-capable 5G AR routers monitor network quality in real time. They dynamically and automatically select the optimal WAN link that meets the Service Level Agreement (SLA) requirements of applications, while maximizing the overall usage of WAN links. With SD-WAN, 5G AR routers enable multiple traffic steering methods, including link quality-, load balancing-, and application priority-based traffic steering. This ensures that traffic of key applications is always transmitted on the optimal link, and enterprise customers have a high quality application experience.

Since the COVID-19 outbreak, the enterprise business model changed substantially. Contactless businesses and services, such as online education, remote office, and telemedicine, have quickly gained in popularity. At Huawei, for example, the number of remote office employees has increased exponentially, and the number of WeLink video conferences doubled daily at the beginning of the outbreak. Meanwhile, 270 million students staying at home in China have been taking over 24,000 different e-courses through 22 online education platforms. As a result, video services have gained importance in a variety of sectors. However, video is a packet loss-sensitive service, with high requirements on WAN links that are prone to packet loss due to traffic bursts and congestion. To address the problems, 5G AR routers innovatively apply WAN optimization to ensure the SD-WAN application experience.

The industry typically uses Forward Error Correction (FEC) to ensure video streaming quality. It transmits redundant frames at the transmit end and attempts to use these to recover the lost data packets at the receive end. Huawei dove deep into application optimization algorithms and developed an innovative A-FEC algorithm. A-FEC calculates and dynamically changes the required proportion of redundant frames based on the packet loss rate and the number of consecutive lost packets. This alleviates or even eliminates the impact of packet loss on transmission. The A-FEC algorithm removes freeze frame and artifact for video applications even at a 20% packet loss. It also improves link usage.

Forwarding Performance Improves, Ready for WAN Service Surges

5G services require 100 times more bandwidth, and the introduction of SD-WAN further complicates service processing. When SD-WAN is enabled on a traditional router, this results in an 80 percent performance reduction. To deploy

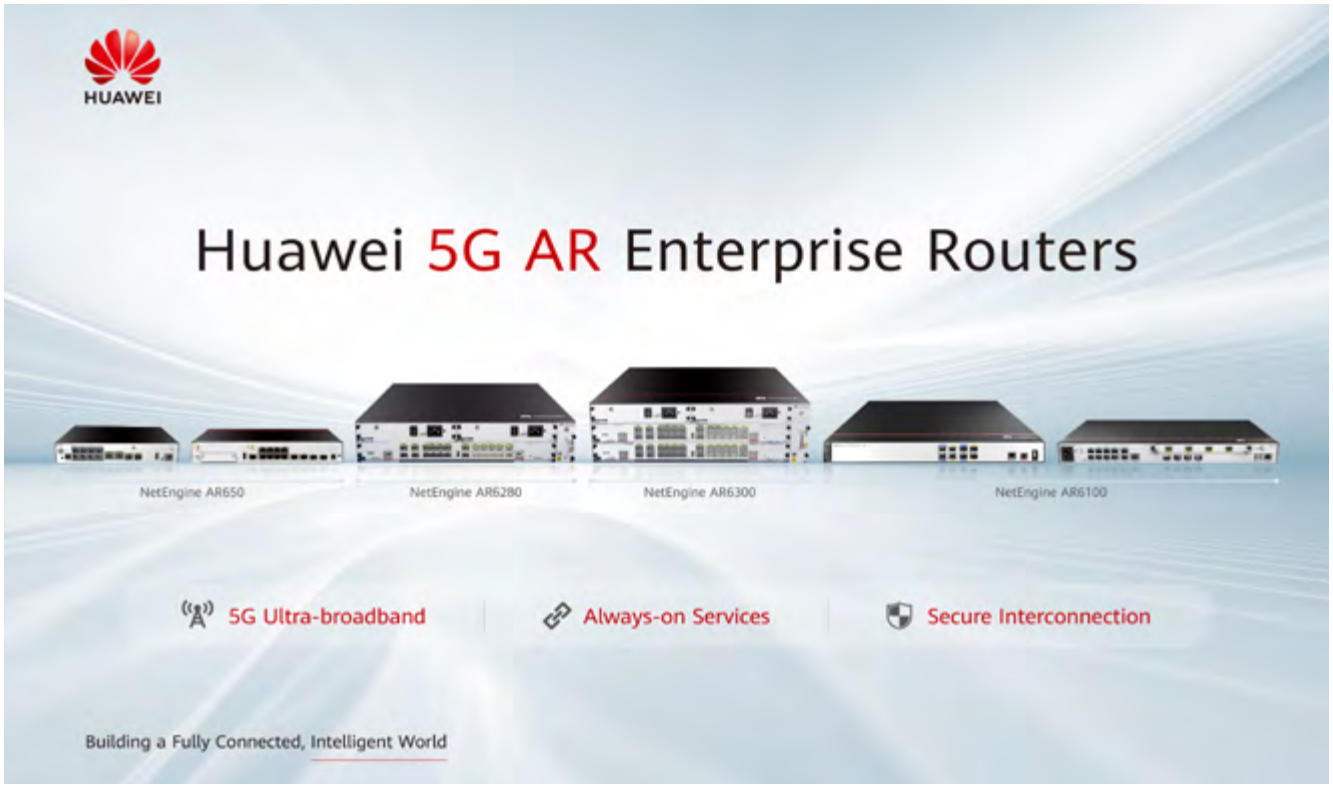
SD-WAN, enterprises require high-performance routers for a WAN upgrade. That's where Huawei's 5G AR routers come in. They use an innovative "multi-core CPU + Network Processor (NP)" heterogeneous forwarding architecture, marking a groundbreaking forwarding technology for enterprise branch routers. Huawei's 5G AR routers stand out with many hardware and software innovations. In terms of hardware, Huawei's 5G AR routers use the NP to quickly offload Layer 2 to Layer 4 traffic, efficiently forwarding basic services. The routers also integrate five hardware acceleration engines: Internet Protocol Security (IPsec), hierarchical Quality of Service (HQoS), security, Service Awareness (SA), and application optimization, further improving the forwarding performance. In terms of software, Huawei's 5G AR routers incorporate in-house ultra-fast algorithms, maximizing the multi-core forwarding performance.

By combining these hardware and software innovations, Huawei's 5G AR routers offer triple the forwarding performance of comparable products from competitors, as certified by Tolly. For more information, see Tolly's test report on Huawei's next-generation NetEngine AR enterprise routers.

Summary

The rise of 5G and SD-WAN is accelerating the pace of intelligence and cloud transformations of enterprise services on enterprise WANs. According to the China Construction Bank (CCB), their smart banks powered by 5G and SD-WAN will soon replace traditional over-the-counter banks to expand the scope of self-services and offer 327 basic financial services, greatly improving the efficiency of financial services. Behind this is the upgrade of their enterprise WANs. By using Huawei's 5G AR routers, CCB is transforming into 5G+ smart banking, which will provide innovative services such as interactive robots, smart teller machines, Financial Capsules, and AI customer service.

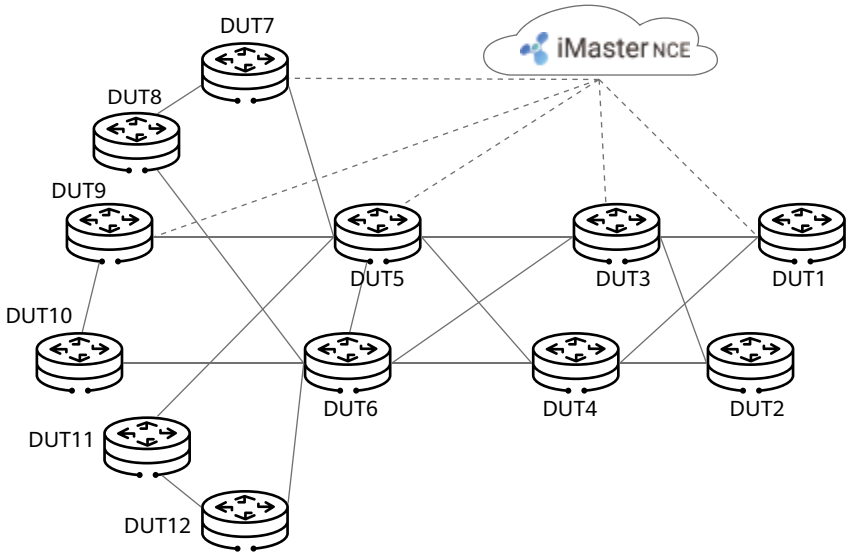
When deployed at the egress of enterprise WANs, Huawei's 5G AR routers provide ultra-broadband 5G channels and ultra-high service processing capabilities for enterprises. SD-WAN also provides an oustanding application experience and builds high-speed and super-quality WANs, facilitating the digital transformation of enterprises. ▲



Intelligent WAN Solution Passes the EANTC Test

By Li Wei, Data Communication Product Line, Huawei Technologies Co., Ltd.

In January 2020, the European Advanced Networking Test Center (EANTC) conducted a three-week independent test on Huawei's intelligent WAN solution for the all-service intelligence era, covering. The test cases are designed from the aspects of super capacity, intelligent experience, and autonomous driving. Using Huawei NetEngine 8000 X/M series routers and iMaster Network Cloud Engine (NCE), the test was successfully carried out, which impressed EANTC test experts. The following figure shows the network topology.



DUT	Device Model
DUT 1, DUT2, DUT5, DUT6, DUT8, DUT11, DUT12	NetEngine 8000 M
DUT3、DUT4	NetEngine 8000 X
DUT7	NetEngine 8000 F
DUT9, DUT10	ATN

Figure 1: Test networking

Super Capacity: Hardware Platform with Most Extensive Interfaces, Flexible Adjustment of Slice Bandwidth

Huawei's NetEngine 8000 series products support full-series access-side interfaces, such as PCM, E1, SDH, GE, and 10GE, as well as network-side 100GE and 400GE interfaces, meeting the requirements of extensive interfaces and high bandwidth for enterprise services and allowing on-demand access for production and office services. iMaster NCE manages network slices through the entire lifecycle, featuring flexible bandwidth adjustment and hard isolation of slice resources to ensure the bandwidth of critical services.

- **E2E 400GE ensures optimal cost per bit.** According to a report published by LightCounting, the demand for 100GE interfaces will continue to increase over the next two years, and the demand for 400GE interfaces will increase rapidly. The test conducted by EANTC focuses on the line-rate forwarding capabilities of 400GE and 100GE interfaces. It uses a tester

Huawei iMaster NCE implements full-lifecycle GUI-based slice management operations, slice-based bandwidth hard isolation and SRv6-based forwarding paths optimization, meeting SLA requirements such as service bandwidth and latency and ensuring optimal experience of key services. ››

leveraging the RFC 2544 test suite to simulate data traffic. Both the device and tester are directly connected to each interface in order to test the forwarding capabilities and power consumption of 400GE and 100GE interfaces. The test results show that Huawei NetEngine 8000 X8 4T board supports line-rate forwarding and it consumes only 0.28 W/G of power, 30 percent lower than the industry average.

A WAN is connected to a large number of external and internal enterprise networks and therefore has high requirements for FIB capacity. This test verifies the maximum FIB capabilities of the NetEngine 8000 X series, which is connected to Spirent TC. The test result shows that the maximum number of IPv4 entries is 4M, the maximum number of IPv6 entries is 2M, and the learning speed is 10k per second, outperforming the industry average.

- **Network slicing allows flexible bandwidth adjustment, and hard resource isolation guarantees bandwidth.** On a traditional network, all services share bandwidth resources and preempt each other. As a result, the bandwidth for key services can't be guaranteed. The hard resource isolation solution can ensure the development of 5G vertical industries and enable numerous industry networks over one physical network. In the EANTC multi-vendor interoperability test held in 2019, some basic tests were performed on the hard slicing technology. However, the automated full lifecycle slice management has always been a major concern. The test conducted in 2020 verifies the slice management capability of iMaster NCE. The test results show that Huawei iMaster NCE implements GUI-based full lifecycle slice management, including creating, modifying, and deleting slices. In the test, iMaster NCE was used to create two hard slices: one to carry URLLC services, and the other to carry eMBB services. A tester was then used to simulate a large amount of burst traffic in order to exceed the allocated bandwidth on one slice. This resulted in many of packets being lost on this slice, but the service traffic on the other slice remained normal without experiencing any congestion or packet loss. Subsequently, a new slice was created on and then deleted from iMaster NCE. This operation didn't affect normal service flows on the two original slices.

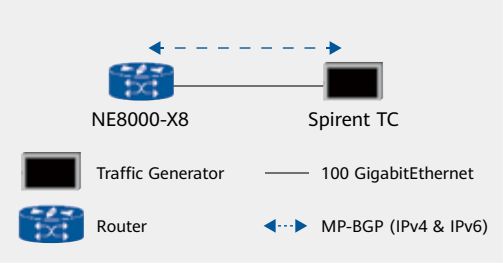


Figure 2: Testing topology of FIB capabilities and BGP route learning speed

Prefix Type	Count	Max Delta Time	Learning Rate
IPv4 only	4,000,000	37s	108,108 routes/s
IPv6 only	2,000,000	35s	57,142 routes/s
IPv4+IPv6	IPv4: 2,000,000 IPv6: 1,000,000	60s	100,000 routes/s

Table: Maximum numbers of IPv4 and IPv6 FIB entries and BGP route learning speed

Intelligent Experience: SRv6-Based Application-Oriented Intelligent Traffic Steering and Latency Commitment

In the all-service intelligence era, office and production services are carried on one network, but different industries and applications have different latency requirements. For example, smart grid requires a transmission latency of less than 15 ms. Because the traditional networks use the best-effort forwarding mode, the forwarding path can't be controlled and the end-to-end latency can't be ensured. This means traditional networks can't meet application requirements in the industry. The EANTC test is designed to verify whether Huawei's intelligent WAN solution addresses this problem. In this test, SRv6 is used to implement intelligent traffic steering and latency commitment. Different

Figure 3: Topology of SRv6-powered latency-based path computation

latencies are set for different links to check whether the forwarding path on an End-to-End (E2E) network meets the latency requirements. The test results show that Huawei routers and iMaster NCE use SRv6 Policy to implement path selection through latency-based path computation. This meets the requirements of latency SLA, as well as other SLAs such as link costs, bandwidth, and specific paths. iMaster NCE can also automatically adjust and optimize services in real time to ensure SLAs if the packet status changes, for example, a link is interrupted. No packets are lost during service adjustment and optimization.

Autonomous Driving: Intelligent O&M Through the Entire Lifecycle to Move Towards Autonomous Driving

Traditional network O&M lacks refined data collection technologies and therefore service quality cannot be accurately learned and faults cannot be quickly located. This test verifies the industry's first In-situ Flow Information Telemetry (iFIT) solution by simulating packet loss caused by link congestion on forwarding paths. The test results show that Huawei routers can report real service data to iMaster NCE through iFIT in an E2E manner, and iMaster NCE displays information about service quality (such as latency and packet loss rate) in real time. The results also show that it takes no more than one minute for iMaster NCE to detect that the number of lost packets exceeds the preset threshold. iMaster NCE immediately triggers iFIT hop-by-hop detection after detecting the threshold-crossing occurrence. The forwarding path and SLA change information of the service flow are displayed on the GUI of iMaster NCE in real time, and faulty nodes are clearly displayed. In addition, Topology-Independent Loop-Free Alternate (TI-LFA) is used to achieve protection switching of faulty nodes within 50 ms.

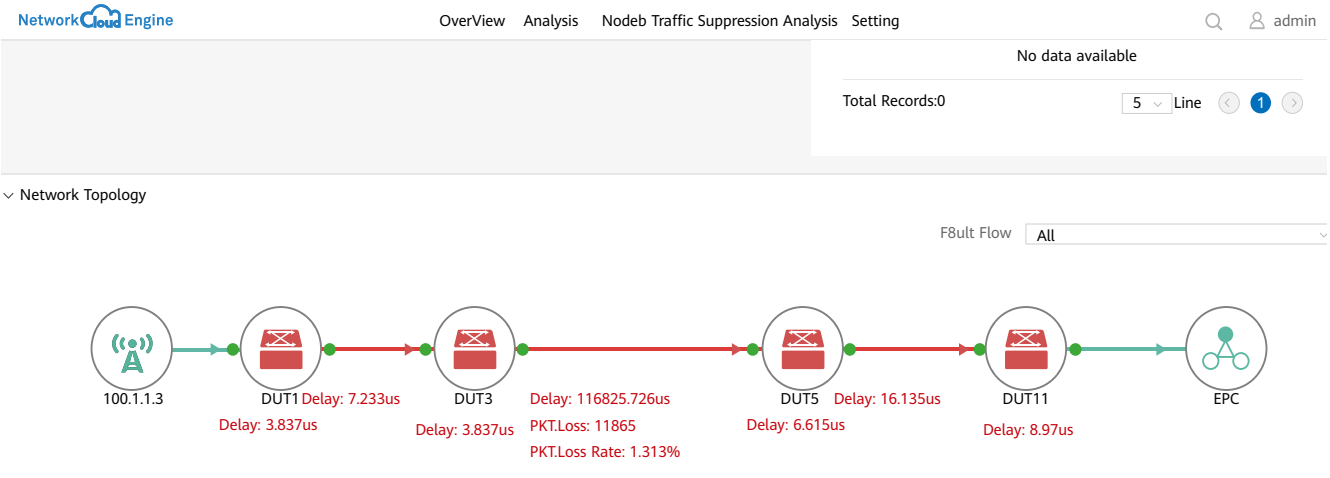


Figure 4: Test result of hop-by-hop latency and PLR

WAN Solution Oriented to the All-Service Intelligence Era

This test verifies that Huawei's intelligent WAN solution features super capacity, intelligent experience, and autonomous driving. E2E 400G is used to guarantee the optimal cost per bit. Network slicing is used to flexibly adjust bandwidth for 100 percent bandwidth guarantee. In addition, key technologies, such as constraint-based SRv6 Policy path computation and dynamic optimization and iFIT, the next-generation OAM technology for real-time monitoring and fast fault demarcation and locating, lead WAN into the all-service intelligence era.

"In the EANTC test, we simulated the real network evolution requirements of service providers and tested the issues that concern carriers during the construction of 5G converged transport networks. We evaluated a wide range of functional aspects of Huawei's SRv6 implementation across the NetEngine 8000 and ATN family and NCE — with impressive results. Huawei has demonstrated its industry-leading capabilities, providing more intelligent IP network experience and simplifying network operations and maintenance through NCE," said Carsten Rossenhoevel, Managing Director of EANTC.

About EANTC

EANTC (European Advanced Networking Test Center) is internationally recognized as one of the world's leading independent test centers for telecommunication technologies. Based in Berlin, Germany, the company offers vendor-neutral consultancy and realistic, reproducible high-quality testing services since 1991. Customers include leading network equipment manufacturers, tier-1 service providers, large enterprises and governments worldwide. ▲

The E2E service quality (such as latency and packet loss rate) can be detected and shown in real time based-on NCE and iFIT. In addition, Topology-Independent Loop-Free Alternate (TI-LFA) is used to achieve protection switching of faulty nodes within 50 ms. ››

Testimony from EANTC:

In the EANTC test, we simulated the real network evolution requirements of service providers and tested the issues that concern carriers during the construction of 5G converged transport networks. We evaluated a wide range of functional aspects of Huawei's SRv6 implementation across the NetEngine 8000 and ATN family and NCE — with impressive results. Huawei has demonstrated its industryleading capabilities, providing more intelligent IP network experience and simplifying network operations and maintenance through NCE.

— Carsten Rossenhoevel, Managing Director of EANTC

Chinese Banking Giant CCB Builds **the First '5G+ Intelligent Bank' Offering New Marketing Services**

By ***Shang Jiantao, Data Communication Product Line, Huawei Technologies Co., Ltd.***

When was the last time you visited your bank? When was the last time you carried out a transaction at the bank counter? Internet finance is now at work in every aspect of our lives. Gone are the days of always needing to physically visit a bank branch, where you'd have to queue up to be served at a bank counter. Now, more and more people use mobile banking to handle their transactions, including money transfers, loan, wealth management, tax payments, and automobile financial services. And this can all be done with just a few simple clicks. In this changing environment, traditional bank branches face unprecedented challenges in their operating mode, and are at risk of becoming obsolete.

What direction should traditional bank branches go in as they look to evolve? This a key decision for industry players to consider.

CCB Launches "5G+ Intelligent Bank" to Unleash New Marketing Services

"When stepping into this branch, I'm really impressed by how high-tech every corner of it is. Flashy robots, personalized customer journey display, remote expert service over the STM, eye-catching Financial Capsule, and fantastic automobile financial services experience...You name it. It is totally different from a traditional over-the-counter branch."

"Once entering the Financial Capsule, I'm immersed in a future financial service space. The clever robot recommends the latest wealth management products and intuitively presents the revenue. I really love it."

These are a few observations about the "5G+ intelligent." Beijing's Qinhuayuan branch of China Construction Bank (CCB). Driven by its need for next-generation system and financial technology strategy, CCB applies innovative technologies such as financial cloud, 5G, Internet of Things (IoT), and Artificial Intelligence (AI) to accelerate the transformation from traditional over-the-counter branches that focus on transaction settlement to smart branches that center on marketing and services, as well as launching the first-of-its-kind future-proof 5G+ intelligent bank.

CCB's 5G+ intelligent bank innovatively launches application scenarios such as Financial Capsule, Smart Teller Machine (STM), robot, and home bank, and provides 327 functions for common financial services, reshaping the service process from the perspective of the entire customer journey. This intelligent bank integrates online and offline mobile banking services, WeChat banking, and branches, and offers multiple fun interactive games. The end result is significantly improved transaction handling efficiency, minimized queuing time, and more fun and interesting financial services transactions. These make 5G+ intelligent bank an ideal marketing and service center.

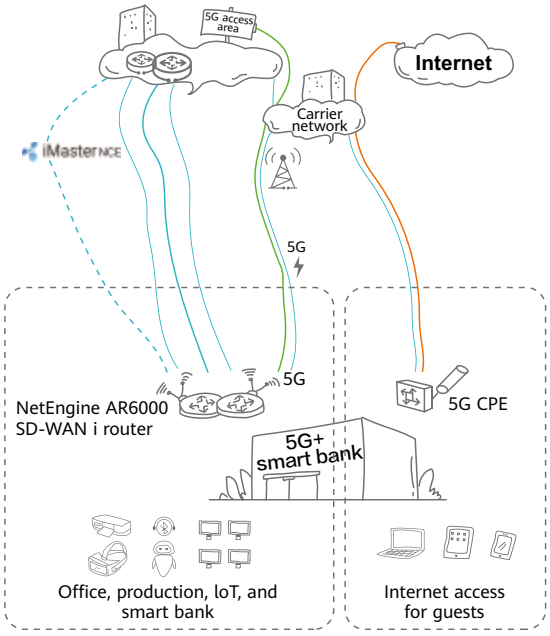
But none of this is possible without the WAN infrastructure. While the 5G+ intelligent bank continuously optimizes the financial services experience, it also drives the exponential growth in traffic. As such, bank branches require ever-demanding real-time data transmission performance and high bandwidth. MSTP private lines commonly used by traditional branches are seemingly

mature and stable, but offer rates of only 2 to 4 Mbit/s bandwidth. This falls far short of the ultra-large bandwidth required by the wide range of smart applications in the 5G+ intelligent bank. Compounding this problem, to cope with ever-changing business environments, branches have more stringent requirements on mobility and provisioning speed. With more than 10,000 branches across the globe, CCB urgently needs to find a new way to improve the Operations and Maintenance (O&M) and management efficiency on such a large number of complex WANs.

China Construction Bank and Huawei jointly build the world's first-of-its-kind 5G+ intelligent bank by innovatively combining 5G with SD-WAN. Using 5G and MSTP, SD-WAN provides intelligent banks with dual service channels to the cloud. This delivers super capacity, intelligent experience, and autonomous driving benefits to innovative services such as Financial Capsule, Smart Teller Machine (STM), and humanoid robots.

5G + SD-WAN: Building a "Bridge" for Smart Connection of Bank Branches

CCB is a pioneer in financial technology innovation, proactively exploring disruptive connection technologies, so CCB was eager to introduce Huawei's SD-WAN and 5G technologies into WAN construction for 5G+ intelligent banks. The 5G network functions as the underlay network, providing the network infrastructure with ultra-high bandwidth and ultra-low latency for intelligent banks. On top of this 5G network and the legacy MSTP private lines, SD-WAN is used to build an overlay network. In this way, high-speed interconnection channels can be quickly built between CCB's branches and the financial cloud. The cloud-based iMaster NCE, a network management and control system, implements automated configuration for complex branches. The combination of 5G and SD-WAN leads the development of WANs in the banking sector, and quickly extends the range of CCB's inclusive financial services while enabling fast rollout of 5G+ intelligent banks.



Source: influential official account ITXXXL's article — CCB Launched a First-of-its-Kind '5G+ Smart Bank' in the Banking Sector

- **Cloud and 5G: 100x Bandwidth, Millisecond-Level Latency, and Plug-and-Play**

5G features high bandwidth and low latency, as well as being cabling-free. Such characteristics make the 5G network ideal for the banking sector. By deploying Huawei's NetEngine AR enterprise routers, CCB builds dual service channels (5G and MSTP private lines), achieving 100-fold bandwidth increase for smart branches. Specifically, the tested rate of 5G+ intelligent banks can reach up to the Gbps level, fully supporting the exponential growth of data traffic at intelligent banks. And with facial recognition, intelligent voice, augmented reality, and virtual reality technologies, customers can quickly handle financial transactions such as banking services, consultation and reservation, and 5G Wi-Fi surfing, as well as enjoying personalized and dedicated services in various scenarios. In this way, 5G+ intelligent banks can provide full-journey, immersive, and personalized

financial services experience.

Other features of 5G are fast deployment and high mobility. This means that intelligent banks can be quickly rolled out without waiting for carriers to install or deploy private lines. It also facilitates quick provisioning of smart branches and setup of demonstrative mobility services; for example, connecting community banks and call centers through 5G/LTE and Internet, or deploying temporary financial service branches at large event venues to provide onsite financial service assurance.

- **Application-Based Intelligent Traffic Steering, Ensuring Optimal Financial Services Experience**

SD-WAN builds an end-to-end overlay network to logically combine intermediate network nodes, and 5G implements one-hop access to the cloud for intelligent banks, greatly simplifying the network topology. Smart banks often have dozens of applications. These applications can be monitored and identified in real time using SD-WAN, which enables access to the cloud through 5G and MSTP private lines. SD-WAN also transmits traffic of key financial applications over the optimal path selected by means of key application identification, dynamic path optimization, traffic steering based on the Service Level Agreement (SLA), application priority, and bandwidth usage. This ensures the optimal experience for key applications.

- **Intelligent O&M and Unified Cloud Management**

SD-WAN orchestrates and schedules network-wide link and bandwidth resources based on applications. It also leverages intelligent application identification to identify a broad range of applications such as key financial applications, IoT applications, and Internet applications in real time, and presents the real-time key indicators including the status and bandwidth usage of applications, links, sites, and devices. This facilitates capacity expansion, link optimization, and site adjustment, and optimizes network investment and planning. What's more, SD-WAN provides the centralized network O&M and management tools, as well as comprehensive network policy configuration tools to implement unified management of LANs, WANs, and security networks. It also automates the entire process ranging from network provisioning, service deployment, and fault locating, all the way down to routine inspection. In addition, the Geographic Information System (GIS)-based network topology information and multi-dimensional visualized reports based on links, applications, users, sites, and devices help quickly locate network faults while optimizing network policies, enabling financial services to be carried on a simple and reliable network.

CCB has a unified intelligent O&M platform that features strong technical support and easy integration capabilities. Huawei's SD-WAN Solution can easily integrate with this platform by using open northbound RESTful APIs provided by iMaster NCE. This integration facilitates E2E resource association and full-process automation. To be more specific, based on CCB's distinctive financial services, the intelligent O&M platform provides a unified self-service User Interface (UI), which provides complete user-oriented service directory, resource application, process approval, and other functions. Furthermore, the intelligent O&M platform delivers SD-WAN network configuration and policies to NetEngine AR routers, achieving association between underlying network resources and financial services requirements. This helps build efficient and flexible WANs that suit financial services and drive the transformation of financial technologies (FinTech).

- **High Controllability and Security, Ensuring Financial Services Security**

Network security is crucial to the development of FinTech. Based on Huawei's brand-new NetEngine AR routers and iMaster NCE, CCB can implement all-round security protection from the device, link, and policy perspectives. On the 5G-powered wireless virtual private network of CCB, Huawei SD-WAN Solution orchestrates security service chains based on security policies to implement end-to-end encrypted transmission of service data, guaranteeing the security of each transaction.

5G+ Intelligent Bank: Keep Innovating

Driven by the pursuit of better financial services experience and quality, CCB has never ceased in its FinTech innovation. As 5G+ intelligent banks are sweeping across China, the combination of 5G and SD-WAN will offer more diversified flexible access options for intelligent banks, and better meet security and flexibility requirements of financial services. Because of these advantages, 5G+ intelligent banks will extend the scope of inclusive financial services and transform into all-scenario financial services experience centers that offer customers an improved banking experience. ▲

Agricultural Bank of China: Building a Future-oriented Cloud Interconnection Network in the Digital Era

By ***Xu Qingbang, Senior Architect, Agricultural Bank of China***

Agricultural Bank of China's Thoughts on Digital Transformation

In recent years, the rapid development of Internet finance has brought unprecedented challenges to traditional banking and accelerated digital transformation in the financial industry. Facing the continual emergence of digital technologies represented by Artificial Intelligence (AI), cloud computing, big data, and blockchain, Agricultural Bank of China has focused on FinTech innovation and deep integration between the financial industry and new technologies in an effort to accelerate data-centric digital transformation.

With the advent of the cloud era, distributed architectures flourish. Developing online, digital, and intelligent financial services depends on the building of bank data application capabilities. Along with network development trends such as host deployment closer to the user side, application cloudification, and financial data lake construction, the data traffic model changes dramatically. This in turn extends data flows from intra-DC forwarding to inter-DC backbone forwarding. As the key infrastructure for data transmission, networks must support fast rollout of numerous innovative financial services, provide diversified service experience for different users, and allow for flexible access in complex environments. This requires the basic network architecture to be transformed during digital transformation.

To address these challenges, Agricultural Bank of China continues to explore and research innovative technologies. Based on its transformation strategy, the bank aims to build intelligent, standardized, and automated networks to provide optimal service experience for data forwarding and maximize data monetization. Specifically, it plans to build a next-generation "ABC ONE"-based intelligent network architecture. "ABC" — the acronym for Agricultural Bank of China — stands for AI, big data, and cloud computing, and "ONE" represents an Open Network Ecosystem.

Agricultural Bank of China's traditional backbone network connects 36 level-1 branches and also multiple DCs and subsidiaries worldwide. As the network architecture is transformed to multi-city multi-DC, problems such as limited access capability, complex DC interconnection, and weak multi-service transport capability are gradually exposed. Faced with this, the bank has prioritized building a next-generation backbone network in its network architecture transformation. Segment Routing-Multiprotocol Label Switching (SR-MPLS) is a relatively mature backbone network forwarding technology that has been widely used. However, considering the scalability and universality of technologies and that IPv6 will replace IPv4 in the future, the bank decided to deploy SRv6 that perfectly combines IPv6 and SR. SRv6 inherits SR advantages and provides application identification, differentiated service capabilities, large-scale 5G/IoT access, and future-oriented infinite scalability. As early as 2017, Agricultural Bank of China elected to use IPv6 and SRv6 as key technologies for its next-generation backbone network, and incorporated them into its innovative research and work plan. The bank is committed to building an intelligent, multi-service, and industry-leading network platform to comprehensively advance global service development.

Construction and Practices of Agricultural Bank of China's Next-Generation Backbone Network

To support digital transformation, Agricultural Bank of China's HQ Data Center (DC) started the next-generation intelligent backbone network project in 2017 and worked with Huawei to implement innovative project planning. Adhering to the multi-city multi-DC development strategy, the project established network design objectives covering robust architecture, intelligent operation, and easy management, and formulated a phase-by-phase construction plan.

Agricultural Bank of China first completed reconstruction from a traditional MPLS VPN backbone network to a Software-Defined Networking (SDN) Wide Area Network (WAN) backbone network, achieving the first successful deployment of SR-MPLS TE in the financial industry. With SR capabilities, the bank preliminarily virtualized WAN link resources, implementing unified network resource scheduling and flexible service deployment.

Through comprehensive technical research and verification jointly conducted with Huawei based on service requirements, Agricultural Bank of China finally chose SRv6 for its intelligent backbone network and completed the evolution from SR-MPLS to SRv6 in early 2020, achieving the largest-scale SRv6 deployment in the financial industry. Coupled with the infinite scalability of IPv6, SRv6 meets the requirements of high-speed inter-DC access and enables future capability expansion on the intelligent backbone network.

Through two phases of project construction, Agricultural Bank of China has improved financial service capabilities in the following aspects:

- **Simplified architecture**

A layered architecture is adopted for backbone and access networks, enabling branches, subsidiaries, and partners to locally connect to the HQ DC through the nearest access points and achieving fast service provisioning.

- **SDN introduction to the control plane**

SDN eliminates manual service configuration and delivery, and allows users to uniformly schedule backbone network routers through a controller, implementing one-stop service provisioning. The E2E service provisioning time is reduced to several minutes, a significant improvement over the one to two weeks that used to be required, improving efficiency by hundreds of times.

- **Improved link usage on the forwarding plane**

Traffic used to be forwarded over the shortest path, without the capability of application quality awareness. Now, traffic can be intelligently forwarded segment by segment based on the Class Of Service (COS). This enhances the capability of processing sensitive services such as online transaction, audio, and video services, and it improves service quality and link usage.

- **Differentiated SLA services for different customers**

Financial services are growing rapidly. IoT, AR, 5G, and many other services are all carried on the backbone network, requiring the backbone network to provide differentiated service capabilities based on applications. SRv6 can classify applications in a refined manner and select the optimal forwarding path based on the latency and bandwidth, assuring good user experience for key services.

- **Reduced network complexity**

SRv6 replaces multiple protocols previously used, simplifying network configuration and O&M and significantly improving service deployment and O&M efficiency.

- **Support for IPv6 evolution**

As the foundation of communication between IT systems, networks must first evolve to IPv6. Enabling IPv6 on the backbone network helps all of Agricultural Bank of China's IT systems evolve to IPv6.

Adhering to the IPv6 Development Strategy, Leading Industrial Network Transformation

In 2019, the SRv6 Technology and Industry White Paper was released, describing the technical values, key technical points, industry development, and usage scenarios of SRv6. This marks that SRv6 had been widely recognized in the industry. SRv6 commercialization requires services, networks, and industry applications to be streamlined in order to build an E2E industry ecosystem based on continuous innovation and pioneering practices. Agricultural Bank of China put SRv6 into commercial use on a large scale, promoting network technology innovation in the financial industry and accelerating the industry progress towards IPv6. The bank's network transformation practices in SRv6 and other key technologies are extremely valuable and significant to the financial industry in the following aspects:

- Accelerates digital transformation and maximizes the value of financial data.
- Fosters a fertile network environment for financial technology innovation, catalyzing the development and innovation of emerging technologies such as 5G and IoT in financial service scenarios.
- Supports financial service transformation, bringing new technical dividends.
- Sets a benchmark of innovative IPv6 evolution in the financial industry.

Future Prospects

In-depth integration of next-generation information technologies and finance has become an irreversible trend. To achieve business success in the future, banks must continuously carry out product, service, and model innovation based on networks. Future networks must be Autonomous Driving Networks (ADNs) with self-learning capabilities.

The successful large-scale deployment of SRv6 on the next-generation backbone network accelerates the digital transformation of Agricultural Bank of China. Moreover, as a key turning point of SRv6 deployment in the financial industry, it sets a benchmark of technological innovation for the financial industry, providing valuable reference for financial network construction. During next-generation network construction, Agricultural Bank of China will continue to work with Huawei to innovate in various fields such as network slicing, In-situ Flow Information Telemetry (iFIT), and AI-based intelligent O&M to build a next-generation intelligent ABC ONE-based network. ▲

Bridging Space and Time with Telemedicine

By Xu Shenglan and Li Qiwei, ICT Digital Marketing Dept, Huawei Technologies Co., Ltd.

Online consultations and telemedicine are creating new diagnosis and treatment models that use medical resources more efficiently, replacing long queues in crowded hospitals with a patient-oriented, personalized, and collaborative networked service.

In 2019, China's telemedicine market was worth 11.45 billion Chinese yuan (US$1.62 billion). According to Zhao Jie, director of the National Telemedicine Center of China (NTCC) at the First Affiliated Hospital of Zhengzhou University (FAHZU), telemedicine is crucial to fighting the COVID-19 epidemic and essential for public health. He stresses that the telemedicine technology of tomorrow will offer greater potential and allow anyone, anywhere access to high-quality healthcare services.

Making Telemedicine Accessible Anywhere

- **WinWin: What was the original aim and mission of the National Telemedicine Center?**

Zhao Jie: We set up the Henan Provincial Remote Consultation Center in 1996. In 2012, telemedicine was widely applied, and in 2014, the center was upgraded to the Henan Provincial Telemedicine Center.

This marked the establishment of a complete telemedicine service platform in Henan, covering 108 county-level healthcare facilities in the province. We set up data centers in 18 cities that year, and in 2016, equipped each of the 108 facilities with equipment for scanning medical records.

The telemedicine platform now offers a full range of functions, including full consultations, remote pathological diagnosis, remote imaging diagnosis, remote ECG diagnosis, remote education, surgical guidance, and remote monitoring. This has established a five-level interconnected comprehensive telemedicine service system.

In 2018, Henan Provincial Telemedicine Center, founded by FAHZU, was formally upgraded into a national-level facility called the National Telemedicine Center of China, becoming the first national telemedicine center in Henan.

To date, we've offered our telemedicine services free of charge, including terminals, network usage fees, remote consultations, and remote training for Tier-1 hospitals.

The remote consultation system is proven to boost diagnosis and treatment standards and optimize patient structuring. We've achieved the national aim of treating minor illnesses at the county level and keeping 90 percent of consultations at county-level health facilities.

In a populous province like Henan, service standards offered by primary-tier healthcare professionals can be very uneven. The remote consultation and training system has dramatically enhanced their standards and the service capacity of hospitals at the primary level.

- **WinWin: How developed is telemedicine in China overall?**

Zhao: Telemedicine is a new healthcare model that has emerged along with advancements in computer and communication technology and combines modern medicine with ICT.

It meets demands for inter-hospital, inter-regional, and even international medical assistance and collaboration, and maximizes the sharing of healthcare resources. The telemedicine healthcare model has tremendous value in solving healthcare problems in China such as the difficulty and expense of seeing a doctor who's located far away and inefficient appointment systems.

Telemedicine in China has gone through various stages of development, including simple communication over the telephone, video over IP on software like QQ, specialist video systems, and advanced video conferencing systems. But none of these systems are able to collect and transmit key medical diagnosis data in the required timeframe.

Henan Provincial Telemedicine Center decided to build a leading nationwide telemedicine service system in collaboration with Huawei and other partners. The system acts as a regional collaborative healthcare service platform. It has multiple remote functions, including training, consultation, pathological diagnosis, and imaging diagnosis. It also offers an ECG diagnosis and monitoring center and clinic and a precision medicine center. The system supports seamless data integration and exchange between hospitals, transforming traditional video conference-based telemedicine into a data exchange service platform.

Sharing information and resources on telemedicine platforms promotes access to high-quality medical resources in smaller healthcare institutions in Henan, supporting county-level hospitals and providing them with guidance and teaching. Not only does this reduce the difficulty and expense of visiting bigger hospitals in towns and cities for patients in remote and rural areas, it also drives tiered diagnosis and treatment in the province.

- **WinWin: What are the National Telemedicine Center's long-term plans?**

Zhao: Since founding the National Telemedicine Center, we've established a seven-level medical service system spanning the international, national, provincial, city, county, township, and village levels.

The center has set up system interoperability with other provinces and cities, including Shandong, Xinjiang, Shanxi, Sichuan, Fujian, and Guizhou, as well as countries like the US, Russia, and Zambia. It also conducts research for the National Health Foreign Aid Telemedicine Platform and the Belt and Road Health Silk Road Telemedicine Platform.

The platform currently connects to more than 1,300 healthcare facilities within the province and beyond. Every year, it facilitates over 40,000 online consultations; diagnosis for over 500,000 cases in specialist wards, including ECG, pathology, and imaging; and more than 300 distance training sessions, with a combined audience of 500,000. In the future, we will build a system based on one private network, one platform, and one data center to provide services globally.

Defeating Distance

- **WinWin: What role has the National Telemedicine Center played so far in combating the COVID-19 epidemic?**

Zhao: As the chair of the Telemedicine Special Committee of the Chinese Health Information Association and a supporting institution of both the National Telemedicine Center and the National Engineering Laboratory for Internet Medical Systems and Applications, FAHZU was keenly aware of the critical role of telemedicine in fighting the epidemic.

We quickly conducted drills on epidemic prevention and control, telemedicine system deployment, and technical solutions. We also communicated with and reported to Henan's Epidemic Prevention and Control (EPC) command and the leaders of Henan Health Commission to make advance arrangements and take proactive action.

Henan's EPC command and the Health Commission decided to build a remote consultation system covering all designated healthcare facilities in the province. National Telemedicine Center's entire staff worked to optimize the plan, coordinate materials and stakeholders, and put together 18 emergency teams overnight.

Partnering with Huawei and others, they set up the remote consultation system to act as a comprehensive service system for EPC and remote telemedicine, overcoming numerous difficulties to complete the first batch of system deployments to 130 health facilities in less than 82 hours. The system was based on 5G SA and fixed-line converged networks.

As the outbreak progressed, they completed deployment of the consultation system in 17 additional designated healthcare institutions as well as all isolation wards at FAHZU, all in just two days. They also deployed a 5G SA mobile rounds system for isolation wards at FAHZU. This would provide a robust information support platform for EPC in the province.

With the systems in place, Henan's EPC command could monitor isolation wards in all 147 designated hospitals and clinics, using mobile rounds to understand the changing condition of all critically ill patients in the province. This meant

all those who were seriously ill could receive consultations from province-level specialists via the system.

An expert group organized by Henan Province Department of Health could also conduct daily real-time consultations for critical patients in all 147 designated health facilities using the system, and it allowed us to explain treatment plans and provide technical guidance for medical staff in all health facilities in Henan.

As a result, the success rate of critically ill patients' consultations and treatment was dramatically improved and the ability of first-tier hospitals and clinics to deal with the epidemic was enhanced, increasing survival rates. The system was a first line of defense for seriously ill patients and increased the quality of EPC in Henan considerably.

• WinWin: What impact will the epidemic have on the development of telemedicine in future?

Zhao: Without a remote consultation system acting as basic support, first-tier healthcare facilities would have faced huge challenges treating COVID-19 in Henan. Thanks to the system, Henan was able to unify and standardize diagnosis and treatment plans, which significantly improved the treatment of patients with COVID-19.

For the digital transformation of healthcare in the future, telemedicine applications based on video conferencing will gradually be more personalized, as mobile devices such as smartphones become increasingly ubiquitous. Every patient will be able to receive precision services on mobile devices.

As cutting-edge technologies like cloud computing, IoT, big data, and 5G gradually mature, more potential will emerge for optimizing processes and enhancing the efficacy of telemedicine. With the help of cloud, case information can be shared between different health institutions, and diagnosis and treatment information can be quickly added or changed, providing a reference for doctors to fully understand patients' conditions and formulate suitable treatment plans.

Next-gen telemedicine systems will integrate different information systems, network technologies, medical imaging equipment, and traditional medical systems, as they evolve into a new generation of integrated telemedicine systems.

Future Cooperation

• WinWin: Moving forward, how will new technologies such as 5G help to upgrade telemedicine technology and benefit more people?

Zhao: The application of 5G in the healthcare field will promote systematic reform and accelerate the transformation of public hospitals. The hospitals of tomorrow will be able to conduct cross-border medical treatment and become "hospitals without borders." 4K high-definition video bandwidth supported by 5G technology will allow different healthcare institutions to share high-quality medical resources, rapidly improving the standard of health professionals at the primary level. 5G will also help large public hospitals integrate clinical research and fully integrate hospital management systems.

5G offers high bandwidth, low latency, and high reliability, meeting the needs of human-machine interconnections and real-time data sharing. In the event of an mergency anywhere in Henan, for example, FAHZU emergency command vehicles and ambulances can arrive at a specified location very quickly to carry out on-site command and treatment.

Since 2019, FAHZU has carried out China's first 5G healthcare demo project, working with Huawei and others to carry out analysis, joint debugging, and network testing of service scenarios like 5G emergency rescue, remote B-scans, remote consultation, intensive care, and VR. We've built China's first 5G non-standalone healthcare experimental network and 5G standalone smart healthcare private network, which involved setting up 30 5G base stations in FAHZU's three branch hospitals. And we've implemented Henan's first 5G rural telemedicine pilot in Guangshan County, Xinyang.

• WinWin: How would you describe the partnership between Huawei and National Telemedicine Center and what do you anticipate for the future?

Zhao: With FAHZU's telemedicine service platform and telemedicine system driven by both audio/video tech and data, we've enabled data sharing. This is unique in China. We signed a strategic cooperation agreement with Huawei in 2011 and, together, we selected regional collaborative healthcare hospitals for each of Henan's counties and cities. Then in 2015, we established a joint innovation center for telemedicine and big data. Huawei was also heavily involved in constructing the National Telemedicine Center, providing products and solutions, including active-active data centers, video terminals, and medical big data. Going forward, we will step up cooperation. Deploying a core platform comprising Huawei HD video terminals and with FAHZU acting as a hub, we will connect all secondary healthcare facilities and above in Henan Province to the National Telemedicine Center, achieving the true sharing of high-quality medical resources and transforming the future medical ecosystem. ▲

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Leading Network Security into **the Intelligent Defense Era**

As digital transformation picks up pace among enterprises of all sizes, they are encountering increasingly prevailing and ever-changing network security threats. However, threat discovery cannot keep up with the pace of threat penetration. This is because the industry-wide approach to analyze threat samples heavily depends on humans, resulting in inefficient threat query and threat signature extraction that lags behind the growth of threats. Meanwhile, threats can't be accurately identified based on signatures, causing additional loss once the line of defense is breached. More importantly, threats can't be predicted and threat defense isn't intelligent at all. And while attackers join forces, the targets each fight their own battle, with just little collaboration.

To resolve all these issues, we introduce AI into the security field in order to make border defense intelligent. By leveraging AI chips, the computing power is also improved several times over. All these make faster, more accurate, and more intelligent threat defense a reality, injecting intelligence into network security protection in the era of Connectivity of Everything.

- AIFW: The Intelligent Solution For Enterprise Cybersecurity
- AIFW: Empowering Border Defense

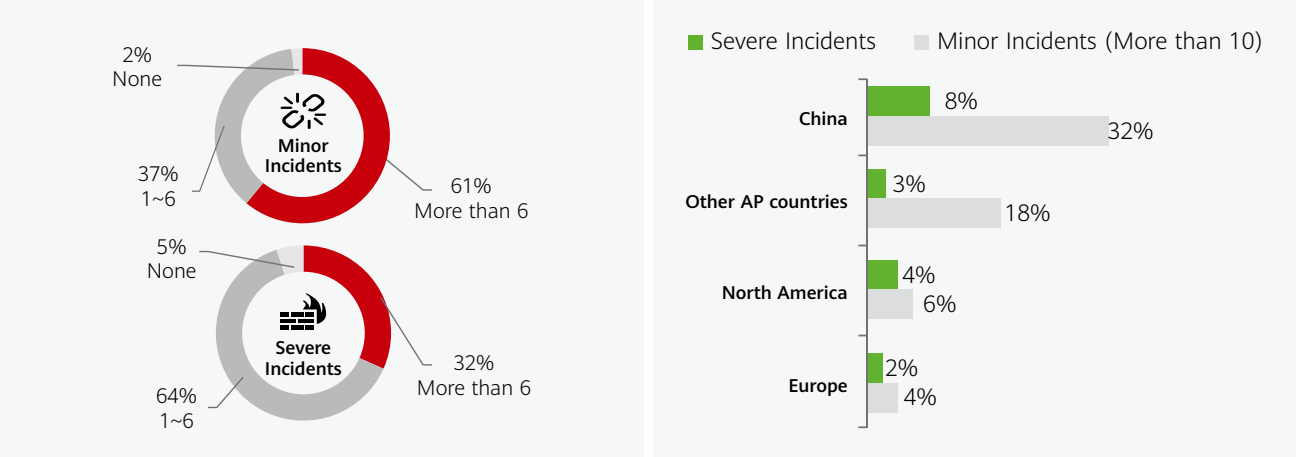
AIFW: The Intelligent Solution For Enterprise Cybersecurity

By ***Forrester Consulting***

Technology development is a double-edged sword. It benefits enterprises and individuals, but it also arms criminals. The situation of network security has become more severe in recent years, as intelligent and automation technologies can be conducive to new types of cyberattacks that are more diverse, complex, and extensive.

Security incidents are so frequent in companies that they've become a major challenge in business development.

"Approximately how many security incidents affected your company in the past 12 months?"



Base: 200 decision makers for network security and firewall deployment from large and midsize enterprises worldwide

Source: A Forrester Consulting independent research commissioned by Huawei

The Increasingly Severe Network Security Situation

- **Cyberattacks are complex and diverse**

As more applications are exposed to the internet, attempted attacks by cyber criminals grow rampant (see Figure 2). In 2018, CNCERT (China's National Computer Network Emergency Response Technical Team) captured nearly 140,000 ransomware attacks; and into 2019 this number has continued to rise. Targeted attacks such as the evasion technique, the zero-day exploit, credential theft, and professional phishing are all becoming more sophisticated, and variants of attacks

Network attacks are becoming more diversified, complex, and multi-dimensional. Attacks come from both the internal and external networks, posing severe challenges to traditional NGFWs that use signatures to identify threats. ››

Cyberattacks are becoming more diverse, sophisticated, and extensive than ever, and attacks come from both the outside and from the inside, posing severe challenges for traditional NGFWs.

Rank	China	Other AP countries	North America	Europe
1	Malicious URL	Malicious URL	Social Engineering	Malicious URL
2	Social Engineering	Attack at web port	Malicious URL	Attack at web port
3	Malicious code implantation	Social Engineering	Malicious code implantation	Social Engineering
4	Attack at web port	Large-scale DDoS attacks	Large-scale DDoS attacks	Malicious code implantation

Base: 200 decision makers for network security and firewall deployment from large and midsize enterprises worldwide

Source: A Forrester Consulting independent research report commissioned by Huawei

only make things worse. Widespread and continuously evolving hacking techniques and tools may explain the advancement of cyberattacks. Well-planned and organized APTs hinder security analysts of companies using Next-Generation Fire Wall (NGFW) from locating the problem among multiple threats in the cyber kill chain.

- **Extensive security attacks**

The development of cloud computing, 5G, and the consequent explosive growth of Internet of Things (IoT) have expanded the security boundaries of companies, leading to more extensive cyberattacks. The targets go beyond computers to all exploitable ICT devices, and the attackers originate both from the outside and from within, or as third-party vendors. Internal cyberthreats in particular are harder to detect than external attacks because the attackers have legitimate access to information. Enterprises must increase prevention and protection measures to counter extensive attacks, strengthen the defense lines against internal and external threats, and use other security products to block threats in the entire network.

Enterprises Using NGFW Are Challenged

To defeat evolving threats and attacks, firewall technologies continue upgrading actively to solve problems in performance, operation, and maintenance. Nonetheless, cyber criminals have also made great technical strides over the past decade. Increasingly rampant and intelligent security attacks will severely challenge NGFW's abilities of prevention and control as we are entering an age of intelligent IP era.

- **NGFW struggles with rapidly mutating threats**

NGFW can identify application vulnerabilities

more effectively than previous firewalls, but its rule engine still has significant limitations. The existing solution would generate a signature for a single threat that has been identified, but once the threat mutates, the signature no longer works. This means the NGFW needs to be continuously updating its signature database, which requires person-power to manually renew the solution. However, each local device can only accommodate limited number of signature databases, making it hard to respond to new changes, so the Operation and Maintenance (O&M) personnel have to change the rules constantly, in order to maintain prevention and control capabilities. Through continuous variants of threats, cyber criminals can easily put firewalls to passive responses. Untimely updates open a window for attackers to sneak in. Therefore, the post-event management must intelligently shift the focus from experience to data and insights, to address severe security challenges.

- **NGFW stumbles in extensive attacks**

Cybersecurity threats spread quickly in all dimensions, but NGFW can only protect the preset protocols or applications in the database, and it can do nothing to those outside the database, even if they are of the same type. For intranet attacks, it is critical to swiftly spot the threat and locate the breached computer through means like behavior analysis and abnormal traffic detection, in order to mitigate damage, stop internal diffusion, and build both a comprehensive fence against the Advanced Persistent Threat (APT) attack chain and a detection network that spans the boundary of the enterprise.

- **NGFW maintenance is stressful**

Routine maintenance is critical after NGFW deployment. The O&M personnel update the rules continually for threat mutations. Meanwhile, most NGFWs lack effective data analysis capabilities, requiring O&M personnel to manually analyze massive security logs. Their workload is heavy and demanding, but the effect can't be guaranteed. Log analysis relies heavily on the experience of security personnel, which undoubtedly increases the company's investment in operation and maintenance, as well as risks caused by staff turnover.

AI Brings Important Opportunities

AI technology can map massive amount of information to high-dimensional spaces with better information abstraction capabilities, bringing new opportunities to security protection with its generalization and inferential capabilities.

- **AI disrupts the prevention and control of cyberattacks**

Threat prevention and control are two primary tasks for any firewall. AI provides more accurate APT detection, more powerful event analysis, and a closed defense loop that spins faster, which greatly enhance the firewall's ability to prevent and control threats. Specifically, AI can:

- **Defend new threats effectively.** Traditional solutions, based on signatures or rules, are relatively static and struggle to catch up with rapidly mutating threats in proactive defense. AI technology goes beyond the limitations of human beings' low-dimensional cognition and can better understand the behavioral patterns of threats and attacks at a deeper level. In practice, supervised and unsupervised learning are used to spot frequent variants of malware, locate breached hosts and zombies, detect the theft of encrypted outgoing messages, and identify malicious behaviors like low frequency or distributed brute force attacks. AI learning taps into massive data to generate defense models based on scenario analysis; it upgrades the models continuously according to the real-time data to achieve self-evolution.
- **Strengthen intelligent analysis of security incidents.** Various attacks do leave traces in security logs, but it requires a lot of person-power to detect the threats (from countless logs of operating systems, threats, and network protection) and refine insights to continuously enhance prevention and control capabilities. AI can revolutionize event analysis of cyberthreats. For example, AI knowledge mapping can sort local knowledge such as attack and defense database and threat events, and use them with environmental, behavioral, and intelligence data to dig into data and better detect and defend from threats targeted at critical assets.
- **Support quicker response to APT attacks.** When an intrusion is detected, it is vital to quickly locate and separate the problem and carry out sensible defense. The AI-based APT defense model is more lightweight than traditional solutions and can be easily integrated to the local firewall. Improving on the collaborative external detection in the past, the AI-based APT defense model shortens the exposure time of APT attacks and helps minimize the losses.

- **AI empowers integrated security protection**

AI improves security data analysis and provides better threat detection and prevention capabilities than static rule engines, equipping enterprise firewalls for cyberattacks. AI can also connect equipment in the network for joint machine learning, in order to optimize the defense model on a regular basis.

- **Federal learning continually optimizes the defense.** Restricted by industry sensitivity and policies in some countries, many companies are still uncertain about in-depth sharing of security data with each other. Through encrypted exchanges of parameters, federated learning can improve the sharing model without moving the data, thereby enriching the training data sets for AI to build distributed AI collaborative defenses. AI firewall can also utilize the threat intelligence in the entire network to sustainably and swiftly update the detection and response model to maintain effective defense.
- **Deploy intranet defense and enhance collaborative detection.** A firewall can set built-in traps that will form a safety net for internal threats, using AI-based traffic analysis to identify malicious or illegal traffic for collaborative detection in the intranet.

- **AI provides necessary tools to improve O&M efficiency**

The shortage of senior security O&M personnel is a consensus in the industry. Improving O&M capabilities is one of the most important challenges for the existing prevention and control technology. AI can efficiently analyze massive logs, sparing more time for the O&M personnel. It can also reduce redundancy in security rules through intelligent tuning or even automated generation, reducing the pressure on O&M personnel to maintain huge databases.

AI Firewall Is An Inevitable Choice

In the era of intelligent IP networks, NGFW is severely challenged by increasingly complex security situations, while AI brings new opportunities for enterprise firewalls. This means NGFW should embrace AI and evolve into the Artificial Intelligence FireWall (AIFW) to strengthen prevention and control, to build integrated protection capability, and to improve operation and maintenance efficiency. To make the most out of AI and maximize the prevention and control performance of AIFW, dedicated AI chips, cloud-edge collaboration, and security ecosystem are indispensable for firewall evolution, the reliable safeguard of enterprises, and progression for the entire industry.

- **AI chips fuel the engine for local apt defense**

To build localized defense against APTs, AIFW needs a built-in AI detection engine to respond to threat mutations through self-evolution. Encryption and decryption, packet detection, and traffic forwarding already consume a lot of the computing power of a firewall, but the AI detection engine also demands massive computing power to process mass data and AI inference. Therefore, AI chips are a must-have to enhance computer power for detection, effective emergency response, and other functions of the firewall, providing shorter response time than the cloud's big data solutions. In principle, the selection of chips should vary due to the diversity of computational tasks, thus dedicated security chips, co-processors, and AI chips will become increasingly important for AIFW.

- **Build your cybersecurity platform upon extensive collaboration**

The growth of IoT applications will extend the security boundaries of enterprises and impact the form of the firewall. Boundary defense requires a collaborative threat detection of AIFWs and other APT defense equipment and clouds.

In the long run, comprehensive security prevention and control also requires extensive alliance in the ecosystem to remain proactive against cyberattacks. Firewalls will need to be open to share or exchange local intelligence for closer collaboration. Companies need to leverage the advantages of partners to share security solutions and experience, which can also promote the development of technologies like AI and IoT and form a virtuous circle. Multiparty collaboration will be critical to securing the victory in the ongoing battle against cyber criminals.

Key Recommendations

As we enter the age of intelligent IP era, cyberattacks are becoming more diverse, sophisticated, and extensive than ever, posing inevitable challenges for companies. Forrester recommends that:

- **AI empowers the next generation of firewalls — the AIFW.** As a general-purpose technology, AI will be applied widely in various business scenarios, including cybersecurity. For cyberattacks already armed by intelligent technologies,

firewalls based on rule engines are obviously outdated. Enterprises should turn to AIFW for comprehensive local defense against APTs. Adopt AI chips to accelerate task processing and collaborate with AI capability centers on the cloud to continuously update security models and ensure cybersecurity in all aspects.

• **Embrace intelligent applications to improve the O&M efficiency.** Intelligent and automated operation and maintenance is the choice of the times. AI-enabled applications like traffic analysis, threat detection, and behavior identification reduce the workload of O&M personnel. The AI-driven intelligent tuning of security rules solves the problems of manual updates, and greatly improves O&M efficiency. As AI detection of unknown threats gets more accurate, false alarms will be significantly reduced, bringing on another leap in O&M quality.

Build your cybersecurity platform upon extensive collaboration. Cyber criminals only exploit a single breach at one time, but the company needs comprehensive defense for being at a disadvantage. As attacks go rampant, companies must collaborate and embrace an extensive ecosystem, share security intelligence, and use information from the entire network to build increasingly powerful security models and to jointly win the battle against cyber criminals. ▲

Building a Fully Connected, Intelligent World

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Earned Recommended Rating from NSS Labs

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- Excellent performance: built-in AI chips and dedicated security acceleration engine, improving protection performance by up to **five-fold**
- Simplified O&M: service-driven intelligent security O&M, reducing OPEX by over **80%**

Leading Intelligent IP Networks

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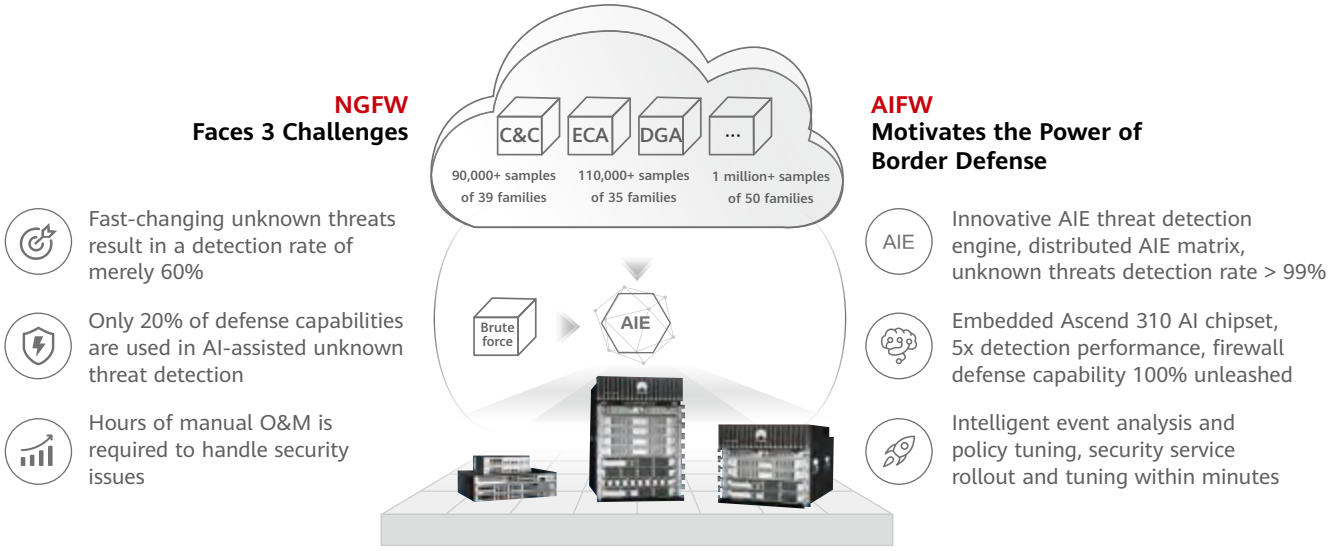
AIFW: Empowering Border Defense

By Yuan Fang, Data Communication Product Line, Huawei Technologies Co., Ltd.

As digital transformation is sweeping across the globe, the accompanying unprecedented connections, explosive data, and mushrooming intelligent applications are redefining the way we live and work. Amid this trend, interactions between individuals, between individuals and enterprises, and between enterprises are flourishing more than ever. This, in turn, boosts economic and social development.

Extensive applications of cloud computing and big data analytics are accelerating digital transformation of enterprises, and intelligent service upgrades are driving the revolutionization of enterprise networks. All these trends have created unparalleled challenges for network security. Moreover, cyber criminals won't stop in their attempts to gain access to personal privacy, enterprise confidentiality, and computing resources. Everything has its advantages and disadvantages, and digitalization is no exception. While it adds convenience to our lives, it also leads to many security risk.

Gartner defined Next-Generation Firewalls (NGFWs) in 2009, and since then, these security devices have become increasingly important and used to meet numerous challenges. The first challenge is coping with the ever-increasing unknown threats. Even known threats evolve into a wide range of unknown threat variants to bypass security. Such variants are difficult for NGFWs to detect based on signatures. The second challenge is defending against multi-faceted threats. The rapid development of 5G and IoT allows for an increasing number of devices to connect to the Internet. However, these devices can be vulnerable to hackers to initiate multi-faceted attacks. According to a survey conducted by Forrester, 49 percent of enterprises are undergoing many more intranet threats than ever before. This indicates that the scope prone to attacks is widening,



HiSecEngine: First Terabit AIFW in the Industry, Fast and With a Low False Negative Rate

namely, attacks may come from both external and internal networks. By exploiting these vulnerabilities, attackers can initiate sophisticated attacks that form a comprehensive attack chain, from initial compromise, remote control, and lateral movement, to theft and damage.

Traditional NGFWs, however, cannot cope with these issues and are calling for a revolutionary upgrade.

AIFW: an AI-Powered Safeguard

Recently, AI technologies keep on developing iteratively. In addition, new technologies such as Deep Leaning (DL) can make optimal use of big data accumulated in this mobile Internet era to make breakthroughs in learning accuracy. Applying AI technologies into all sectors can significantly improve the production and life efficiency. The network security domain also witnesses wider applications of AI technologies, most of which are built on big data-powered security threat analysis that is typified by high investments, discouraging most customers from deploying it.

However, in addition to these domains, AI technologies can also be applied to firewalls to increase network security. These AI technologies are highly effective at mapping mass information to high-dimensional space through their superb information abstraction capabilities. The generalization and reasoning capabilities developed in this process open up new opportunities for security protection. Moreover, AI technologies can perform operations at a higher efficiency than manned operations and sophisticatedly interpret the patterns of threats and attacks. For example, supervised and unsupervised learning can detect ever-evolving malicious files at a higher efficiency, detect compromised hosts and devices as well as encrypted malicious traffic, and identify malicious behaviors such as low-frequency or distributed brute force cracking. In addition, the AI learning model can make full use of mass data, generate defense models based on scenario data analysis and training, and continuously upgrade and evolve the models in line with real-time data on the live network. Therefore, AI technologies are the optimal choice to eliminate the shortcomings of traditional NGFWs, enhance threat detection capabilities, and automate threat handling.

Fully unleashing AI technologies in the network security domain requires substantial computing power. Relying only on the service processing CPU of firewalls, the traffic forwarding capability of firewalls will drastically decrease once AI is enabled. Therefore, the AI chip needs to be embedded into firewalls to meet the high requirements for computing power.

After in-depth research and stringent verification, Huawei has successfully launched brand-new lineups of HiSecEngine USG6000E and USG12000 AIFWs. These two AIFWs series are equipped with Huawei's exclusive AI-powered threat detection engine — AIE — to handle threats in real time at the network edge and accurately detect more than 99 percent of unknown threats. Furthermore, Huawei HiSecEngine AIFWs have built-in AI chips to deliver up to 8T FLOPS of computing power, achieving a fivefold performance increase in unknown threat detection without deteriorating their traffic forwarding capability. As such, attack defense capabilities of AIFWs are fully unleashed.

AIFW: Highly Recognized by Authorities, Customers, and Markets

Huawei HiSecEngine USG6000E series AIFWs were officially launched in January 2019. As verified by authoritative organizations in China, they can detect threats that cannot be detected by traditional NGFWs as well as external connections created by infected hosts through the Domain Generation Algorithm (DGA). As verified, the USG6000E can detect 99,715 out of 100,000 malicious domain names in the 41 DGA families, achieving a detection accuracy of 99.7%. In addition, the future-proof AIFWs can accurately detect 100 percent of 38 types of Remote Access Trojan (RAT) families and 34 types of malicious behavior families in encrypted communications.

Since their debut, more than 50,000 HiSecEngine USG6000E series AIFWs have been delivered and have helped users in all sectors detect and eliminate various new threats, receiving high recognition in the market.

"The industry's pioneering AIFWs launched by Huawei successfully overcome the limitations of static rule engines on traditional NGFWs, enhance threat detection capabilities, and address challenges facing security O&M through enabling automation," said Denzel Song, President of Huawei Security Domain. "The AIFWs also leverage AI chips to deliver significantly stronger intelligent detection capabilities, laying a solid foundation for in-depth implementation of AI technologies into security gateways. With AI, network devices and the cloud can collaborate with each other, boosting the development of a security interaction ecosystem; a much more solid security platform can be built through multi-party collaboration, safeguarding enterprise networks." ▲

Hi

Rethink IP
New Connection New Dimension

Building a Fully Connected, Intelligent World

Rethink IP with Huawei IP Club

By ***Guopeng, Marketing Director of Data Communication Marketing & Technical Sales Dept.***

Today digital transformation is sweeping across the world. New technologies such as AI, 5G, and Wi-Fi 6 are constantly emerging. In this context, we face new changes and challenges. To address them, we should make concerted efforts. At Huawei, we have always been hoping to establish a new kind of "connectivity" of thoughts. Through such new connectivity, we can share, get inspired, and unite as one team to handle new challenges together. Such "connectivity" of thoughts is exactly where Huawei IP Club aims to build.

IP Club is initiated by Huawei, aiming to building an open, free, friendly thought-sharing platform for IP technical supervisors, engineers, and industry analysts, and key opinion leaders.

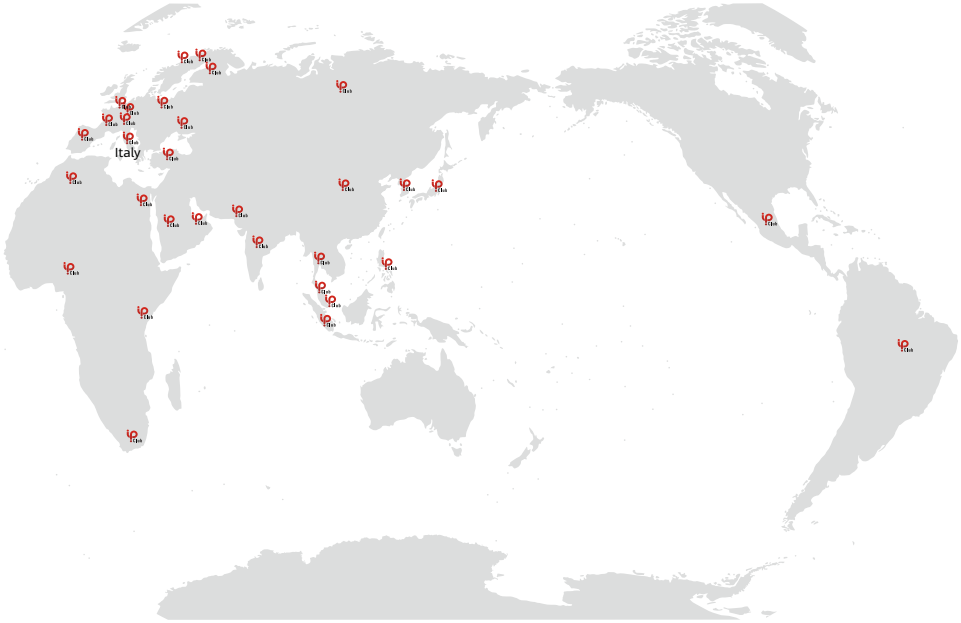
In IP Club, you will be joined by the best minds in the industry from around the world, engaged in thought-provoking conversations about future network development trends, explore new opportunities, share perspectives on digital transformation, and chart the way forward.

Since its launch in early 2018, IP Club has held nearly 140 theme events in 30 countries and regions, attracting more than 17,000 technical experts from various industries. Because of the impact of the COVID-19 in early 2020, IP Club moved from offline to online. To date, 35 online events have been held in 22 countries, with more than 10,000 participants.

Huawei will invest in IP Club over the long-term, to make it the global platform of choice for those interested in IP technology. We welcome more to join us. Together, we will "Rethink IP" to create greater value for customers, the industry, and ourselves. Let us join hands to build a fully connected, intelligent world. ▲

Register as an IP Club member

https://events02.huawei.com/ipclub/mall/html/registrationForm.html



Becoming an Internet Architecture Board Member

By Robin Li, IAB member of IETF & Chief Standards Representative of Data Communication Product Line

At the beginning of 2019, I was honored to become a member of the Internet Architecture Board (IAB) of the Internet Engineering Task Force (IETF). IETF in IP industry is equivalent to 3rd Generation Partnership Project (3GPP) in mobile network, and an IAB member is equivalent to the vice president of the Project Coordination Group (PCG) of 3GPP. I have been engaged in IP R&D since I joined Huawei in 2000.In 2009, I started to participate in IP innovation research and the promotion of IETF standards. It took me 20 years to become an IAB member. These 20 years also map the journey of Huawei router products, from unknown products to the top of the global carrier, which demonstrates how much Huawei has progressed in the IP domain.

From Naive to Mature

In 2005, the product line started investing in the MPLS solution's R&D. I was responsible for design and development of a series of MPLS features. Just when we were about to complete the development of the Fast Reroute (FRR) feature, a major defect was found: when a link failed, traffic could be properly switched to the backup link within 50 ms; but, after the link recovered, it took one second to switch the traffic back to the original link. After some troubleshooting, it became clear that we hadn't considered the service logic of traffic switchback during the design process. As a result, the FRR feature became totally unavailable and needed a redesign. In 2006, MPLS-TE primary/backup protection feature received several major complaints because we hadn't considered the need for secondary protection. When the primary and backup paths were both interrupted continuously, VPN traffic was interrupted continuously. I have worked on numerous features during my career over a decade in MPLS R&D, but these two complaints are more significant. As I've always said, setbacks are part of life.

Every time we slipped up, we strived to rise again. We gradually added features and deepened our understanding of networks so that we could be more aware of customer pain points and innovate accordingly. We proposed a challenging goal to provide uninterrupted MPLS tunnels. To achieve this goal, we developed the best-effort path feature of MPLS TE tunnels and allowed users to specify multiple MPLS TE tunnels for load balancing in a tunnel policy. We also allowed services to be switched back to MPLS LDP tunnels when MPLS TE tunnels are interrupted. In the MPLS TE FRR solution, we developed the feature of delayed switchback upon link recovery to ensure zero packet loss. These features played an important role in the key project development for a multinational carrier in Spain. The customer found that our design was more complete, easier to use, and more intuitive than competitors' offerings.

We will always face hardships and setbacks, but they are essentially the accumulation of experience that allow us to grow and give us a better understanding of service scenarios and technologies. With new technological opportunities such as SRv6, we are in a good position to quickly innovate and formulate standards, taking a lead in the development of next-generation IP technologies.

Long-term accumulation of these hardships is the basis for innovation. As individuals or organizations, we need to continuously improve ourselves and stay ready.

From Shots in the Dark to Vision-Driven

The industry recognizes the dedication of Huawei employees. A can-do attitude is pivotal to our success. However, when it comes to divergent technological innovations in the IP industry, it is critical to select a technological route. In the past, Huawei's R&D was driven by market projects. To try to win bids for projects, marketing engineers would receive numerous requirements, making technological development erratic and inaccurate. R&D faced great pressure in delivery and was overburdened. After long-term accumulation, we are now able to understand the network and customer pain points and must learn to make strategic efforts.

At the beginning of SRv6 technology development, the product line was divided on technology selection. In 2017, we spent a lot of time discussing whether to use SR-MPLS6 or SRv6, which was still quite new. Even after some SRv6 features were delivered, Kevin Hu (President of Huawei's Data Communication Product Line) held multiple meetings for discussions. Through several rounds of discussion, we gradually came to understand that SR-MPLS6 was just a supplement of the MPLS feature. An IP network strategy oriented towards 5G and cloud can be built only on SRv6. With this realization, we reached a consensus and made every effort to implement SRv6.

R&D is difficult for such emerging technologies, but what's more challenging is keeping up with market expansion and industry guidance. In the past, Cisco led the IP industry, and others followed. This was the first time that Huawei took the lead in a technical transformation. We defined application scenarios, aligned with customer strategies, and built an industry ecosystem. We started from scratch and advanced cautiously, but the whole journey was full of excitements.

More importantly, we jointly developed technical innovations with customers to bring benefits of SRv6 to customers, which were well recognized. We had deployed nearly 20 SRv6 commercial networks in 2019. Under the guidance of the expert committee for promoting large-scale IPv6 deployment, we set up an IPv6+ technology innovation team to integrate new technologies such as SRv6 into China's IPv6 industry strategy.

To further promote industry consensus, we have organized multiple SRv6 industry forums. Because of unforeseen circumstances, the second forum was held a week ahead of schedule. We got the draft of the presentation slides only two days before the meeting. We had to align and communicate with the speakers day and night. Working so much overtime gave a sore throat the night before the meeting. At this time, the meeting affairs team leader called and wanted to determine the seat arrangement for the guests. Because I had a speech the next day, I asked her to go through the possible arrangements, and I responded only with "yes" or "no," to protect my voice. After the forum, a familiar feeling arose. After working at Huawei for a long time, I feel that our work is often like a glass — smashed to pieces suddenly and placed in front of us, and then we put it back together piece by piece, until at the last moment, the glass was finally ready. Able to be stitched together and displayed beautifully in front of the world.

From Talent-Centric to Team-Centric

At the end of 2006, the MPLS feature started to be widely used in the market. We needed to add many features features. However, because of organizational changes, the MPLS development team had only two experienced employees. I had to find a workaround and struggled to cope with the situation. I even felt a bit depressed at one point. At the retreat meeting for the product line, I finally got angry and complained about the difficulties brought by the organizational changes to the MPLS feature. Chen Jie, my colleague and old friend, comforted me and said, "I understand you very well. You are upset because of the passion you have for MPLS." The word passion struck a chord with me. During this intense period of work, technologies and products seemed to bring us endless trouble and pain. But when I heard Chen Jie's words, I felt positive, even moved. In the days that followed, this feeling encouraged me, and we worked hard to re-build an MPLS team. I was later transferred to different positions focusing on different fields, such as solutions, key account development, planning, architecture,

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standards, research, and industry. Every time I got a new position, I would focus on team development, and these team members have become the backbone of Huawei IP.

In 2010, when promoting innovation in IP protocol, I communicated with a predecessor at the Huawei US Research Center. He told me that Cisco's success was attributed to a close combination of products, standards, and markets. In contrast, Nortel Networks proposed many good innovative ideas, but its products failed to keep up. That's why NT failed. Alcatel-Lucent has done a good job developing products and solutions, but has limited influence in developing standards. I was deeply impressed by these words. How do we organically combine Huawei's products, standards, and market? David Wang later became President of the Network Product Line, where he also pointed out the shortcomings of IP standard innovation. The product line strengthened the operation of the IPSSC and established project teams for key standards, such as SRv6, telemetry, and 5G transport. The team members are key to areas such as pre-research, standards, products, solutions, marketing, and sales, where they form a joint innovation force. The product line developed the NetCity mechanism, carried out joint innovation with key customers, and made products and solutions more competitive through fast iteration. In 2019, the Genome in a Bottle (GIAB) mechanism was launched. Experts from different fields, such as product management, solution architecture, and standards, were arranged to hold scenario-specific and future-oriented strategic workshops with key customers. These moves have made our work more organized and effective.

While promoting SRv6 innovation, our team members contributed innovative ideas in many emerging fields, such as network slicing, iFIT, DetNet, SFC, BIER6, and APN6. I was always excited to communicate with team members about their ideas, and these innovative ideas have gone beyond the scope of SRv6. A strategic blueprint for IPv6+ has gradually become clear, along with a huge opportunity for the 5G and cloud era. I feel strongly about the strength of the team. I'm glad that we have a strong team that paves the way for future innovation and development.

From Timid to Self-Confident

In 2008, I left the familiar SE position and went to Europe for business development with Tier-1 carriers. I was full of anxiety at that time. When I spoke with customers, they would sincerely tell me, "Do not look down on yourself. Our relationship is not 'we give requirements and you develop products and solutions based on them.' We value Huawei's status as a multinational company, and hope to learn from your industry experience and get some guidance from you." When I participated in the IETF standards, an industry predecessor from Huawei's research center in Canada told me, "Huawei must send its best IGP and BGP experts to the IETF. The language barrier isn't a problem. The most important thing is the technology. Huawei supports countless large-scale networks all over the world. Such experience is unparalleled." Boosted by these words of encouragement, we have made the impossible possible on the road of protocol innovation.

In IETF meetings, a person can typically present a maximum of three to five topics. To open up innovation of IP standards, I made 15 presentations at the IETF 88 meeting in 2013, covering almost all important working groups in the routing field, talking to experts in various fields. As we have published many articles and presentations, the peers who attended the IETF 88 meeting said that Huawei's innovation in the routing domain with its lack of innovation is going to have a big impact. Over the past few years, Huawei has made significant contributions to the standardization of SDN transition, SRv6, telemetry, and other fields. These contributions have been well received by peers. In early 2019, I was honored to become a member of the IETF IAB, the first IAB member from Huawei and even from an Asian enterprise. What's more, I'm glad that our work in IETF has attracted the attention of customers, especially our innovation in the strategic direction of IPv6+. Customers are impressed by Huawei's new ideas and feel that Huawei has changed.

In 2019, Huawei maintained its leading position in the global carrier IP market. IPv6+ innovation and standardization were in full swing. Huawei's commercial deployment of SRv6 far exceeded that of competitors. We are giving it everything we've got to lead in innovation, and are assuming major responsibilities to promoting IP technology innovation and continuously contributing to the IP standards community. A multitude of IP heroes have progressed their way up from zero. They have matured, gained confidence, and become more firm. Our young colleagues may be as hesitant as I once was, but I'm sure a new generation of IP heroes will emerge among them.

We are facing one of the best development opportunities in history. Let's strive ahead with confidence. ▲

Robin Li (third from the right) and colleagues

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