Transforming consumer experience and industry capabilities with E2E 5G

How technology is connecting the unconnected

Dell'Oro on telecom market trends for 2020

The road to intelligent connectivity

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

In this new intelligent world, AI will be as ubiquitous as
the air we breathe. It will be the invisible presence that constantly strives
to make our lives better, dissolving borders, simplifying business,
and bringing us closer as human beings.

It is our privilege at Huawei to be the ones that
connect the world to its next leap in civilization – a leap forward
where technology lifts the world higher, bringing
digital to every person, home, and organization.

Building a Fully Connected, Intelligent World

The road to intelligent connectivity

The coronavirus pandemic has demonstrated the value of telecommunications infrastructure in a way that we've never seen before, with big data platforms, high bandwidth, low latency, and elastic capacity all proving essential to keeping society functioning and helping to fight the virus.

After businesses got back up and running in China, for example, network traffic quickly increased by 70 percent in 46 percent of the nation's data centers. In Europe, Italy's lockdown saw subscriber call minutes shoot up by 50 percent, while data traffic from WFH and online education increased fourfold and fivefold, respectively.

The Body of European Regulators for Electronic Communications (BEREC) asserts that the crisis has shown the importance of full connectivity and will in turn influence its work over the coming years.

At the same time, more nations are prioritizing the Industrial Internet to drive manufacturing and foster emerging industries. On April 23, 2020, the China Alliance of Industrial Internet (AII) released nine white papers, setting out eight major directions: Industrial Internet top-level design, campus, network, identifier resolution, edge computing, information modeling, industrial intelligence, and digital twin.

From the perspectives of macro policy, technical readiness, and network architecture standards, the Industrial Internet is maturing and creating new requirements for connectivity. These requirements center on quality (differentiated services and assurance capabilities in bandwidth, latency, jitter, and availability), elasticity (scalable connection resources), synergy (cloud-network synergy and connection-computing power synergy), and automation (agile delivery, online operations, and automated O&M).

Diverse scenarios and complex networks will become the new normal. Huawei believes that the connectivity domain requires a complete upgrade guided by the convergence of connection technologies, big data, and AI.

Driven by technology and business, Huawei will work with customers and partners to target the four major requirements of quality, elasticity, synergy, and automation. Together we will build full-scenario smart connectivity networks for consumers, homes, and enterprises, harnessing 5G, F5G, intelligent IP, and autonomous driving networks.

Executive Director,
President of ICT Strategy & Marketing

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Transforming consumer experience and industry capabilities with E2E 5G

The evolution from 1G to 5G has spanned a relatively short 30-plus years, but the way people live and work has been transformed beyond recognition. What technologies are underpinning this transformation?

Gan Bin
Chief Marketing Officer,
Wireless Network, Huawei

As 5G can match the network speeds of fixed fiber, 5G will play a greater role in home wireless broadband access scenarios.

When 5G was first defined, it had two key goals: One, improve the mobile Internet experience, and two, enable the digital transformation of industries.

In 2019, 62 operators worldwide announced commercial 5G rollout, nearly 200 5G devices were launched, and 5G spectrum was distributed in more than 50 countries. In 2020, 5G will enter a critical period of accelerated development, kicking off a new chapter in commercial deployment, the industry ecosystem, and industry applications.

Following a decade of investment in 5G research that dates back to 2009, Huawei has built leading advantages in standards and technology, commercial products, and the industry ecosystem. In 2020, Huawei has released a series of full-scenario, ultra-broadband products and solutions that deliver seamless coverage for subscribers; provide network infrastructure for cloud, big data, and AI to empower every industry; and build a digital ecosystem where all things are connected and intelligent.

All-scenario 5G

To balance capacity and coverage and provide subscribers with a consistent experience, different combinations of macro-, pole-, and micro-site products are needed for different scenarios.

Huawei's all-scenario product portfolio forms a three-layer, three-dimensional network architecture: macro sites for 5G basic coverage, pole and micro sites for supplementary coverage in difficult-to-build areas, and micro sites for indoor digitalization. For macro sites, Huawei has launched a Massive MIMO product that weighs only 25 kg. Under European regulations, it can be transported and installed by just one engineer, which can dramatically improve network deployment efficiency for carriers.

Huawei boasts an extensive Massive MIMO product portfolio and unsurpassed performance thanks to industry-leading software and algorithms, including MU-MIMO, SRS antenna selection, and full-channel Beamforming, which combine to boost capacity, rate, and coverage. In 2019, RootMetrics and Connect tested 5G network performance in South Korea, the UK, and Switzerland. They found that that subscribers could experience download speeds on Huawei-built 5G networks that were 1.5 to 2 times faster than competitor networks, even with 20-percent less spectrum resources.

As 5G can match the network speeds of fixed fiber, 5G will play a greater role in home wireless broadband access scenarios. In many regions of the world, it isn't viable to implement home broadband access using fixed networks due to

In operators' networks, Super Uplink has been shown to reduce latency by 30 percent and boost the uplink rate by four times.

restrictions such as the high cost of fiber rollout, the complexity of upgrade projects for low-speed copper, and right of way over private land.

However, it's easy to provide high-speed wireless broadband access to households by deploying outdoor customer premise equipment (CPE) in locations near 5G sites and pairing them with indoor units that convert the signals to wireless. This solution avoids the need for trenching, underground cables, and drilling through walls to connect homes, representing the best choice when fiber cannot be deployed.

In 2019, 4G fixed wireless access (FWA) solutions were rolled out in more than 230 networks across 120 countries, and now serve 100 million homes. In the future, more households and SMEs will be able to enjoy gigabit access rates and diverse 5G services through 5G FWA.

Simplified 5G products

Thanks to its extensive experience in network deployment and first-mover advantage in 5G commercialization, Huawei recognizes the challenges, such as spectrum dispersion and limited space for antenna mounts, that operators face with commercial 5G rollout. That's why Huawei has developed a pioneering line of simplified Massive MIMO products and solutions, including 400 MHz ultra-wideband Massive MIMO and simplified Blade AAU. These solutions can help operators deploy 5G networks with seamless coverage more cost effectively and efficiently.

Contiguous large bandwidth on mid-band spectrum can maximize 5G Massive MIMO performance and strike a balance between capacity and coverage. However, many

operators are likely to obtain discrete spectrum that isn't contiguous, due to factors like high satellite occupancy and discrete spectrum allocations. Huawei has launched a Massive MIMO product that supports up to 400 MHz bandwidth. Using a single module, operators can utilize all the discrete spectrum within 400 MHz, helping them reduce the amount of hardware they need, simplify site deployment, and slash TCO.

As mobile communications have developed and new standards evolved, we've seen an incremental rise in the deployment of antenna modules to the point where most operators around the world are challenged by a lack of space. Huawei Blade AAU simplifies this complexity by integrating 5G Massive MIMO AAU and legacy RAT passive antenna modules into one unit. This active + passive integrated design keeps the total height of the module under 2 meters.

The design supports all sub-6 GHz frequency bands, so that operators can swap out their legacy 3G/4G antennas for Blade AAU. It also solves the issue of only having a single antenna mount for 5G deployment. Furthermore, Blade AAU's integrated design slashes site installation time, boosting 5G network construction efficiency and shortening rollout time. Since its launch, Blade AAU has become the preferred choice of many operators around the world and has been deployed commercially in multiple networks around the world, including in Switzerland and China.

2020 will be the year of commercial 5G rollout on a wide scale around the world. The mainstream choice for deployment is TDD mid-band spectrum. But deploying 5G networks

on sub-3 GHz FDD spectrum can enable rapid coverage and achieve lower latency. 5G can be deployed directly onto newly acquired FDD spectrum, as 5G NR technology will dramatically improve spectrum efficiency and subscriber experience. To build 5G on existing FDD spectrum, Huawei's Dynamic Spectrum Sharing (DSS) solution can allocate real-time dynamic spectrum resources in milliseconds based on LTE and 5G service and traffic requirements, thus maximizing spectrum resource utilization. In November 2019, Huawei's DSS solution was verified and rolled out commercially in European networks. Millions of Huawei FDD RRU modules can be upgraded with the new solution, which will help speed up 5G deployment.

For the sustainable and healthy development of mobile communication networks, 5G connectivity has to be green. Huawei offers comprehensive energy-saving solutions with new technologies, new site forms, and AI-based network coordination, which combine to drive up energy efficiency.

Huawei's technical design, algorithms, advanced materials, and heat dissipation technology have culminated in 5G AAUs with equal energy consumption to 4G RRUs, while offering 50x the capacity. Huawei's AI-based energy-saving solution enables fine-grained, precise

energy-saving based on the service requirements of different scenarios by implementing collaborative signal, channel, and carrier shutdown technologies across multiple RATs and bands, all without impacting KPIs.

Industry digitalization with 5G E2E solutions

With the 5G Release 16 standard expected to be completed in 2020, 5G capabilities in URLLC (ultra-reliable low-latency communication) services will increase. As the 5G target network architecture, standalone (SA) will support customization needs. Huawei currently provides end-to-end (E2E) support for both non-standalone (NSA) and SA architecture, from the RAN and core network to devices and chipsets, with full support for simultaneous NSA/SA device access. This can help operators build full-service capability for end-users, homes, and industries.

In legacy TDD systems, resource (time slot) allocation mainly focuses on eMBB requirements, causing downlink capability to far exceed uplink capability. With 5G enabling the digital transformation of industry in the future, demand for high uplink bandwidth and low latency, such as from 4K/8K live streaming services, will grow. Meeting these requirements will be impossible on TDD frequency bands alone. To address this, Huawei has launched its E2E Super Uplink

solution, which coordinates the use of TDD and FDD spectrum, boosts uplink capabilities, and slashes latency. It enables the TDD system to work with full uplink bands to enhance uplink capabilities. Already accepted by 3GPP, Huawei's Super Uplink solution currently offers E2E support for RAN, core networks, and devices. In operators' networks, Super Uplink has been shown to reduce latency by 30 percent and boost the uplink rate by four times.

To better support the digitalization of industries, Huawei has launched an E2E slicing solution for the RAN, core network, transport network, and devices. By automatically generating, managing, and operating slices on the network side, operators can meet diverse industry application needs on the same infrastructure. Huawei's E2E slicing solution supports service assurance for a wide range of industry scenarios, including telemedicine, smart ports, smart factories, and cloud VR/AR. This allows industry users to cut costs and improve efficiency, while enabling carriers to explore new markets.

2020 will be a key year for commercial 5G rollout. With the industry's widest experience in 5G deployment and the most complete product portfolio, Huawei is ready to walk with carriers and industry verticals into a new era of connectivity, productivity, and value. ◨

How technology is connecting the unconnected

Technology should benefit all of humanity. That's why Huawei is committed to creating leading solutions to connect the unconnected as fast as possible.

Ritchie Peng
President, 5G Product Line, Huawei

Over the past 30 years, wireless network capacity has increased by 10,000 times, with a new generation of wireless communication technology coming out every decade, and today's generation taking us into the gigabit era. But, the digital divide still exists. Across the globe, millions of people, households, and organizations are unable to reap the benefits of this technological development because they're not connected to the Internet.

According to GSMA, 750 million people lack mobile Internet coverage and half of the world's population lack Internet access. Even in Western Europe, there's still only weak coverage in 50 percent of buildings.

Technology should benefit all of humanity. That's why Huawei is committed to creating leading solutions to connect the unconnected as fast as possible. For example, the RuralStar series of solutions can provide high-quality voice and data services at optimal TCO in all network scenarios in rural areas.

Fixed Wireless Access (FWA/WTTx) solutions address last-mile access problems for households in densely populated urban areas and sparsely populated rural areas, while our DIS (Digital Indoor System) meets the diverse needs of indoor coverage service scenarios.

These solutions are bringing wireless connectivity to unconnected rural stars, homes, and buildings.

Remote with RuralStar

In around 30 percent of Africa, operators find it hard to guarantee network transmission and power supply due to their remoteness. Because traditional solutions incur high CAPEX and ROI takes eight to ten years, carriers are unwilling to roll out networks in remote areas.

Without wireless connectivity, people not only miss out on the convenience of the Internet, they also cannot develop the digital skills necessary to lift them out of poverty.

Starting in 2017, Huawei has released a series of solutions for villages to meet the burgeoning voice and data needs of people in unconnected areas and reduce operator ROI for rural network deployment. They include RuralStar for villages with populations of over 1,000 and RuralStar Lite for settlements of between 500 and 1,000 people.

These solutions dramatically reduce the cost and difficulty of site deployment by transforming satellite transmissions into wireless backhaul, substituting towers for simple poles, and shifting from diesel to solar power. They also eliminate the need for fences and cabinets as all equipment is pole-mounted.

RuralStar solutions have been deployed in over 50 countries, providing high-quality voice and high-speed data services to more than 40 million rural dwellers.

Huawei launched RuralStar Pro at the 2020 Huawei Products and Solutions Launch in London. The new solution includes features that fill coverage blind spots in extremely remote rural areas with fewer than 500 people.

Adopting an all-in-one design, RuralStar Pro uses high integration-density chips and, for the first time, integrates baseband, radio frequency (RF), and wireless backhaul functions into one

RuralStar Pro includes features that fill coverage blind spots in extremely remote rural areas with fewer than 500 people.

module. These features dramatically lower the power used across the whole site and reduce dependency on support infrastructure, with only two solar panels needed to meet the power consumption demands of the whole site. The use of simplified poles installed directly into the ground simplifies civil engineering works and enables fast four-day delivery. Automated plug-and-play site installation solves the issue of the lack of specialist technicians in extremely remote rural areas.

RuralStar Pro adopts innovative hardware to simplify the support infrastructure required, greatly reducing the cost and difficulty of site deployment. The payback period for carriers is just three to five years, even for rural villages with populations of under 500.

WTTx: Connecting unconnected households

In affluent densely populated places, fiber rollout can be incredibly difficult and slow due to hurdles like private land and right of way. In some cases, it can take years to gain access to certain buildings and properties, meaning that operators cannot provide broadband services to residents. Young renters are often reluctant to install home broadband, despite being heavy Internet users, because they move addresses often.

And in remote areas, issues like high

deployment and maintenance costs, long construction cycles, and poor ROI are common because of the number of processes involved in deploying wired home broadband. These include trenching, installing troughs, and laying underground cables, making it unsuitable for less developed regions.

Developed by Huawei, WTTx is a wireless broadband access solution that provides a fiber-like experience to meet the needs of the broadband market. The solution has gained traction in the mobile market over the past few years.

In the 4G era, WTTx harnessed Huawei's Massive MIMO solution combined with high-performance customer premises equipment (CPE) for maximum spectrum efficiency. WTTx raised spectrum efficiency by three to five times, and cut the cost per gigabyte to between one-quarter and one-tenth of traditional MBB services. It continues to provide fast, low-cost wireless home broadband services for densely populated urban areas and sparsely populated rural areas alike.

In overseas markets, WTTx boasts over 100 million users, forming an effective way to supplement optical fiber broadband connections. In Sri Lanka, for instance, one operator increased broadband penetration from 9 percent to 26 percent of households by leveraging WTTx, helping 800,000 people escape the digital vacuum.

The 5G WTTx service is a natural evolution of 4G WTTx. Industry observers believe that it's the 5G service most likely to be rolled out first commercially. It will provide homes with a gigabit user experience and meet the medium- and long-term fixed broadband service requirements of smart homes, 4K, AR/VR, and SMEs.

Huawei's latest WTTx CPE is lightweight and easy to install. Two forms of weather-proof outdoor installation – wall- and pole-mounted – are supported. The outdoor and indoor units are connected by a flat cable that can be fed through a gap between the window and frame, so that holes don't need to be drilled in the wall. This avoids the time-consuming expense of professional installation.

DIS: Connecting unconnected buildings

Over 70 percent of traffic on 4G networks originates from indoor locations. Industry predictions show that as 5G service types and the scope of the industry continue to grow, more than 80 percent of future data traffic will originate from indoors. In the 5G-powered era, indoor mobile networks will therefore become a core competitive strength for operators.

In legacy macro site coverage solutions offering outdoor-to-indoor coverage, the signal can only provide

shallow coverage. When it penetrates obstacles such as brick walls, glass, and cement, a good experience promised by deep indoor coverage cannot be guaranteed.

However, since legacy components like combiners and power splitters don't support 5G's new frequency bands, there's no way to support MIMO by installing extra feeders and antennas. This prevents smooth evolution from a distributed antenna system (DAS) to 5G.

Huawei has launched a series of new 5G DIS products and solutions that are less than 2L in volume to bring 5G into buildings and enable industries.

For high-volume, high-value scenarios requiring a good experience, such as airports, train stations, and shopping malls, Huawei has launched a more powerful 5G 4T4R LampSite product, which supports headend equipment at the 160 MHz, 200 MHz, and 300 MHz bandwidths to meet the needs of various deployment scenarios. By the end of 2019,

LampSite had been deployed in more than 20,000 buildings by almost 40 operators in 28 countries.

In 2020, 5G will gradually rollout to factories, hospitals and other vertical industries as 5G modules for industry are commercially adopted on a wide scale. Huawei launched LampSite EE for industry scenarios based on five 5G capabilities: indoor ultra-broadband, indoor precise positioning, industrial-grade ultra-low latency, indoor high reliability, and industrial-grade high-density concurrency. The solution is designed to help carriers and enterprise users build modern wireless networks and accelerate the digital transformation of vertical industries.

Wherever connections go, more opportunities emerge, triggering socioeconomic development. Huawei designs industry-leading network solutions that can connect the unconnected and help eliminate the digital divide, so that everyone can enjoy universal, equal Internet access. ◧

Powering industry verticals with deterministic networking-oriented 5G core

The 5G core adopts cloud native, one core, real-time operations, and edge computing to deliver 5G Deterministic Networking, differentiated services, and a deterministic experience for all industries, thus making the core key to accelerating industry digital transformation.

Jerry He
President, Cloud Core Network Marketing, Huawei

2019 witnessed the start of 5G rollout. 5G networks and services were deployed faster than expected, with a total of 348 global operators having invested in the latest generation of wireless technology. Of these, 61 have commercially launched 5G services, including augmented reality, virtual reality, and fixed wireless access.

A study by Keystone Strategy and Huawei SPO Lab reports that investment in industry digital transformation is increasing year on year. By 2025, it's estimated that

the revenues of global ICT vendors will reach approximately US$4.7 trillion based on ten industry verticals:

1. Manufacturing/supply chain
2. Smart city
3. Energy/utilities
4. AR/VR
5. Smart home
6. eHealth
7. Smart agriculture
8. Intelligent retail
9. Automotive
10. Drones/autonomous vehicles

The 5G market is expected to be worth US$1.6 trillion, more than 50 percent of which will go to mobile operators. 5G is key to industry digital transformation, and Chinese operators and their industry partners are leading the way.

In 2019, China's Ministry of Industry and Information Technology (MIIT) held its second 5G application contest. A total of 3,731 projects were entered, covering more than ten industries and three scenarios: smart life, digital governance, and industry digitalization. Smart life applications bring immersive experiences and new innovations to life and work. Digital governance applications focus on improving urban governance capabilities and efficiency. Industry digitalization applications utilize 5G in industries to drive digital transformation and develop new enterprise opportunities.

An analysis of more than 100 applications from over ten industries showed that the requirements of industry digital transformation using 5G networks can be divided into three dimensions: differentiated networks with capabilities that can be orchestrated, dedicated networks with guaranteed data security, and self-service (DIY) networks with automated management.

Differentiated networks

Differentiated networks are critical for industry digital transformation. Unlike the consumer market, industries have diverse requirements. For example, remote metering prioritizes massive network connection density over bandwidth and latency, while telemedicine and autonomous driving depend on low latency within a deterministic range, plus strict security and reliability. The magnitude of these 5G capabilities can be hard to appreciate; for example, to reach a reliability rate of 99.9999 percent, an annual fault time of only a few seconds is acceptable. Previous generations of mobile technologies focused on bandwidth, but 5G revolutionizes industry by providing multi-dimensional network capabilities while guaranteeing experience.

Dedicated networks

Dedicated networks securely isolate data and protect data privacy, a common requirement of business globally. Industrial internet and smart grid applications, for example, have high requirements for network security, roles, domain-specific management, resource isolation, and data and signaling security. Campus-limited access to production data and user data is a common requirement for dedicated virtual isolation networks.

Self-service (DIY) networks

Self-service (DIY) networks enable agile innovation in industry verticals. Industry users need to customize, design, and tailor their networks to meet frequently changing service user requirements. For instance, a campus IoT

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service user needs to orchestrate, schedule, and manage IoT network service parameters to flexibly deploy networks and applications, or to add or delete devices.

5GDN (5G Deterministic Networking), with guaranteed SLAs, can apply to industries with less rigid SLA requirements, but most suit market segments with the strictest requirements and highest potential revenues.

Building CORE-based 5GDN

5GDN uses 5G network resources to build manageable, verifiable, and deterministic virtual private mobile networks, offering customers a predictable and differentiated service experience.

Before 5G arrived, the MBB network was a best-effort network, and only-fixed network private lines had specific SLA requirements. Unlike individual or home packages, enterprise private lines, which receive the

same bandwidth as consumer packages, not only require bandwidth guarantees, but also SLA guarantees for reliability, service availability, professional services, and more. For the Industrial Internet, which has strict requirements, IEEE and IETF have defined the TSN standards and established the DetNet working group to study the development of deterministic communication in industrial automation and other fields.

Mobile networks and fixed networks differ in SLA guarantees because a mobile network comprises the radio access network (RAN), transport network (TN), and core network (CN). With scarce resources, the RAN is open and prone to interference, and unpredictability leads to non-deterministic results. CN is key for network topology and resource scheduling, service orchestration and scheduling, and E2E service experience management. Furthermore, the CN provides a deterministic experience for service

applications and networks based on service awareness, helping the RAN become more deterministic. Therefore, the CN is regarded as the real core of 5GDN, perhaps even of the entire 5G era. To ensure they benefit from this, operators can plan and build a 5GDN based on the "CORE" factors: Cloud native, One core, Real-time operations, and Edge computing.

Cloud native

Cloud is the foundation of 5G. 5G will increase data traffic by more than 10 times, 75 percent of which will be generated at the edge, increasing the construction of edge gateways 100-fold. This requires a powerful cloud platform to support the agile, efficient, and elastic on-demand core network. The microservice and container technologies provided by Cloud Native make the entire network more reliable, flexible, and agile.

Huawei's next-generation, hyper-converged cloud platform combines IP and IT capabilities, and fully integrates network forwarding acceleration, graphics and imaging acceleration, and AI computing acceleration capabilities. It reduces bit costs and improves the energy efficiency ratio, meeting the 5G requirements of huge traffic volumes and high bandwidth. The Huawei Telco Converged Cloud (TCC) uses the dual-engine architecture of VMs and containers to implement flexible resource

scheduling and meet data and service isolation requirements. This simplifies deployment, protects investment, and enables smooth evolution to meet different deployment and service requirements of the central and edge networks.

One core

5GDN must be an access agnostic core that supports all radio access technologies (RATs), since the existing 2G/3G/4G terminals and services are inevitably involved. Some industry applications are highly dependent on voice and SMS services, so a voice network and efficient voice codec capabilities are also crucial.

Based on microservices, 2G, 3G, and 4G are integrated into the 5G core network, allowing network resources to be flexibly and dynamically shared and all existing services to be inherited. The centralized deployment of its control plane and one-stop user plane simplifies network architecture, ensures smooth software evolution, reduces network delay, improves user experience, and supports migration to 5G without changing cards or numbers.

Real-time operations

Dynamic network slicing is implemented on 5GDN, requiring the full automation of network deployment, provisioning, O&M, and other processes. Work order-based processing on traditional networks cannot accommodate the

efficient development of industry services. Therefore, the portal mode can be used so that industry users autonomously handle processing. Each industry user customizes and purchases required slices from the online store, and then manages the network slice through one-click provisioning, remote monitoring, and O&M.

Huawei's fully automated multi-dimensional dynamic slicing achieves the multi-dimensional slicing of users, services, and network capabilities by integrating the management plane and multi-dimensional intelligent modeling. Dynamic slicing also enables the fine-grained orchestration of microservices. With the fully automated programmable pipeline engine, one-click slicing deployment is implemented within minutes. Huawei's in-house AI algorithm engine and global resource scheduling capabilities support second-level precise awareness of slice SLA, real-time resource scheduling, dynamic optimization, and closed-loop management.

Edge computing

5GDN uses MEC to deliver differentiated connectivity and SLA guarantees for enterprises and industries. The high-performance connectivity provided by MEC enables operators to combine connectivity with applications to fit service requirements and the SLA requirements of different industries.

Operators need to select appropriate industries and scenarios by exploring opportunities for early 5GDN deployment during network planning.

Based on the enhanced connection plus computing capability, Huawei's ultra-high performance heterogeneous MEC provides deterministic low latency on demand, a complete development platform with tools to accelerate service innovation, and cloud-edge collaboration to share the ecosystem on public cloud for quick edge ecosystem rollout.

The Huawei 5G LAN provides virtual private network services on the 5G public network, providing wider coverage, convenient mobility, and secure access, with ubiquitous 5G dedicated local area networks (LANs) for verticals.

Global application of 5G deterministic networking

5GDN cannot be deployed in one go, and 5G deployment by operators is still in the early stages. Operators need to select appropriate industries and scenarios by exploring opportunities for early 5GDN deployment during network planning. Independent areas, like enterprise campuses and ports, should be prioritized for 5GDN deployment. Machine vision integrated with video for industrial scenarios is also suitable for early 5GDN deployment. Industries themselves can choose when to deploy 5GDN. Some industries with high SLA deterministic requirements, such as the electric power industry, may want to prioritize 5GDN deployment.

Huawei was the first company in the industry to propose the idea of Deterministic Networking in May 2019. In June at MWC Shanghai 2019, Huawei and its industry partners established the 5GDNA (5G Deterministic Networking Alliance). In Feb 2020, Huawei, the China Academy of Information and Communications Technology (CAICT), China Mobile, China Telecom, China Unicom, and other partners jointly released the *5GDN Industry White Paper.*

To date, 5GDNA has more than 100 members with a series of cross-industry collaboration based on 5G deterministic networking in fields such as multimedia, industry, energy, healthcare, and IoV. The 5GDNA has showcased many 5GDN use cases, such as Shanghai Yangshan smart port; the smart grids constructed by State Grid Corporation of China (SGCC) and China Southern Power Grid (CSG); the Haier smart factory in Qingdao; the AR-based cultural tourism project at Beijing Expo – the Wonderland of Mountains and Rivers; and AR ads in Shenzhen Airport. These achievements demonstrate the feasibility and business value of 5GDN applications in verticals and indicate the success of the 5G ecosystem.

5G brings unprecedented changes and opportunities to the telecom industry. By exploring the CORE and 5GDN concepts, telcos can finally break growth bottlenecks. H

Powering premium private lines with All-Optical networks

Optical Networking 2.0 (ON2.0) enables high-quality private lines with guaranteed bandwidth, low latency, high availability, and fast service provisioning. ON2.0 helps carriers build OTN premium private lines and provide an outstanding service experience.

Simon Lu
President, Transmission Network Domain, Huawei

The combination of fifth-generation fixed fiber (F5G) and 5G will accelerate the arrival of a fully connected, intelligent world. By 2025, 100 billion devices will be connected across the globe and 30 percent of homes will enjoy gigabit broadband; a total of 1.3 billion 5G subscribers will be using 5G networks, which will have covered 58 percent of the world's population; and around 337 million people and 10 percent of companies will use

VR/AR. Moreover, all enterprises will use cloud services, 85 percent of enterprise applications will be deployed on cloud, and 180 ZB of data will be generated each year.

The explosive growth of 2C, 2H, and 2B services is driving carriers to accelerate full-service deployment. But, it's a growth that presents a challenge for bearer networks. 5G requires a tenfold increase in network bandwidth, connections, and availability compared with 4G. It also requires a 90 percent decrease in latency, packet loss, and service provisioning time.

In the 2B arena, business private lines will open up the enterprise market as government and enterprise services migrate to cloud. In addition to offering secure, reliable, and carrier-class

network services, carriers must provide one-stop, self-service, bundled cloud and network services that are agile and intelligent if they hope to remain competitive.

The near-obsolete and segmented point-to-point dump pipes of optical networks provide only physical connections that cannot meet the transmission requirements of new services in the 5G era. Transforming from connection-centric dumb pipes to experience-centric service transmission networks is a current priority of carriers.

ON 2.0: All-optical service transmission networks

Huawei has launched its ON 2.0 solution to help

carriers build all-optical service transmission networks that offer faster speeds, new sites, and smart O&M, and enable carriers to deliver an outstanding service experience.

- **Faster**: Single wavelength 200G/400G is now the standard rate of next-gen optical transmission. Advancements in materials, chips, and algorithms have accelerated speeds towards the Shannon limit. Huawei's Super 200G solution doubles fiber capacity while slashing TCO with CFP2 green design. And Huawei's latest 800G optical module supports multiple rates from 200 Gbps to 800 Gbps, with industry-leading performance and spectral efficiency. Huawei has also launched the industry's first single-fiber Super C solution, achieving the industry's highest per-fiber capacity of 48 Tbps, reducing per-bit cost, and meeting the bandwidth requirements of new services.

- **New sites**: Advances in the optical and electrical layers promote the wide application of optical-electrical convergence and all-optical cross-connections, reducing the layers of the backbone and metro networks and enabling the unified transmission of 2C, 2B, and 2H services. Huawei's all-optical cross-connect OXC product is the world's only commercial product of its kind. It can build a 3D backbone network and support large-capacity all-optical grooming and one-hop connection between sites, implementing fast E2E service provisioning. Huawei's new Liquid OTN solution uses flexible hard pipe technologies to simplify architecture and adapt to premium private lines, premium video, and 5G integrated transmission scenarios, building an all-optical base for the 5G era and enabling the prosperity of various industries.

- **Smart O&M**: The iMaster NCE intelligent management and control system achieves full-lifecycle management in optical networks, improving the private-line experience. Preventive maintenance through AI modeling reduces the network fault rate, while the cloud-based smart brain and network planning design ensure that resources are available and that traffic volume is predictable, so capacity expansion is rational and service provisioning fast.

Four ways All-Optical can boost profits for carriers

ON 2.0 will evolve optical networks from infrastructure networks to service transmission networks and enable new services. High-quality OTN government and enterprise private lines will emerge as an important service for carriers, providing an outstanding experience for business users that builds differentiated competitiveness. Carriers can boost profits in four main ways:

- **Bandwidth**: As hard pipes, OTN private lines inherently have ultra-high bandwidth. Next-gen Liquid OTN technology supports flexible bandwidth adjustment from 2 Mbps to 100 Gbps, meeting the high availability requirements of government and enterprise customers, while supporting the pay-as-you-grow business model. This will attract more private line customers.

- **Low latency**: Emerging network services are a huge market. To compete in this market, latency, like bandwidth, will become a key marketable parameter of competitiveness.

High-quality OTN government and enterprise private lines will emerge as an important service for carriers, providing an outstanding experience for business users.

Huawei's OTN+NCE private-line transmission network features simplified architecture, one-hop transmission, and Liquid OTN technologies, achieving ms-level E2E latency. The iMaster NCE private line latency map implements visualized, manageable, and guaranteed private-line latency. It ensures an optimal service experience for enterprise customers, while allowing carriers to provide diverse latency packages based on customer needs.

- **Availability**: Huawei offers the industry's most advanced ASON 2.0 technology, which supports large networks and automatic recovery in seconds and exceeds 99.99% availability. ASON technology can protect services against multiple fiber cuts, automatically switching diamond services to available routes within 20 ms. The built-in AI chip can predict service interruptions so that configurations can be optimized in advance for smart O&M and risk prevention. Furthermore, a flexible network with multi-route protection can be provided to boost stability and the availability of data transmission. Carriers can provide SLA availability at various levels based on customer requirements.

- **TTM**: Huawei's iMaster NCE supports real-time visualization and unified management and control of network resources. Coupled with the plug-and-play CPE, the NCE supports the rapid online E2E provisioning of private line services, shortening service provisioning time to hours. Enhanced time sequence prediction using AI algorithms and historical data yields informed budgeting and procurement decisions, avoids urgent capacity expansion, and shortens TTM to within a week. Carriers can provide different TTM packages based on customer requirements.

Who's using ON 2.0?

Huawei is at the forefront of transforming industries, promoting the industrial application of ON 2.0, and helping carriers develop business models.

- **2B private line**: China's top three carriers have built more than 20 OTN private line networks with Huawei to meet increasing demand from government and enterprise customers, particularly financial services and Internet companies. In December 2019, Thailand's CAT and Huawei released the first high-quality OTN private line network in Thailand for medium and large enterprises in the public and private sectors, laying a solid network foundation for Thailand's digital transformation.

- **In the 2H video transmission field**: Huawei helped China Mobile to launch its first OTN 4K live video broadcast network. This solution directly pushes live streams from video sources to the OLT through hard pipes, ensuring zero congestion, zero packet loss, and low E2E latency. This solution meets the key transmission requirements of 4K live broadcasts and will be able to support ultra-HD video and VR in the future.

Huawei is also working with the world's leading carriers to explore service scenarios for next-gen optical networks, launching NetCity joint innovation projects and quickly implementing solutions with DevOps that help carriers maximize business value. We believe that ON 2.0 will lead the global optical network industry into a new era. Huawei will work with carriers and industry partners around the world to jointly usher in a new era of optical networks and build a fully connected, intelligent world.

Building AI-boosted Intelligent IP Networks

After more than 30 years of development, IP networks have laid a solid foundation for network connectivity. Now, they're critical to realizing the ubiquitous connectivity that will power an intelligent world.

Kevin Hu

President, Data Communication Product Line, Huawei

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,

Cloud AI iMaster NAIE
Industry's first network AI unit

AI-boosted network management iMaster NCE

Industry's first NCE system that combines governance, control and analysis

AI-boosted Equipment AI Turbo

A comprehensive range of AI Turbo products

Business logic and strategy

iMaster NAIE

iMaster NCE

AirEngine WLAN | CloudEngine Switch | NetEngine Router | HiSecEngine Gateway

Three-layer Architecture of Huawei Intelligent IP Networks

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. Test results show that our AI-powered Wi-Fi solution can:

• Improve the throughput of wireless air interfaces to 58 percent over the industry average.

• Reduce the Wi-Fi channel interference rate to 49 percent over the industry average. In addition, AI can be used for Autonomous Driving on campus networks.

• Rectify about 85 percent of faults within 10 minutes.

What will the Intelligent IP Network look like?

Super Capacity is the basis of Intelligent IP Network architecture. At present, applications including 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 bandwidth more flexibly and efficiently to simultaneously support multiple services, including office work, production, and computing, on a single physical network. Hard bandwidth isolation for traffic from different services enables 100-percent committed bandwidth to support key services for verticals, production networks for enterprises, and IP private lines for operators. 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.

Huawei believes that Intelligent IP Networks have the following characteristics:

Intelligent Experience is the ultimate goal of an Intelligent IP Network. Currently, 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. This 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. Currently, 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 for the Intelligent IP Network

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 an 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

AI training can continuously evolve, enabling the entire system to become smarter so that it adapts to rapid changes in services and networks, thus boosting service quality and experience.

status of the physical network in real time, detect anomalies, 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. It 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, thus boosting 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 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 in DCNs. Huawei's solution can detect 75 types of frequent faults within 1 minute, locate them within 3 minutes, and rectify them within 5 minutes. Huawei's AI-powered DCN solution can implement intelligence in understanding service intent, selecting the optimal network path, evaluating change risks, detecting faults, and rapidly locating the root-cause of faults. 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, 5G + cloud + 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.

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, quick provisioning in WAN networks needs to be resolved 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, 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 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 fivefold. By leveraging 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.

Customer-centricity is Huawei's core philosophy. Customers' 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. ▪

AI-powered services for 5G evolution

Network planning, construction, maintenance, optimization, and operations need to evolve intelligently to support new 5G services, applications, and user experiences. AI can increase the accuracy of user experience-based network planning to increase agility and add intelligence to resolving experience issues.

Bill Tang
President, Global Technical Service, Huawei

I n 2016, Huawei started to apply AI to business processes and the technical work involved in serving its customers, integrating more than 30 years of industry experience into deploying machine intelligence and machine learning (ML) models on its platforms. This technology enables us to provide higher-quality and more efficient services, and more powerful capabilities for developing solutions for our customers.

After three years of successful practice, Huawei Service has accumulated a set of human-machine collaboration methods for designing and implementing service solutions, and built a digital platform of knowledge and models, as well as a training and certification system for new talent.

Agile network construction

We apply AI to each phase of 5G network construction to increase the accuracy of network planning and make rollout more efficient. Multiple data points from areas covering the 5G business, users, and evolution of existing technology are used with ML and iterative computing to quickly and accurately create plans for different scenarios. Technologies such as photogrammetry, optical character recognition, voice recognition, and computer vision are introduced in the survey, design, commissioning, integration, and acceptance phases to continuously improve engineering automation and quality of delivery.

Huawei is also exploring integrated

digital delivery equipment to improve the operational efficiency of sites. Its Integrated Service Delivery Platform is shared with customers, equipment vendors, and partners for project delivery management. Information and instructions from the operator, equipment vendor, and partners are automatically exchanged during project implementation, which makes communication smoother, management smarter, and network construction more efficient.

Intelligent O&M

The co-existence of 2G, 3G, 4G, and 5G networks drastically increases the number of connections between people and things, providing a wide range of services for users but also increasing the number of service requests and issues facing O&M

personnel. Data analysis shows that network O&M problems are increasing by 5 percent annually.

In 2019, Huawei Service provided more than 580,000 cases of technical support on more than 1,700 networks worldwide. Conventional O&M using people and isolated O&M tools isn't sustainable. The introduction of AI for human-machine collaborative IT operations (AIOps) is the preferred choice.

AIOps O&M will not mean breaking the O&M system and abandoning existing tools. Instead, an O&M knowledge platform using existing models can drive the evolution of existing domain- and phase-based, human-dominant O&M to human-machine collaborative O&M.

AIOps won't substitute people; instead, it will enable them to play a greater role with the assistance of machines. O&M talent will take new positions such as network policy engineers, orchestration engineers, and data analysts. People will focus on more important roles in intent design, troubleshooting and key decision-making.

Smart operations

5G is ushering in a new era of communications. It will bring better services, applications, and unprecedented experiences for consumers. It will also create an opportunity for operators to break the conventional "pipe" business model, enabling them to develop new digital services, explore new business models, and foster new industry partnerships.

Huawei has completed an experience model

for the first batch of 5G services, released new experience and network construction standards, and built an AI-based experience management solution with service-network synergy to provide real-time, dynamic adjustment of service experience and network policies. With its convergent data service operations platform and intelligent engine, Huawei helps operators accurately and efficiently attract new users, promote user activity, retain users, and increase value, transforming their conventional operations into smart operations.

Huawei will increase investment in its service experience lab and continue to explore the use of digitalization and AI to more quickly resolve complex user experience problems and prepare for more service scenarios in the future.

Open ecosystems

We believe in simplifying things for customers by dealing with the complexity ourselves. Huawei Service abstracts rules, models, and algorithms from a large number of successful practices and encapsulates them in an open, unified technical platform for customers and partners to use. We want to lower the threshold for applying AI technologies, making them more available and easier to use. Operators and global partners can develop new talent with new methods and skills based on the company's Digital Transformation Practice Center.

Huawei will continue to invest in and improve the capabilities of AI-powered technical platforms by exploring intelligent and agile network construction, intelligent O&M, smart operations, and improved user experiences with operators, industry organizations, and global partners. ∎

> *AIOps won't substitute people; instead, it will enable them to play a greater role with the assistance of machines.*

Dell'Oro on telecom market trends for 2020

At the end of 2019 and in early 2020, we held a series of talks with Dell'Oro Founder and CEO Tam Dell'Oro and Dell'Oro Vice President Stefan Pongratz on telecom market trends.

Dell'Oro Group is a leading independent market analysis and research firm that covers telecommunications, enterprise networks, and data center IT infrastructure. Dell'Oro's main focus started out as networking and telecommunications, before expanding into servers and storage systems, including providing detailed analyses on data center cloud providers.
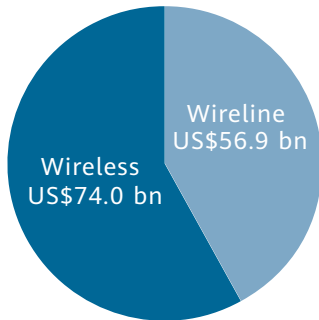
Overall telecom trends

Communicate: What can we expect to see in 2020's telecom market?

Dell'Oro: With the overall telecom equipment market growing by around 2 percent in 2019,

Telecom Equipment/Services Technology Mix 2020 US$131 bn

Wireline US$56.9 bn
Wireless US$74.0 bn

*Dell'Oro Group
Includes: Broadband Access, Microwave & Optical Transport, Mobile Core Network & Radio Access Network, Network Equipment Services, SP Router & CE Switch

the second consecutive year of healthy growth, we can expect multiple technology shifts to unfold across telecom networks in 2020. Now's the time to review some of the more important near-term market and technology drivers.

We're optimistic about how the overall telecom equipment and services market will develop in 2020. Another year of growth in the wireless and wireline markets will be propelled by ongoing shifts from 4G to 5G, 802.11ac to 802.11ax, 100 Gbps to 200 Gbps and 400 Gbps wavelengths, and 100 GE to 400 GE. Technology splits between wireless and wireline are expected to remain fairly stable, with wireless investments expected to outperform wireline both sequentially and in absolute terms. We expect wireless equipment and service CAPEX to account for 55 percent to 60 percent of 2020 revenues.

While upside and downside risks to the medium-term outlook are broadly balanced, short-term risks lean to the downside, reflecting supply chain and macro-economic uncertainties due to COVID-19.

Trends in wireless

Communicate: What will happen in the wireless market in 2020?

Dell'Oro: Thanks to large-scale deployment in China, Korea, and the US, 5G NR continued to accelerate at a rapid pace throughout 2019,

5G RAN and Core Infrastructure Revenue*

US$10~20 bn
US$6.2 bn

2019   2020
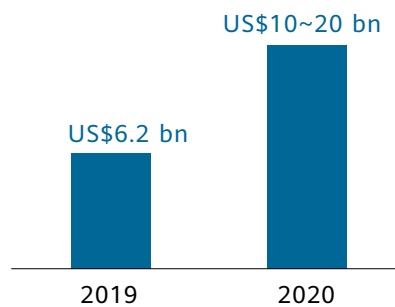
*Dell'Oro Group

much faster than expected four or five years ago, and even as recently as a few months ago. This will continue in 2020.

LTE will remain an important technology for many years to come. It will support emerging markets, manage mobile data traffic growth, and ensure an optimal LTE+5G NR experience for outdoor urban, indoor, and rural settings. Weak revenue growth for operators will limit total CAPEX, and service providers are expected to continue to shift CAPEX from 4G to 5G. The upside from 5G NR will be more than enough to offset declining LTE investments, propelling the overall RAN (2G-5G) market for the third consecutive year of growth.

The Massive MIMO business case has changed significantly over the past two to three years, with the technology now regarded as a basic building block of mid-band NR deployment.

LTE will support emerging markets, manage mobile data traffic growth, and ensure an optimal LTE+5G NR experience for outdoor urban, indoor, and rural settings.

The path to 5G became clearer during the second quarter of 2019 as the options narrowed to two: Option 3: 5G NSA, which utilizes EPC, and Option 2: 5G SA, which utilizes the 5G core.

We recently revised the 2020 Massive MIMO outlook upward, driven by surging shipments and improved market sentiment for 2020. The overall 5G NR transceiver installed base – Massive MIMO plus Non-Massive MIMO for sub 6 GHz and Millimeter (mmW) macros and small cells – is projected to exceed 100 million by 2020.

Suppliers and operators are accelerating their dynamic spectrum sharing (DSS) roadmaps, although some operators have voiced that the transition will probably take longer than expected. However, we remain optimistic that DSS will be pivotal for upgrading low-band LTE sites to NR in the second half of 2020. DSS timing for operators will depend on their overall 5G strategies, as well as device availability. Is DSS a 5G logo, an improved experience, or a stepping stone towards something bigger?

The interest in non-public networks (NPN) is also increasing, and we remain optimistic of small IoT growth in the area of Industrial IoT and Industry 4.0 in 2020 spurred by (1) Suppliers reporting healthy vertical traction; (2) More countries exploring how to allocate spectrum for verticals; (3) The expanding ecosystem of industrial devices; (4) Emerging use cases that require cellular QoS.

The path to 5G became clearer during the second quarter of 2019 as the options narrowed to two: Option 3: 5G NSA, which utilizes EPC, and Option 2: 5G SA, which utilizes the 5G core. In 2020, we will see the first 5G Standalone (5G SA) networks emerge from service providers in China, Korea, the Middle East, and the US. Even with 5G core investments in 2020, NSA using EPC is dominating the deployment mix, so the

5G core/RAN ratio will be significantly smaller than the typical LTE core/RAN ratio over the near-term.

Communicate: What are the main drivers of the shift from 4G to 5G?

Dell'Oro: The main growth drivers haven't changed and include: (1) The rapid shift towards 5G NR for mobile broadband (MBB) applications, which in turn shortens the deployment phase. (2) New CAPEX in IoT, Fixed Wireless Access (FWA), In-building, and Public Safety for both private and public deployment scenarios. (3) The shift from passive to advanced antenna systems, which will shift CAPEX from the antenna to the RAN market.

While the shift from 4G to 5G is much faster than anyone expected, the migration from EPC to 5G core EPC is more gradual. This means the 5G core/RAN ratio will underperform compared with the typical LTE core/RAN ratio.

Communicate: What major 5G use cases do you expect to emerge?

Dell'Oro: The long-term 5G vision will take time to materialize, but we're extremely optimistic about near-term opportunities. Our forecast that 5G NR will be deployed at a faster pace than LTE and surpass LTE in 2021 hinges on certain assumptions: (1) Compelling business cases will arise for MBB applications via 5G NR mid-band. (2) 5G midband spectrum will be available sooner than LTE spectrum was during 3G to 4G transition. (3) New dynamic spectrum-sharing (DSS) technologies will simplify and accelerate migration from LTE to 5G NR. (4) 5G will initially be just another G. Long-term 5G will

be more than another G, but it will take time to reach the full potential of 5G. (5) Complete 5G systems to address new use cases will be deployed gradually, at a slower pace than sub 6 GHz MBB 5G NR.

The overarching long-term vision for potential 5G use cases hasn't changed much since the 3GPP Standards RAN Workshop in 2015. The four main use cases are: (1) **Enhanced mobile broadband (eMBB)**, with extremely high data rates and low-latency communication in some areas and reliable broadband access over large coverage areas; (2) **Massive Machine Type Communications (mMTC)** that supports up to 1 million devices per square kilometer; (3) **Ultra-reliable low-latency communications (URLLC)** in two sub-segments that reflect the tradeoffs and different opportunities between extreme latency and reliability; and (4) **Fixed Wireless Access (FWA)**.

Over the long term, 5G has the potential to be a game changer and go far beyond traditional eMBB use cases, paving the way for new applications and use cases that will alter the way humans and machines communicate and heavily impact the wireless-based economy. But clearly the industry has come to terms with the fact that it will take some time to realize 5G's full potential.

Even as the 5G narrative and near-term technology drivers have evolved with 5G initially being just another G, the long-term vision that 5G will be more than just a faster and bigger pipe still holds. We're more optimistic about the outlook today than we were in the middle of the 4G rollout, partly because there are so many opportunities independent of the shift from 4G to 5G.

Trends in wireline

Communicate: What can we expect from the wireline market in 2020?

Dell'Oro: The demand for WDM equipment continued to accelerate throughout 2019.

Wireline Market in 2020

US$42.9 bn   US$43.0 bn

2019   2020
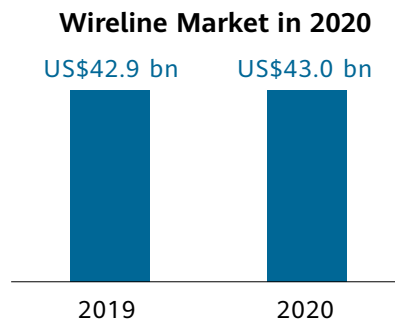
*Dell'Oro Group
Includes: Broadband Access, Microwave & Optical Transport(nonmobile splications), SP Router & CE Switch

Combined with more stable investment trends in PON and SP Core Routers, this was enough to offset the declining cable CAPEX we saw in the overall wireline equipment market – Optical and Microwave Transport (excluding mobile backhaul), Broadband Access, and SP Router & CE Switch – and deliver another stable year.

We anticipate that a confluence of factors will characterize wireline technology trends in 2020.

Wavelength speeds: First, the business case for higher wavelength speeds will improve in 2020 when vendors, including Huawei, begin shipping 800-Gbps-capable line cards. These cards will use the latest optical components, including 90+ Gbaud and photonic integration, and the most powerful coherent DSPs with probabilistic constellation shaping that will bring wavelength performance to near

Shannon's limit.

The shift from 100 Gbps wavelengths to 200 Gbps and 400 Gbps will accelerate in 2020. The use of 200 Gbps wavelengths has already increased, resulting in a steady price-per-bit decline. With the availability of 800-Gbps-capable line cards, the market will deploy more 400 Gbps wavelengths this year.

IPoDWDM: The adoption of IPoDWDM will increase. While it's a decade old, IPoDWDM has never been widely deployed, partly because the target market was core routers deployed in long-haul networks. A better opportunity for IPoDWDM is in metro access applications such as data center interconnect. With the 400G ZR in a QSFP-DD form factor, we should see IPoDWDM more widely deployed in metro applications such as data center interconnect and distributed access architecture (DAA).

Wi-Fi 6: The migration from 802.11ac to 802.11ax will change how service providers think about home networking. In addition to speed, capacity, and range improvements, Wi-Fi 6 also can dramatically improve how service providers provision, manage, troubleshoot, and analyze home networking services. It provides options for remote, zero-touch provisioning of devices and services, and the automatic adjustment of Wi-Fi channels to ensure peak performance.

10G EPON: Cable operators are expected to launch their first 10 Gbps services in 2020, but these will not be tied to the DOCSIS 4.0 specification. Instead, they will rely on 10G EPON from remote OLTs housed in traditional optical nodes. While focused on Full Duplex

DOCSIS to support the mass market delivery of 10 Gbps services to existing residential customers, one US operator is also sprinkling in 10G EPON in greenfield deployments, particularly in regions where it competes with fiber-based ISPs. Other cable operators are following a similar path. But instead of Full Duplex DOCSIS, they will rely on Extended Spectrum DOCSIS (ESD). In both cases, outside plant spectrum will increase to 1.8 GHz.

All leading router vendors will roll out a number of new IP router products that support high-density 400 GE interfaces. Commercial deployments will start to ramp in the second half of the year, and large-scale deployments that contribute meaningful growth will begin in 2021.

With the acceleration of 5G NR, service providers will upgrade IP mobile backhaul networks to support higher-capacity requirements, and upgrade their fiber networks from copper. Routers and switches that support 10 GE, 25 GE, 50 GE, and 100 GE interfaces are expected to be deployed at cell sites and aggregation points. These features will help underpin the shift towards seamless connectivity.

In short, 2020 should be an eventful year as operators continue to advance their wireless and wireline networks to cope with increasingly demanding end user needs while balancing investments to ensure relatively stable capital intensity ratios.

Telecom Capex coverage detailing revenues and investments of over 50 carriers worldwide. ◨

5G: The key to unlocking the future of digital platforms

5G rollouts are commencing around the world, with the technology and its potential making global headlines. However, not every business is aware of the full benefits for the enterprise that the technology can deliver.

Malcolm Rogers, Senior Analyst, GlobalData

Rather than simply providing faster mobile broadband, 5G is a network architecture evolution. It will entail a new way of building mobile networks, and the components of this architecture can deliver different business benefits. Through 5G features such as E2E network virtualization, network slicing, massive machine type communications, ultra-low latency, and mobile edge computing, a 5G network can deliver a technology platform that enables enterprise benefits such as cost savings, improved customer experience, enhanced safety, and new revenue streams.

5G's potential

Globally, 5G network rollouts are accelerating in every region. Handset vendors continue to launch new 5G-ready smartphones and consumers have begun experiencing mobile download speeds well above 100 Mbps. Indeed, 5G can provide high-

capacity connections, boosting video streaming and decongesting rush-hour buffering. However, 5G isn't just about an enhanced mobile broadband experience for the everyday consumer, it will also transform enterprise network architecture. 5G will deliver bandwidth of up to 10 Gbps, which is only possible today over a dedicated fiber connection. But beyond high-capacity links, 5G will drive carrier network transformation. A key component of 5G networks is E2E virtualization (from RAN to core), which enables network functions to be cloud native and artificial intelligence (AI) to be integrated, and drives automation.

Despite the hype around the technology and its potential for enterprise applications, up to 60 percent of IT leaders say that they're not fully aware of the benefits of 5G, according to research by GlobalData.

Connecting everything

Beyond enhancing mobile broadband speeds, 5G will be intrinsic in delivering the next generation of IoT solutions for enterprise and government. Currently, 4G/LTE IoT networks can support sensor connections in the thousands on a single cell. These sensors, devices, gateways, and other connected things collect data, communicate with each other and the network, and collect and analyze business data. This class of solution uses 5G's enhanced

capacity for connecting to a site and is referred to as massive machine type communications (mMTC). mMTC solutions will be the underlying technology that delivers smart utilities, smart manufacturing, and smart city concepts such as dynamic traffic control, and will be used widely in predictive maintenance.

For enterprises, mMTC works to reduce downtime, increase asset utilization, and improve worker safety, ultimately lowering the unit cost of production. These technologies will be central to delivering outcomes for Industry 4.0 and smart city projects that are occurring across the globe.

Take a slice

5G will do more than connect machines and sensors across the factory floor. 5G also has the potential to transform traditional corporate network architecture. Historically, mobile networks have never been viewed as a primary access means for an enterprise wide area network (WAN). However, as 5G proliferates, and more standards and features are added to operator networks, enterprises will begin to consider 5G as a legitimate and critical component for a next-gen wide area network (WAN) solution.

As 5G networks mature, new capabilities will be added. One feature, which is planned to be standardized in the coming years, is network slicing,

or the logical separation of different virtual networks running on the same underlying physical infrastructure. Network slicing, when integrated into a corporate WAN, will enable IT managers to create separate network slices that adhere to policies around bandwidth, quality of service, and more, all on a per application basis. It also allows for networks to be partitioned. Considering the mMTC component of 5G, where operational technology will also be supported alongside IT systems, slicing will be critical for security and compliance as well.

When it just can't wait

Another critical component of 5G evolution is the introduction of ultra-low latency mobile services. Currently, 4G/LTE networks can deliver network latency as low as 50 ms, and while this is sufficient for many business tasks, it can deliver next-gen solutions like autonomous vehicles, real-time video analytics, and remote surgery. 5G has a target minimum latency of 1 ms, with many carriers and their vendor partners already achieving sub-30 ms latency in real network environments, which is 10 times faster than human reaction speeds. This opens up a host of new possibilities for industry, healthcare, and even consumers.

A critical enabler of ultra-low latency applications running on 5G networks will be 5G mobile edge compute

(MEC). MEC is a technology platform that brings the compute and storage functions of traditional data centers and cloud, and brings them physically closer to the edge of a network, where devices collect and transmit data. MEC platforms will differ from other forms of edge compute by natively integrating into the 5G network, which is a key factor that will help deliver ultra-low latency applications. MEC will enable enterprise to run workloads quickly, without the need to keep servers on site, but also without the need to send data all the way to a cloud or data center for processing. This will drive the use of AI for automation and other use cases, with the ability to run AI models more quickly and effectively.

MEC can also enhance security. By placing compute resources at a 5G base station on site, or nearby, sensitive data does not have to travel far for processing. This will be critically important in heavily regulated industries like banking, healthcare, aviation, and government.

Globally, enterprises are already adopting hybrid cloud services, which sees a combination of public cloud, private cloud, and on-premise compute environments used by the same company. 5G will help drive the adoption of edge into this paradigm, as the technology enables even more granularity in the optimization of where applications run.

Putting it all together

The true potential of 5G doesn't come individually from enhanced mobile broadband, massive machine type communications, network virtualization and slicing, ultra-low latency, or mobile edge compute. Rather the true potential is unlocked through a combination of two or

more or all of these elements together. The most impactful 5G solutions and use cases draw on multiple components. Some of these include autonomous vehicles; augmented/virtual reality and mixed-reality for field workers; dense sensor monitoring for asset tracking and preventative maintenance; and the use of wearables to improve applications like workplace health and safety, real-time video analytics, multi-tenant network environments, and tactile Internet.

Right now many operators are focused on the more pragmatic – delivering enhanced download speeds and decongesting networks at peak hours. For example, fixed wireless access (FWA) for businesses and homes is an early use case being put forward by operators like Verizon in the US and Optus in Australia. However, there are technology trials happening around the world that are helping industry move towards the full potential of 5G. Globally, mobile operators are rushing to visualize their network core, transport, and RAN to prepare for the 5G future. The more forward-looking operators are working with partners to trial more advanced 5G services, for example, SK Telecom in South Korea offers a factory automation solution based on 5G MEC. The idea for these operators is to use 5G to transform mobile networks from providing connectivity to becoming a digital platform that supports enterprise solutions.

5G use case: 5G smart port from ZPMC, China Mobile, and Huawei

ZPMC, one of the world's largest crane and steel structure manufacturers, partnered with Huawei and China Mobile to design a solution for port operators that enables the increased automation of port operations, enhanced worker safety, and

Globally, mobile operators are rushing to visualize their network core, transport, and RAN to prepare for the 5G future.

quicker processing of goods through ports.

The solution draws on several critical components of 5G, including enhanced mobile broadband throughput, network compartmentalization, ultra-low latency, and mobile edge compute.

The 5G Smart Port solution consists of the following two parts:

1. 5G+MEC campus-network: The 5G smart ports implemented by China Mobile, ZPMC, and Huawei are built through the 5G-MEC campus-network. A 5G base station, on–site at the port's campus, supports both public services and campus private services. China Mobile defines independent sub-PLMNs (Public-Land-Mobile-Networks) and provides separate SIM cards for ports. Public- and private-network users access different sub-PLMN cells and establish routes respectively with the public 5G core network and the port's local 5G-MEC (UPF).

2. 5G Port applications:

   a. Remote-control cranes: Cameras on the port's cranes transmit multiple 1080p video images to a control center through the 5G network. The crane driver performs operations remotely based on video images from the site. Depending on the size of the crane, the number of cameras ranges from 6 to 27. The 5G network provides 30 Mbps – 120 Mbps uplink bandwidth and 30 ms low latency.

   b. IGV (Intelligent-Guide-Vehicle): Ports rely on manual driving of container trucks. Some automated ports use 4G-based AGVs (Automated Guided Vehicles). However, AGVs cannot assess the surrounding road conditions. IGVs install cameras and sensors around the vehicle and transmit detailed road conditions to the MEC platform over 5G. A single IGV needs 8 channels of 1080p video images, occupying about 40 Mbps uplink bandwidth, and requires a latency of 20 ms. The speed of an IGV can reach 40km/h, twice the speed of an AGV. The end-to-end horizontal transport efficiency can be increased to 2.5 times more than an AGV. Self-driving container trucks that can reduce labor costs will also be realized with the same technologies.

   c. In smart ports, more applications such as IVS (Intelligent Video Surveillance) and AR remote maintenance are using the capability of connectivity and compute provided by 5G and MEC.

5G use case: 5G smart airport from China Eastern Airlines, China Unicom, and Huawei

China Eastern is one of the world's largest airlines and, with China Unicom and Huawei, has developed a 5G smart travel solution for Beijing's Daxing Airport. The solution was designed to improve customer experience, drive the automation of ground tasks, improve airline on-time percentages, reduce airport Wi-Fi congestion, enable low-latency AI-based applications, and future-proof the networking environment.

The solution draws on several critical components of 5G, including enhanced mobile broadband throughput, ultra-low latency, and mobile edge compute.

In partnership with China Eastern, China Unicom and Huawei deployed a 5G network in the newly built Beijing Daxing Airport, the biggest 5G airport in the world and the first where airlines have integrated 5G in to the civil aviation business flow.

China Unicom's network covers the whole of Beijing Daxing Airport with 3,000+ 5G LampSites and 80+ outdoor 5G Active Antenna Units (AAU).

The network provides a massive amount of data transmission, which China Eastern Airlines needs to unlock truly personalized services for their customers. The network capacity in Daxing Airport is designed to meet 10 TB/day and can support flexible capacity expansion. Network speeds can exceed 1.2 Gbps and deliver a superior 5G experience for passengers.

It has sufficient capacity and coverage to serve both the aviation network and passenger access in the public network. Most scenarios are based on 5G indoor networks, while the network also leverages 3G and 4G infrastructure. Sharing infrastructure improves network operation efficiency and reduces costs by eliminating the need for two co-located networks.

China Eastern Airlines utilizes the 5G network to manage three aspects of its business:

• Passenger services such as automated check-in and face-recognition ID checks using an AI application running on edge.

• Luggage tracking and management by both passengers and CEA staff.

• Personalized communications with passengers.

The 5G Smart Travel Service was commercialized in September 2019 and aims to achieve:

• A maximum of 20 minutes from check-in to boarding. Passengers no longer need to show ID or scan QR codes. They can complete all travel transactions from ticket purchase to check-in, security checks, and boarding just by having their faces scanned. Flight attendants can guide them to their seats using the facial recognition system. China Eastern Airlines staff will wear 5G augmented reality (AR) glasses with facial recognition to quickly identify and assist passengers.

• Convenient paperless luggage service and end-to-end visible luggage transportation. Using the world's first RFID permanent luggage badge, the partners developed a 5G baggage tracking solution that allows passengers to track the status of their checked-in baggage on an app. Thanks to the higher 5G uplink capacity, Daxing Airport will use HD video to luggage monitor and alert staff when luggage is mishandled. This allows for the better management of luggage, ensuring the correct routing of luggage and preventing flight delays.

• Personalized services to improve the passenger experience throughout the entire trip, including pre-flight reminders, check-in, boarding, changes to boarding gates, baggage claims, and transfers. These services can be tailored to passengers' locations, membership tiers, and time requirements. For example, passengers can see information about their upcoming flights on the smart display as they walk through the airport. Their face ID will be recognized and information will be displayed anonymously to protect privacy. VIP passengers in the lounge can use HD conference and cloud services. ◫

Unlocking all-service intelligence with intelligent IP networks

IP networks are the foundation for connecting everything. With more than two decades of development and service evolution, the IP industry has gone through three generations: Internet, triple-play, and all-service intelligence. All-service intelligent solutions will enable carriers to power 5G vertical industries, the cloud migration of enterprises, and next-gen services like cloud VR.
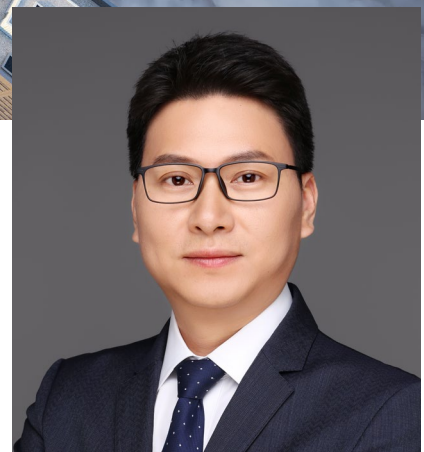
Chen Banghua

Vice President, Data Communication Product Line, Huawei

The predecessor of today's Internet, ARPANET, originally used Network Control Protocol (NCP). But as more computers connected to networks, it became harder for source computers to locate target computers on complex networks. So,

ARPANET replaced NCP with TCP/IP on January 1, 1983, paving the way to the Internet. In 1997, Multiprotocol Label Switching (MPLS) based on IP technology was created to meet reliability requirements and improve the forwarding efficiency of carrier networks, marking the start
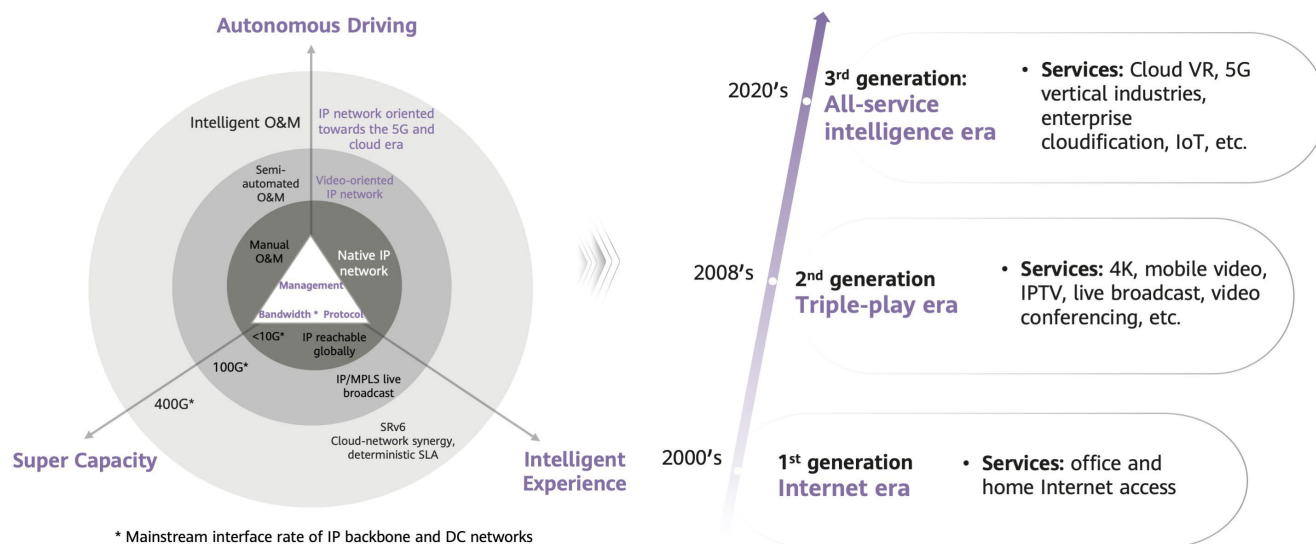
Evolution of IP in Three Generations

of the wide adoption of IP technology on carrier networks.

The first generation, the Internet era, arrived with the new millennium. Internet services were carried over IP, the main service types were office and home Internet access such as email and telephony, bandwidth requirements were low, and network-side interfaces were mainly GE and 10GE. Service experience requirements could be met if the network was reachable and network O&M was mainly command-based.

2008 marked the beginning of the second generation – the triple-play era. As 4K and mobile video services began to emerge, bandwidth requirements increased rapidly and 10GE and 100GE interfaces were mainly adopted on the network side. The quality of high-priority services,

like IPTV, could be guaranteed through simple QoS. Simple tools were used for basic O&M automation.

The third generation, the all-service intelligent era, began in 2020. GSMA expects 170 carriers to commercially deploy 5G by 2020, and with 5G we will see new applications such as cloud VR. At the same time, enterprise cloudification will become the norm, with more than 85 percent of enterprise applications globally expected to be deployed on the cloud by 2025.

For new services such as cloud VR, 5G for vertical industries, and enterprise cloudification, carriers expect to simplify network construction and reduce costs by using one network to carry all services. Moreover, key services, such as 5G B2B, will require strict SLA assurance. And network automation and intelligent O&M will

become increasingly important.

New requirements of the intelligent all-service era

Tenfold bandwidth growth:

Transporting services like 5G, gigabit home broadband, and cloud private lines is driving explosive traffic growth. Compared with video services in the 4G era, new services that offer immersive experiences, such as cloud VR/AR, require more than 10 times the bandwidth. In South Korea for example, the bandwidth of the typical Cloud VR/AR service is more than 80 Mbps, and these services can increase ARPU by 300 percent. At the same time, home broadband is shifting from 100 Mbps to 1 Gbps, with 234 carriers in 57 countries having launched 1 Gbps broadband services. In addition to bandwidth growth, key services, such as 5G B2B

As 5G enables numerous industries and allows millions of enterprises to move to cloud, IP networks need to meet SLA requirements such as stable latency assurance and fast TTM.

services, require stable bandwidth. For example, in remote first-responder healthcare scenarios, stable bandwidth of at least 50 Mbps is required to transmit real-time HD images of patients in ambulances to hospitals.

Experience guarantees: As 5G enables numerous industries and allows millions of enterprises to move to cloud, IP networks need to meet SLA requirements such as stable latency assurance and fast TTM. These SLA requirements may be stipulated in the contracts signed between carriers and enterprises, and therefore an SLA commitment is a necessity. In smart grid transport scenarios, for example, to ensure uninterrupted power supply and shorten the accident isolation time to milliseconds in scenarios with high power supply requirements, E2E network latency can't exceed 15 ms. From the perspective of enterprise cloudification, cloud services are inherently agile and can be deployed within minutes, requiring IP networks to move with the cloud and support fast service provisioning.

Intelligent O&M: 5G vertical industries have stricter requirements on network reliability. In the financial services industry, for example, any interruption to securities trading lasting more than 30 minutes must be reported to the CSRC. This means that network faults must be quickly located and rectified. For enterprise cloudification, the flexible deployment of complex cloud services requires IP networks to support intelligent O&M, real-time visualization of network quality, and quick fault location.

Huawei's intelligent IP network solution opens up the all-service intelligent era

To meet the requirements of the all-service

intelligent era, Huawei has taken the lead in deploying big data analytics, AI, and next-gen protocols on IP networks, helping customers build IP networks with super capacity, intelligent experience, and autonomous driving capabilities. . Huawei's intelligent IP network solution leverages the NetEngine series of routers and provides the industry's first E2E 400GE, which enables carriers to build a base network at optimal cost per bit. The solution uses FlexE-based network slicing to guarantee and flexibly allocate bandwidth for key services. With SRv6 technology that's a year ahead of the industry average, the solution provides intelligent experience, enabling the fast provisioning of services such as enterprise cloudification and committed latency for key services. Combined with iMaster network cloud engine (NCE), the industry's first platform with integrated management, control, and analysis, and the iFIT solution, it supports intelligent O&M functions like fast fault location and real-time network optimization.

Super capacity: E2E 400GE and FlexE-based network slicing

All-service transport brings continuous growth to telecom network traffic and increases the bandwidth cost for carriers. As such, it's vital to reduce cost per bit while boosting network capacity. 400GE will replace 100GE as a cost effective, next-generation networking technology, with PAM4 encoding doubling the efficiency of transmission and achieving optimal cost per bit.

To meet future traffic growth requirements, Huawei has launched the industry's first E2E 400GE solution covering data centers and the access aggregation, metro aggregation, metro core, and national backbone layers. Huawei is the primary contributor to 400GE standardization

and the only vendor that can provide 10, 40, and 80 km full-distance 400GE optical modules. In February 2019, Huawei launched the industry's first commercial 400GE.

In the same way that traffic congestion may occur regardless of how wide a road is, traditional IP networks can fail to guarantee bandwidth for key services even if 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 industry scenarios such as 5G telemedicine, manufacturing networks, and carrier IP private lines. Bandwidth slices can flexibly adjust to adapt to service changes. Huawei's FlexE-based network slicing technology is five times more fine-grained than the industry average, supporting more vertical industries and

finer bandwidth scheduling.

Intelligent experience with SRv6

In the 5G and cloud era, different services have different SLA requirements and networks must be able to provide connections based on SLAs. On traditional networks, service provisioning is implemented through static configuration, so network resources cannot be configured in real time based on service intent. Using SRv6 technology, Huawei's intelligent IP network solution can intelligently select the optimal path and adjust it in real time based on service intent and network congestion status to continuously provide the optimal connection experience. SRv6 can select an optimal low-latency path for latency-sensitive services, such as smart grids, to ensure committed latency.

The intelligent IP network solution uses SRv6 to accelerate service provisioning to within minutes, implement cloud-network synergy and one-hop access to the cloud, and support 50-ms protection

switching across 100 percent of all topology-independent scenarios, ensuring high service reliability. As the largest contributor to SRv6 standards, Huawei has participated in formulating more than 59 percent of all SRv6 standards. To date, more than 20 carriers have deployed SRv6.

Autonomous driving: iMaster NCE powers full-lifecycle intelligent O&M

iMaster NCE deployed in the intelligent IP network solution provides customers with full-lifecycle intelligent O&M covering network planning, construction, maintenance, and optimization, and helps them transform their networks into autonomous driving IP networks.

As network scale and complexity increase, passive maintenance based on subscriber complaints cannot meet O&M requirements. However, intelligent IP networks can use iFIT technology to detect network status in real time and quickly identify network faults or potential risks. Operators can also accurately identify root causes and automatically rectify faults through model matching, minimizing or even preventing experience degradation.

Huawei has proposed a five-level autonomous driving network evolution standard to help upstream and downstream industries explore the evolutionary path of autonomous driving networks. Currently, Huawei is introducing AI and other technologies to evolve IP networks into autonomous driving networks. For example, AI-based analysis on more than 80,000 KPIs using the iMaster NCE enables real-time health checks on routers so faults can be predicted before they occur. To date, more than 100 carriers worldwide have commercially deployed iMaster NCE and

in 2019, the solution won the highest evaluation from GlobalData, making it the only market leader in the WAN controller field.

Intelligent IP enables 5G and enterprise cloud migration

Huawei has successfully implemented smart healthcare, smart grid, and smart port solutions in more than 30 industries. For example, in 2019, Huawei helped China Mobile launch the world's first 5G smart healthcare solution for three scenarios: inside, outside, and between hospitals. The solution mainly covers emergency rescue, remote consultation, and remote B-mode ultrasound, ensuring the experience of medical services. In terms of cloud private lines, Huawei has helped carriers quickly migrate services to cloud and provide high-quality experience for more than 40 industries, including government and enterprise, education, tax, and finance.

As a world-leading provider of intelligent IP network solutions, Huawei has invested heavily in R&D for more than two decades. Huawei's router products and solutions have been deployed in more than 140 countries and regions, ranking top in global market share for two consecutive years. In the 5G and cloud era, intelligent IP networks featuring super capacity, intelligent experience, and autonomous driving capabilities will underpin the development of data communication networks over the next 10 years. Huawei believes that the wide-scale commercial use of intelligent IP networks will begin in 2020.

Based on customer centricity and continuous innovation, Huawei will continue creating value for customers with intelligent IP networks. ◪

Smart 5G service and software solutions for smart operations

5G will open the door to new services, applications, and quality of experience for consumers. It will also empower operators to disrupt the pipe model and develop new digital services, business models, and industry scenarios. However, doing so successfully requires a platform + intelligence approach.

Zheng Ruguo

Chief Marketing Officer,
Global Technical Services,
Huawei

The emergence of new services, networks, and technologies coupled with increasing network and service complexity poses new challenges for the planning, construction, maintenance, optimization, and operation of 5G networks.

Expectations are high

End users have higher expectations, making 5G service quality assurance difficult. The best-effort service model is no longer viable. Instead, clear and differentiated SLA guarantees are required. To help operators overcome new 5G challenges and achieve smart operations in the 5G era, Huawei Service and Software has launched a series of 5G service and software solutions based on platform + intelligence

Reconstructing networks with intelligence

To improve investment efficiency and

provide differentiated experiences for new services, the planning and construction of 5G networks demands precision from the outset. With Huawei's CWR@Digital solution, operators can digitally transform their network operations. CWR@Digital provides a digital operations' sandbox for big data analysis by the OSS and BSS, enabling carriers to digitalize the entire network construction process, including insights, planning, and construction. Network planning provides the following benefits:

• First, intelligent insights increase the proportion of high-value users per carrier site. AI and big data analysis in the intelligent insights process accelerates the identification of high-value areas from months to weeks or days, with 75 to 85 percent accuracy. CWR@Digital can even provide real-time geographical insights at the grid, cell, site, or building level, helping operators make precision investments.

• Next, precise planning enhances network coverage. Huawei's SmartCare® E-Planning model includes indoor-outdoor coordination simulation planning and serves as the springboard for the industry's first network construction standard for 5G service experience. SmartCare® E-Planning enables resource collaboration on-site construction and network quality optimization.

• For large-scale 5G deployment, Huawei's 5G digital integration solution enables a site digital twin and Huawei's 3D network construction standard, T-BIM, which slashes site TTM by 30 percent.

• For building indoor networks, Huawei helps operators formulate the best evolutionary path for 5G, using AI predictions of data traffic growth and user experience. The solution provides optimum indoor point location design and route planning, with Huawei's Choose modelling algorithm reducing construction costs. To increase the value of indoor networks, Huawei adopts a 2C/2B dual-network collaborative network construction model instead of a purely 2C service-oriented network model.

Huawei's Integrated Service Delivery Platform (ISDP) is a digital delivery platform that allows operators, equipment vendors, and partners to transfer information and instructions during project implementation. It achieves process-driven operations, data openness, IT-based operations, progress visualization, and quality management, improving the efficiency and quality of 5G network deployment and achieving agile network construction.

5G B.E.S.T. Network boosts experience

Although carriers have built 5G sites to solve coverage issues, wide coverage does not necessarily equal a good network experience. For example, Massive MIMO requires the 3D simulation and optimization of more than 10,000 parameters, making 5G optimization significantly more complex than 4G. The Huawei DISCOVERY network optimization platform summarizes and consolidates over 100 network optimization rules, 50+ AI models, and the network optimization experience of more than 6,000 projects. The capabilities of DISCOVERY are more than a year ahead of the industry average.

Huawei has launched 5G B.E.S.T. Network, a solution that leverages DISCOVERY to provide intelligent network optimization sub-solutions. These include commercial rollout assurance, ultimate speed assurance, and network latency optimization. The commercial rollout assurance solution accurately identifies various issues with 5G, such as poor coverage and blind spots, helping operators reduce subscriber complaints in the initial stages of commercial use. The speed assurance solution adopts the industry's first CSI optimization and RANK UP technology for device-pipe-core collaboration to tap the potential of the network and further improve 5G speeds. The network latency optimization solution speeds up the delimitation of latency problems from weeks to days, and

Huawei's unique patent Super FEC reduces cell-edge latency by up to 20 percent.

Huawei's 5G B.E.S.T. Network solution has helped operators top the tables in European P3 5G speed tests, rank first in IHS Markit tests of speed and latency in South Korea, and deliver competitor-beating 5G networks in China and the Middle East.

5G SOC: Three new features

The 5G era has delivered new commercial opportunities for operators thanks to new digital services, differentiated experience requirements, multi-dimensional monetization models, and new 2B scenarios. Typical 5G digital services, such as cloud VR, AR, and gaming, require more from networks. Cloud VR, for example, demands end-to-end perceived latency of under 70 ms.

Utilizing the customer experience management of more than 160 networks around the world, Huawei's SOC solution helps operators forge the best service experience with three new features: differentiated-experience monetization models such as MBB business class; new service experience management, for example, cloud VR/X, HD video, and live streaming backhaul; and SLA guarantees for new 2B scenarios, like smart port and smart campus.

Huawei's SOC solution boasts the world's first 5G new service experience standard, which can help operators quickly build new service experience models. The solution's industry-leading experience analysis capabilities deliver a service identification accuracy of 90 percent. The next-gen performance management platform reduces unit energy consumption by 40 percent and boosts service performance by 1.5 times.

AUTIN: Smart O&M with human-machine collaboration

O&M complexity service requests have skyrocketed, given that multiple wireless generations now coexist on operator networks, the number of people-to-things connections has doubled, and new services are constantly emerging. Moreover, faults are more difficult to solve, operations personnel are in short supply, and the cost of operations is soaring. Operations transformation is sorely overdue and carriers must transform their existing operations model and evolve to automated and intelligent O&M.

Huawei is the first in the industry to propose AIOps – an intelligent operations model based on human-machine collaboration that will help carriers evolve from manual O&M to automated and intelligent O&M. The aim of shifting to this new model doesn't do away with the existing O&M system or existing O&M tools. Instead, it adds an O&M knowledge platform that hosts O&M knowledge and models and incorporates O&M processes, operations steps, and actual O&M requirements. This kind of platform will help carriers shift away from a human-based O&M model towards a human-machine collaboration model, domain by domain and stage by stage.

The first step is skills transformation. O&M personnel must become data analysts, network strategy engineers, and application orchestration engineers. Their expertise and experience will be converted into O&M assets and incorporated into OWS, an intelligent operations platform. OWS can then leverage these assets to implement intelligent O&M.

Huawei is the first in the industry to propose AIOps – an intelligent operations model based on human-machine collaboration that will help carriers evolve from manual O&M to automated and intelligent O&M.

Thanks to this human-machine collaboration model, Huawei's 5G intelligent O&M solution disrupts the linear growth relationship between O&M resources and hardware, utilizing automation to reduce human errors and improving O&M efficiency. It also harnesses AI to predict and prevent network and service faults, improving O&M quality, thus ensuring ultra-reliable 5G networks.

Through joint innovation in 5G O&M, China Unicom and Huawei implemented automatic generation and fault visualization on cross-domain network topology, intelligent fault detection, cross-network/cross-domain intelligent fault diagnosis, and staff training.

World's first billing solution for 5G SA networks

Operators want to achieve strong 5G ROI but face a host of challenges with business models and ecosystems. For example, 5G services require a unified billing system that covers individuals, households, and enterprises, and provides multi-dimensional monetization capabilities. An agile and open billing system is also necessary so that partners can quickly roll out services.

Huawei's Convergent Billing System (CBS) R20 is the world's first billing solution that supports 5G

SA networks. Enabling operators to accelerate the monetization of new 5G services, the CBS R20 has already been deployed on STC Kuwait's network with a leased line package offered to enterprises with guaranteed SLAs.

It boasts industry-leading advantages in monetization capabilities, industry standards, and system architecture. First, CBS R20 supports the flexible combination of more than 1,000 charging factors and dimensions and over 100 common 5G service packages, all of which are deployable in minutes. Second, the solution aligns with service-based architecture and interfaces defined by 3GPP, enabling smooth upgrades from existing charging systems for operators. It also supports both 5G NSA and 5G SA networks.

The CBS R20 enables operators to generate extra revenue from partners' services by opening more than 300 APIs. It fully supports containerization and virtualization, which can significantly lower OPEX through unified and automated operations. The solution can, for example, carry out automated capacity expansion according to system capacity without manual intervention. Online upgrades allow operators to test new functions on the live network, shortening project times from four to six months to a month or less.

Training 5G digital talent

For operators, succeeding in 5G depends on having teams who grasp key technologies like 5G, AI, and cloud, and who understand the needs of industry customers. Huawei's 5G training and certification solution features content developed by Huawei, operators, and the industry. It adopts a range of training models, including integrated online-offline, hands-on, and action-based, to improve teaching efficiency.

The certification solution boasts three major capability systems: 5G consulting, 5G training, and 5G certification. These help operators quickly put in place specialist staff capabilities in service scenarios such as 5G network deployment, agile operations, and service operations.

Since 2017, Huawei Service has adopted AI in its production and operation processes, serving carriers in the areas of planning, construction, maintenance, optimization, and operations. Harnessing machine learning and human-led machine intelligence approaches, Huawei will continue to optimize its platform for E2E 5G services and software solutions, empowering operators to develop high-quality and efficient services, better solve customer problems, and maximize the commercial value of 5G. ▉

Digitalizing site power for green connectivity and computing

Huawei's 5G Power can help customers quickly build intelligent sites, optimize TCO, and meet the requirements of 5G, including more base stations, more equipment room hardware, and higher power consumption.

Peng Jianhua

President, Telecom Energy, Huawei

By 2025, the number of people-to-people, people-to-things, and things-to-things connections will exceed 100 billion. With the growing adoption of 5G networks, experience- and business-driven connectivity and computing are becoming ubiquitous. The rise of new services, such as online healthcare, online education, online office, smart home, VR, AR, and autonomous driving, is demanding broader network connections, higher bandwidth, and content and

computing that are closer to users.

We've seen a series of major new changes taking place in communications networks, including increased wireless frequency bands and sites, fiber replacing copper, all-optical FTTx, equipment room capacity expansion, and FMC/ICT convergence. Base stations will also evolve from communications and connectivity functionality to "social stations" with a full array of functions.

So, how will these developments change site power infrastructure?

Seeing the future to create a better now

• **Optimizing CAPEX and OPEX**: The number of

base stations, the amount of equipment room hardware, and power consumption are rising. Site construction involves building traditional equipment rooms, rigging together multiple boxes in the power system, and overlaying multiple systems. Multiple stages are needed, including engineering surveys, negotiations, approval, and civil construction. Construction cycles are long, investment requirements are high, and fast service provisioning is impossible. Site management is complex and evolution difficult. The current structure incurs high site CAPEX and OPEX.

• **CT and IT convergence**: Advances in 5G technology and the increase in service applications have resulted in computing getting closer to users and the convergence
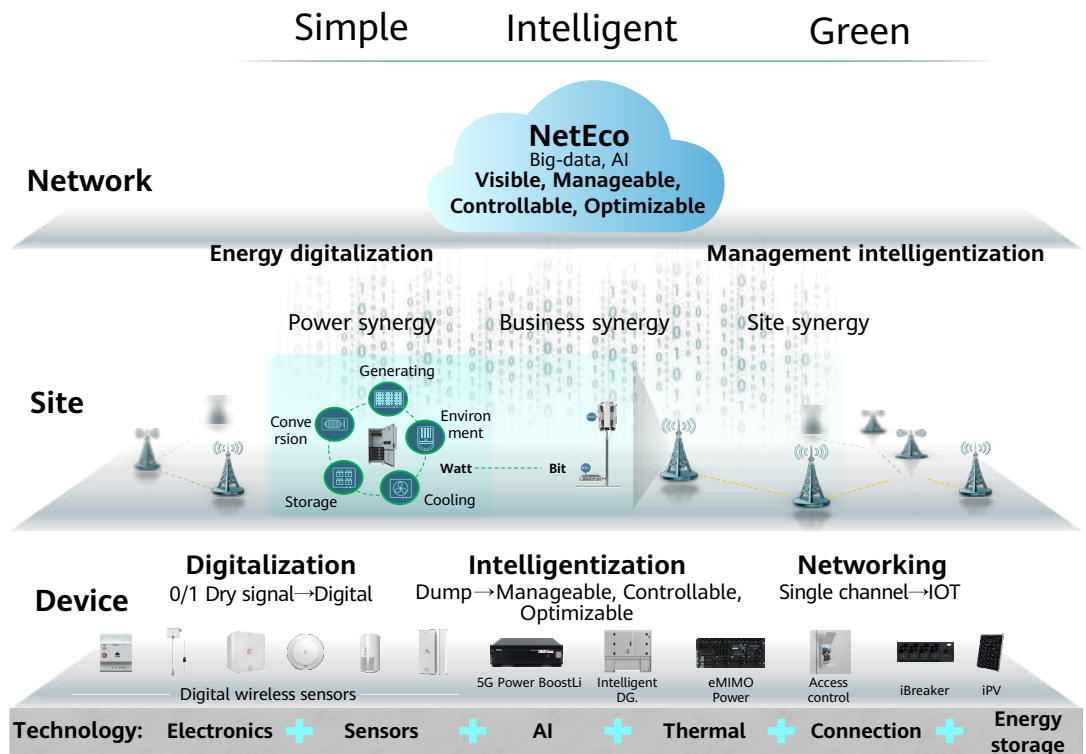
5G site power target network

of CT and IT into ICT architecture. A typical example is the increase in the proportion of IT equipment in sites, with trends moving towards AC and DC power supply.

- **Redefining energy storage systems**: Lead-acid batteries are fast being swapped out for lithium batteries. While ordinary lithium batteries have advantages, they're a simple combination of battery cell and structural component, which can only provide simple backup power. They cannot be coordinated, enable only imprecise management, and waste resources. They're also expensive to evolve and difficult to operate and maintain. In the 5G era, the architecture of base station energy storage systems needs to be redefined.

- **Solar energy and new energy sources**: Various factors are encouraging operators to add solar energy to all base stations, including climate change and the need to conserve energy and reduce emissions, the continued drop in cost of new energy sources such as photovoltaics, and the rising cost performance of applications. This is eliminating the need for diesel generators, so all sites can be diesel-free, helping energy networks contribute to the UN's sustainable development goals (SDGs) and cutting OPEX.

- **Digitalization and smartification to minimize O&M costs**: 4G O&M for roughly 80 percent of base stations involves manual on-site inspections to locate issues and troubleshoot faults, with average annual O&M per site potentially costing tens of thousands of dollars. In the 5G era, the surge in the number of connections and sites will lead to ever-more-complex O&M. Legacy O&M methods will result in soaring O&M OPEX. The need to

greatly improve site O&M efficiency will drive the full digitalization and smartification of energy infrastructure.

- **Open infrastructure**: Site power infrastructure will become more open, and sites will evolve from communication stations into social stations that provide functions like site sharing, energy infrastructure sharing, and advertising space rental. Sites will be able to accommodate capabilities like environment- and security-monitoring equipment and peripheral power supply. Site- and energy-sharing in this way will maximize site resource utilization.

5G Power powers 5G

Huawei's 5G Power is a next-gen site power solution designed to create a simple, intelligent, and green telecom energy network. It utilizes Huawei's extensive experience in 5G network evolution, materials science, and key technologies in power, power electronics, thermodynamics, IoT, and AI.

By adopting digital technologies such as AI, big data, and IoT, the solution enables real-time connectivity and the global management of grid power, energy storage, temperature control, and loads, supporting a fully intelligent energy network with intelligent power output and intelligent O&M for site energy systems.

High-density, efficient power output technology, new energy resources, and intelligent technology achieve an efficient, eco-power network at three levels – modules, sites, and networks – so carriers can build end-to-end green, efficient energy networks and support sustainable development.

By reserving space for future capacity expansion and additional hardware, carriers can achieve smooth expansion and save costs when evolving to multi-band 5G.

This approach opens up base station resources, transforming them from communication stations into social stations that maximally utilize resources.

In 2019, Huawei's 5G Power solution won ITU's Global Industry Award for Sustainable Impact, demonstrating that Huawei can provide solutions that conform to ITU's international standards for 5G power.

Accelerating 5G deployment and optimizing TCO

By reserving space for future capacity expansion and additional hardware, carriers can achieve smooth expansion and save costs when evolving to multi-band 5G. Huawei is enabling them to do this by making breakthroughs in power density and power and energy storage density. Offering "1 site, 1 cabinet", "1 site, 1 blade", "1 cabinet instead of 1 equipment room", and "converged ICT in 1 cabinet", the advanced 5G Power solution enables 5G deployment in various scenarios without needing to renew the mains, build equipment rooms, add cabinets, or replace cables, thus helping customers rapidly deploy 5G and achieve optimal TCO.

1 Site, 1 Cabinet: represents the world's first intelligent, unified and comprehensive energy platform for 5G power. It integrates a 5U, 36 kW power supply capacity, which is double the industry average, while the 3.6U, 150 Ah5G Power BoostLi energy storage system beats the industry average energy storage density by 220 percent. Multiple power supply inputs, including mains supply, solar energy, and diesel generators, and multiple voltage output standards, such as DC 48V/12V/24V/36V, AC 220V, are supported

on one platform and one system. With the solution, all equipment can be housed in one cabinet. The 1 site, 1 cabinet principle supports the smooth evolution of all services and enables network-wide intelligent management. It makes 4G sites 5G-ready without increasing CAPEX for new 5G deployment, achieving E2E TCO savings of 50 percent.

1 Site, 1 Blade: For remote AAU/RRU scenarios, Huawei's 1 Site, 1 Blade solution comes equipped with the industry's first 6 kW blade, which features natural cooling, a small footprint, maintenance-free capabilities, and fast service provision. The unique butterfly design and cutting-edge cooling technology reduce wind resistance by 40 percent and improve cooling efficiency by 25 percent.

For equipment room scenarios, Huawei's simplified CO-MIMO power solution provides new architecture, is compatible with all standards, and offers a range of benefits: 55 percent lower volume, 70 percent less load, 30 percent higher capacity, and an E2E efficiency boost from 80 percent to 92 percent. The solution can help customers retrofit and expand the capacity of services at the original site without needing new leases, new equipment rooms, or engineering work, which in turn supports simplified evolution towards 5G for CO equipment rooms.

It also supports connections to renewable energy, ensuring power supply for converged IT/CT equipment and MEC-ready capabilities. The unique CO BoostLi power storage system supports a maximum of 6000A ultra-high power. The solution is equipped with intelligent automatic fire-extinguishing technology for lithium batteries, an industry first that maximizes

system safety.

Site power goes fully intelligent

Huawei is accelerating the digital transformation of base stations by adopting AI and IoT. Harnessing these digital technologies, 5G Power optimizes coordinated scheduling between various systems, such as power supply modules, site hardware, and the network. This enables intelligent power output and intelligent O&M for site power systems, driving the full smartification of the site power network.

On the power output side, Huawei has proposed the "bits managing watts" and "zero watt if zero bit" concepts. The intelligent coordination of Huawei 5G Power's multiple subsystems – intelligent power supply, intelligent energy storage, and intelligent network management – supports the intelligent peak shaving and maximum power point tracking (MPPT) of grid power. This maximizes site power supply capacity and helps operators deploy 5G without modifying the mains supply or adding power cabinets. Exclusive 57V intelligent constant voltage technology supports AAU power supply without replacing cabling, reducing line loss and unleashing 100 percent of the energy storage capacity.

5G Power also adopts innovative intelligent metering to solve the issue of inaccurate energy management. By supporting intelligent electricity metering, the power consumption of all electrical loads in a site can be calculated separately without adding electricity meters. This enables customers to precisely measure the

The industry-leading rectifier (98-percent efficiency), heat resistant materials, and phase-change cooling temperature control save 5,000 kW of electricity per site per year.

power consumption of each load, according to tenants, frequency bands, and sectors, giving them accurate data to improve energy efficiency and carry out precise investment.

The 5G era will require more accurate power backup and precision power-down management according to service priority. Huawei has redefined shutdown logic, with shutdown strategy implemented in an intelligent and coordinated way, using multi-dimensional indicators so that sites can execute precise power-down based on service importance. This function also allows precise power management, dramatically reducing investment in energy storage.

With the Huawei 5G Power BoostLi energy storage system, Huawei has unlocked greater potential in site energy storage systems. The system provides a three-tier architecture comprising local BMS, energy IoT networking, and cloud BMS. Underpinned by intra-site, inter-site, and site/network energy storage collaboration, coupled with big data analytics and AI algorithms, the solution supports intelligent voltage boosting, intelligent anti-theft, the intelligent hybrid use of batteries, and intelligent parallel operations. This will ensure ultimate reliability for power supply and backup; maximize battery value; and meet new demands for applications, intelligent collaboration, precision management, and all-scenario applications in site energy storage in the 5G era.

Rethinking O&M

5G Power applies simplified IoT networking to support a digital dashboard, the visibility of energy consumption per bit, and energy efficiency/PAV visibility for the entire site power network; remote O&M manageability and battery/diesel generator state of health (SoH) management; smart scheduling controllability; and AI big data analysis optimization. For site asset management, Huawei's 5G Power integrates multiple smart anti-theft measures including digital anti-theft and AI image analysis. These measures clarify site asset management and evolve anti-theft systems from physical to digital.

Modules, sites, network: 3-layer optimization for green networks

In traditional power supply systems, the sole focus is on rectifier efficiency. Other parts of the power supply are limited by structure and capacity, which means they aren't considered. Huawei's 5G Power uses AI to enable communication and real-time connectivity, and the global management of grid power, energy storage, temperature control, and loads. These capabilities achieve green connectivity and computing, saving energy across three layers: modules, sites, and the network.

Energy efficiency at the module level is achieved with an industry-leading rectifier (98-percent efficiency), heat resistant materials, and phase change cooling temperature control, helping save 5,000 kW of electricity per site per year.

Operators can cut energy use at typical sites by 50 percent by eliminating diesel generators and adding solar panels at all sites. Corresponding measures include reconstructing old and inefficient power system and indoor-to-outdoor site conversion, with technologies like AI-supported iSolar, a digitalized overlaid solar energy solution, super-fast charging, intelligent

network management scheduling, and intelligent collaboration.

At the network layer, cloud-based intelligent network management identifies inefficient sites and allows intelligent network-wide coordination between the mains supply, power supply systems, energy storage, and loads. Intelligent management also includes precision energy efficiency management and the optimization of site energy consumption across the whole network, helping carriers build fully green, efficient energy networks.

Social stations: Maximizing site resource utilization

The power system, which in the past formed part of base stations' support infrastructure, is now the cornerstone of the network, and even a key determining factor in whether 5G can rapidly develop.

Huawei believes that as 5G becomes more widespread across industries and ICT convergence ramps up, the sharing of network infrastructure will also increase. Opening the capabilities of site power systems will need to increase and sites will have to evolve from traditional communications into site sharing and energy-sharing to maximize site power efficiency.

Huawei's industry-first super site power supply MEC solution harnesses intelligent integrated power supply and unified power supply architecture that's compatible with all input and output standards. It enables flexible modularized expansion, provides ultra-high power supply and backup capacity, features ultra-high heat treatment capacity, and delivers class A

environmental adaptability.

It also supports the co-deployment of ICT devices and full-scenario applications. Thanks to the large power supply and backup capacity, the MEC solution enables site power sharing, backup power, and electric vehicle charging/power exchange for businesses and residents.

Flexible multi-standard output capabilities can ensure power leased sites, covering diverse functions such as security monitoring, disaster detection, and outdoor advertising.

Maximizing investment efficiency

With the aim of achieving ubiquitous green connectivity and computing, Huawei is a leader in the digitalization of site power. It works with the telecommunications industry to explore and drive the development of 5G based on the concept of simple, intelligent, and green. We will continue to concentrate on the challenges facing customers in the 5G era and help them build future-oriented, fully digitalized, intelligent green networks that meet sustainable development goals and save OPEX. ⬛

How CAT Telecom Thailand took the lead in premium private lines

Thailand's major enterprises are embracing cloud, big data, and AI, and stepping up the pace of cloud migration. CAT is a state-owned telco that aims to build a high-quality network and provide premium private line services for enterprises to support the government's Thailand 4.0 model.

Liu Xi

Vice President, Transmission Network Domain, Huawei

n 2016, the Thai government launched the Thailand 4.0 model to accelerate Thailand's socioeconomic development over the next 20 years by transforming traditional agriculture, SMEs, and service industries with digital technology.

Developing its digital economy is key to the nation's economic transformation, ICT innovation, and the Thailand 4.0 model.

Reshaping the market landscape

CAT provides several standard datacom services for government and private customers. In 2019, CAT's overall market share of around 16 percent ranked second in the 2B market, a position that it's maintained for years. Although CAT has

consistently provided high-quality private-line services for its customers, it wanted to improve its competitive advantages and began exploring how to do so.

Thailand's enterprise private line services are mainly used in the following scenarios:

1. Large-capacity point to-point connections for data center interconnection (DCI).

2. Cloud connections for vertical industries such as government and finance.

3. VPN connections for medium and large enterprises.

4. International IPLC connections for multinational enterprises.

5. Broadband services for homes and domestic SMEs.

Issues with current private line services

Currently, private line services mainly use Ethernet and MPLS VPN technologies. Price is determined by bandwidth and services are differentiated with simple SLAs. Ring topology is used for protection and the maximum availability is a weak 99.9 percent. Network resources aren't visualized and service provisioning needs to be confirmed node by node, leading to long service provisioning times, complex configuration, and difficult bandwidth adjustment.

After services are provisioned, private line services and other services are transmitted together, which means they may affect each other in peak hours. In addition, due to the

homogeneity of technologies and services, many carriers and ISPs are competing in the market on price to attract customers, driving down the price each year. Rapid cloud migration by large enterprises means that the experience and the services offered by current private-line products don't match requirements.

Unique, differentiated, and premium

CAT has customers in the government, finance, banking, and transportation industries, with VIP customers mainly based around Bangkok. Based on its existing 100G cross-border interconnection network, CAT decided to expand the coverage of its private-line network for enterprise users by adding and reconstructing a number of sites.

• First, it deployed two new OTN aggregation sites in the metropolitan area, which will increase the total number of enterprise customers tenfold and cover around 70 percent of ultra-large enterprises, large enterprises, and data centers.

• Second, CAT reconstructed existing 10+ ROADM sites and ILA sites into OTN aggregation sites, so that the entire network can support 150+ SMEs, 10+ large enterprises, and five data centers.

• Third, the entire network uses unified controllers to manage and provision services, which improves network resource utilization. Based on this network construction plan, CAT and Huawei built the first OTN premium private-line network in Thailand. Using Huawei's E2E OTN + iMaster NCE solution, CAT constructed a flattened network covering the entire country. The iMaster NCE intelligent

The iMaster NCE intelligent management and control system is used network-wide to implement E2E management, achieving a one-hop connection to the government and enterprise cloud.

management and control system is used network-wide to implement E2E management, achieving a one-hop connection to the government and enterprise cloud through OTN-based hard pipes.

The premium private line network provides the following features:

High security and wide coverage: OTN hard pipe isolation, exclusive bandwidth, and full coverage in Thailand.

High availability: service protection through ASON and a link availability above 99.99 percent.

Guaranteed ultra-low latency: guaranteed low latency and real-time latency visualization.

Intelligence and agility: plug-and-play CPE and the provisioning of private line services within days.

Enhanced experience: network resource visualization and online service survivability analysis.

The entire premium private-line network was completed in 2019 and is now up and running, serving Thailand's lucrative government and enterprise market with premium services and paving the way to Thailand 4.0

Providing premium private line services for enterprise customers in Thailand

Using the OTN premium private line network now enables CAT to provide differentiated services for its enterprise customers.

Private line interconnection for large-scale Internet enterprise data centers: CAT premium private line products support fast switchover and recovery upon occasional faults, with a network availability of 99.99 percent.

Financial industry: The unique ms-level low latency of the CAT premium private line ensures nearly real-time transmission of information such as transactions, settlement, and market information queries. This enables financial enterprises such as securities companies and banks to outperform competitors.

Transportation industry: Hard pipe isolation facilitates secure and reliable scheduling.

Intelligent healthcare industry: High reliability and low latency allow surgical interns to remotely observe operations performed by experts. Moreover, adjustable bandwidth allows medical images to be quickly uploaded to the cloud for analysis.

On December 16, 2019, CAT and Huawei officially released Thailand's first OTN premium private line network, recommending it to 150 customers from 70 enterprises across Thailand, including companies in the ICT, banking and investment, payment security, and logistics and transportation sectors. At the launch event, the Thailand government data and cloud service center (a third-party data hosting center for government agencies) reached a cooperation intention with CAT.

Looking to the future, CAT will further cooperate with global partners such as Huawei to promote the application of innovative OTN technology in Thailand, build a leading OTN premium private line network, and accelerate the digital transformation of enterprises in Thailand. **H**

China Mobile Jiangsu pushes automation to prepare for 5G

In an interview with Mobile World Live, Chen Ying, Chief Engineer in the Network Department for China Mobile Jiangsu, outlined the operator's roadmap for streamlining O&M to prepare for the 5G era, including increases in network scale and complexity.

MWL: What prompted China Mobile to transform O&M in Jiangsu province?

Chen Ying: There are two main factors. The first is workload driven. The expected increase in the number of users and business traffic will boost network maintenance work. This problem needs to be solved by improving operation and maintenance efficiency. The second aspect is driven by new technologies. The evolution of 5G network architecture to cloudification requires O&M personnel to deploy and maintain network services through resource orchestration.

MWL: What are your main objectives and timeframe?

Chen: The goal of China Mobile Jiangsu is to increase the level of automation and intelligence in network operations by using technical methods, so that machines can take on repetitive and basic tasks and improve operational efficiency without increasing OPEX. Our goal is

to double the automation rate of network O&M within three to five years.

MWL: What specific areas did you focus on in the beginning?

Chen: Network O&M covers many different areas, including mobile broadband, fixed broadband, NFV, and 5G network operations. Our intelligent operations transformation started with the less automated areas of O&M, for example, allocating wireless network resources, transmission maintenance, and checking trouble tickets for handling fault alarms.

MWL: What benefits will intelligent operations bring?

Chen: Intelligent operations reduce costs, improve efficiency, and enhance quality. For example, some wireless network resources can now be dynamically allocated province-wide using software.

MWL: Why did you select Huawei as a partner? What can Huawei deliver that other vendors are unable to?

Chen: The main consideration was that Huawei has rich experience in telecoms networks. The company has the largest market share of ICT O&M services in the global market and manages hundreds of networks. Currently, thousands of DevOps and a large number of partners have launched more than 1,000 O&M applications on Huawei's Operation Web Services (OWS) platform to enrich their capabilities

MWL: How will the platform help evolve an intelligent O&M model?

Chen: Huawei's OWS is a cloud-based operation platform that offers four modules: perception, analysis, decision-making, and execution. It implements unified data services, automation, and open orchestration capabilities. The platform can separate design and running status, and achieve layered decoupling and on-demand deployment to enable agile transformation.

MWL: Why is a next-generation OSS architecture so important?

Chen: The main direction of future network evolution is the cloudification of network architecture. In the new cloudified network era, the next-generation OSS is a must

to improve control and O&M on networks. It's essential for functions such as control, allocation, self-healing, and the scaling of cloud network elements. The OSS will also manage the requirements, application, allocation, installation, configuration, and start-up of the resource pool in next-generation networks.

MWL: How can the open platform be programmed with specific models and algorithms to enable operators to transform O&M?

Chen: Huawei's OWS uses a microservice architecture to decouple capabilities for future OSS architecture. It implements full-stack network monitoring and automatic and intelligent operations through a unified platform and breaks down O&M information silos caused by the traditional OSS. It also supports the visualized orchestration of multiple service scenarios and flexible multi-vendor integration and interconnection.

MWL: What are the key capabilities of the OWS in troubleshooting and predicting interruptions?

Chen: The OWS platform implements automatic rule deployment and intelligent application for fault management, change management, and preventive maintenance to realize automatic alarm correlation compression, automatic fault

diagnosis and recovery, and work-order automation. The platform uses machines to undertake repetitive tasks previously done by people, accelerating and improving the standardization and quality of operations.

MWL: How are you preparing for a future-oriented 5G?

Chen: In the 5G era, network scale will become very large and complex. An efficient and agile intelligent operation mode is critical. Automation and intelligence are key to improving 5G service quality and transforming the skillsets of O&M personnel. For example, service provisioning and recovery and end-user service quality awareness can be realized with more intelligence embedded in O&M systems.

MWL: What are the main responsibilities of Jiangsu Mobile in relation to 5G network construction and O&M by China Mobile?

Chen: China Mobile began to implement its "5G+" plan in 2019. Jiangsu Mobile assumed the construction of the 5G core network as a pilot for China Mobile. We've worked with Huawei to incubate and implement the 5G intelligent operations solution, transform personnel capabilities, and contribute to using innovation as a pillar of power.

5G Power: Creating a green grid that slashes costs, emissions & energy use

A joint innovation between China Tower and Huawei, 5G Power is a key advancement that will promote the maturity of the 5G power industry by introducing a new approach to the power model for 5G sites.

By Chen Dongxu, Senior Engineer, China Tower and
Ye Wanxiang, Chief Engineer of Site Power Facility domain, Huawei

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In 2019, the 5G Power solution won ITU's Global Industry Award for Sustainable Impact. For operators, it provides a replicable power solution that can slash site retrofitting costs.

5G Power is based on intelligent technologies like peak shaving, voltage boosting, and energy storage. These capabilities make it possible to deploy sites without changing the grid, power distribution, or cabinets during 5G evolution.

5G Power was designed to address the energy challenges of 5G deployment and improve investment efficiency for operators. In the future, 5G energy solutions will need to meet the demands of simplified deployment, rapid construction, efficient energy saving, and smooth evolution.

5G construction: Energy and emissions

China Tower is a world-leading tower provider that builds, maintains, and operates site support infrastructure such as telecommunication towers, high-speed rail, subway systems, and large indoor distributed systems. As of June 2019, China Tower boasted a combined 1.954 million sites with a value of 315.36 billion yuan (US$44.3 billion).

On June 6, 2019, the Ministry of Industry and Information Technology issued 5G licenses, and since then Chinese carriers have been ramping up large-scale 5G deployment. By the end of the year, more than 130,000 5G sites are expected to be put into operation nationwide. Hangzhou in Zhejiang Province is aiming to build China's first "5G City", having already achieved contiguous 5G network coverage.

5G network construction differs significantly from 4G in terms of networking modes, product forms, and performance parameters. The power consumption of 5G hardware is between two and four times greater than 4G, posing unprecedented challenges for site infrastructure construction. It calls for systematic research and innovative 5G energy solutions to meet the energy challenges brought by 5G.

The 5G era will be a fully mobile, fully connected smart era. It will see the growth of connections and communication between people, between people and things, and between things and things. With the number of global connections set to exceed 100 billion by 2025, 5G will engender a greater diversity of

scenarios and service requirements. 3GPP defines three main 5G scenarios:

1. **eMBB**: Enhanced Mobile Broadband at 10 Gbps.

2. **uRLLC**: Ultra Reliable and Low Latency Communications at 1 ms.

3. **mMTC**: Massive Machine Type Communications at 1 million/km².

Energy consumption per unit of data (watt/bit) is much less for 5G than 4G, but power consumption is much higher. In the 5G era, the maximum energy consumption of a 64T64R active antenna unit (AAU) will be an estimated 1 to 1.4 kW to 2 kW for a baseband unit (BBU).

Base stations with multiple frequencies will be a typical configuration in the 5G era. It's predicted that the proportion of sites with more than five frequency bands will increase from 3 percent in 2016 to 45 percent by 2023. In a site with multiple frequencies, maximum power consumption for the whole mobile tower will exceed 10 kW. At 10 or more frequency bands, site power consumption surpasses 20 kW. And in scenarios where multiple operators share a site,
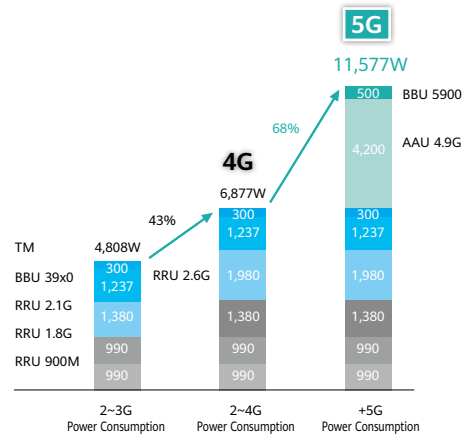

Typical maximum power consumption of a single 5G base station

power consumption is doubled.

This trend will require significant retrofitting of existing site infrastructure, because grid capacity, battery capacity, cabinet heat dissipation, and power distribution will be insufficient, leading to a huge amount of wasted resources.

In scenarios where power has to be supplied to remote 5G high-power AAU, excessive cable loss will lead to excessive voltage drops, and in some remote locations, voltage may even fall below hardware operating requirements and stop AAUs from working.
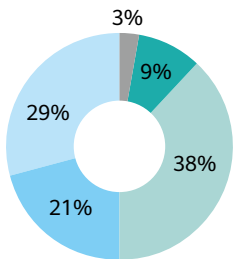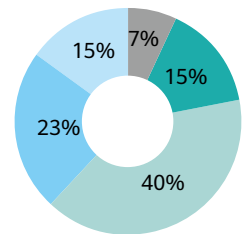

Maximum 5 bands for a single site in 2016
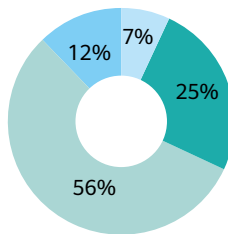
Maximum 7 bands for a single site in 2020

Maximum 9-10 bands for a single site in 2023

Proportion of 5G sites with a different number of frequency bands and changes over time

Power supply systems at more than 30 percent of tower sites may need to be retrofitted, according to Chinese site surveys and engineering surveys. The average cost of increasing grid capacity for a single site is around US$2,800. As there are currently 2.5 million mobile towers in China, retrofitting costs will total around US$2.1 billion.

The growth of power consumption by 5G networks will trigger growth in energy consumption in general. In China, for example, total power consumption by telecoms networks exceeds 50 billion kWh. Once 5G networks are deployed, the power consumption of telecoms networks in China will exceed an estimated 100 billion kWh, generating annual carbon emissions of 27.2 billion kg.

Smart functions with 5G Power

In Hangzhou, the 5G Power solution deployed by China Tower and Huawei supports one cabinet for one site and boasts smart features like intelligent peak shaving, intelligent voltage boosting, and intelligent energy storage.

1. One Cabinet for One Site

The 5G Power solution has a fully modular design and leverages advanced high-density technology, delivering a fourfold increase in power density compared with traditional power supplies, and a 1.7x increase in lithium battery energy density. It supports a 24 kW rectifier, 600 Ah

lithium battery, and 3.5 kW cooling system in a single cabinet. 5G Power meets power supply and backup demands for co-deployed 2G/3G/4G and 5G hardware using a One Cabinet for One Site solution. Traditional solutions, on the other hand, require more cabinets.

Modular rectifier, power distribution, and temperature control components can also be deployed according to requirements. With the same initial investment, the solution delivers 5G evolution capabilities and CAPEX savings of 50 percent when deploying 5G.

2. Intelligent peak shaving

Intelligent peak shaving is used for the Hefeng village base station in Hangzhou. The site's average load is 1.4 kW, with peak loads of 2.7 kW. However, the AC power limit is 1.6 kW. When 5G services were added in tests, peak loads exceeded the power limit.

5G Power's intelligent peak shaving technology leverages smart energy scheduling algorithms of software-defined power supply and intelligent energy storage. That means at peak loads, the smart lithium battery can power the load, support site peak shaving, and reduce the need for the grid to allocate capacity at the typical power levels.

It requires no changes to grid power, cutting retrofitting costs for a single site by more than US$1,800 and lowering the initial investment costs

of 5G evolution.

3. Intelligent voltage boosting

The Xiaoshan site in Hangzhou uses smart voltage boosting technology, with the 5G AAU and power source more than 50 meters apart. When the 5G service was added in tests, a drop in voltage after the 5G AAU was mounted on the tower led to insufficient power supply voltage. This meant the security of the power supply couldn't be guaranteed and the AAU power cabling had to be changed. Moreover, the increased power consumption of the hardware increased line loss and energy wastage.

With intelligent voltage boosting, the 5G power module and 5G Power BoostLi lithium battery work in tandem to support power supply to the system at a constant voltage. The original configuration could only provide 48V, but intelligent voltage amps this up to 48V–57V, without having to replace AAU cabling. Real-world test results of site performance show that DC output voltage reaches 56.9V–8.9V, higher than the traditional 48V power supply.

Intelligent voltage boosting reduces the need for retrofitting power cables and can prevent issues such as fines for 5G sites going offline or increased cable loss when cabling is not replaced. Intelligent voltage boosting can reduce energy consumption of the whole site by 1 percent.

4. Intelligent energy storage

5G Power supports the smart mixing and matching of lithium batteries, including new and old batteries and different capacities, manufacturers' products, and materials. For the true on-demand configuration of batteries, balanced charging and discharging of new and old batteries helps to reduce battery deployment costs.

5G Power builds a green energy grid

China Tower and Huawei conducted joint pilot verification in 2018 and found that the 5G Power solution could support effective 5G site deployment without changing the grid, power distribution or cabinets. This in turn could cut retrofitting costs for a single site by more than US$1,800, save 4,130 kWh of electricity per site per year.

China Tower planned to build or retrofit about 2 million 5G sites between 2019 and 2022. An estimated 800,000 of these sites will adopt Huawei's 5G Power solution, eliminating 900 million kg in carbon emissions every year, helping to realize targets for green power grids for the 5G era.

The 5G Power solution is underpinned by breakthroughs in hardware and software and site-wide coordination. It supports simplified smart and green solutions, helping build a sustainable and green target power grid for the 5G era.

1. Simplified

5G Power supports up to 24 kW in power supply capacity and is only 4U high – 3U for the power source and 1U for the tower that operators share for power distribution. So, existing sites and cabinet space capacities can house the solution. In contrast, a traditional embedded power supply module typically needs to be 7U to 9U in height to achieve the same capacity. This makes it difficult to use existing cabinets and requires new cabinets, increasing the strain on site resources.

5G Power also adopts fully modular architecture, with modular power supply, energy storage, temperature control, and power distribution components. This allows on-demand evolution and supports intergenerational networks. Traditional power supply systems lack the capability for end-to-end evolution. As they cannot be modularly expanded, the entire cabinet has to be replaced if the site's temperature control and cooling capacity is inadequate.

2. Intelligent

5G Power boasts a raft of intelligent features, including intelligent peak shaving, intelligent voltage boosting, and intelligent energy storage. Intelligent functions remove the need to retrofit the mains grid, support on-demand battery configuration, and reduce voltage drop, slashing site retrofitting and O&M costs. Traditional power systems only provide power supply for the site and lack these intelligent features, and sites that use them will require a significant amount of retrofitting to support 5G rollout.

3. Green

5G Power focuses on improving energy and E2E efficiency at the component, site, network, and service level, consuming zero watt when there are zero bits.

Traditional power systems only enable site-level efficiency and cannot coordinate with changes in service power consumption. During service troughs, the power supply cannot sleep or shut off, making altering energy consumption in line with changing service levels and maximizing energy-saving impossible.

5G Power's innovative technology cuts the cost of 5G network evolution and enhances energy efficiency by around 9 percent. Moreover, the solution's energy storage modular expansion capability supports China Tower's power operations services, and the frequency and peak shaving services for the power grid give an additional 8-percent return.

China Tower and Huawei's joint innovation on 5G Power will serve as an important reference for future 5G network deployment and evolution around the world. It will help global operators save on site retrofitting and power costs and boost energy conservation and emissions reduction in sites, helping build a sustainable and green target power grid for the 5G era. H

HUAWEI P40 Pro+ | 5G

CO-ENGINEERED WITH **Leica**

HUAWEI Mate30 Pro ⁵ᴳ

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5G Rethink Possibilities

Kirin 990 5G SoC | SuperSensing Cine Camera*