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06/2016
ISSUE
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Rebuilding the value of telecom video

A good view is a cloudy view

Monetizing MBB the smart way

The Pipe Strategy
The Key to ICT's Potential

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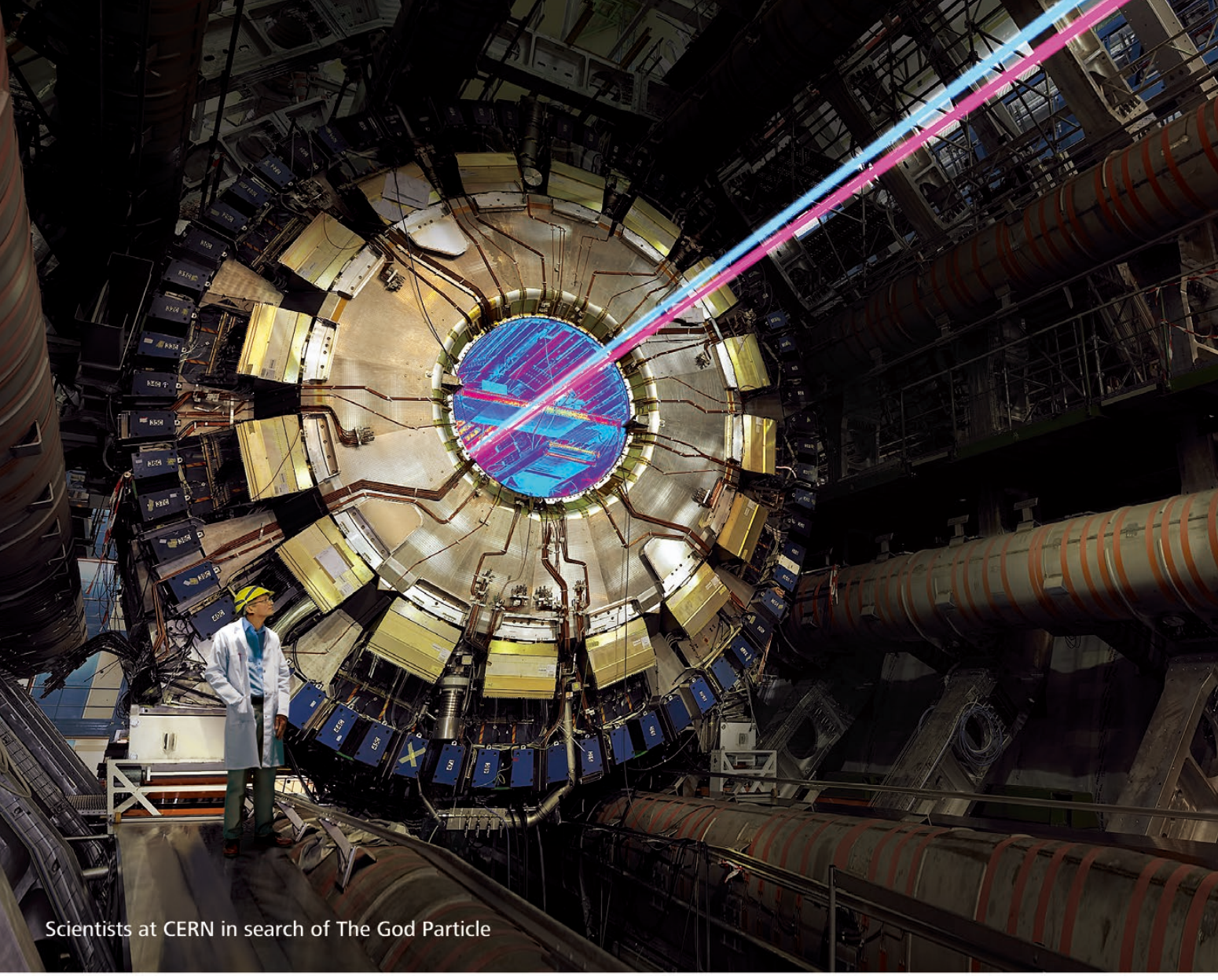

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Decades of patient investment, for a moment of divine clarity

Focus · Persevere · Breakthrough

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Publication Registration No.:
Yue B No.10148

Digitizing economies with innovative tech

The Economist’s think tank predicts that the global economy will increase by a modest 2.7 percent in 2016, continuing the sub-3 percent growth rate that has characterized global GDP since 2011. In contrast, the global digital economy is growing at an astonishing 10 percent every year, and is accompanied by an unprecedented revolution across the planet as more countries realize that national economic development shouldn’t just focus on GDP – it also needs to consider the quality of economic growth.

Over the last decade or so, the rapid development of ICT has delivered high broadband network penetration and availability. A huge amount of data has been accumulated as a result of Internet-based business innovation, which is laddering-up stages of national innovation from foundation to Internet to data.

More nations have come to understand that digital infrastructure is the key to accelerating the transformation to a digital economy. Whether it's Germany’s Industry 4.0, Singapore’s Smart Nation, or Digital Malaysia, each initiative is basically the same. In the future, broadband, data centers, cloud computing and the Internet of Things (IoT) will drive the development of each other, pushing society from Data Innovation to a more intelligent, efficient and collaborative innovation period – Augmented Innovation.

Huawei estimates that by 2020, a new All Cloud era with cloud computing, IoT, big data analytics, and AI will come into being, which will usher in an unprecedented wave of innovation that will transcend physical limits. In this new era, technological development will streamline everything and be prioritized over strategic design, and transform every vertical through full digitalization and cloudification.

However, economic digitization cannot be achieved overnight. Currently, 41% of businesses in the EU are non-digital, with fully-digitized enterprises accounting for only 2% of the total. With the key technology enablers advancing rapidly, a new horizon is upon us. Be it governments, enterprises or individuals, each party should harness this tide of tech development, both for economic advancement and a sustainable tomorrow.

Sally Gao, Editor-in-Chief

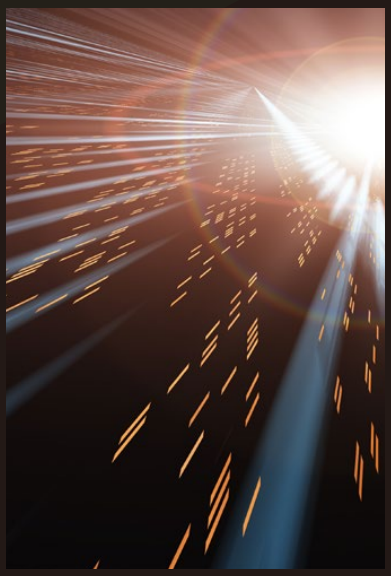
CONTENTS communicate ISSUE 79

COVER STORY

The Pipe Strategy The Key to ICT's Potential

Huawei will provide an agile network architecture and open platforms to speed the digitization of our customers.

P04



FOCUS

Drilling down to the core with NFV

In telco digital transformation, network function virtualization and software-defined networking promise immense value.

P12

FOCUS

Welcome to the cloud: Business transformation through next-gen cloud evolution

P18

FOCUS

A good view is a cloudy view

Delivering IT resources on the cloud and on-demand can help operators lower costs, engender innovation agility, and generate new revenues.

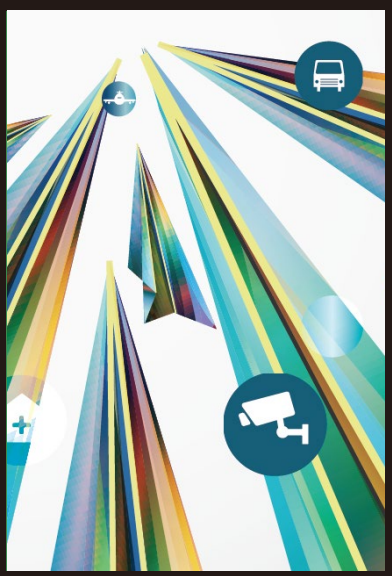
P23

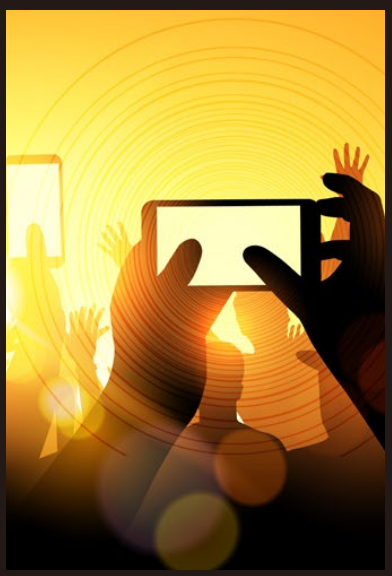
PERSPECTIVES

Monetizing MBB the smart way

Strategic digital thinking can boost CSPs position in the digital ecosystem and drive innovation to provide advanced services.

P26





Ryan Ding
President, Huawei
Products & Solutions

The Pipe Strategy

The Key to ICT's Potential

Huawei's ambition is to develop value from connections, bandwidth, and data. We will provide an agile network architecture and open platforms to speed the digitization of our customers, including telecom carriers.

At the Huawei Global Analyst Summit 2015, I spoke about three facets of innovation at Huawei: fundamental innovation, allied innovation, and open innovation. Fundamental innovation is at the heart of what Huawei does, and over the last year, we have made some very pleasing breakthroughs in this area. For example, Huawei and our partners developed standards for 4.5G which were ultimately accepted by 3GPP. Huawei helped China Mobile build the world's first large scale test site for 5G tech in Chengdu, and successfully completed field trials. Like Huawei, many companies across the industry are now starting to focus their development efforts on NB-IoT. In cloud computing, Huawei and Deutsche Telekom recently announced that the world's first carrier-operated public cloud will open for business very soon in Germany.

With our alliance partners, Huawei has also launched a number of projects. These include creating alliances for NB-IoT, 5G VIA, and OPNFV. Huawei has also formed strategic partnerships with leaders, such as Accenture, from many industries.

To support open innovation, Huawei held its first Huawei Developers Congress in 2015. Over 5,000 developers attended, laying a strong foundation for the future expansion of Huawei's open innovation programs.

At this year's two biggest global events, MWC 2016 and CeBit 2016, the buzzwords were undoubtedly IoT and virtual reality (VR). IoT will stimulate new demand for pipe bandwidth, and different players from the top to bottom of the industry are grouping into a wide range of alliances to shape IoT into a fully-fledged commercial industry. Then there's VR – for many, the first thought that VR conjures up is simply worry at the sheer bandwidth it demands. But a deeper analysis shows that there are many more issues, including latency and how to safeguard the full, end-to-end experience.

For Huawei, the industries that emerge out of these two technologies will be vital opportunities and future growth hotspots for us. They include smart home, smart manufacturing, and the Internet of Vehicles.

Opportunities and challenges of a Better Connected World

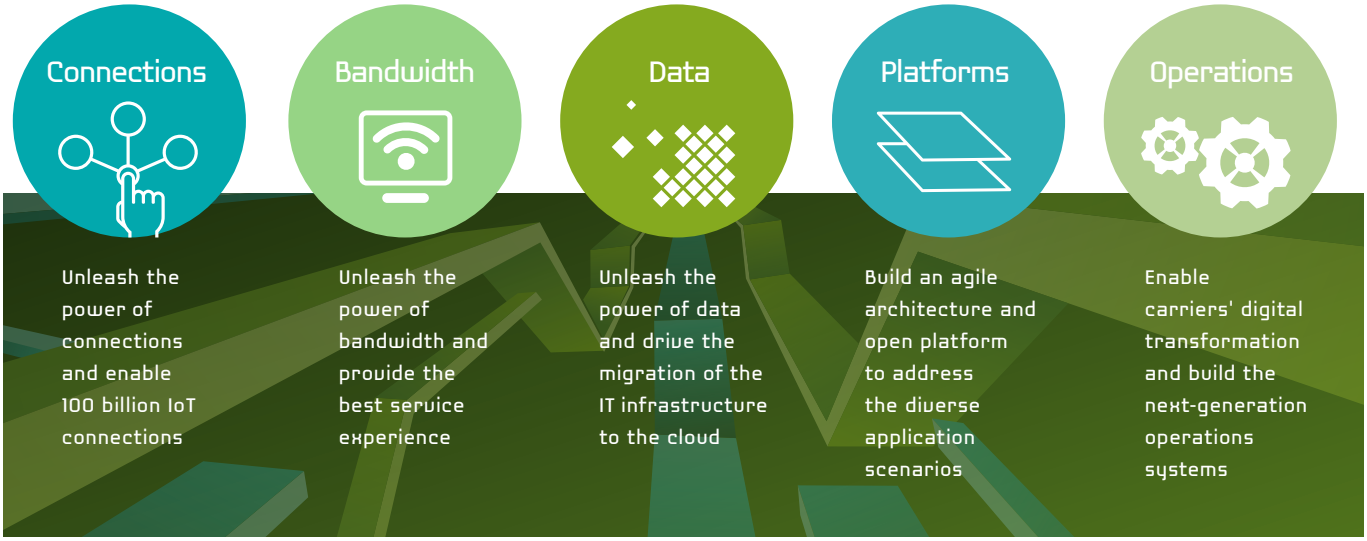
Over the past few years, a series of incremental changes in the ICT industry have brought about fundamental change in the way the world connects. A Better Connected World is emerging, and huge business opportunities will appear with it.

First, a Better Connected World will demand new types of connections. Connections between people, connections between things, and connections between people and things – the number of users is set to explode by ten times or more. In most industries, 99 percent of productive resources are not yet connected. We believe that when they are linked electronically, businesses will find more opportunities.

Second, there will be opportunities for new types of experience. Up until now, the

Over the past few years, a series of incremental changes in the ICT industry have brought about fundamental change in the way the world connects.

Huawei's five major initiatives



telecom industry has focused on the quality of the voice experience and browsing experience. Today, new ways of working and new types of experience are emerging from high definition video, like 2K, 4K, and 8K, and augmented reality (AR) and VR technologies. For example, Facebook has just announced that virtual reality will power its next generation of social media platforms. Alibaba has also launched a strategy for using VR to change the way people buy online. Authoritative sources predict that the online video market will be worth US$500 billion. Tag on AR/VR, and we're looking at a trillion-dollar industry.

The third opportunity is the digitization and cloudification of the entire ICT industry. The scope for profiting from this transformation is coming swiftly into focus, and many carriers are now gearing up to enter the cloud market. They will leverage their existing infrastructure, networks, and experience in serving their local business communities to deliver public cloud services – public cloud will be another trillion-dollar industry.

All of the changes I've described are unfolding right before our eyes. New connections are linking to new businesses. New spaces for imagination are expanding. We'll see more and more new kinds of products, new modes of service, and new channels of interaction and ways of doing business.

But as the world changes, it will present a series of new challenges to our ICT infrastructure – challenges on a scale never seen before. In terms of raw demand, we're not looking at a doubling or tripling. It's going to blow up by a factor of ten, or even one hundred. In terms of bandwidth for individual connections, a 30-40 Mbps connection is enough for a user to watch a 4K high definition video. But for a top quality VR experience, we need bandwidths of at least 5.2 Gbps. That means that over the next ten years, users will need their connection speeds to rise from an average of less than 10 Mbps today to thousands of megabits/second (i.e. gigabits), or even tens of gigabits. In terms of number of connections, there are about 5 billion devices connected to the Internet today. In ten years' time, there will be 100 billion. The volume of data usage will bring new challenges: today, the average data consumption per person, globally is less than 1 GB. By 2025, we will be consuming 1.7 GB of data per person every day.

But Huawei believes that the toughest challenges will not be the scaling up that the figures above imply. We believe that the biggest challenge will come from the new

diversity of ways and scenarios in which data is being used.

If you've followed the development of 5G standards, you'll have noticed that the biggest break from previous generations of communications technologies is in the definition of the three separate scenarios that 5G must serve. The first scenario is eMBB (enhanced mobile broadband), which will mainly serve the needs of people using mobile devices. The second is mMTC (massive machine-type communication), which will serve huge numbers of device-to-device connections. The third major scenario is URLCC (ultra-reliable and low-latency communications). From its conception, the 5G market has included these three different scenarios, and that raises a problem for the telecom industry. We cannot build three independent networks to serve these three needs. So we will have to find a way to meet the needs of all the different industries we serve in just one network.

Huawei's pipe strategy

Huawei's strategy is to invest in enabling a more efficient, more integrated system for data logistics, connecting people with people, people with things, and things with things. Huawei's pipe strategy means a focus on the flow of data: its transmission, storage, distribution, and display. This data pipeline strategy is at the core of Huawei's business, and over the next few years, Huawei will be investing heavily in five big initiatives that build from this core strength.

The power of connections

The first key is connections. How do we expand the potential for connectivity to enable 100 billion Internet of Things connections? Metcalfe's Law tells us that the value of a connection rises with the square of the number of connections in a system, so to boost the value of our connections, we must make more of them. Huawei's Global Connectivity Index report found that connectivity represents a huge market. The value of connectivity to smart cities, and in other areas, is enormous. 55 percent of connections are in industry, and 45 percent are individual connections for personal consumption. IoT remains a challenging industry because it is fragmented into many different standards, interconnection is difficult, and applications are extremely varied. At MWC 2016, specialists in the field pointed out that some of the biggest challenges are not in connecting devices, but in security and data protection. What can Huawei do to address these questions?

Huawei's approach to IoT is to focus on connectivity, following a 1+2+1 strategy. The first 1 is

Huawei's strategy is to invest in enabling a more efficient, more integrated system for data logistics, connecting people with people, people with things, and things with things.

LiteOS, the base layer IoT operating system. Huawei released this very lightweight OS in 2015, and its features include a tiny core of just 10K, millisecond latency, and ultra-low power consumption.

The 2 means two primary access modes: wired and wireless. Our IoT solutions enable Internet access, no matter how the device wants to connect. For wireless access, Huawei is focusing investment on NB-IoT, which offers ubiquity because of its breadth and depth of field. The Huawei NB-IoT solution generates 20 dB of gain over other technologies, and can support more than 100,000 IoT connections within a single cell. Battery life for devices can reach up to 10 years.

Our goal is that gigabit speeds should be available to everyone, not just those with fiber connections, but over copper or coax connections as well.

In wired access, Huawei aims to make its solutions finer-grained, for deployment in enterprises, factories, and a wide range of scenarios.

The final 1 is the cloud-based IoT platform. This single platform enables access by tens of millions of IoT terminals, and ensures end-to-end security. The platform is also where we make the system open: The southbound interface enables fast integration, and can be configured to support any new terminal within five days. The northbound interface is also open, so that third party applications can connect to the Huawei platform and manage and monitor terminals on it.

For IoT, Huawei is focusing on four industries: telecom carriers, energy, manufacturing, and Internet of Vehicles. At the same time, Huawei will be helping to build up the broader IoT industry, and reduce some of the fragmentation that currently afflicts IoT. Huawei is a member of the NB-IoT Forum and OSGi Alliance, and will continue to push for the adoption of universal standards across the IoT industry.

The power of bandwidth

Another major issue for the industry is bandwidth. How do we deliver enough bandwidth to meet the needs of future customers? New technologies, like 4K and 8K HD video, cloud, and AR/VR, demand more bandwidth and a better experience. That's why Huawei is confident that our ongoing investment in ultra-broadband will bear fruit.

Huawei has proposed that we need to build ultra-broadband networks to meet the needs of new technologies and form the foundation of the Better Connected World. In wireless, Huawei is focusing on developing 4.5G, to give every user a peak access speed of 1 Gbps or more. We have already achieved this target in networks built for Hong Kong Telecommunications and other carriers. In 2016, Huawei will build more than sixty 4.5G networks around the world. Huawei is also raising the bar in wired access. Our goal is that gigabit speeds should be available to everyone, not just those with fiber connections, but over copper or coax connections as well. In 2016, we will be deploying networks that enable gigabit access over copper last-mile networks.

But it's important to remember that high bandwidth does not necessarily mean a good experience. For a good experience, a network must also offer low latency, high throughput, and broad coverage. Technology breakthroughs are needed at every stage in the end-to-end delivery of these high quality networks. Achieving high throughput requires that the network-wide routing protocols of networks affected by packet loss, latency, or restricted bandwidth respond dynamically, so that high volumes of video or VR data can continue to flow. The key to low latency is flatter networks with fewer layer transitions to slow signals. Codec standards can also improve performance: Huawei is promoting global use of High Efficiency Video Coding (HEVC), also known as H.265, which can reduce the demand for bandwidth by up to 30 percent.

Another technical innovation by Huawei has been to evolve the Mean Opinion Score (MOS) standard for voice service quality into a new standardized system for assessing video experience quality, V-vMOS. Working with the ITU, Huawei is promoting this standard to help the entire industry accurately assess the quality of its video services. As a result, carriers are able to invest in every link of the end-to-end service chain, and see the value of their investment reflected in superior experience, rather than just pursuing ever larger bandwidth.

Other forward-looking technologies in which Huawei is investing address the challenges of VR/AR and the Internet of Vehicles. In these areas, Huawei is focusing on three key technologies.

The first, core technology is undoubtedly 5G. Over the past few years, Huawei has developed some revolutionary new technologies which enable 5G to carry data three times more efficiently than the current 4G standard. In a field test conducted by Huawei and China Mobile in Chengdu, we recorded peak speeds of 3.6 Gbps using the 100 MHz band, a very low band. We're also looking at how 5G performs in high spectrum bands: at the MWC in February this year, Huawei presented a 5G prototype which demonstrated 40 Gbps of bandwidth over the 28 GHz band. With Deutsche Telekom, Huawei has unveiled a 5G showcase offering speeds of up to 70 Gbps over the 74 GHz band using 1.8 GHz bandwidth. Network slicing will be another core feature of 5G – at MWC 2016, Huawei and Deutsche Telekom also demonstrated end-to-end slicing in two different scenarios. Data was transmitted from the core network through to the air interface, and successfully recorded 1 ms URLLC and 1.5 Gbps speeds with slicing in effect. These demonstrations give us confidence that 5G will rev up mobile broadband, and spark a revolutionary wave of innovation in our industry.

The second technology on which Huawei is focusing its investment is all-optical switching networks. When 5G arrives, carriers will need ever more powerful bearer networks linking their 5G base stations. At the MWC this year, Huawei demonstrated a 320 T all-optical switch, which requires just 200 W of power. This means that this revolutionary all-optical switching technology uses 99.9 percent less power than traditional switches. We will be running a pilot trial of this product in 2016, and by 2017 we plan to be installing it in customer networks. We're confident that this revolutionary technology will drive a revolution in optical communications.

The third technology in which Huawei is investing is application-driven networking (ADN). SDN coordinates and allocates resources across the entire network to boost efficiency, but future networks will be more fragmented and serve more diverse scenarios. Whole-network rules for resource allocation may not apply, so ADN allows the user experience to drive the network. Resources will be allocated depending on specific application needs. Moreover, these resources will not only be fixed and wireless network bandwidth, but storage and computing resources. This assemblage will ensure that both human users and machine applications receive the best network connection experience, and the efficiency of the network will rise accordingly.

The power of data

Once again, the key is data, the oil of the digital age. Data will be the most precious resource for every company and every industry. Today, we're seeing explosive growth in data, but data processing remains extremely expensive. For example, in China it currently costs about 5,000 yuan (US$800), to process one terabit of data. By comparison, data storage with Amazon costs about 2,000 yuan per year per terabit. With these high costs, how can we enable the value of the data? The only way is to shift IT infrastructure into the

cloud to help customers mine economic value from their data. To do that will require three changes: first, restructuring hardware to solve speed and efficiency issues; second, improvements in software to enable resource sharing; and third, mining data for value to enable service innovation.

Huawei began investing in cloud technology in 2008. To date we've constructed over 660 data centers around the world, over 250 of which are cloud data centers. From the start, Huawei has maintained a uniform structure for its cloud engineering. This structure supports public cloud, private cloud, and hybrid cloud; and it meets the cloud needs of a wide range of IT services. The hardware developed by Huawei includes SSD and the OceanStor OS, which has brought increased openness to the storage sector.

In cloud computing, we've invested in core I/O chipsets, and in 2015 we launched the 32-socket KunLun server, also with open architecture. For software, Huawei has invested in three platforms: our FusionSphere cloud operating system, based on OpenStack; our FusionInsight Big Data platform, based on Hadoop; and FusionStage, our distributed PaaS platform. This software helps our customers to manage the full lifecycle of their data products. It also gives them the power to deploy services within seconds, and to configure their cloud environments within minutes: Ultimately, it helps customers be agile.

Agile and open platforms

To handle the increased diversity of application scenarios in future networks, Huawei's core strategy is first of all to cloudify and create more agile architecture, then to open up the platform and enable our partners.

Over the last few years, Huawei has stuck to the SoftCOM strategy, which is to gradually cloudify industries using cloud data centers. Cloudification has several levels: equipment, network, services, and operations. To enable equipment cloudification, Huawei is pushing for a gradual shift from virtualization to cloudification – from NFV to NFC. To support the cloudification of networks, Huawei launched the world's first carrier-class SDN controller this year. This unified platform enables control of a carrier's entire network, and combines network control functions for carrier networks, data center networks, and enterprise networks.

To cloudify services, Huawei helps its customers achieve agile competitiveness by giving them a cloud-based business platform. Finally, to cloudify operations, Huawei's goal is to help its customers achieve Internetized operations. To support that goal, we will launch the world's first ICT-O product this year, which will help customers balance the needs of NFV and data centers for various resources. It will automate service deployment, centralize network control, and improve user experience.

Huawei has observed the increasing digitization of industries, and clearly recognizes one fact: Most companies lack a

deep insight into all industries. Only telecom carriers have that breadth. That's why Huawei's strategy is to focus on pipes, and to open up our technological resources: in information transmission, IoT connectivity, Big Data, and storage, and computing. We provide SDKs for our partners so that they will provide end-to-end solutions for different industries.

In 2015, we organized the first Huawei Developers Congress, and attracted 5,000 developers. By the end of the year, Huawei had 50,000 developers working worldwide. But Huawei's dream remains greater still: We hope that by 2020 we will have one million partners developing on Huawei's open platforms. To achieve this, Huawei announced in 2015 that it would be investing US$1 billion over the next five years to enable its partners to develop on the Huawei SDK platform.

We've also built a dozen OpenLabs around the world to carry out interoperability testing with our partners and jointly innovate services. Our OpenLabs have built deep partnerships with more than 600 industry partners, including Microsoft and RedHat. When customers buy Huawei products, they're buying not just the fruits of our development, but the combined wisdom of the ecosystem that supports us.

Digital transformation for carriers

Finally, and most importantly: How can Huawei help carriers complete their digital transformation? Huawei believes that the biggest challenge for carriers lies in the transformation of their ICT infrastructure over the next few years. Future customers will demand not just basic telecom services, but ICT services and a ROADS experience. At the MWC in both 2015 and 2016, Huawei held wide-ranging discussions with global carriers on the ROADS strategy and on digital transformation. We shared and learned a lot in these conversations, and as a result crystallized the Huawei strategy of focusing investment on three core platforms that will support next-gen carrier systems with an open, Internetized architecture.

The first platform is BES: The keyword for this platform is agility, with an online front end, service-based back-end, and cloud-based architecture.

The second platform is IES: The keyword for IES is automation. Its southbound interface integrates network resources like SDN, NFV, and CaaS; its northbound interface is open, and supports third party innovation. The Huawei IES is currently being piloted with Belgian Telecom and in Huawei's own public cloud.

The third platform is the Big Data platform. This is the core of the whole system. It makes both the BES and the IES smarter, more open, and more agile. Huawei is already working on a series of innovations and joint big data pilots with customers such as China Unicom Sichuan and China Unicom Shanghai.

Speeding up digitization

Without a doubt, the Better Connected World will demand bigger bandwidth, faster networks, and more data. These are Huawei's most important strategic opportunities, and they're where Huawei's focusing its energy. Huawei's pipe strategy encompasses the transmission, storage, distribution, and display of information. Our R&D investment follows this pipe strategy. Huawei's ambition is to keep on investing, and to keep on developing value from connections, bandwidth, and data. At the same time, we will provide an agile network architecture and open platforms to speed up the digitization of our customers in every vertical, including telecommunications.

Drilling down to the core with NFV

Operators are finding it tough to adjust to the rise of mobile Internet, with over-the-top (OTT) content providers seeming to hammer the nail further into the coffin. The new rules of the game are disrupting existing value chains, with services increasing but revenues remaining stagnant. Operators are staring at the unpleasant view of a dumb pipe. But, a Better Connected World beckons that promises ubiquitous connectivity. For operators, the situation is something like Charles Dickens described in A Tale of Two Cities: "It was the best of times, it was the worst of times, it was the age of wisdom." They need to find the wisdom to step on the path to the best of times.

By Liu Hao

Rapid changes in the industry have been paralleled by a shifting landscape for users, networks, and services landscape. Operators have had no choice but to transform, or risk becoming shipwrecked on the shores of failure.

Network experience is pivotal to their success, which is why network transformation is a focal point of digital transformation. At the core of this sits network function virtualization (NFV) and software-defined networking (SDN), both of which promise immense value.

Restructuring with NFV

NFV is a key enabling technology for restructuring networks, architecture, operations, and services. It decouples software from hardware using standardized IT hardware platforms and virtualization tech to replace the private dedicated network elements of traditional telecom networks. NFV will help increase the flexibility of network operations, improve management and maintenance efficiency, and cut costs.

NFV's importance and huge commercial value in the network evolution process have made it a cornerstone of operators' future network development strategies. In October 2012, 13 operators – including AT&T, BT, Orange, and Deutsche Telekom – set up the Industry Specification Group for Network Function Virtualization (NFV-ISG) at ETSI (European Telecommunications Standards Institute). With the remit of developing NFV architecture and technology and promote network function virtualization, NFV-ISG released a series of white papers proposing goals and action plans for the new technology.

The world's leading operators have set out network transformation strategies based on NFV and SDN. For example, AT&T's Domain 2.0 plan outlines the carrier's goal to virtualize 75 percent of its networks by 2020, which includes shifting from hardware – to software-centric network infrastructure and restructuring its services on cloud-based open networks that open up network capabilities to third parties. Telefónica unveiled its UNICA

NFV is a key enabling technology for restructuring networks, architecture, operations, and services.

project, which has multiple aims: build SDN-capable networks, deploy cloud-based telecom services, realize agile deployment for telecom services and universal cloud services, give users on-demand access to these services, and simplify network control.

At the 2015 Mobile World Congress in Shanghai, China Mobile announced NovoNet 2020, an ambitious vision for combining SDN and NFV tech to build a next-gen network that enables flexible architecture with open interfaces, scalable capacity, and global resource scheduling.

Expect a massive market

According to a July 2015 IHS Infonetics research report, the NFV market will skyrocket from a value of US$950 million in 2014 to US$11.6 billion in 2019, a compound annual growth rate of 65 percent. At present, standards organizations, open source communities, operators, and equipment vendors are collaborating to advance the NFV value chain. After more than three years of growth, NFV technology is maturing.

Sky high: The core reaches the cloud

While the NFV era is on the way, it's happening in the context of immense operator networks and extremely complex service scenarios. So, which scenario will be the first to embrace NFV? The consensus is core networks, in the following order of planes: control, signaling, data, and media. Core networks will be the first step on the way to full NFV adoption.

As for operators evolving their core networks with NFV, industry experts point out that the switching and control center network is the primary feature of a telecom plant. After the move to cloud networks, core networks must continue to offer carrier-grade services such as high reliability and performance, fault recovery, and open architecture. To do so, they need a cloud-based software design.

To start with, operators need to build agile networks. Compared to the rapid service innovation and responsiveness of OTT players, operators take much longer to introduce new services or capabilities due to their traditional network architecture. NFV and SDN enable operators to integrate the scalable resources of cloud-based infrastructure, including SDN and NFV service elasticity. The result is unified scheduling, network coordination, and VNFs (Virtualized Network Functions) based on service requests. Based on automated end-to-end resource deployment, schedule flexibility, and faster TTM, service instances increase during times of growth and decrease during periods of slow growth.

To achieve this, operators require advanced cloud-based software architecture that separates programs and data. With service state storage in an independent distributed database, service processing units can scale to meet service needs by flexibly adding or releasing virtual

machine resources without service downtime.

Next, operators need to build smarter, automated networks. Currently, the following trends are taking hold: network virtualization of data centers, decoupling software from hardware, network personalization, introduction of massive third-party services, and the auto-orchestration and auto-scaling of services and resources. Each of these features requires a maintainable, serviceable, and operable network alongside a unified smart orchestration system that can:

- Enable unified scheduling and dynamic updates of networks, resources, and network elements based on different services and policies.
- Automatically integrate and consolidate operations to automate service orchestration and maintenance, slashing workloads and reducing maintenance complexity.
- Monitor service KPIs in real time so that an alarm is triggered when KPIs hit the set threshold, and automatic recovery begins.
- Support end-to-end fault localization within an environment where hardware and software are decoupled. The system needs to consolidate and analyze security information like logs, alarms, and output exceptions from each component to ensure rapid fault localization and threat forecasts.

No matter how operators transform their networks, they must have a multi-layer strategy for reliability backed by innovative technology to deliver five-9 (99.999%) carrier-grade reliability after adopting NFV.

Finally, operators need to create more services and value through cloud-based networks. In their current state, they have little chance of beating OTT players when it comes to innovative service applications. However, they have accumulated vast digital assets over a long period of time that yield considerable value, which they must find a way to harness and unleash.

Operators can employ emerging NFV/SDN technologies to flexibly integrate their network capabilities, provide services (such as VNF as a Service) directly to third parties by opening up their network capabilities, create a new ecosystem, and increase revenues. To this end, they need

Operators can employ emerging NFV/SDN technologies to flexibly integrate their network capabilities, provide services directly to third parties by opening up their network capabilities, create a new ecosystem, and increase revenues.

The foundation is in place for NFV to stake its claim as a key enabling technology in the network evolution process.

support in offering third parties a one-stop platform that provides exposure to network capabilities, including a DevOps mode that supports the entire service lifecycle, from development to maintenance.

Moving forward, such a platform will need to encapsulate communication capabilities – including voice, video, conferencing, SMS, and access to location, bandwidth, and data – into APIs (application programming interfaces) and SDKs (software development kits). This will accelerate service innovation and release, and create an environment conducive to win-win outcomes between operators, their partners, and even OTT players.

It's worth noting that legacy telecom networks are unable to meet the varied requirements each vertical has for network capabilities. For example, the Internet of Vehicles requires ultra-low latency, video streaming sites need high bandwidth, and banks need the highest possible level of network reliability. NFV and SDN technologies enable VPN (virtual private network) slices that support the unique communication characteristics of each enterprise or industry. In other words, operators will be able to divide traditional telecom networks into thousands of network slices, with each slice meeting the custom needs of individual enterprises and industries. Such a model, which could be called Network Slice as a Service, would help operators better meet user needs in different personal, household, business, and specific industry scenarios.

Vodafone launches the world's first cloud-based VoLTE commercial network

For operators, the benefits of NFV go beyond reducing OPEX. The core value of agile, smart, and value-added cloud-based networks made possible by NFV is the extra revenue they can generate. Major operators are keen to begin extracting this value. Having accumulated useful experience in NFV deployment, they're now starting to walk the walk.

Despite being a leading global telecom operator, Vodafone's traditional telecom services like voice and SMS have been hit by OTT services. NFV has offered Vodafone an effective solution to this problem by providing the company a means to build smart pipes, optimize its networks, improve its management efficiency, and make its networks smarter and more controllable, all the while slashing maintenance costs. Moreover, NFV enables Vodafone to fully open up its underlying networks, and drive innovation and flexible deployment of Internet services.

Vodafone announced its One Cloud strategy to move everything to the cloud as far back as 2013. The goals of this transformation strategy are to challenge OTT services and, more importantly, adapt to the explosive growth of data traffic in the Internet era, deliver a better user experience, and change its role from a pipe provider to a service provider.

A key step in this strategy was to construct an NFV cloud-based VoLTE network – the world's first – in partnership with Huawei in 2014 in Italy. Vodafone teamed up with Huawei again to launch the network commercially for its Italian subsidiary in July 2015. Serving as the primary systems integrator, Huawei provided a cloud-based IP Multimedia Subsystem (IMS) network and delivered a vertically integrated, end-to-end system with a horizontal service layer, while guaranteeing carrier-grade capabilities over the cloud-based network.

Vodafone and Huawei worked together to develop the CloudHealth tool kit at Huawei's NFV/SDN open lab. When simulated errors were inputted into the system in a mirrored network environment, CloudHealth automatically detected sub-optimal performance and initiated automatic system recovery. This new system can issue a warning of potential system-level faults a full three hours in advance of system failure. Previously, simply detecting and localizing faults could take four hours after they had already occurred.

NFV live network pilots in China: Generating valuable experience

Chinese operators have also been hit by the sudden rise in OTT services. In response, they're transforming their networks, with NFV as a must-have technology. China Mobile, in partnership with Huawei, kicked off the pilot deployment of an NFV cloud-based core in September 2015. The operator's subsidiaries in Shaanxi and Anhui provinces ran test applications of NFV technology on their live networks and a small-scale field trial of the pilot network. These tests aimed to verify cloud-based networking, technical specifications, service capabilities, maintenance, and full-lifecycle management.

Then, on December 10, 2015, China Mobile, alongside Huawei, HP, and Inspur, completed the first cloud-based VoLTE call over its pilot NFV cloud-based network, demonstrating that the IMS system had successfully connected with a live network in a multi-vendor hardware environment.

Following this breakthrough, China Mobile completed another first, with a cross-province HD video call based on its pilot NFV networks in Shaanxi and Anhui.

Nevertheless, NFV-based networks can't be built overnight – the process is complex and requires operators to fully consider how NFV-based networks align with network transformation and comprehensive development strategies, meaning the large-scale commercial deployment of NFV-based networks will take place over the long term. Tier-1 operators such as Vodafone and China Mobile are currently piloting NFV technology, providing a useful reference point for other operators that are considering NFV deployment.

The foundation is in place for NFV to stake its claim as a key enabling technology in the network evolution process – a process that operators must follow.

Welcome to the cloud

Business transformation through next-gen cloud evolution

The default service delivery setting of today's digital era is a ROADS experience. These five letters represent the expectations of modern consumers: Real-time, On-demand, All-online, DIY, and Social. To provide a ROADS experience and satisfy new business and user demands, telcos are using cloud infrastructure to transform their IT capabilities, increase efficiency, and get new services to market faster.

By Allan Mow, Gracen Duffield & Lu Xi

Burdened by a rigid infrastructure, telcos are struggling with high total cost of ownership (TCO), exacerbated by a lack of agility, visibility, and mature systems. Under threat from agile competition and with income shifting away from voice and traditional data, telcos are under great pressure to maximize efficiency and create revenue streams by delivering new customer-oriented services.

Unsurprisingly, more telcos are looking to cloud evolution to help remove pain points and get up to speed with industry trends. By building next-gen service-driven cloud data centers (CDCs) based on open cloud platforms such as OpenStack, they can

reduce costs, become more innovative, and accelerate time to market (TTM) to overcome challenges and stay ahead of the game.

In the clouds

High TCO

Traditional IT costs eat up as much as 8 percent of an operator's gross revenues in developed markets (Feldon 2014). The primary contributors are low resource utilization, vendor lock-in, and aging equipment.

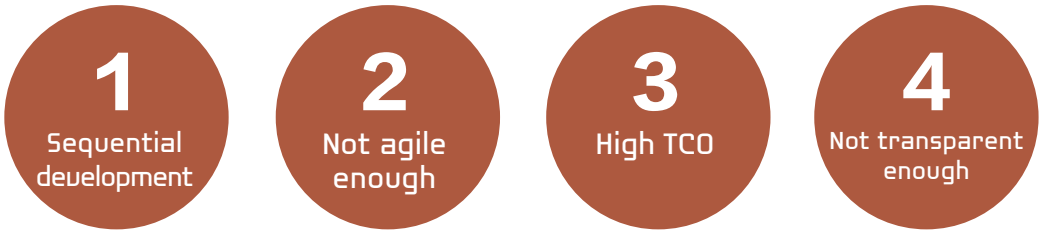
Due to siloed infrastructure, we've found that CPU utilization for non-virtualized servers averages between 10 percent and 20 percent, with peak utilization rarely topping 60 percent. Often designed to accommodate a handful of once-a-year Black Friday-type peak load events, excess capacity sits idle for the other 360 or so days. One Huawei customer found that average CPU utilization for one of its opcos was a pretty dreadful 16 percent. Even worse, it couldn't deploy new applications due to a lack of available resources.

Locked-in to proprietary technology places telcos at a significant disadvantage when it comes to negotiating with vendors on discounts on licenses and hardware renewal. In a more subtle form of lock-in, vendors might only support certain certified configurations. When 70 percent of its servers reached the end of its support lifecycle, one Huawei customer discovered that licensing and configuration restrictions stopped it moving applications to available servers, incurring a whopping US$200,000 bill for new licenses – twice as much as an OpenStack solution. The final nail in the coffin is older equipment, which uses more space and power, is inefficient, and raises costs when it begins to wear out.

Through consolidation and by virtualizing server and storage solutions, open-cloud architecture provides shared resources in consolidated frameworks under automated unified management systems. Open technology protocols with multiple hypervisors integrate heterogeneous commodity equipment. These improvements drive down TCO by helping telcos improve resource utilization. They also evade vendor lock-in and assess older equipment TCO to reduce power, cooling, and facility costs. CDCs also provide better management tools for automation, lowering labor costs on low-value tasks.

Lack of agility

With traditional siloed infrastructure, segregated resources cannot be shared and deployed when they're needed, instead sitting idle. Complex application integration coupled with a mish-mash of software platforms makes adopting a shared service model for efficiency and cost saving extremely difficult, because supporting each system requires different skills and knowledge. This leads to capacity constraints that hinder IT delivery as each new project requires an additional buildout when DCs are at near-full physical capacity. Meanwhile, the procurement and installation of the dedicated infrastructure needed for each new project extends lead time.



Cloud infrastructure eliminates the need for clunky procurement processes, and makes it possible to deploy shared heterogeneous resources and manage them intelligently on a shared platform. These improvements boost agility and TTM, which can in turn support the development and competitive delivery of diverse digital and cloud services with minimal lead times.

Lack of visibility

Problems with high TCO and a lack of agility are worsened by poor visibility when it comes to capacity, performance management, and SLA attainment due to the lack of standardized architecture and processes.

With opcos often operating independently or acquired through M&As, telcos lack a consolidated, real-time view of their business-wide resources because different tools, reporting structures, and management portals are in play. One Huawei customer, for example, was unable to produce consolidated reports on the capacity of each of its infrastructure domains and application layers because its server, storage, backup, and network teams used different data capture tools. Without a working CMBD, it was unable to correlate raw data and services.

Traditional telcos also lack end-to-end performance management tools, making it difficult to quickly identify the cause of performance issues, despite the use of reactive monitoring to alert support staff about compromised assets. Meanwhile, telco IT departments often focus on specific task completion metrics in their SLA management and KPIs, rather than correlating performance with financial measurements, which telco executives care more about.

Cloud transformation can provide better visibility on current capacity, performance, and KPI levels to provide better support for decision making and integration with partners and suppliers.

Growing up

Telcos often find themselves tied down by their existing processes, tools, and technologies. For instance, manual processes, workflow tracking, and poor change management can be destabilizing and impact service availability. Too often, DR capabilities are untested, which can impact availability and SLAs. IT directors often feel their company would struggle with a disaster-level event because the backup of siloed applications is extremely inefficient. SLA management is not always automated, often

focusing on captured results, not proactive management.

Service requirements must be checked against current availability and DR capabilities. Cloud transformation helps an organization mature by virtue of better IT management control, processes, and operations.

An overview of the cloud transformation process

It all begins with strategy – assessing industry trends, opportunities, and pain points; understanding customer goals; and defining an action plan. This is followed by Discovery and Analysis, where gaps and requirements are identified by comparing current and end-state IT. TCO is analyzed, and people, processes, and technology are assessed to ensure strategies can be fulfilled. Then Planning and Design sets out each stage of transformation, including implementation, execution runs books, and migration waves. During each implementation stage, new cloud architecture is installed, tested, validated, and migrated, leading to knowledge transfer. Finally, continuous improvement involves validating services, optimizing, and providing guidance to ensure continued excellence.

Implementation: four steps to the cloud

Implementing cloud architecture is a four-stage process. Stage one involves server and storage virtualization to increase machine efficiency and reduce complexity. This is followed by resource pool architecture construction in stage two, which helps build operators' capabilities for innovating IT services and speeding up TTM. In the third stage, unified management tools, performance monitoring, capacity monitoring, and SLAs are put in place to enable unified management and automation. Stage four sees a flexible and cost-effective cloudified architecture provide service virtualization and consolidation.

During the cloud evolution process, telcos must implement mature processes and operations that span day-to-day operations, ITIL process frameworks, and technology domain readiness. By implementing practical improvement plans, operators can be sure that their people, processes, and tech can support cloud transformation and deliver business returns.

Transformation deploys technology and processes that support a broad range of business goals. Among these, telcos often first choose an internal cloud to optimize their OSS and BSS alongside new big data

By implementing practical improvement plans, operators can be sure that their people, processes, and tech can support cloud transformation and deliver business returns.

With a distributed cloud architecture and point-to-point interconnections, operators can achieve unified management, presentation, and operations.

applications. XaaS, including IaaS, can then be developed for external customers. As sophistication rises, NFV (network functions virtualization) and network support can be used to create dynamic network functions for next-gen customer cloud services.

What does the end picture look like?

With a distributed cloud architecture and point-to-point interconnections, operators can achieve unified management, presentation, and operations. Global operators' CDCs in different regions allows scalable logical resource pools that incorporate physical and virtual resources.

To follow industry trends, telcos need a unified, consistent, and long-term vision of a comprehensive, inclusive, agile, and unified cloud architecture: "Comprehensive" satisfies current and future CT and IT requirements; "inclusive", or open, supports low-cost heterogeneous COTS (commercial off-the-shelf) hardware and software; and "agile" deploys applications and services faster, lowering TTM.

OpenStack and legacy support

According to Gartner, 75 percent of operators employ a dual-hypervisor strategy for virtualization and cloud. They do this to balance risk management, avoid vendor lock-in, and save costs. But, it complicates their business and, in the long run, increases OPEX. Deploying an open cloud platform such as OpenStack over multiple hypervisors unifies management and saves costs.

OpenStack also provides flexibility for future innovation and cuts costs by 30 percent compared to proprietary platforms.

First migrating less critical applications to the open cloud platform can minimize risks and immediately cut costs – it also gives IT staff experience using the platform while they develop the ecosystem.

In a nutshell

More than just a new piece of hardware, cloud transformation also matures and modernizes operations by integration and migration, and increases utilization through resource consolidation and intelligent virtualization.

By transforming IT, telcos both reduce costs and expand their capabilities to develop new offerings. According to Gartner and Huawei Market Intelligence, transformation lowers TCO on existing infrastructure from an average of 60 percent to 48 percent, while almost doubling spending on innovation from 19 percent to 35 percent. Overall, cloud transformation cuts IT costs by an impressive 20 percent.

In a dynamic environment replete with challenges, cloud transformation helps operators overcome chronic problems, frees up resources to focus on new objectives, and cultivate opportunities to ensure long-term business success.

A good view is a cloudy view

Our hyper-connected and intelligent digital world presents great opportunities for operators if they embrace cloud transformation to offer transformative new services. Delivering IT resources on the cloud and on-demand can help operators lower costs, engender innovation agility, and generate new revenues.

By Ronald Chung

Gartner predicts that the cloud service market will be worth more than US$200 billion by 2020, US$10 billion of which will be up for grabs. Operators are better placed than other cloud service providers to deliver cloud services to various verticals and governments thanks to a legacy of high brand equity, strong cloud infrastructure, excellent local service support, assured network performance, secure data center networks, and managed IT services.

For enterprises, cloud services are becoming indispensible, which IT budgets are increasingly reflecting. In response, more than twenty major operators have mapped out digital transformation plans to align their businesses with an enterprise IT strategy.

There are a number of possible starting points for transformation: modernizing data centers or constructing new ones, providing managed cloud services and public cloud services, migrating telecom services to telecom clouds, optimizing BOSS (business and

operation support system) with operation and support clouds, and NFUI (network function virtualization infrastructure).

For example, Deutsche Telekom and Telefónica already offer public cloud services, and South Africa's MTN has unveiled its Reload 2020 strategy, which includes a cloud platform. The three major Chinese operators – China Telecom, China Mobile and China Unicom – have launched digital transformation strategies to tap the cloud for silver from the Internet of Things (IoT), Internet +, telecom services, and public clouds.

Breathing life into business

Enterprises are relying more on operator cloud platforms, requiring operators to develop cloud services portfolios with tailored support and services that meet the needs of different verticals, including public clouds, vertical market clouds, and managed enterprise clouds.

In fact, operators are likely to become business advisors to customers by serving as the prime contractor in government and vertical market projects and as solution planners for all sizes of enterprise. To play such a role, operators need to build up a cloud ecosystem and partnership management capabilities.

Operators will therefore need to propose mature, stable, and manageable IT solutions that meet the requirements of customer projects.

The way to reach the clouds

Cloud transformation is not as simple as just deploying a platform and selling capabilities. It calls for an entirely new business model with new business operation processes, security compliance, selling approaches, pricing models and support services. To manage, market, and run a new cloud business, operators either need to parcel this work to their IT divisions or set up new digital divisions or new subsidiaries.

As a leading ICT solution provider, Huawei has identified four main areas of cloud transformation for which it can provide operators with full support: modernizing data centers, cloudifying internal IT systems, cloudifying telecom services, and providing B2B cloud services.

Data center modernization: forms the foundation of cloud transformation. Modernizing data centers simplifies telcos' internal IT and resource allocation for external customers, including public or enterprise cloud services. It centralizes physical, network, IT and virtualized resources, facilitating management and monitoring. Operators use a number of business and support systems, which carry out functions such as sales and marketing, accounting, and billing to deliver commercial cloud services and other cloudified telecom services.

Modernizing data centers involves expanding IT systems and replacing IT equipment. The various systems can create a heterogeneous IT environment with servers and storage from multiple vendors. But, this can lead to issues with vendor management, SLAs, and cost control, especially when new service plans and new business or market opportunities are in play.

Internal IT cloudification: simplifies central

resource management and distributed resource allocation in heterogeneous IT environments so different departments can retain assigned, allocated, and virtualized IT resources on the cloud platform.

Operators are adopting new and different business models for traditional services, including core, mobile, and value-added services (VAS), which are still dependable sources of revenue. Technological advancements such as software and hardware decoupling can boost service deployment agility and allow more dynamic network resource scaling and management. Operators are using cloud technology to implement NFV and migrate VAS to the cloud, making them much more like Internet firms that are able to achieve rapid deployment and launch core services or VAS.

Cloudification will provide operators with new opportunities to sell B2B cloud services, such as IT resources and IT applications. To target different enterprise sectors, operators will need to understand market solutions and major government ICT policies, such as Industry 4.0, Internet Plus, and Industrial Internet.

In the enterprise market, operators will be able to provide vertical clouds using simple IaaS (infrastructure as a service) with specific PaaS (platform as a service) and SaaS (software as a service) applications to deliver self-service web portals. Through these, companies can access IT on-demand, online, and in real time to meet their needs for service support, data localization, and data privacy. Global operators will be able to leverage their worldwide sales networks to offer enterprise ICT service packages that bundle VPNs, leased lines, and telecom services for multinational companies that lack local IT support in certain locations.

In the vertical market and government sectors, telcos will require industry knowledge and standards to support customers. Operators will be well placed to attract this market due to strong brand equity, network and IT infrastructure readiness, trusted business partner status, support and service quality, and expertise. Operators will also be able to up-sell NBN (national broadband networks) and national data center solutions to help governments formulate national ICT policies and plan G2C (government to citizen), G2B (government to business) and G2G (government to government) e-gov strategies.

When it comes to the four areas of cloud transformation – modernizing data centers, cloudifying internal IT systems, cloudifying telecom services, and providing B2B cloud services – Huawei's business visualization service sets out the transformation process, from existing data center infrastructure to cloud data center infrastructure. It also shows how cloud resources can improve the efficiency of service operations, how traditional telecom services can be evolved into cloudified telco services using new NFV infrastructure, and how cloud services can help operators enter different enterprise sectors. The business visualization service also outlines product capabilities, solution approaches, business consultation, and enterprise architecture.

Time and again, operators have chosen Huawei as their primary cloud transformation partner. Deutsche Telekom did so for its Open Telekom Cloud project, praising Huawei's tech knowhow, R&D capabilities, and efficient leadership, which it stated helped expedite the launch of the public cloud. China Telecom partnered with Huawei on a cloud transformation project for Jiaxing city government's IT services, with many factors working in Huawei's favor when it came to selection: its powerful brand presence in China, strong software development and support capabilities, integration with the China Telecom network infrastructure, and adoption of a new business service model.

Cloud transformation is the way forward, and choosing the right partner can unlock the door to future business successes.

Monetizing MBB the smart way

Communication service providers (CSP) must focus on the digital enablement ecosystem to get ready for the digital economy.Technologically, this ecosystem includes cloud, big data, IoT, and MBB services. It also incorporates e-commerce, multi-sided business models, convergence, and on-demand customer experience. Strategic digital thinking can boost CSPs position in the digital ecosystem and drive innovation to provide advanced services for customers.

By Mohammad Alakhras

CSPs continue to be squeezed financially. Data volumes are increasing exponentially, with new-generation networks like LTE driving mobile data usage. These can create new revenue streams, and help mobile service providers stay competitive. However, the ability of most telcos to monetize MBB hasn't kept pace with the rise in data consumption, so profits are diminishing.

It's not enough to add more cookie cutter offers or unlimited and basic tiered data plans. It's getting cheaper to get online but sales volumes are declining, and markets are shrinking. A flat rate all-you-can-eat pricing model lacks stability, sending service providers into a downward spiral because it ignores growth potential and shifts the competitive focus from quality and service differentiation to price.

Successful offering strategies are essential for fixed and mobile operators to directly manage mobile broadband operators, and there are several that CSPs can use to leverage the benefits of LTE and capture market share.

What to offer

An unlimited flat-rate offering divides the cost of the network evenly across the customer base, and is extremely simple to implement and market. Competitive differentiation is based on price and access speed, shifting focus from quality and service differentiation to price competition. But it exposes carriers to the risk of diminishing returns based on the cost-plus pricing model, and it can create congestion by encouraging overconsumption.

A use-based offering shifts more of a network's costs to the heaviest users. It can make bandwidth utilization more efficient and encourage better compression technology to deliver content online. Use-based offerings are susceptible to anti-consumer manipulation by CSPs. They can suppress activities that are generally encouraged like future growth and innovation on the Internet and cause some customers to avoid services.

CSPs must remove barriers to use, address individual needs, and finally create new revenue

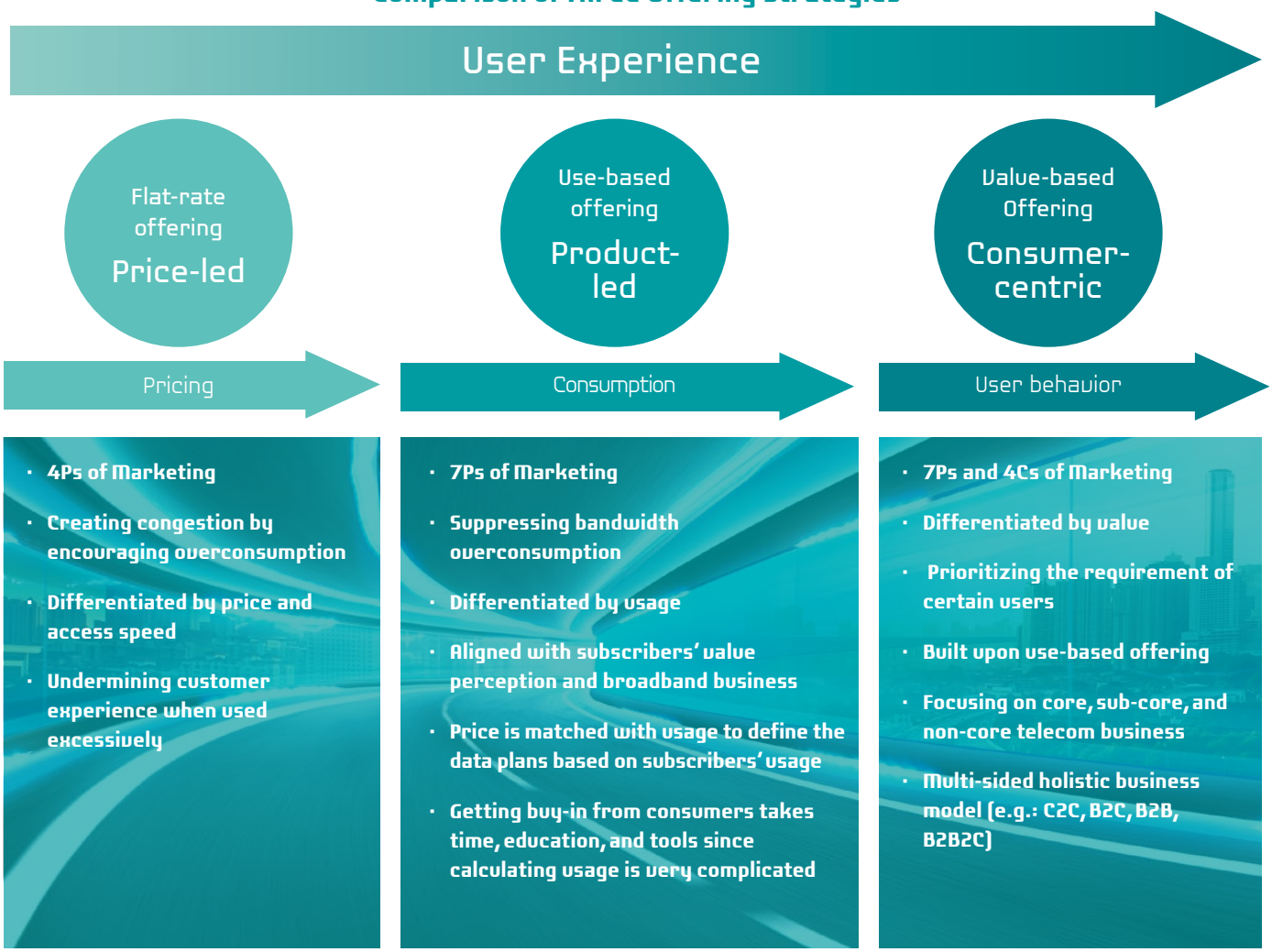
streams. Incumbents in particular should lead the market by creating sustainable revenue models, analyzing consumption, marketing new products immediately, and conveying the value of more advanced services to customers.

A value-based offering for broadband will enable a better match between the price customers pay and the value they derive from services, so it is important to start defining tier levels that fit consumer behavior, profiles, and use needs without impacting customer spending. For example, demographics and psychographics through new multi-sided and data-driven marketing models can identify and personalize offers to a variety of market micro segments, increase customer value, and reduce churn.

Some CSPs exploit the traffic explosion introducing new data-centric offers and commercial models to improve revenues, retain customers, and monetize network investment. Such offers succeed only when they're paired with a reliable LTE network.

The Vodafone group offers VAS extensively, including big names like Spotify and Netflix, to promote

Comparison of Three Offering Strategies



a premium network experience in regards to speed and coverage. The US market tends to have a family oriented approach to mobile services like share plans. In Europe, the approach is more personal, leading some MNOs to focus on multi-device offerings for single customers, for example, Wind Magnum, which offers one extra data-SIM in addition to voice plus data plans.

Sample Offering

App Specific Offering: CSPs can retain customers, stimulate data usage, and generate new revenues by giving customers unlimited access to social networks under a value-for-money package that detects the customer's attempt to use a specific service. This could be an HTTP music site, or applications like VoIP, IM, Facebook, and YouTube. Offerings can be based on service type, for example, downloads, mobile TV, or music streaming; content type; device type, such as smart phones or tablets; time of day; loyalty points; and usage behaviour.

Below are some examples:

amazon

Amazon customers can pay US$0.99 to download any book from the Harry Potter series.

To get existing customers more comfortable with the idea of using mobile data, CSPs can give free or low cost samples of mobile broadband that steer them towards plans.

It is difficult to determine how many people would use mobile social media without a promotion. For example, Turkcell reported that its free Facebook offer helped spark an 820 percent increase in mobile Facebook use in 2010. By the end of the year, 6.5 million Turkcell customers were accessing Facebook on their phones each month. Equally, Twitter Zero led to a 340 percent increase in mobile Twitter use. These translated into significant up-selling opportunities for the company. Turkcell sold 30,000 social media packages in the first week the add-on was available, and 600,000 in the first four months. Turkcell reported that this promotion increased ARPU by 9 percent.

skype

Smartphone users can enjoy unlimited Skype-to-Skype, discounted international calls in "always on" status for US$2.99 per month and Windows Live Messenger for US$2 per month.

To get existing customers more comfortable with the idea of using mobile data, CSPs can give free or low cost sample of mobile broadband that steer them towards plans.

Digital services such as mobile money, IoT, and cloud services are a blue ocean for CSPs.

Bandwidth on-demand offering: CSPs can improve customer QoE and generate new revenue by offering on-demand methods when customers subscribe to a higher QoS service, for example, a boost button to improve QoS on YouTube.

Time and location offering: CSPs can provide data offers based on specific times and locations to target casual mobile broadband and short-term travelers, for example, special packages with a certain data cap limited by hours, days, or weeks.

- **DIY offering:** CSPs can attract more customers and improve customer experience by allowing customers to customize their tariffs and services according to their own needs; for example, happy hours and preferred destinations, location based charging, preferred communication channels, and interest in future promotions.

- **Multi-tier offering:** CSPs can offer data plans with multiple tiers: flat-rate first for trial followed by a use-based pricing model, before moving to flat-rate pricing again when customers are drawn to 4G networks.

- **Digital services** such as mobile money, IoT, and cloud services for consumers and enterprises are a blue ocean for CSPs; they're aiming to create double-sided business models to either compete or forge tie-ins with players such as OTT service providers. Established customer and billing relationships coupled with a large amount of behavioral data are key advantages enabling CSPs to widen their presence across the digital services landscape. Some examples are below:

AT¢T's wireless network powers two-way vehicle communications, remote engine diagnostics, and the infotainment feature in Tesla's cars.

Verizon offers home automation and energy management solutions that can be controlled remotely from iPod touch, smartphones, or Fios TV.

Vodafone's connected cabinets' service enables retailers to monitor cabinets' stock and temperature remotely and view real time itemized sales.

Malaysian provider Digi held a promotion allowing customers five consecutive days of unlimited WhatsApp access. Singapore's SingTel recently began bundling WhatsApp with its tiered pricing plans.

Canada's third-largest wireless provider TELUS signed a strategic partnership with Microsoft to promote VoIP provider Skype on its network's smartphones. Skype runs on both Wi-Fi and the wireless networks, and although using the latter incurs data charges, TELUS customers receive unlimited Skype-to-Skype voice calls and instant messages. TELUS allows its customers the option to purchase Skype credit and have the charge turn up

on their monthly TELUS bills.

To shift to value-based MBB offerings, CSPs must first develop new strategies by establishing new objectives, a timeline, and KPIs that extract the most value from MBB assets, as both the broadband service and service delivery differ from traditional voice services. Thus the traditional strategies applied for voice networks may no longer be useful.

Next, they must assess whether the current organization is vital for CSPs to support value-based offerings. For example, vertical silos need to be dismantled to facilitate integrated service delivery and communication across different lines of business.

Finally, the operating processes need to be redesigned in a way that encourages the seamless delivery of services and improve customer satisfaction. For example, marketing departments need to develop and deliver new communications plans that clearly cement the benefits of the new offering in customers' minds. To eliminate bill shock, carriers must also develop tools that enable customers to easily monitor how much they're consuming and alert them when those levels are nearing tier limits.

The bottom line is that innovation in multiple directions is the key to driving new groundbreaking offerings and improving customer experience.

Innovation strategy

The marketing organization needs innovation capabilities to build a long-term offering strategy and ecosystem based on pricing, services, and consumer behaviors. It's also vital to work on the following aspects:

- Understanding the differentiation capabilities for empowering CSP's commercial and marketing strategies and objectives, and identifying where to invest in mobile broadband capacity, while avoiding over-dimensioning and unnecessary expenditure.
- Adapting the CSP portfolio and business model to a digitization strategy and market trends.
- Analyzing and articulating how systems and technology transformation can transform and improve business efficiency.
- Innovating new products, processes, services, or ideas to cover core, near-core, and non-core telecom business.
- Ramping up customer experience by understanding their needs to eliminate weaknesses and optimize delivery channels.

Service differentiation is the best option for CSPs and their customers. CSPs benefit through new revenue channels, improved network utilization, and the ability to offer differentiated service models by optimizing individual user experience at the right price point. The industry should move away from flat rate penetration pricing and start experimenting with new offering models based on sophisticated traffic analysis and traffic prioritization mechanisms that result in more advanced pricing structures.

Competitive differentiation can be based on multiple value dimensions that could combine pricing, traffic, consumption, and consumer analysis. With multiple differentiated offerings, consumers can pay for what they need because they will receive the QoS and value they expect from their subscription plans.

Rebuilding the value of telecom video

The proliferation of smart devices and the sharp increase in bandwidth have caused video consumption to soar to the extent that it now accounts for over 60 percent of global data traffic. What are the leading carriers doing in response?

By Zhang Aijun

Carriers know that video is no longer just a value-added service that complements broadband – instead, it's a key service that carriers are placing at the center of their future transformation strategies for business growth.

With its 012 strategy, China Telecom Sichuan aims to leverage its Fusion video service to attract subscribers. Meanwhile, Telefónica, which has a large customer base in Spain, pledged its commitment to establish itself as a video company by 2020.

The ticket to a bright future

Carriers can learn a lot from over-the-top (OTT) providers. The omnipresent Tencent app WeChat has become one of the company's core products, forming a key part of its connectivity strategy because of the app's powerful capability to connect users, even though it doesn't generate profits. However, Tencent views WeChat as its channel to the mobile Internet.

Due to the rise of OTT, carriers are seeing reduced revenue from core voice and data services. Video, with its capacity to connect users, will become a basic service for carriers, on top of traditional voice and data, because of its future role as a chief medium of communication in the coming information society. 4K/8K video has already brought about an explosive increase in value for carrier pipelines. Ultra HD video has given carriers a perfect strategic opportunity to avoid being turned into dumb pipes and reverse low revenue growth. For carriers, video is without a doubt the ticket to a bright future over the long term.

When it comes to stimulating consumers' insatiable appetite for consumption, user experience is king. But, the traditional way of running services can't meet the demands of future experience-centric requirements. This is where video will help – it will act as a connector to experience-based operations. Carriers will be able to integrate video with key network elements to provide the ultimate experience for users, connecting them and ensuring business success.

Future predictions hold that video will penetrate all industries, including entertainment, telecom, and the already booming video application industry. Carriers will be able to use video to help services penetrate into different ecosystems, with video as the glue that binds carrier capabilities and different industry ecosystems together.

Video will activate and maximize the value of carriers' network assets. Globally, growth in operator data services is slowing year on year, so carriers have sailed into the red ocean by competing on price with mobile and fixed-line broadband services. 4K/8K has given them a new way to assert their value – by delivering a video experience, they can once again offer differentiated value.

Hybrid video

To provide video as a basic service, carriers need to build five supply chain systems: product, technology, content, new services, and O&M.

If the service positioning of a video services changes, the infrastructure that supports the service will also need to change, as illustrated in the table.

Carriers that view video as a basic service will need to build a stable, reliable, and secure service system that is experience-focused and based on an advanced architecture that guarantees sustainable development, ensures rapid service launch, and enables carriers to improve their operating capabilities.

Better experience, better competitiveness

Huawei's customer design center commissioned industry analysts Ovum to survey users from China, the US, France, Indonesia, and Brazil to find out requirements for video experiences. The top three factors

are interaction quality, content quality, and playback quality.

Interaction quality

Ovum's survey discovered that users spend the most time viewing schedules and switching between programs, and are most concerned with system response speed. This meshes with two well-known theories: the three-second theory and the 700 ms pain-sensing theory.

Three-second theory: When a user is browsing content or using a function, the user will stop using the service 100 percent of the time if the wait time exceeds three seconds.

The 700 ms pain-sensing theory: People have a 700 ms touch endurance time, and only a system response within this time is deemed to be quick enough.

A system should keep within these thresholds to retain users

Huawei's video solution provides zero-wait interaction to ensure the best performance, covering EPG browsing (< 0.5s), channel change (< 0.7s), and playback (< 1s).

Content quality

When used in relation to users, content quality refers to content richness and content grade.

When constructing their own content supply chains, carriers must ensure content grade from the outset and build in various quality criteria for different screen resolutions. In response to the industry need for a unified quality measurement system for video, Huawei worked with ITU to build the next-gen video quality measurement system, V-vMOS to help carriers with risk management and content quality control.

Because they lack content, carriers need to build new content supply channels to quickly enrich their content. Huawei's Digital inCloud video aggregation plan provides a one-stop solution to help carriers quickly build digital ecosystems.

Playback quality

Outlined in the organization's Y.1541 technical report released in December 2011, the ITU-T defines good playback quality as a system that shows no problems during four hours of playback, with a packet loss rate of less than 0.1 percent and image jitter of no more than 50 ms. Huawei trials show that it would be very expensive to build a network that meets ITU-T standards. Therefore, to ensure an excellent user experience, carriers and video service platform providers must consider new technologies that can provide a great user experience even when network quality is middling.

Huawei's FEC+RET technologies help carriers lower network requirements by maximizing packet-loss-rate tolerance to 1 percent and network-jitter tolerance to 1,300 ms.

Openness, integration, and rapid service rollout

When video becomes a basic service and a future user connector for carriers,

they act as super-aggregators. This means the openness and integration capabilities of basic service platforms will be crucial to guarantee the longevity and vitality of products and services. Quick integration into different industries and a fast response time when user requirements change will be the main challenges carriers face when running video services. The key to overcoming these challenges will be to build a future-oriented open service platform architecture.

The core features of this type of architecture are as follows: module decoupling, independent and expandable service features, cloud deployment that supports the linear expansion of massive numbers of users, an external integration framework that enables third-party ISVs/DSVs to develop EPG/UI/OTT clients.

Systematic O&M for scaled service development

Systematic O&M capabilities can be differentiated from traditional services in three ways: automated device management, visualized fault demarcation, and smart operation design.

Automated device management: Network-wide device management and automation tools – such as one-click remote OS installation in batches, one-click remote software patch upgrades, and one-click periodic inspection – will vastly improve daily O&M efficiency. Carriers need to develop capabilities in this area.

Visualized fault demarcation: Video is a whole-process service. When a user-reported fault cannot be quickly identified, various engineers must provide on-the-spot services, sharply increasing O&M costs. An end-to-end visualized fault demarcation system can provide the solution. After a fault is reported in the Call Center, the system will give with the possible causes. This enables precise ticket dispatch, improving O&M efficiency.

Smart operation decisions: As data is critical to intelligent decision-making, a data analysis platform focusing on video and big data enables content and user labeling for a better understanding of services, content, and users, thus refining the video service and improving profits.

Secure and reliable services

Providing secure and reliable services for massive numbers of users is a long-term requirement for operators. Compared to OTTs, carriers' services are safer and more reliable, which is vital for users when choosing video service providers. However, with operators providing video services for potentially millions of households, large-scale service interruptions are bad for users and also operators' reputations and brands. They should therefore consider service reliability when constructing a video service platform that will be used by millions of people.

Service reliability is measured based on the following video service features:

- Backup of the video source.
- Regional disaster recovery mechanism of video services.
- Multi-level disaster recovery mechanism of video services.
- Upgrade by service unit in multiple time windows to avoid affecting service use.
- Security mechanism, including the OS security hardening mechanism and non-encryption mechanism for sensitive user information.

Ultimate visual and VR experiences with 4K video

With the 4K industry chain maturing, 2016 will see the large-scale commercial adoption of 4K video services, bringing cinema-grade audiovisual experiences to consumers' homes. With the rapid development of virtual reality (VR) and augmented reality technologies, 4K video will soon provide the ultimate immersive VR experience and become a true force for connecting people.

Unifying policy management

By Su Yinbo

A brief look at policy management

In June 2004, 3GPP Release 5 introduced the Policy Decision Function (PDF). PDF was initially a small part of the P-CSCF (Proxy Call Session Control Function) that correlates subscriber signaling sessions and bearer sessions. It was redefined and enhanced in Release 6 by separating from P-CSCF to become a standalone entity. In Release 7, 3GPP combined PDF and CRF (Charging Rule Function) to form PCRF (Policy and Charging Rule Function). PCRF is widely deployed in today's MBB networks.

Other standards organizations, such as ETSI, WiMAX Forum, and PacketCable, have defined standard architecture for policy management tools for different types

Unified policy centers that can manage multiple access networks and deliver a consistent, high-grade experience for users are a must-have for operators due to evolving network architecture from standards organizations coupled with service growth, including on mobile broadband (MBB), fixed-line broadband (FBB), software-defined networking (SDN), and Wi-Fi networks.

of networks. ETSI's FBB network policy function is RACS (Resource and Admission Control Sub-System), while the WiMAX Forum and PacketCable's network policy tools are both known as PCRF. The network architecture and interface protocols of both these latter tools are consistent with 3GPP standards.

3GPP has greatly influenced the development and maturity of policy management tools, and most products adopt its standards. According to Infonetics, the global policy management market in the wireless and fixed markets in 2015 were worth close to US$1.5 billion and US$1 billion, respectively. Most recently and already accepted by the industry, 3GPP Release 12 and 13 define policy management methods and network architecture protocols for 3GPP networks (2G, 3G, and LTE) and non-3GPP networks (FBB, Wi-Fi, CDMA, Cable and WiMAX), covering terminals, pipelines, cloud applications and services, and unified policy centers for multiple access networks.

What policy management can do for networks

Policy management tools can dynamically configure network resources on a per user and per service flow basis. Network resources include MBR, QCI for access prioritization, pre-emptive ARP, data use by subscribers, and switching the charging mode between online and offline.

Mobile broadband networks

For some time after 3G networks were rolled out, the lack of content was failing to use operators' 3G data networks effectively. This

4K video technology is proliferating, but there's a distinct lack of 4K content.

changed with the advent of Apple and Android phones and the OTT revolution they started. Content would no longer be a factor that limited the development of mobile networks, and operators were able to use policy decision functions to convert voice subscribers into 3G data subscribers.

MBB networks policies

Unlimited bandwidth with speed limits: In 2012, AT&T was forced to withdraw the unlimited broadband plan it had released two years earlier, because its network lacked a policy management system and couldn't handle the traffic increase. In 2016, it launched a new unlimited package, this time embedded with policy management. Subscribers can enjoy unlimited speeds as long as they don't use more than 22 GB of data, after which speed is throttled.

This type of policy is also widely adopted by carriers in Europe and the Middle East. Saudi Arabia's Mobily has marketed an LTE tariff for business users that offers a similar bandwidth policy to FBB plans, which helped the operator quickly lead the market.

Bundled policies for devices: After deploying their 3G networks, China's big three operators began promoting plans with bundled high-end smartphones, such as iPhones or Samsung handsets, if subscribers sign up for a two-year data plan.

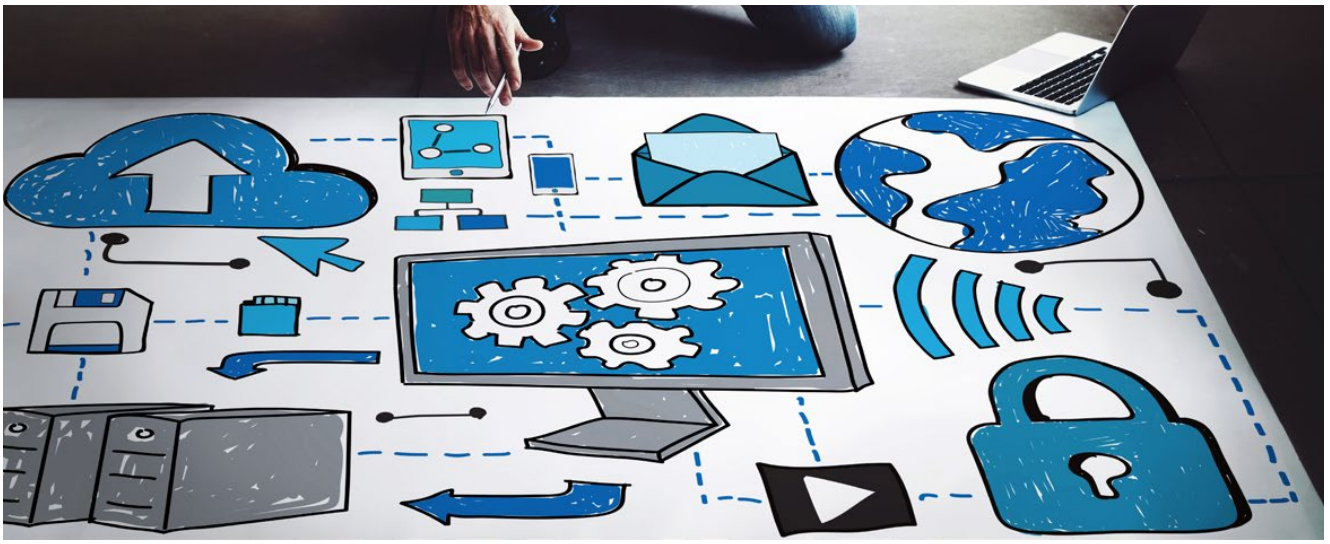
Family quota policies: In Norway, Telenor released a multi-user shared quota policy that spans multiple devices or brings in family members under a large data plan. Six months after launching this plan, 20 percent of Telenor's existing data subscribers had signed up.

Management policies on charging rules: In the UAE, du's policy control system for billing rules and quota management on its 3G network gives an offline charging policy for within-quota subscribers, passing usage information to the policy control system. When the quota is reached, the policy control system instructs the gateway to switch to an online charging policy. The gateway then interacts with the OCS (online charging system) to execute PAYG charging. This means the growth in data services won't be restricted by the charging system, and slashes investment in charging systems.

VoLTE quality assurance policies: VoLTE services are currently being rolled out around the world. Policy management makes it possible to establish dedicated transmission pipelines for VoLTE services, thus guaranteeing the quality of the network experience for HD audio-visual services on VoLTE.

Fixed-line broadband networks

When it rolled out its FBB network, China Telecom first offered plans with data usage quotas. For example, subscribers could purchase a certain amount of data for a set price, for example, 200 MB for 30 yuan. But, this failed to significantly increase subscriber numbers, so the operator quickly switched to an unlimited data business model. Differently priced



plans offer different speeds – 1 Mbps, 2 Mbps, and 8 Mbps – but data is unlimited. While this kind of FBB network model partly reduces the need for policy management, it's still required.

FBB network policies

Limiting heavy users: Telefónica Deutschland leases the last mile of its FBB network to other local operators, charging them for bandwidth used and limiting access speeds for bandwidth hogs who use more than 100 GB per month on its fixed-line network. Ethio Telecom currently offers data usage plans for its FBB network, and has seen a slow rise in subscriber numbers. It plans to launch unlimited data usage plans in 2016 with a speed limit. International traffic creates the majority of Ethio Telecom's subscriber bandwidth, meaning the carrier must pay international operators, which makes a policy decision function essential to avoid losing money when offering unlimited plans.

Accelerating 4K intelligent bandwidth: 4K video technology is proliferating, but there's a distinct lack of 4K content. Subscribers are reluctant to pay for high bandwidth speeds like 100 Mbps just to watch 4K video when they don't need it for other services. A number of subsidiaries of China Telecom and China Unicom have deployed commercial policies for intelligent bandwidth acceleration, so subscribers can increase access speeds temporarily if needed.

Many operators are opting for fixed-mobile convergence, including Kenya's Safaricom, Mobily, and Indonesia's Indosat, all of whom are busy constructing FBB networks.

Content would no longer be a factor that limited the development of mobile networks, and operators were able to use policy decision functions to convert voice subscribers into 3G data subscribers.

Converged operators can greatly enhance subscriber satisfaction with cross bundles offered under policy management solutions. China Telecom began offering integrated bundles in 2010, with its E8 and E9 plans providing different types of Internet access methods, including MBB, FBB, and Wi-Fi, to give subscribers a consistent online experience across different network types.

The rapid growth in broadband networks has helped service virtualization and cloud services emerge and, with the appearance of important computing services such as cloud services and big data, the industry has turned its gaze to SDN. SDN enables much finer control of a network with the logical and comprehensive policy management of sessions, subscribers, devices, and application layers. SDN networks execute different routing policies depending on application type, and the system can choose the optimal path for forwarding packets by determining the level of traffic on network nodes in advance.

With the evolution of network architecture from standards organizations and the growth in network services, unified policy centers need to manage multiple access networks, including MBB, FBB, SDN, and Wi-Fi. They must also deliver a consistent, optimal experience for subscribers. As well as unified network access, policy management can also enable services for subscribers on devices and content providers on the cloud.

What's in it for subscribers?

Policy management tools now provide subscriber services via a real-time communication channel.

Subscriber notifications: Policy control systems can issue real-time notifications to subscribers in various ways, including SMS, web pages, and toolbars. These notifications, for instance, might encourage subscribers to buy more traffic when they've used up their quotas, or provide information about roaming charges and information about their plans when they roam.

Real-time precision marketing: China Mobile uses the real-time notification function of its policy management system as a major marketing channel, and has developed many marketing policies. For example, when subscribers approach a China Mobile store, they might receive a notification telling them they can upgrade to a free USIM card, or a news app might push a text message for signing up to China Mobile's charge-free mobile news service. China Mobile has increased its marketing success rate by more than 30 percent thanks to this type of precision marketing.

Fast service acquisition: The UK's EE uses a policy control system to analyze users' SMS content and determine the type of plan subscribers want to sign up for. It then notifies the BSS to start charging when they do. Subscribers can sign up to services

wherever they're connected, greatly enhancing user satisfaction.

Access network selection: Most mobile carriers operate a number of networks including 2G, 3G, LTE, and Wi-Fi, all of which may experience different levels of traffic at any one time. Policy control systems can manage subscriber network access based on a range of conditions. On Ooredoo Kuwait's network, for example, heavy LTE users who use more than 30 GB of data per month are offloaded to the 3G network to avoid congesting the LTE network.

Policy management's value for cloud services

Policy management can enable OTT content cooperation and management, helping operators to develop new market opportunities.

Network bandwidth capability opening (OTT cooperation): Under paid terms, China Telecom has opened up subscriber bandwidth management capability on its policy management system to third-party OTT provider Kunlei, whose VIP users can get 100 Mbps bandwidth speeds when downloading content.

Content bundling policies: Movistar Chile offers different plans such as Mail + Chat, Redes Sociales, and Navegación, so subscribers can access different types of content. By leveraging an OTT vendor's huge customer base, operators can boost subscriber numbers.

Increasing IT in policy management

Policy management systems are becoming more infused with IT in that they're applying to more areas and systems that are integrated into operators' other IT systems. By integrating policy management with big data analytics solutions, operators have developed new market opportunities with precision marketing.

Continual improvements are being made to these systems in terms of policy deployment. Unified policy operation platforms and marketing language can configure policies and automatically generate and issue different scripts for policy configuration, accelerating service TTM.

By 2020, there will be 7 billion Internet subscribers, 100 billion connections, and 40 exabytes of data used per month. To take full advantage of the value of this coming explosion in data, operators will need a unified policy center to provide subscribers with an optimal, seamless experience across networks.

Policy management can enable OTT content cooperation and management, helping operators to develop new market opportunities.

NB-IoT

When narrow-minded is best

IoT predictions for 2020 from analysts Machina are bursting with zeros – both in the 14 billion IoT-enabled devices we'll see by then and also in the trillions of dollars that the IoT market will be worth. More modest is the bandwidth that IoT devices require (narrow) and the unit cost that makes them viable (US$5). For operators, the right NB-IoT business models coupled with the right plays open up a multitude of verticals. Let's find out more.

By Gary Maidment

A shot in the arm for LPWA

Though superficially promising, the decade-old Low-Power Wide-Application (LPWA) market has hobbled along with multiple ailments since it was born. Expensive to run and maintain, patchy standards, low reliability, poor security, and complex network overlay....LPWA didn't seem to have much to offer.

Then NB-IoT arrived on the scene like a cure-all, eliminating LPWA's defects while keeping its kaleidoscope of power-lite advantages.

Stay narrow to go wide

IoT dramatically expands the scope of people-based computing into the area of autonomous smart devices. For telcos, NB-IoT provides the conduit to enter this lucrative market. For them, selling data and selling connections will bring in the revenues.

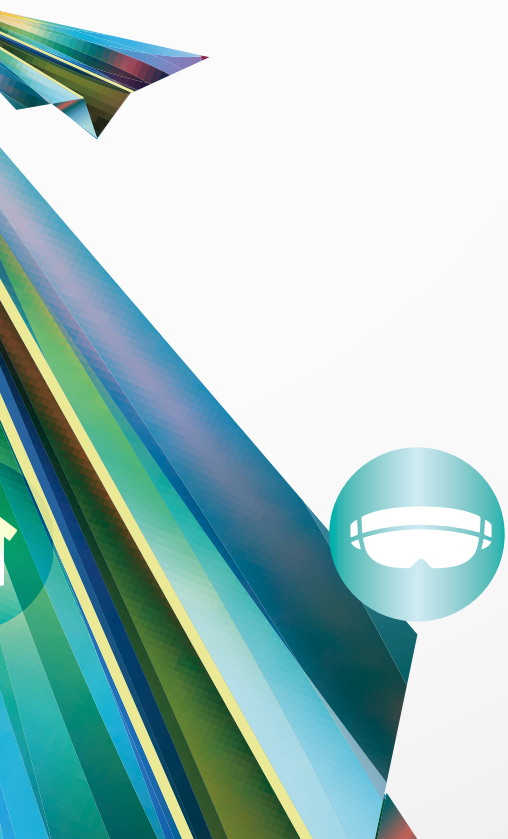
NB-IoT as a subset of IoT has much room to grow. But to connect things, the capacity of an NB-IoT cell needs to be much larger than an MBB cell. Assuming 40 devices per household, for example, a capacity of 100K for concurrent connections in each cell is required. When this is possible, NB-IoT can help telcos manage the commercial value of big data.

Where will this big data come from?

There are four types of IoT use cases where LPWA tech can apply: public, industry, IoT appliances, and, personal.

Public: Application scenarios include smart metering for water, gas, and electricity; alarms for both security and events like fires and gas leaks; and smart trash cans.

Industry: Examples include logistics, asset tracking, and smart agriculture.



>> Snapshot: Smart agriculture

Normally a sector of slim margins, agriculture is a keen IoT adopter. Precision agriculture is where this sector is heading, with a market that will be worth a predicted US$3.7 million by 2018. Using GPS and in-field and in-equipment sensors to provide a steady data stream for big data analytics to unscramble, farms can achieve gains like improving crop yields, maximizing water utilization, and optimizing feed mix for cattle.

Such improvements are essential because of population growth – three days from now, the world will have more than 684,000 mouths to feed according to the Population Institute, with a 2 billion jump in population expected by 2050 from our current figure of around 7.4 billion. To keep pace, we need to produce 70 percent more food.

This is why IoT and analytics are being sown in areas like soil, weather, crops, pesticides, and weather. Precision agriculture can maximize productivity and minimize waste by helping farmers know when to plant and harvest and predict expected yield.

+ 20 dB

better indoor coverage than GSM

100 k

connections per cell

high reliability carrier-class security ubiquitous coverage rapid network upgrades unified business management

10-year

battery life

low power costs

$5-10 per module
$1-2 per chipset

low cost terminals plug and play

Appliances: Requiring a home gateway, appliances such as fridges with NB-IoT embedded devices rely on short-wave technologies like Z-wave and Zigbee to improve home management.

Personal: The next big thing for individual use is wearables – an estimated 168.2 million units will be shipped by 2019, representing a CAGR of 74.8 percent. A few years later in 2022, the industry will be worth US$1.6 billion. Often centering on health and fitness, companies like Jawbone, Nike, and GoPro are active in the wearables area, while heavy hitters like Samsung, Apple, and Sony are making a noise in the smart watch space. Smart bikes and tech for monitoring children are other examples of personal IoT.

Deployment scenarios

The recently agreed 3GPP tech for the LPWA deployment of NB-IoT offers three deployment scenarios: guard band, in-band, and standalone. Standalone deployment mainly uses new bandwidth, guard band adopts the bandwidth reserved in the guard band of existing LTE networks, and in-band uses the same resource block as existing LTE networks.

Deploying NB-IoT in frequency bands like 700 MHz, 800 MHz, and 900 MHz is the best option, because these bands are popular with telcos and thus exist in already large and established ecosystems – as of July 2015, there were 14 LTE 900 MHz networks.

Advantageously, mobile operators running GSM 900 MHz or LTE 800 MHz have a clear upgrade pathway to NB-IoT. Equally, 1800 MHz enables the largest number of commercial LTE networks in the world, with L1800 coverage dominant in the UK,

China, Australia, and Singapore. L1800 software upgrade is in fact the simplest way to launch NB-IoT, especially for telcos that are short of low-band spectrum.

How's the NB-IoT ecosystem shaping up?

Unlike traditional telco services, NB-IoT has a long tail ecosystem, starting from chipsets, modules, and vertical devices and moving down to the application platform. Although this makes it hard to commercialize the NB-IoT industry, more companies are developing NB-IoT products like chips, modules, devices, and infrastructure.

As a precondition for a healthy industry, vendors, telcos, and verticals are starting to cooperate on building an E2E ecosystem. 2015 was indeed a busy year for NB-IoT – Neul produced the first NB-IoT chipset, performing several trials with telcos with its first-gen chipset Iceni, with plans to release its second-gen chipset, Boudica, in 2016. Doing so will help create standardized NB-IoT technology. Also in 2015, Switzerland's U-blox stepped on the scene as the first company to produce an NB-IoT module in which it embedded the Neul chipset. This year, U-blox plans to release 850 MHz and 900 MHz modules in a further commitment to standardizing NB-IoT technology in 2016.

Connectivity is a valuable contributor to telcos' bottom lines, and so teaming up with IoT tech vendors and chipset manufacturers makes good business sense to make the most out of solutions like smart metering, smart parking, and pet tracking. Connectivity platforms already exist in the cloud in many markets where telcos have deployed IoT services. But there's more to it than just connectivity – telcos can climb further up the value chain with an infusion of ambition.

By offering NB-IoT Network-as-a-Service on cloud to governments and industries, telcos can exploit their security, billing, and big data assets. They can also incorporate QoS and SLAs into their NB-IoT NaaS business models to become E2E service providers, while keeping their options open to outsource aspects of their business to partners.

Where does Huawei come into play? Huawei's business modeling framework can be tailored to specific nations and scenarios to give the right mix of investment, use case deployment, and business models for telcos.

With this in mind, one thing is clear: The all-pervasive future of IoT is narrow.

By offering NB-IoT Network-as-a-Service on cloud to governments and industries, telcos can exploit their security, billing and big data assets.

Integrating SDN

Three approaches for one-stop enterprise cloud VPN

ICT technology is a powerful tool for fast innovation. For businesses wanting to enter new markets more quickly, innovate faster, and increase productivity, it's clear what's needed: flexible, reliable, customizable and more efficient ICT services.

By Shen Hongyuan

It's all about strategy

Demand for traditional services like voice, SMS, and video is falling. Following a number of years of growth, a gradual slowdown is also happening with value-added services like broadband services, both fixed and mobile, and IPTV. But, demand for new types of enterprise services such as VPNs and cloud-based data centers is on the up, and it's growing rapidly.

Enterprise ICT cloud services present lucrative opportunities for carriers. They want to provide easily accessible enterprise IT services akin to the way public utilities are provided to homes or offices, where resources are delivered centrally via pipelines and accessed on demand without

any need for on-site facilities.

Applying the analogy to enterprise IT services, cloud computing service providers can construct large-scale IT cloud infrastructure that offers computing, storage, and value-added services (VAS) via the Internet (VPN). Businesses can then enjoy professional, high-quality, pay-per-use, and elastic IT services without needing to build their own IT infrastructure.

Utilizing their vast network resources, carriers can provide enterprise users with one-stop enterprise cloud VPN services with end-to-end (E2E) VPNs; pay-per-use cloud resources; and elastic, customizable VAS. This cloud + VPN service model will transform the way companies consume ICT resources. Enterprise users will be able to access cloud and network VPN services and enjoy high-quality ICT cloud services with ease.

By applying their strengths in networks and becoming the main point of access to these services for businesses, carriers can stake a claim in a trillion-dollar enterprise ICT market and create new growth drivers and strategic opportunities.

However, carriers face significant obstacles in achieving this goal. One issue is that decades of siloed construction means they use different vendor hardware and service management systems in different product domains. As a result, carriers typically need 12 to 24 months to launch a new service. This long process involves many steps: selecting technology, waiting for vendors to develop products, integration and verification, and deploying solutions on existing networks. Then, provisioning a new service requires a further 15 to 45 days to coordinate different domains, technologies, and vendor resources, and streamline different systems and departments.

It's crucial for carriers to overcome issues like separating the services and service support systems of clouds and pipelines, a lack of experience in one-stop enterprise cloud VPN service provision, siloed pipelines, and the slow rollout of VPN services.

Huawei's SDN integration service helps carriers provide one-stop enterprise cloud VPN

SDN is a new solution to address the challenges that carriers face. As part of its SDN integration service, Huawei has developed three approaches that apply its full understanding of WAN networks, data centers, and VAS: SDN WAN network evolution, VAS service pre-integration and modeling, and ICT resource orchestration.

The solutions are supported by Huawei's SDN Open Lab and Planning and Simulation platform. These approaches will ensure that carriers can resolve typical service system issues and support carrier network transformation and integration. They will help carriers transform traditional siloed networks, enable cloud and network coordination, and provide one-stop cloud VPN services for enterprises such as on-demand flexible pricing, a range of VAS, service deployment in minutes, and online self-service.

Approach 1: SDN WAN network evolution to speed up service launch and boost service capabilities

Huawei's SDN WAN evolution service helps operators accelerate service launch and boost service capabilities. At Huawei, we believe that carriers need a layered, step-by-step approach for the SDN transformation of traditional WAN networks. Given carriers' large legacy network inventories, SDN transformation necessitates a long-term, gradual evolutionary process. Huawei's SDN WAN network evolution service includes two kinds of solutions: overlay and underlay.

- **Overlay: accurate design and quick E2E integration**

With the overlay solution, a software-defined logical network is overlaid on the legacy network, which remains unchanged–as far as possible. Service logic is put in place by defining the logic network. An overlay solution allows carriers to support new cloud services on their original network architecture, deploy new services with much greater ease, and protect historical investment. Huawei's overlay solution is compatible with hardware from more than 10 mainstream telecoms vendors. It also supports topology recovery and capacity analysis for networks with over 10,000 nodes, allowing for accurate identification of resource bottlenecks and future service growth forecasting – analysis that can be used to develop the optimal overlay solution, so that E2E integration can be quickly completed.

- **The underlay solution: multi-layer collaborative design and a 30 percent increase in service capabilities.**

The underlay solution introduces SDN architecture and integrates IP/MPLS backbone networks and optical networks by reconstructing legacy network hardware. This simplifies network O&M, enhances network intelligence and automation, and improves the coordination of IP and optical networks.

In one case, Huawei's underlay solution helped a carrier customer boost planning efficiency by 50 percent and resource utilization by 30 percent. In this project, Huawei's IP + optical joint planning solution included IP and optical network coordination design for topology, capacity, and service protection.

Approach 2: VAS pre-integration and modeling for the most competitive VAS

Carriers must perform pre-integration and verification for every new VAS. With traditional networks, which are tightly coupled with service systems, this requires integrating the service system with many surrounding nodes, each of which may have dozens of interfaces. It also requires developing new code. The highly time- and labor-consuming work of connecting large numbers of nodes and interfaces means new service launches takes a long time, making it difficult for carriers to keep up with market demand.

- **Quick integration with VAS pre-integration**

Supported by the Huawei SDN Open Lab in Beijing, Huawei's VAS pre-integration service provides advanced integration and verification on VAS and delivers the best industry practice for new VAS integration in just seven days. To date, Huawei has partnered with over 20 major VAS providers and offers more than 50 typical VAS. Huawei has completed more than 30 E2E VAS pre-integration projects in markets around the world, helping carriers quickly launch outstanding VAS for enterprise customers at low cost. Huawei has earned widespread recognition for its service from carriers and partners alike.

- **Finding NEMO (network modeling) to quickly customize service templates for enterprises**

Service customization and innovation are core concerns for carriers. On traditional networks, northbound interface abstraction is performed using a bottom-up approach, which causes problems like interface complexity and difficulty with conflict detection and standardization. Huawei's next-generation NEMO programming language targets these problems and meets carriers' needs for convenient service customization.

NEMO offers carrier service designers a service template customization tool that's easy to use. NEMO abstracts network hardware from the top down, employing universal network operation modes and application-centered network models. The solution is designed to suit the needs of enterprise users in different industries. Huawei has developed six typical service scenarios, through the practical application of NEMO and analysis of carrier business services, and developed over 20 typical network models using the NEMO language. The models are provided as part of Huawei's SDN cloud data center solutions and they're updated dynamically. Carriers' service design is significantly simplified and service innovation and deployment is accelerated.

Approach 3: ICT resource orchestration for convenient enterprise self-service

Huawei's ICT cross-domain service orchestration offers SDN network services and resource orchestration, including underlay and overlay solutions; cloud data center services; allocation for cloud services including data center cloud computing, storage, and virtual data centers; and the centralized orchestration of ICT resources on both cloud and network. A self-defined portal provides convenient self-service for enterprise users, delivering on-demand application for cloud, VPN, and VAS services, with immediate resource provision-on-subscription, and dynamic loading and deletion, and capacity scaling.

Shoulder to shoulder with carriers in the SDN revolution

SDN will bring opportunities for network transformation and innovation, and it will be crucial for carriers to seize them. No one is better placed than Huawei, with its continual investment in SDN R&D and with global SDN experts, including more than 20 senior system architects, 100 system architects, and 2,000 professional service engineers. They act in concert to provide customized SDN integration services and technical support to help carriers do so.

Huawei's Beijing-based Open Lab is Huawei's SDN-based Global Network Evolution & Experience Center. It focuses on SDN network evolution and service transformation. Through the center Huawei has formed partnerships with over 20 service partners for VAS pre-integration and verification and completed over 30 E2E service integration projects in markets around the world, earning widespread recognition for its service from carriers and partners alike.

By promoting open cooperation in SDN integration services, Huawei has built a win-win SDN ecosystem in cooperation with industry partners and developers, including carriers, standards organizations (ONOS and ODL), and OTTs.

Huawei is committed to promoting its open SDN ecosystem and innovative solutions to quickly meet customer requirements and develop the SDN sector.

CloudDB Unified integrated data layer for cloudified networks

The unified integrated data layer is a new, data-centric architecture that can de-layer networks, simplify network operation and maintenance (O&M), slash TCO, and open and monetize data.

By Xue Qingfeng

The proliferation of mobile Internet has created a competitive battlefront between telcos, over-the-top (OTT) content providers, and virtual operators. Traditional business models built on mobile, broadband, and traditional data services no longer satisfy customers' fast-changing requirements. Equally, the decline of telcos' numbers advantage when it comes to customer base is creating the dumb pipe scenario. So, they're turning to service innovation for the answer.

5G services and the Internet of Things will soon be hitting communications networks hard in both requirements and the diversity of what people want. Telcos will need flexible network architecture that can scale down TTM to days or even hours.

But, to match the speed and service diversity of IT companies, they'll need innovative communications tech. They also need to learn how to better correlate and aggregate data from different network elements and service systems. Then, they can open up the goldmines data operators are sitting on, because siloed data prevents the monetization of this extremely valuable resource – an

area that quickly needs resolving.

Services and data: We're better off apart

With all major telcos having developed network virtualization strategies, a new round of cloudification and virtualization on telecom networks will come into being, bringing with it opportunities and challenges. Telcos are asking how agile networks can stop them competing with OTT players and instead get them cooperating to share new market opportunities. The best way to do this involves flexible network architecture that's designed to better satisfy diverse requirements.

Core networks should be the first candidates in mobile communication networks for virtualization. Software decoupling and hardware generalization means that the virtualization process will cut TCO heavily. Reconstructing software architecture can separate applications and data, enhancing network flexibility to meet different service requirements and ensuring a lossless service experience. Once applications and data are separated, traditional network elements are separated into a standalone service layer (VNF or virtualized network function) and a data layer (database). In this type of set-up, the service layer only manages the service logic of applications, while the data layer handles the application data. This allows for greater service flexibility, rapid deployment, and network elasticity.

A standalone cloudified unified data layer meets the requirements of applications for data storage, data processing, and carrier-grade reliability, while cloudified networks with unified data layers also present a solution for data siloes.

Unified data layers can integrate and aggregate subscriber data (HLR/HSS), session data (MME/IMS), policy data (PCRF), and a range of different IT systems data, so data can then be shared on the unified data layer between VNFs. Data analysis and data opening using the unified data layer also lets telcos carry out rapid data monetization with carrier-grade reliability. OTT and third parties can cooperate, enabling both sides to benefit.

Unity with Huawei CloudDB

CloudDB is a unified, open integrated database for cloudified networks. Built on Huawei's industry-leading SDM (subscriber data management) solution, it incorporates the ultra-high reliability of HLR/HSS, which is noted for its nine-year zero downtime.

The next-gen evolution of the SDM database solution has the following core functions:

Multiple application data integration: CloudDB manages the subscriber and session data of a number of traditional core network elements, including HSS, UPCC, DRA, IMS and MME. It provides cloudified database services for traditional telecom IT systems and third-party applications, and supports a wide range of data types, such as profile, session, and unstructured data, as well as data models like relational, key-value, and JSON. The solution provides rapid online time for new applications and services thanks to a large number of data access interfaces, including LDAP, SQL, Reset, SOAP, and SPML; flexible data models; and the online configuration of service provisioning functionality.

Super-high capacity and high performance: CloudDB uses a fully distributed architecture design with non-polar linear expansion and theoretically unlimited capacity. The database capacity is lab-verified for up to 1 billion users, and the solution can process 1.6 million operations per second with 99 percent of data latency under 1 millisecond.

Ultra-high reliability: CloudDB ensures 99.9 percent general hardware reliability and 99.9999 percent software and data reliability. This means it can deliver

data services with high availability, ensuring service continuity for applications. CloudDB has no single point of failure due to its system-wide distributed redundancy architecture that runs alongside rapid software and hardware fault detection and recovery capabilities.

Automated seamless switching and takeover mechanisms ensure a lossless service experience, while multiple active datacenters are on hand for backup and disaster recovery. Automated data conflict decision-making mechanisms ensure data consistency among multiple active data centers if a fault occurs.

Ultimate levels of integration: CloudDB employs automatic data compression and storage, and allows for the mixed storage of memory and hard disks. The data dictionary automatically compresses and merges identical data, with flexibly defined policies identifying active and inactive data, and migrating inactive data from the memory to hard disks. Moreover, the wake time for hard disk data is down to the millisecond. Compared with an integrated SDM database, CloudDB raises integration by 40 percent, bringing substantial savings in storage and memory space.

Flexible data resiliency: CloudDB supports a data layer unified load balancer that automatically performs lossless elasticity, scalability, and data migration based on session loading and storage space conditions. With a multi-datacenter heterogeneous disaster recovery architecture, the automatic flex time of CloudDB's databases is less than 10 minutes. Each database is independent, requiring no association between databases, which simplifies resource orchestration.

Flexible deployment: To meet different needs, CloudDB supports flexible data redundancy and data consistency policies based on different applications and different data property configurations, including strong consistency and final consistency. Data caching is deployed on the application side to reduce data access latency, and N-Way multi-site disaster recovery and All-Active multi-datacenter backup architecture are supported. Any datacenter can act as the primary data node for providing data services without read and write restrictions, which maximizes system resource utilization and reduces bandwidth load requirements.

Built-in data analysis and opening capabilities: CloudDB's built-in big data analysis engine can perform convergence analysis on the data it stores, and collect other network data using data federation technology, on which it can perform correlation analysis. The system can also perform historical data analysis on subscriber information collected from each network element, with data mining creating complete subscriber profiles. The system supports data opening, and provides a large number of API interfaces, which facilitates flexible and diverse new service development and slashes new-service TTM.

The face of the future

Huawei is leading the industry charge to roll out cloud datacenters. It has been working with Telenet in Belgium, which is set to commercially launch a cloudified SDM solution based on CloudDB. At the same time, the Indonesian operator Telkomsel has performed much better since service innovation, including O&M and user experience, thanks to a unified data aggregation and open platform (Dynamic Subscriber Profile or DSP) based on the CloudDB solution. The platform aggregates and opens up subscriber information network-wide in real time. As well as software and hardware decoupling, network virtualization is also driving network architecture analysis and reconstruction.

The unified integrated data layer can facilitate network de-layering, simplify network O&M, drive down TCO, and open and monetize data – for the cloudification and virtualization of traditional telecoms networks, the unified data layer is the face of the future.

4.5G Hello gigabit MBB, HD, and the Internet of Everything

4.5G is the next evolutionary step up from 4G on the way to 5G. It delivers gigabit mobile broadband (MBB), HD user experiences and Internet of Everything applications, through just software and minor hardware upgrades to legacy 4G infrastructure. Huawei has led the way with commercial trials of the solution, which has already been standardized by 3GPP. With over 60 networks rolling out this year, 2016 is the dawn of the new gigabit MBB era.

By Zhou Dongfei

Introducing 4.5G: The natural next step

Speed and capacity requirements on operator networks arecontinuing to surge. By 2020, skyrocketing growth in data consumption and users will see 6.7 billion projected MBB users devouring 5GB of data each – a massive tenfold increase over 2014. Accompanying this will be an exponential growth in IoT connections by the turn of the next decade.

Today's 4G networks will not be up to the job of supporting this rise in data, users, and connections. This is where gigabit 4.5G can step in. Offering faster speeds, lower latency, and better connectivity than the best current 4G technologies, 4.5G will help telcos deliver new services and command new business opportunities. The solution will support emerging applications, such as virtual reality, real-time automated industrial applications, and Ultra HD video – as well as vital transformative ICT technologies such as cloud computing, big data analysis, cellular IoT (CIoT), and broadband trunking. Meanwhile, with four

years to go until 5G is deployed, 4.5G will provide a smooth evolutionary transition via software with minor hardware upgrades, while offering advantages like quick deployment, rapid time to market for services, and protection of legacy investment.

The 4.5G solution is based on the 3GPP's new LTE marker, LTE-Advance Pro, standardized in October 2015. Proposed by Huawei and accepted in the industry, the three 4.5G benchmarks are: **Gbps** (for MBB with gigabit-plus peak rates versus 100 Mbps for 4G, better capacity and cell edge throughput); **Experience 4.0** (HD user experience with 4.0+ MOS and U-vMOS for voice and video); and **Connection+** to power vertical markets with support for cellular NB-IoT and LiTRA (LTE integrated Trunked Radio) for public security networks.

Gbps: Gigabit mobile is here

4.5G offers improved peak rate, capacity, and cell edge throughput compared with 4G. It achieves this by leveraging enabling capabilities including 3CC, CA (carrier aggregation), massive MIMO, and 256QAM. It provides 1.2 Gbps peak rate (eight times 4G), which will support new high-speed terminals and applications. Meanwhile, 4.5G eNodeBs deliver 600 Mbps, six times the capacity of 4G, for simultaneous playback of 75 2K video channels (8 Mbps per channel) compared with only 12 on 4G. Finally, 4.5G enables a tenfold increase in average cell edge throughput (30 Mbps), meeting 2K/4K UHD video requirements.

The key 4.5G Gbps technologies

Massive MIMO (FDD)

Massive MIMO will greatly increase spectral efficiency and improve cell edge user experience. Huawei's innovative eMIMO (enhanced MIMO) will maximize the advantages of 4T4R RF modules, which will be widespread by 2016. These work in medium and high frequency bands, and have four TX channels, supporting 4x2 MIMO and 4x4 MIMO. eMIMO also supports Blade RRU with traditional antennas, Blade RRU with split antennas, or AAU (Active Antenna Unit) with 4T4R capability.

Massive MIMO (TDD)

Massive MIMO (TDD) will increase spectral efficiency by between three and five times, maximizing operators' investments in base station and spectrum. At its core is an ultra large-scale multi-antenna system. Each module integrates 128 RF channels and 128 built-in antennas, featuring the maximum specification and highest integration levels, considerably decreasing networking costs while enhancing intensive coverage. The solution supports all mainstream LTE-TDD bands and 4G terminals. A single Massive MIMO base station delivers 3D-coverage to a large area, removing the need to deploy multiple cabinets. China Mobile Shanghai and Huawei launched the world's first massive MIMO eNodeB on a commercial 4G network in September 2015.

Massive CA

4CC and 5CC CA (deployment planned for 2016) will increase peak rate, cell edge throughput, and average cell throughput. Huawei's eCA (enhanced CA) uses inter-eNodeB CA based on relaxed backhaul to greatly boost the proportion of SCell activations. This innovative solution also allows flexible aggregation of optimal PCells and SCells for CA UEs to significantly increase perceived data rates. eCA will further optimize PCell and SCell selection, simplify implementation, and decrease inter-cell interference.

High-order modulation

Set for commercial deployment in 2016, 256QAM will raise peak rates by 33 percent compared with 64QAM, and is designed to maximize outdoor macro cell capacity.

Flexible bandwidth

4.5G will improve use of spectrum re-farmed from 2G and 3G by using any bandwidth from 1.4 MHz to 20 MHz.

Say hello to HD voice and video with Experience 4.0

With enhanced voice and video technologies, 4.5G will usher in HD mobile voice and video experiences with MOS and U-vMOS scores of over 4.0. This will deliver vastly improved user experiences compared with current 4G offerings.

VoLTE Plus

On early-stage 4G networks, featuring circuit switched fallback to 2G or 3G, average MOS is only 3.3 (Huawei mLAB). Typical user complaints include long call setup, unclear voice quality, noise, and dropped calls. A more advanced solution, VoLTE improves MOS; however,raising MOS to over 4.0 for entire networks remains an immense challenge, mainly due to signal level and inter-cell interference at cell edges.

4.5G boosts MOS to over 4.0 by using VoLTE Plus to enhance cell edge performance and ensure VoLTE-quality voice in interference, handover, and high traffic scenarios. 4.5G will also leverage new codecs such as EVS (enhanced voice service) in 3GPP's Release 12. The codec supports an audio bandwidth of 20 kHz (for MP3 quality), and features high resistance to latency, jitter, and packet loss. This will prove handy in telcos' battle against free OTT voice services, which are already delivering HD-level quality. Performance based on EVS will continue to improve with 4.5G.

Video Plus

Globally, the average U-vMOS

4.5G boosts MOS to over 4.0 by using VoLTE Plus to enhance cell edge performance and ensure VoLTE-quality voice in interference, handover, and high traffic scenarios.

for 4G networks sits at lower than 3.5, according to Huawei mLAB. With 4.5G networks, operators will be able to boost U-vMOS scores thanks to higher peak rates, as well as Huawei's innovative Video Plus solution. First, 4.5G delivers suitable data rates for 2K/4K HD video required for a 4.0+ U-vMOS score – that is, 8.4 Mbps and 8 Mbps for 2K in the video loading and playing phases, respectively, and 32 Mbps and 18 Mbps, respectively, for 4K. And, with Video Plus, 4.5G eNodeBs leveraging the WTCP proxy shorten initial buffering latency, perform video load balancing in high traffic scenarios, and adopt an optimized video scheduling mechanism to ensure video service quality without affecting other services. This is crucial because 4G's U-vMOS score for initial buffering latency is particularly low (under 3.5).

Connection+: More connections, more business

4.5G technology will bring the fully connected Internet of Everything one step closer to reality, creating exciting new business opportunities in vertical markets.

NB-IoT

By 2020, there will be a projected 3 billion CIoT connections, up from 240 million in 2014. The vast majority of these will rely on low power wide area networks (LPWAN). The enhanced capabilities of 4.5G NB-IoT will meet key LPWAN requirements. These capabilities include: wide coverage (20-30 dB coverage enhancement over GSM for low signal locations); massive connections (100,000 connections per cell compared with up to 2,000 with 4G); high power efficiency (10 year battery life); cost savings (modules 30 percent cheaper than GSM); optimized architecture (insensitivity to transmission latency and downlink transmission); and extensible capabilities such as mobility, roaming, and locating. With their wide coverage, mobile networks will be well positioned to provide access to a multitude of CIoT applications via 4.5G NB-IoT.

LiTRA

Huawei's LTE-powered – and 3GPP-approved – LiTRA brings trunked radio for public security, public utilities, and enterprise into the broadband era, delivering new capabilities and addressing legacy shortcomings. With 4.5G LiTRA (LTE-integrated trunked radio), telcos will be able to provide enhanced applications for these markets. High-bandwidth and low latency, LiTRA offers voice performance rivaling traditional PTT as well as high-speed broadband data services, including video calls, video surveillance, file transfer, and GIS services.

Deployed over existing LTE networks, LiTRA significantly reduces total cost of ownership, and provides better network coverage and roaming services. This remedies short fallings due to the private-network architecture of legacy solutions. LiTRA's compatibility with smart LTE terminals also opens

up a previously closed industry chain, enabling operators to provide more professional and efficient trunking services. LiTRA also offers improvements like QoS, MCPTT, and congestion control to address the particular requirements of public security scenarios. Huawei's LiTRA E2E product solution facilitates rapid service deployment.

Rolling out soon to a network near you

Huawei and dozens of global leading telcos, including Vodafone and Deutsche Telekom, have collaborated on 4.5G deployment since 2014, when Huawei first proposed the concept. In 2015, 1 Gbps+ transmission rates on commercial networks were demonstrated in multiple markets worldwide. And pre-commercial deployment of NB-IoT has got underway in some European and Asian regions. Meanwhile, the governments of UK and Korea have begun constructing national LiTRA-based public-safety networks. 2016 will see the major deployment of 4.5G networks, with 60 networks planned for rollout by mainstream operators.

To facilitate the introduction of 4.5G, Huawei has spearheaded efforts on terminal maturity, verification of key technologies and industry readiness, working with major chipset and terminal manufacturers to provide support for multiple antenna, carrier aggregation, and 256QAM technologies. In 2016, a number of chipmakers launched 4.5G chipsets for terminals which will drive commercial use of 4.5G smart terminals. Qualcomm and Huawei's HiSilicon both released chips – Snapdragon 820 and Balong 750 respectively – that support 600 Mbps peak rate and 4x4 MIMO on a single carrier at the end of 2015.

The path to 5G

4.5G will provide a smooth evolutionary process toward 5G's commercialization. Adopting 4.5G will facilitate phased introduction of candidate 5G technologies via software upgrades and network architecture modifications for long-term coexistence between 4.5G and 5G and eventual adoption of 5G. Meanwhile, some services marketed under 5G between now and 2020 will likely be based on 4.5G. As operators move towards 5G, stepping up to 4.5G will help them deliver better capabilities and user experiences, roll out more services, protect current investments, and command new business opportunities, so they can gain and maintain a crucial winning competitive edge.

4.5G will provide a smooth evolutionary process toward 5G's commercialization.

IoT Collaborating on connections

The Internet of Things (IoT) is destined to change life and revolutionize every industry, with the integration of IoT into verticals creating a new commercial landscape. Germany's Industry 4.0, China's Industrialization and Informatization Program, and America's Industrial Internet all focus on using ICT technologies to reconstruct traditional industries. Integrating the physical and digital worlds simplifies business processes, boosts productivity, improves products and services, and cultivates innovation.

By Zhang Shunmao

Imagine a world like this: You're on the move, and you don't remember locking your front door. So, you whip out your smartphone to check if you have. You're not back yet, and your pet will be hungry – you activate video monitoring and start feeding time. A bit of gardening? You remotely control robots to do some weeding and mow your lawn. At dinner time, you decide you want to know where the beef you're eating came from...IoT will make this kind of life possible.

How will the new industrial revolution achieve such things? By connecting the components of the production system and supply chain system with IoT, so users have easy access to information and maximize productivity and business value.

Key requirements of IoT

Huawei believes that the key five requirements of IoT are intelligent sensors, ubiquitous networks, massive data storage, sharing, and value creation.

Sensors are the basic devices that allow things to communicate, while ubiquitous networks are the architecture that connects them. According to Huawei's Global Connectivity Index 2015, much of the world isn't covered by networks, and the vast majority of things remain unconnected.

In the next decade or so, there will be around 100 billion connections worldwide. However, different industries have different sensor interfaces and incompatible sensors, making interconnections and interoperations impossible. Our goal is to standardize sensor platforms and make them intelligent, so things can connect and communicate to ultimately create more value.

Different connection scenarios have different requirements. For example, super-long battery life is crucial for smart meters, whereas ultra-low latency is a precondition for video surveillance and unmanned driving.

The best solution is to build ubiquitous networks that accommodate all IoT scenarios. Huawei offers a diverse range of access technologies for applications like unmanned driving, smart production, and intelligent meter reading.

The goal of IoT is not to connect things, but to create value. Creating value from data relies on integrating specific industry knowledge, communication languages, and ICT. However, partnerships are required: if

The best solution is to build ubiquitous networks that accommodate all IoT scenarios. Huawei offers a diverse range of access technologies for applications like unmanned driving, smart productions, and intelligent meter reading.

By integrating ICT technologies into various industries, Huawei and its industry partners are leading IoT innovation.

you want to integrate ICT into the automotive industry, for example, you need to collaborate with automobile manufacturers.

When leveraging data to create value, we must also solve problems with data ownership, security, privacy, and sharing.

The 1+2+1 solution

Huawei is a driver of the new industrial revolution, partnering with industry players to build an IoT ecosystem and cultivate the new industry arena. Focusing on sectors like the Internet of Vehicles (IoV), manufacturing, energy, and smart homes, our 1+2+1 IoT solution integrates ICT into specific industries to stimulate innovation.

The first "1" refers to LiteOS – a real-time, lightweight, open source IoT operating system with a standard platform for developing smart sensors, ultra-low power consumption, and real-time responsiveness.

As an open platform for IoT terminals, LiteOS helps partners develop smart hardware quickly and easily, which promotes standardized smart hardware. Huawei offers online and offline support to help its partners easily develop IoT terminals and apps using LiteOS.

"2" refers to wired and wireless connections. For wired access, we launched an SDN-based agile IoT solution; for wireless access, we offer an innovative eLTE solution for enterprises, and LTE-M for developing cellular IoT.

5G technology will help us deliver ubiquitous IoT with ultra-low delay and faster speeds, with user rates reaching 10 Gbps and 1-ms latency. With 100 billion connections in the future, 5G will be essential for core IoT scenarios like smart driving, Virtual Reality, and smart manufacturing.

The final "1" is a unified IoT management platform centering on cloud computing and big data technologies. The platform manages connections, operations and data to perform tasks such as data collection, storage, security, and value creation. The IoT management platform opens up a wide range of capabilities in different industries, regardless of connection complexity, networking, and data collection technologies.

The platform enables industry partners to quickly develop apps for IoT services, and meets industry customers' personalized service requirements.

Team innovation

By integrating ICT technologies into various industries, Huawei and its industry partners are leading IoT innovation.

A safe and secure production environment is critical for sustainable development in the petrochemical industry. One of Huawei's partners – an oil company – extended Huawei's agile networks and eLTE to its factories and deployed sensors on its networks. The solution helps the company monitor factory environment indicators, such as temperature, in real time. It also

supports HD video backhaul for 24/7 remote video surveillance, analysis, and control.

Reports show that energy consumption in buildings accounts for 48 percent of the global total. In Australia, Huawei worked with Optus to cut down power consumption for the University of Melbourne, deploying the agile IoT solution in its buildings and connecting smart sensors to the networks. The solution supports remote perception and control on each floor. As a result, lighting and control power consumption have been slashed by 62.5 percent.

Huawei also collaborated with Vodafone on innovative IoT projects such as automated meter reading across wireless connections. We provided the chips while our partner U Block provided built-in modules for smart meters. Compared to 2G, our innovative Cellar IoT technology boosted coverage performance by 100 times to 20 dB, making basement coverage easier. The number of connections increased to 100,000 per square kilometer, 100 times more than that supported by current 4G networks. We successfully realized ultra-low power consumption, with two AA batteries lasting more than 10 years.

Additionally, Huawei collaborated with SAP to extend network coverage to engineering vehicles. Smart sensors deployed on the vehicles transfer the real-time status of components to SAP's HANA platform via networks deployed by Huawei. The platform analyzes data and detects potential faults with vehicles or components. It sends alerts if necessary, and schedules preventive maintenance in response.

Huawei also offers IoT management platforms for big carriers. The IoT market is huge and fragmented, existing in an enormous, complex ecosystem. The large-scale commercialization of IoT requires an extensive alliance that includes device manufacturers, carriers, ICT vendors, software/app developers, research institutes, and governments. It also requires joint investment and innovation.

Huawei holds key positions in many international IoT organizations, including CIIAII, IIC, AIOTI, oneM2M, IEEE, and OMA. We were lead partner in establishing China's Sensor Industry Working Committee, and in creating the Industry 4.0 Starfire Team with SAO, NXP and CCID. In Germany, we worked with Fraunhofer and SAP to create global Industry 4.0 sample projects. We've also signed strategic cooperation agreements with leading automobile companies to implement IoV.

Huawei believes that collaboration is necessary for IoT to rapidly develop. We will continue to drive the integration of ICT technologies and industry using the 1+2+1 IoV solution.

Together with industry partners, we will fully integrate industrialization and informatization, and execute Industry 4.0. Open collaboration is the key to unlocking a bright future of successive industry innovations.

All about the user with ADN

For network construction, application-driven networking (ADN) provides logically independent network slices to meet the varied networking requirements of different applications. When it comes to the conflict between service differentiation and network neutrality, ADN is the peacemaker.

By Zhang Gong, Huo Dawei & Li Yingtao

Challenges in future networks

1. Operator revenue depends on user base size, but user growth has bottlenecked

The Internet's network architecture was designed with data traffic in mind, not the unique requirements of different applications. As this architecture still dominates, operator revenues rely heavily on subscriber numbers and data traffic volume. Professor Srikant from the University of Illinois makes this exact point by referencing current Internet price plans in Economics of Network Pricing with

Multiple ISPs, including the popular flat rate with cap, smart data pricing, sponsored data plans, and older per-use or monthly quota plans.

With the recent plateauing of subscriber growth and cost jumps for operators, operators are feeling huge pressure from stagnant data revenues coupled with a sharp increase in data traffic.

2. Net neutrality rules restrict service differentiation

Net neutrality was initially proposed as a way of protecting new companies and applications by preventing certain content providers from monopolizing the market, because operators cannot differentiate between different service sources. However, with networks unable to deliver the low latency and high bandwidth required by services like HD video, content providers are constructing their own networks, and in effect strangling operator revenues.

In *A Two-Sided Market Analysis of Provider Investment Incentives with an Application to the Net-Neutrality Issue*, California University lecturer John Musacchio et. al. sets out the idea of the "two-sided market". The paper proposes how net neutrality is not in the public interest in some situations, and can cause the "tragedy of the commons" effect where individual users deplete a resource by acting in their own interest rather than that of the common good.

Professor Vishal Misra of Columbia University introduced the idea of the Public Option ISP to eliminate selective discrimination against content providers during market competition and reduce regulatory costs. Whether it's possible to maintain net neutrality in line with the original spirit of the idea is open for debate given existing network architecture.

Distinct network architectures for different applications

In the era of voice communication, the principal consumer unit was a single person and the basic requirement of telecom networks was person-to-person voice communication. Networks also provided a small amount of data communications, such as telegraphs, alongside this single service.

When it came to network growth, the chief barriers were improving coverage and lowering costs. Research shows that in a voice network, the subscriber call arrival process closely follows the Poisson distribution model, meaning statistically active subscriber numbers remain at a mean value over time, making statistical multiplexing possible.

As a result, hierarchical aggregation became the basic telecom network architecture, which became operators' guiding principle for network construction for many years, encompassing the point of access to the MAN to the backbone. This was able to fully meet subscriber requirements and reduce network construction and management costs.

In the Internet era, there's been a dramatic shift in user network consumption patterns. This has presented a considerable challenge to existing telecom networks that are built on hierarchical aggregation architecture. While Internet user requirements include person-to-person communication, humans-to-things communication occurs in greater numbers, for example, with machines

or datacenters. Communication length and bandwidth requirements have increased and become less determinable in this era.

In *Emergence of Scaling in Random Networks*, which appeared in Science magazine in 1999, Barabasi and Albert point out that Internet applications comply with the features of a scale-free network, also known as a "power law distribution" network. In this type of network, most users are connected to super nodes like Google or Facebook. Most nodes are connected to just a few super nodes, making this type of network fundamentally different to a Poisson distribution voice network.

In *The Flattening Internet Topology: Natural Evolution, Unsightly Barnacles or Contrived Collapse?* Professor Li Zongpeng from Calgary University states how network flattening is inevitable in the Internet era, because flat network architecture is better suited to a power law distribution network and is more resource efficient. Thus, network flattening has become a guiding principle of network construction in the Internet era.

New services like the Internet of Things (IoT), Internet of Vehicles (IoV) and virtual reality (VR), will inevitably impact future network architecture. In collaboration with Professor John Lui of the Chinese University of Hong Kong and Professor Chen Guanrong of Hong Kong City University, Huawei's Future Network Theory Lab released a paper proposing the entirely new Markov Model of processes. The paper points out how the characteristics of future network services will differ significantly from both the Poisson distribution model for voice networks and the Internet-oriented power law distribution model.

In the future, network services will comply with the Markov Process model of process distribution whereby applications will demonstrate diverse dynamic conversion over time, causing greater differentiation in the application requirements of different sectors and services such as IoT apps or HD video.

A processing approach where optimal resource efficiency is concentrated in central nodes doesn't suit applications such as IoV, which requires low latency vehicle-to-vehicle communication in a partial automation scenario. Current network architecture will also have difficulty meeting the requirements for high bandwidth, low latency, and high reliability of a service such as telemedicine. A new application-driven network architecture is therefore necessary to optimize customer experience.

ADN: A role model for differentiated services

Most players in the telecom industry want to improve resource efficiency, especially network hardware, which reduces costs but doesn't increase revenues. But, ADN equally prioritizes application efficiency and resource efficiency because improving application efficiency makes applications easier to use, which in turn improves user experience and increases revenue.

ADN advocates application-led network construction. The ADN solution gives each application a logically separate network to meet the distinct demands of different

applications. ADN helps operators achieve application-oriented network reconfiguration, resource virtualization, and hierarchical control.

Application-oriented network reconfiguration: Abstracting application network requirements. ADN builds multi-dimensional abstract models of applications by analyzing network requirements and their usage features to orchestrate network resources and meet application requirements. To improve user satisfaction, different services can be mapped to different network resources using models like Poisson distribution person-to-person communications services, power law human-to-machine communications services, and Markov process distribution machine-to-machine communication.

Application-oriented resource virtualization: network resource isolation and re-use. NFV and network slicing make it possible to abstract originally unified, unique network resources – such as wireless air interfaces, bandwidth, computing power, and storage space – into multiple logic channels. Then, ADN performs statistical multiplexing on network resources to comply with applications' networks requirements.

Application-oriented hierarchical control: fast neural/slow neural control. ADN provides differentiated services for applications and optimizes network resources.

Application-oriented hierarchical control: fast neural/slow neural control. ADN provides differentiated services for applications and optimizes network resources. According to the concept of fast and slow neural control proposed by California Institute of Technology professor John C. Doyle, ADN performs fast and slow control on network resources in multiple dimensions, including time, space, and value. The slow controller regards slow-changing network information – such as network topology and application service model characteristics – as input, and finds network resource slice division methods and network optimal control points. The fast controller uses network fast-changing information like switch queues and link status to carry out real-time observations. It uses Kalman filter algorithms to drive the network to the optimal control points on different slices at the lowest cost. In cooperation, fast and slow control mechanisms can ensure the whole network operates near an optimum control point, helping optimize application-oriented services.

Focusing on customer experience

The ADN solution gives each application a logically separate network to meet the distinct demands of different applications.

The ADN concept identifies application service characteristics and allocates appropriate resources accordingly.

The biggest transformation that ADN brings over standard communication networks is vertical resource distribution on a per application basis. The architecture for standard communications network is horizontal and layered according to resources with a resource layer, control layer, and application layer at the top. ADN streamlines multiple vertical layers for different applications top-down from the application layer to the control layer to the resource layer, improving user experience by switching from a horizontal to a vertical framework.

Traditional network resource management normally groups network resources by network layer, for example, by access network, MAN, or backbone network. This can maximize resource utilization, but it isn't optimal for application experience because a typical application might be spread across multiple network elements, making launching and modifying an application extremely complicated. In normal circumstances, applications must be modified to adapt to the network for a good user experience.

The ADN concept identifies application service characteristics and allocates appropriate resources accordingly, executing service management on applications, and enabling the network to proactively adapt to them. In multi-application scenarios, the successful application of ADN architecture will hinge on how resources are allocated, the principles they're allocated on, and on balancing the allocation of existing resources and possible future applications.

The system performance of different service traffic models like latency and throughput is significantly influenced by scheduling and resource allocation policies. In *Scheduling in Switched Queuing Networks with Heavy-Tailed Traffic, MIT's Dr. Mihalis G Markaksi* states that unlike services that comply with Poisson arrival characteristics, service types with heavy-tailed distribution adopt multi-queue load balancing scheduling policies, which greatly ramps up performance. Therefore, for system expansion, scale-out policies rather than scale-up policies are preferred.

The Poisson distribution model of voice, the power law distribution model of the Internet, and the Markov process distribution of future networks form the theoretical basis of ADN resource allocation.

ADN architecture incorporates application-oriented resource allocation mechanisms. There are a number of dedicated resource allocation layers: hierarchical network connectivity based on Poisson distribution rules for voice applications; flattened networks based on power law distribution for allocating Internet resources to data centers; and, for IoV applications, autonomous networks based on Markov distribution rules to meet low latency requirements and centralized resource allocation to satisfy massively concurrent applications.

Key resources are reserved to meet the different requirements of future applications based on service development forecasts.

In an ADN framework, cloud technology can support ADN resource allocation. SDN and NFV can support many kinds of applications on a single network by ensuring technological capabilities. Ultra-broadband Internet ensures that resource allocation and scheduling are more flexible and convenient, while the ADN framework uses current technology to enhance user experience. Service diversification and user experience will be typical features of 5G networks, both of which ADN will support.

Dual focus on application and resource efficiency

Early communication networks and that era's Internet focused on voice and high traffic volume and low-cost data services. Network construction and development aimed to raise efficiency and bandwidth under a single service-oriented model that prioritized resource efficiency.

But, future networks will be characterized by a diversity of applications and highly varied requirements on network resources. For example, the resource requirements of two key future applications, HD video and IoT, differ greatly, meaning that a blind focus on resource efficiency cannot meet varied user experience requirements. Application-driven network construction will therefore be common in future networks.

ADN: Good for construction, good for users

ADN optimizes configurations based on different application types when total resources are constant, meeting varied application requirements and driving up user experience. Two real-world examples of heterogeneous application requirements unsupported by current networks are as follows:

IoT applications for automated meter-reading: requires a large number of user terminals and high bandwidth, has high requirements on the control channel, and is highly cost-prohibitive.

Instant messaging applications: creates signalling storms where bandwidth consumption is low but continually refreshes to stay connected, for example, WeChat.

In the first example, network slicing offers a solution. In the second, reserving a certain amount of signalling resources can solve the signalling issue.

ADN provides a framework that supports both these methods.

Resource efficiency through application efficiency

ADN meets requirements for application efficiency to improve user experience without compromising resource efficiency, using tech like SDN and NFV to boost application efficiency.

ADN can also use NUM (network utility maximization) for organic decoupling

and to collectively upgrade application efficiency and resource efficiency, which can reduce network construction costs, increase operational efficiency, and generate revenue from applications.

Application efficiency and resource efficiency will inevitably become mutually complementary, as indicated by the computing industry. The first computers to emerge were specialist computing tools with limited capacity and performance, causing the focus to shift to increasing CPU efficiency. The assembly language of computer programs precisely controls each specific physical resource of the CPU. With higher CPU capabilities and the more advanced C programming language, ease of use and application efficiency improve at the expense of resource efficiency.

With hardware continuing to advance in line with Moore's Law, the emergence of operating systems represented a fundamental breakthrough in computer applications. Increases in application efficiency hugely expanded the market, giving rise to what would become the world's largest industry. Switching from a focus on resource efficiency to a dual focus on application and resource efficiency grows the market, and encourages less priority on resource efficiency.

The time is now for application-led network construction

Most operators already realize that networks should be application focused, and network slices are a trial foray into this space. ADN's major benefit is giving operators the network architecture to support diverse applications and grow beyond the current resource efficiency service model that focuses on traffic and bandwidth. They will open the door to the multi-service application era where application experience is also key.

PARC's GUI allowed computers to meet consumer usage requirements, spawning an entirely new industry and making the likes of Apple and Microsoft possible today. In the same way, we believe that the ADN concept and architecture will help operators support the myriad IoT services of the future, forming a virtuous cycle between application efficiency and resource efficiency, and pushing us towards operating models based on user experience.

An operating model based on customer experience has universal value – it can guide the development of future telecoms networks, and create growth opportunities for new services in storage, computing, and the entire ICT market. Similarly, it will be possible to extend the concept of ADN to create application-driven storage (ADS), application-driven computing (ADC) and application driven ICT (ADICT). "Application" here can be understood in the conventional sense, but also as an industry application. It can apply to new applications that have not yet been invented, and so the growth potential is nothing short of massive.

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