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Creating the Gigaband era

Setting an industry milestone at the Ultra-Broadband Forum 2015, Huawei and its partners defined the future of the ultra-broadband era as Gigaband – a portmanteau of Gigabit and broadband.

Three factors will drive the industry into the Gigaband era. The first is socioeconomic development. In December 2014, ITU's Connect 2020 set down the commitment of governments across the planet for broadband infrastructure baselines, broadband services, and network experience. People now understand that broadband infrastructure is the foundation of the ICT industry and every other sector.

The second factor is enterprise development needs. The reports, Made in China 2025 and Industry 4.0, both point out that traditional broadband networks are no longer enough for smart factories and smart production. A new industry-class broadband network is required, a Mission Critical Infrastructure with higher availability, reliability, and lower latency.

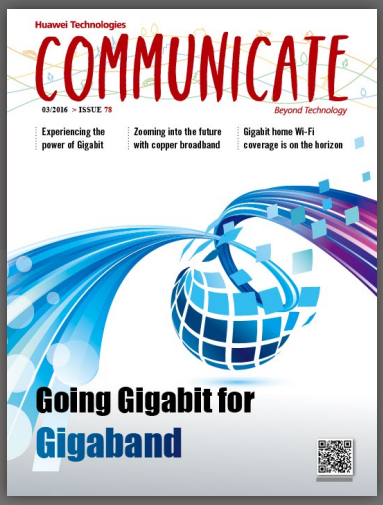
The third factor is new consumer demands. The video industry is evolving to 4K UHD TV. Video streaming now requires 10 times more bandwidth, people are shifting from TV broadcasts to VoD, and new service areas like smart homes are eating up bandwidth. Today, users care more about experience than connectivity, which in turn drives ICT development and network construction in the Gigaband era.

Gigaband has three key features: one, it redefines broadband speeds from 300 Mbps to 1 Gbps; two, it applies to broadband networks that deliver optimal service experiences; and, three, it's designed to cover at least 90 percent of homes with ultra-broadband services at the best U-vMOS (Unified Video Mean Opinion Score) anytime, anywhere. U-vMOS is Huawei's answer to precisely measuring users' opinion of video services.

To promote Gigaband, policies must boost broadband investment, innovation, and construction, and complement these with flexible and affordable solutions that overlay new technologies on legacy networks. Carriers need to commit to building an open ecosystem and key services, such as connections and video, while partnering with app developers and VAS providers to offer comprehensive integrated ICT services.

To date, more than 100 global carriers have launched commercial Gigabit services, setting the scene for us to work together to build the Gigaband era.

Zha Jun
President of Fixed Network Product Line, Huawei



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CONTENTS

Cover Story

06 **Going Gigabit for Gigaband**

SingleFAN 3.0 is Huawei's access network solution for the Gigaband era. It builds broader, faster, and more intelligent access networks so that operators can optimize bandwidth, coverage, and the quality of Gigabit services.

Zhu Hong

Experts' Forum

12 **Experiencing the power of Gigabit: New approaches to Gigabit broadband network construction**

Problems with ROI and user experience need to be addressed for Gigabit broadband services to develop. ROI will determine the commercial value of investment-heavy Gigabit broadband, and user experience will determine its competitiveness.

Shen Chengbin

Focus

16 **Zooming into the future with copper broadband**

The outlook is golden for copper because innovations in localized technologies and network architecture are providing zippier broadband rates on copper-wire networks.

Liu Jianhua & Fang Liming

Let's COMMUNICATE beyond technology and share understandings of the latest industry trends, successful operational cases, leading technologies and more. Based on in-depth analysis of the matters that lie close to your heart, we will help you stay on top of the telecom game.

19 **Single-wavelength rates for 100G access**

Li Shengping

23 **Gigabit home Wi-Fi coverage is on the horizon**

Gao Xiang

26 **D-CCAP: Helping MSOs go Gigabit**

Wang Huan & Wang Qin

Industry Perspectives

29 **The view's great with U-vMOS**

Huawei's U-vMOS video experience standard enables operators to assess and optimize video services so they can build carrier networks that give users the best experience.

Tao Liufei

32 **FTTH: A must-have for the digital home**

To boost FTTH roll out, accelerate digitization, and raise GDP, Fiber-from-the-Home (FFTH) is the best choice for digital buildings and homes.

Wang Huaichun

How to Operate

34 **Smartening up fiber optic networks with intelligent ODN**

Wang Guojun

37 **Smart WO Home: Redefining a happy home life**

Chen Pu

Solutions

40 **All-optical POL: The new choice for campus network construction**

Gu Xiaofeng & Tang Youguo

43 **Breathing new life into copper networks**

Liu Anzhen & Wu Ke

45 **Smiling with Huawei's OpenLife for smart homes**

Zhou Bo

Cutting Edge

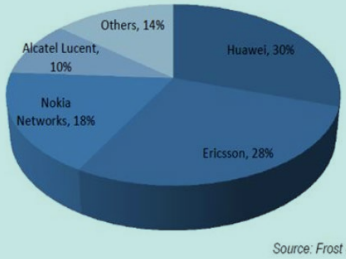
48 **Smart storage, smart analysis, big data, big returns**

Huang Tao, Li Wanlong & Luo Daxin

Achievements >>

Top in SDM

Shenzhen, China, March 3, 2016, Frost & Sullivan's recent Subscriber Data Management (SDM) market survey ranks Huawei first in the 2015 SDM market, with a share of 30 percent. By the end of 2015, Huawei's SDM solution was serving over 310 operators in more than 136 countries.



No. 1 Filer

Shenzhen, China, March 16, 2016, The World Intellectual Property Organization (WIPO) in Geneva announced that Huawei has filed the most patents in the world for the second consecutive year. In 2015, Huawei surpassed Qualcomm, Samsung, Sony, and HP with 3,898 patent applications, 456 more than the 2014 total.

4.5G

Barcelona, Spain, February 26, 2016, At Mobile World Congress 2016, Huawei and Qualcomm Technologies jointly demonstrated 4.5G (LTE TDD+) uplink key technologies using Qualcomm Snapdragon™ 820 processor with X12 LTE, and Qualcomm Snapdragon 652 processor with X8 LTE.

<< Statistics

Shenzhen, China, February 26, 2016, Huawei announced that its FusionServer E9000 CH242 V3 4-socket blade server ranked first in the VMmark 2.5.2 virtualization benchmark test. Based on the Intel® Xeon® E7-8800 v3 series processors, the solution scored a record 47.66.

47.66

97.5%

Hanover, Germany, March 18, 2016, Huawei launched its modular Uninterrupted Power System (UPS) at CeBIT 2016. Its ultra-efficient power module reaches up to 97.5 percent, and is designed with data centers in mind. The data center sector is the world's fifth heaviest energy consumer at 400 billion kWh annually. Each one percent increase in UPS efficiency can greatly reduce yearly power use.

NGFW

San Francisco, March 2, 2016, NSS Labs gave Huawei a "recommended" rating in its Next-Generation Firewall (NGFW) Group Test, reflecting the outstanding performance of the Huawei firewall and its position as one of the industry's leading solutions.

Hanover, Germany, March 18, 2016, Huawei and Vodafone signed a Global Framework Agreement to broaden their strategic alliance in the enterprise domain. Both will be able to better meet the needs of enterprise customers in the areas of fixed and mobile connectivity, NB-IoT, and Total Communications Solutions.

Ecosystem >>

Strategic Alliance

Super Dual Band

Athens, Greece, March 7, 2016, Cosmote and Huawei teamed up to field trial the microwave solution Super Dual Band for multi-Giga backhaul. Super Dual Band uniquely bonds traditional frequency (6 GHz to 42 GHz) with E-band (71 GHz to 86 GHz) to offer better protection based on special link aggregation and advanced QoS schemes.

Hanover, Germany, March 14, 2016, Huawei unveiled its first Openlab in Munich at CeBIT 2016. Openlab is positioned as a new center of excellence to foster collaborative customer- and enterprise-driven ICT innovation. To date, more than 25 partners including T-Systems, SAP, Intel, Alstom, and Hexagon have expressed an interest in participating in the new Openlab.

Munich Openlab

Connected City Lighting

Hanover, Germany, March 15, 2016, Huawei debuted its Connected City Lighting solution at CeBIT 2016, marking the industry's first IoT offering with multi-level intelligent control. Its new tech connects street lights to IoT and adopts a GIS-based management system, enabling cities to enhance the control and performance of every street light.

<< Cutting Edge Technology

Going Gigabit for Gigaband

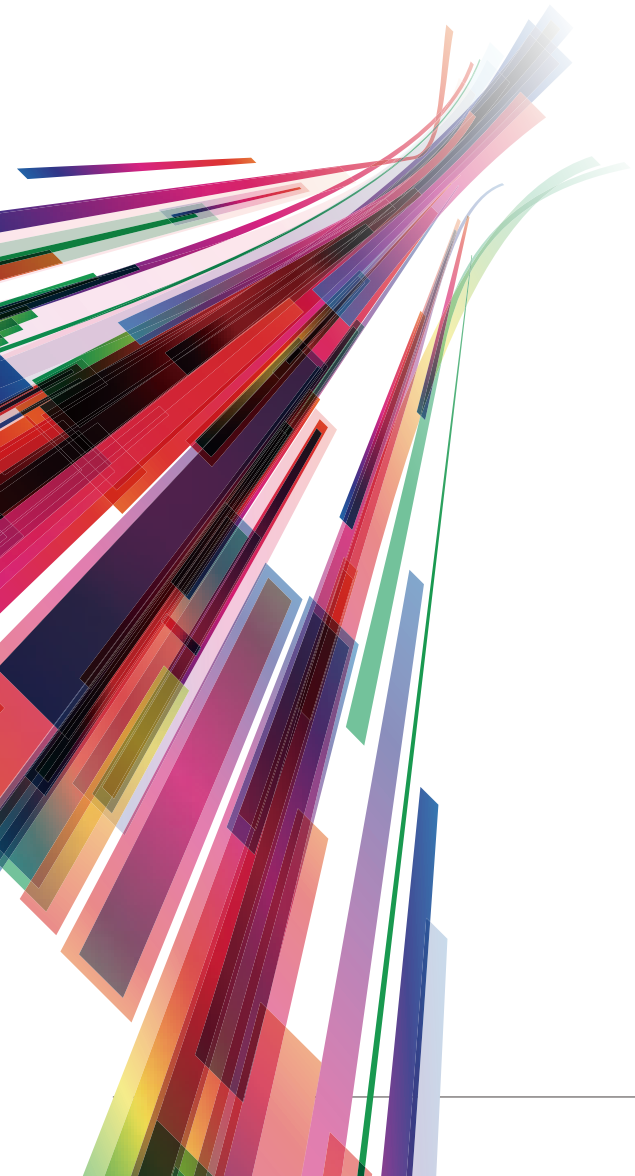
Zhu Hong
Marketing Expert, Access Network, Huawei

SingleFAN 3.0 is Huawei's access network solution for the Gigaband era. It builds broader, faster, and more intelligent access networks so that operators can optimize bandwidth, coverage, and the quality of Gigabit services.

According to Ovum, at least 50 operators were riding the 1 Gbps train by 2015, with Gigabit products commercially available in multiple Asian nations, including Japan, South Korea, Singapore, and Hong Kong. In 2015, Hong Kong's PCCW and Japan's So-net introduced 10 Gbps packages; in May 2015, Chinese carriers began testing Gigabit networks based on 10 Gbps Passive Optical Networks (10G-PON) in small, developed areas of Shanghai, Nanjing, Wuxi, and Chengdu.

SingleFAN 3.0 is designed for the Gigaband era. It can access Gigabit networks through any medium with the following technologies: Giga Fiber, Giga Copper, Giga Coax, Giga Hybrid, and Giga Wi-Fi.

SingleFAN 3.0 provides All Optical Network (AON) smart service solutions for businesses like Smart Home, AON, and Smart Office. Its quick tools function accelerates network deployment and simplifies operations, helping operators to cut CAPEX and OPEX and boost network efficiency.



Gigabit access through any medium

The development of ultra-broadband access technology for different access media will continue to increase speeds. In the future, Gigabit speeds will be available through optical fiber, cooper wire, coaxial cable, or Wi-Fi.

Giga Fiber

Based on Passive Optical Network (PON) architecture, Fiber to the Home (FTTH) has the unique post-deployment advantage of only requiring upgrades on active equipment, so continual increases in speed are possible.

Giga Copper

Giga Copper allows traditional operators to build ultra-broadband over legacy copper networks, which expedites construction, widens coverage, and accelerates RoI. BT provides a great example of applying this solution.

G.fast has stoked operators' interest in using higher working frequencies to deliver ultra-high access speeds of 500 Mbps to 1 Gbps over short distances of copper wire.

The G.fast standard was officially published in December 2014. Its first commercial product offered 500 Mbps broadband, and was launched

Giga Fiber	Giga Copper	Giga Coax	Giga Wi-Fi	Giga Hybrid
Meets NG-PON standards, delivers 10 Gpbs symmetric upstream-downstream speeds	Delivers ultra-high access speeds of 500 Mbps to 1 Gbps over short distances of copper wire	DOCSIS 3.0 supports up to 32 channels and shared bandwidth of 1.6 Gbps, while DOCSIS3.1 will support five channels and 10 Gbps in shared bandwidth.	Next-gen mainstream Wi-Fi standards – 5GHz 802.11ac, theoretically achieving 6.9 Gpbs by using higher order MIMO (up to 8x8)	Enables more flexible broadband access with three fixed mobile convergence solutions: Hybrid Modem (LTE+VDSL2), Hybrid ONT (LTE+GPON), and Hybrid CPE (LTE+G. Fast)

in the Swiss town of Bibern. BT then ran the first UK commercial trial of the technology in the Cambridgeshire town of Hungtington.

As the technology matures, methods such as increased transmit power and enhanced coding efficiency will allow G.fast to be deployed over longer distances of copper cable.

Giga Coax

Cable TV companies face stiff competition from ultra-HD 4K video from OTT providers – the latter must continuously transmit content to users' homes whether they're watching or not. Carrying these signals uses a lot of bandwidth, which was feasible when channels were SD. However, existing spectrum is insufficient to continuously transmit ultra-HD 4K programs. Moreover, one channel can transmit only one program at a time. These limiting factors will push TV to run a video-on-demand model, freeing up spectrum resources on coaxial networks so operators can provide higher bandwidth.

Giga Coax includes Huawei's Distributed Converged Cable Access Platform (D-CCAP) solution, which helps operators implement node splits and upgrade their coaxial networks to Data Over Cable Service Interface Specification (DOCSIS) 3.1. DOCSIS 3.1 is compatible with DOCSIS 3.0 network terminals – current coaxial networks based on DOCSIS 3.0 support up to 32 channels and shared bandwidth of 1.6 Gbps.

Optical node splits will help operators increase bandwidth on optical nodes that supply a large number of users by cutting the number that share bandwidth, which will improve average bandwidth per user. The Danish operator TDC has already lab-tested the solution, and achieved speeds of 800 Mbps. As more spectrum resources are freed up on coaxial networks, the D-CCAP solution will support five channels and 10 Gbps in shared bandwidth in the future.

Giga Hybrid

Giga Hybrid targets carriers with LTE networks, providing FMC capability and more

flexible broadband solutions. The hybrid modem LTE + VDSL2 (Very high-bitrate Digital Subscriber Line 2) is a Giga Hybrid FMC method that binds the bandwidth of both channels, significantly improving user experience in remote areas with low DSL speeds. DT has deployed this solution on a large scale, leading to the award for Greatest Advancement in the Field of Fixed Mobile Convergence at the 2015 Broadband World Forum for its Hybrid Access solution.

Another Giga Hybrid FMC solution is LTE + G-PON hybrid Optical Network Terminal(ONT), which China Mobile has deployed on a large scale. Operators first gain subscribers on their LTE networks and, as numbers increase, deploy fiber where there are enough users. This frees up LTE resources while keeping user-side interfaces and services unchanged.

The third Giga Hybrid solution is LTE + G.fast hybrid CPE (Customer Premise Equipment). Guaranteeing service experience for high-end users and improved customer satisfaction, operators are eyeing this solution as G.fast coverage expands.

Giga Wi-Fi

The popularity of using mobile devices to browse the Internet and watch videos over Wi-Fi means carriers have to ensure indoor and outdoor Wi-Fi performance, coverage, and speeds.

Wi-Fi attenuation through walls requires that 5GHz 802.11ac and G.hn Wi-Fi equipment is used in homes with many large rooms. Running over indoor power lines to extend Wi-Fi signals, the solution allows seamless roaming between rooms, because the SSID of each extender is the same as the main equipment.

With ultra-broadband pipelines in place, an important consideration for operators is how to provide value-added services (VAS) and increase revenue.

Mobile apps on home Wi-Fi networks can also perform self-testing and self-maintenance.

With Gigabit access through any medium, the Giga Wi-Fi solution uses legacy infrastructure to lower construction costs and accelerate deployment.

Smart services for better QoS

With ultra-broadband pipelines in place, an important consideration for operators is how to provide value-added services (VAS) and increase revenue.

A good place to start is ultra-HD 4K streaming video. VAS has enabled the industry to provide triple-play offerings on a large scale. One carrier can give voice, broadband, and video services to users, increasing revenue and customer stickiness.

Another possibility is smart home services, an area where service providers have unique strengths, such as Apple and Google with smartphones and mobile OS, and Haier and Sony with home appliances.

Operators have the edge in network equipment, terminals, and broadband subscriber base. They can provide smart home services through broadband terminals upgraded to smart terminals, which then serve as home control and communications centers without requiring additional equipment.

Wireless protocols such as Wi-Fi, Bluetooth,

Smart Home Services

When broadband terminals are upgraded to smart terminals, they can serve as home control and communications centers.

Video Services

A good place to start is ultra-HD 4K streaming video. Video services help increase operators' revenue and customer stickiness.

and ZigBee let smart terminals and home appliances communicate, and deliver services like home monitoring, security, and appliance control via smart phone apps and the network server. Operators can offer more powerful network security and virtual storage functions through integration with network equipment.

Smart home services are still in their infancy, with operators and equipment providers still exploring the service package types and business models that might differentiate them, and which users would pay for. A few operators like Telefonica, Beltelecom, and China Unicom Sichuan have already started to run pilots for smart home services.

Two other interesting developments are Passive Optical LAN (POL) in all optical network (AON) business parks and smart offices. In AON parks, PON uses less space and power than Ethernet Category 5 cables, and provides higher bandwidth. PON also uses optical splitters to allow point-to-multipoint Fiber to the Desktop (FTTD).

Previously, cloudified office services ran data flows between traditional network neighbourhoods. Now, traffic flows up and down the cloud, which best suits PON as a traffic aggregation technology.

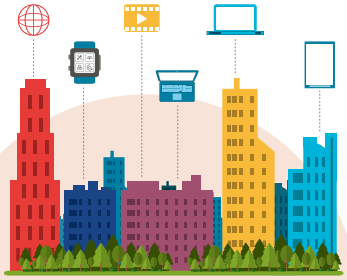
AONs provide full-service, large-scale solutions like voice, broadband, and video for organizations like hotels, enterprises, and school campuses. Smart office solutions provide businesses with services such as remote monitoring on smartphones, Wi-Fi clock-in, intelligent traffic analysis, and Wi-Fi portal ads. These utilize the synergy between smart terminals, Wi-Fi networks, sensors, and cameras, giving SMEs smarter VAS.

Efficiency gains with quick tools

Huawei has partnered with a trencher manufacturer to provide a customizable automatic excavation service that helps operators lay fiber and deploy optical networks faster. With pre-connected optic boxes and modular expansion units, the solution helps lowers costs

Smart Office

provides businesses with services such as remote monitoring on smartphones, Wi-Fi clock-in, intelligent traffic analysis, and Wi-Fi portal ads.



POL in AON

provides POL-based full-service, large-scale solutions like voice, broadband, and video for organizations like hotels, enterprises, and school campuses.

because fusion spicing is unnecessary.

An embedded Optical Time Domain Reflectometer (eOTDR) precisely finds network faults by monitoring the attenuation of reflected optical signals in real time, helping operators quickly resolve problems and restore services.

For copper networks, a copper line pre-assessment system measures attainable bandwidth through line parameters and cross talk. This lets operators advertise the actual bandwidth of their services, increasing satisfaction and minimizing complaints.

For video services, the built-in Video Mean Opinion Score (vMOS) function evaluates and monitors video streaming quality in real time to quickly identify any problems.

A great gig with SingleFAN 3.0

At the dawn of the Gigaband era, Huawei has launched its multi-faceted SingleFAN 3.0 access network solution with smart services for homes, AON campuses, and offices. The solution helps businesses build AONs and provides tools to accelerate network deployment, simplify network O&M, cut CAPEX and OPEX, and boost network efficiency.

SingleFAN 3.0 provides high-capacity, convergent Optical Line Terminals (OLT) for remote equipment in a variety of scenarios, including FTTC, Fiber-to-the-Building (FTTB), FTTD, D-CCAP, and FTTH.

To reduce O&M costs, OLT reduces the number of switch rooms, and provides pipeline wholesale and virtual operations for different service operators on the same hardware platform.

SingleFAN 3.0 supports the auto-discovery and auto-configuration of remote devices with centralized management and unified system-wide architecture and software, meeting requirements for new services like 4K Ultra-HD TV, Smart Home, AON, and Smart Office.

Already deployed in ultra-broadband markets around the world, Huawei's SingleFAN 3.0 access network solution fully delivers the bandwidth and service requirements of the Gigaband era.

Already deployed in ultra - broadband markets around the world, Huawei'sSingleFAN 3.0 access network solution fully delivers the bandwidth and service requirements of the Gigaband era.

Shen Chengbin
R&D Director,
China Telecom Shanghai
Research Institute

Experiencing the power of Gigabit

New approaches to Gigabit broadband network construction

Problems with ROI and user experience need to be addressed for Gigabit broadband services to develop. ROI will determine the commercial value of investment-heavy Gigabit broadband, and user experience will determine its competitiveness.

The swift growth of Fiber-to-the-Home (FTTH) network coverage has been accompanied by more users due to the strong pull of services like 4K HD video and cloud services coupled with the rapid maturity of the FTTH industry.

Broadband bandwidth is higher, with today's FTTH users able to enjoy rates of 50 Mbps and 100 Mbps. Operators, such as Google Fiber, NTT, and AT&T, have begun exploring Gigabit-to-the-Home (GTTH) access networks to outpace their competitors by providing a better user experience.

In China, GTTH broadband has been gaining momentum since 2015. China Telecom launched GTTH products in Shanghai, Jiangsu, and Sichuan, while China Unicom trialed FTTH in Sichuan.

2015 is basically Year One for Gigabit broadband in China. So, the technology is still far from widely available, and the GTTH supply chain is immature. There are also three other problems: First, 10G PON equipment is at least three times more expensive than Ethernet PON (EPON) and Gigabit PON (GPON) equipment, so building


GTTH access networks is much more expensive than FTTH, and the ROI much lower.

Second, a gap exists between user expectations, actual experience, and the availability of applications. Third, many operators piloting GTTH technology want to be perceived as technology leaders, but lack the mature business models to make this happen.

The successful development of Gigabit broadband depends on resolving the problems with ROI and user experience. High-value operations and improving customer experience depend on three things: one, optimizing network construction investment with innovative deployment models that target network coverage; two, raising ARPU with services and applications that exploit the enormous bandwidth available on GTTH access networks; and three, vastly improving user experience on GTTH access networks to ensure product competitiveness and user loyalty.

If these aims are not achieved, competitiveness will remain static and operators' brands may suffer.

New deployment models

High-value operations in high-value areas

For operators, targeting high-value areas can protect against the cost of GTTH networks. High-value users in affluent neighbourhoods or commercial areas are more willing to try and pay for pricier services. Conversely, in low-income communities, Gigabit broadband services are competing with low-price services, yielding lower overall ARPU.

Google Fiber, for example, selected higher-income neighbourhoods in Texas and California to first deploy Gigabit broadband. Similarly, China Telecom piloted GTTH services in a luxury apartment complex in Shanghai, where the average price of an apartment exceeds 25 million yuan (about US$3.8 million). Homeowners in this complex are less price-sensitive, and have higher demands on smart home services, including 4K video and home security. The real estate developer was also willing to help install the advanced networks to boost house sales. Likewise, China Telecom Jiangsu chose to launch its first Gigabit broadband to desktop service at a high-end residential complex in Wuxi.

In these examples, the goals of operators and real estate developers were closely aligned, which enabled the GTTH pilots to succeed. Further afield, AT&T's GTTH product, GigaPower, successfully targeted commercial customers.

When building GTTH networks, operators need to carry out ROI analysis to identify the most profitable customers by considering factors like broadband

Broadband deployment alone cannot guarantee GTTH network profitability. Operators must increase broadband ARPU and user stickiness with VAS and a good range of applications.

penetration, traffic characteristics, spending power, value-added service (VAS) penetration, age profiles, and network transformation costs and difficulty.

Boosting installation rates

The success of broadband access services depend on economies of scale in terms of network size and network resource utilization. For a high-end broadband product such as GTTH, operators need innovative new construction models and mounting solutions to accelerate installation for faster profits.

Operators should select these based on specific business scenarios. Competitive newcomers unburdened by an existing customer base, network, or other service obligations can adopt new models.

Google Fiber based the location of its GTTH network on user interest, locking in users with advance sign-up agreements to quickly generate profits once the network was up and running. In some communities, the installation rate was as high as 60 percent. New operators can also reduce the initial cost of network coverage and improve network installation rates with methods such as thin coverage.

For traditional broadband operators with existing DSL or FTTH networks, balancing reusing legacy network assets and building new networks is crucial.

10G PON-based GTTH network construction models and GTTH user installation rates are closely linked, with mature solutions that allow 10G EPON and XG-PON to coexist with EPON or GPON helping operators to smoothly upgrade their networks. However, coexistence models suit scenarios where installation rates are certain to grow. Low population density doesn't justify the high cost of upgrading the local end unless a strong Optical Distribution Network (ODN) is in place to allow thin-coverage 10G PON networks to overlap with existing FTTH/B networks.

Operators also need to encourage user migration with strategies that focus on customer needs, employ point-to-point marketing and circle marketing, and feature flexible pricing strategies.

GTTH for higher ARPU

It's all about the applications

Broadband deployment alone cannot guarantee GTTH network profitability. Operators must increase broadband ARPU and user stickiness with VAS and a good range of applications.

Gigabit broadband services with the most growth potential include value-added smart-home services, such as Internet TV/OTT video (especially 4K), cloud services, automated homes, home security, gaming, and video telephony. China Telecom Sichuan's innovative VAS model with IPTV as a star service has helped the company successfully expand its all-optical network services.

Operators can also provide better-value home networking and smart home extension services by evaluating and optimizing home Wi-Fi coverage and providing big data services for

smart homes along with interconnected neighbourhood security.

As well as VAS through direct charging, operators can provide VAS with backward charging models across smart pipes, increasing profits from broadband services like home big data services, DPI-based push advertising, and acceleration or offline content caching services for specific applications.

From KPIs to KQIs

Today's competition in the broadband market has moved beyond bandwidth and price to encompass bandwidth, price, user experience, and services.

Of these, user experience is the most important – it's not determined by broadband bandwidth alone, and instead depends on the E2E network that spans devices, pipes, and clouds. So, operators need to shift focus from access bandwidth to E2E user experience. They know that increasing speeds from 2 Mbps to 4 Mbps and 10 Mbps to 20 Mbps greatly increases user experience, but moving up from 50 Mbps to 100 Mbps has negligible benefits.

When boosting access network speeds to GTTH levels, operators need to optimize the bearing capacity of Metropolitan Access Networks (MAN), data centers, and even home networks and devices. The focus needs to be on KQIs that measure user experience rather than KPIs that measure bandwidth, latency, and packet loss.

They need to look past file downloads and web page loading times to a wider range of services such as Internet TV, OTT video, and cloud services. Users will only recognize the value of ultra-broadband networks if operators improve the quality of the services that users want.

4K video consumes a lot of bandwidth, with average rates of 15 Mbps and burst rates of 30 Mbps. Therefore, networks must meet high quality assurance indicators. To optimize network bearing capacity and user experience, operators should localize content with CDN or web cache, de-layered MAN/backbone network architecture, home Wi-Fi coverage, and home gateway performance issues.

User experience on international websites is typically poor, with loading times sometimes running into minutes. Moreover, major operators' international links are perpetually congested due to limited expansion capacity. Even the international dedicated VPNs of some enterprise customers suffer from latency and packet loss. The download experience of international sites can be improved with Web Cache solutions, while indicators for business customers' dedicated lines can be improved by optimizing VPN routing.

Operators need to build KQI evaluation systems suited to Gigabit networks that are linked to the KPI system to appraise services and applications, and then carry out targeted network optimization.

Next-gen smart home network gateways will greatly improve user experience. Various features will be required for smart home services and a core part of GTTH networks. These include user-friendly interfaces, simple controls, value-added applications, strong forwarding capabilities, and wider Wi-Fi coverage. To this end, China Telecom's Happy Me intelligent gateway is a platform for smart home applications and a strategic entry point for services.

Keeping customers happy

To satisfy Gigabit broadband customers, differentiated top-tier services including customer services (CS) are a must. Operators need to develop innovative CS methods alongside internetized customer channels that are flexible, convenient, user-friendly, and efficient, for example, dedicated CS hotlines for Gigabit broadband users. Targeted marketing will be possible through big data analysis on IT, CS, network O&M, and VAS.

Gigabit broadband products include ultra-HD video, home security, interactive gaming, and smart home services. Coupled with the extended services for home networks, the range of products means that faults are often complex, which requires more from maintenance personnel and support systems. Operators therefore need to optimize CS systems, installation and maintenance processes, and ensure their technicians are trained.

GTTH solutions must be precise and adopt different methods to increase network value and boost user perception. A savvy operator can then stand out from the crowd, avoid competition from low prices, and ensure the growth Gigabit networks.

Zooming into the future with copper broadband

The outlook is golden for copper because innovations in localized technologies and network architecture are providing zippier broadband rates on copper-wire networks.

Liu Jianhua
Senior Engineer, Access Network
Technology Research Dept., Huawei

Fang Liming
TMG Director, Access Network
Technology Research Dept., Huawei

The arrival of Fiber to the Home (FTTH) promised to be the next big thing and supplant the near decade-old Asymmetric Digital Subscriber Line 2/2+ (ADSL2/2+). A brief boom in FTTH deployment caused fixed-line operators (FLO) to realize that FTTH was a good fit for residential areas, but not for upgrading older areas with new ultra-broadband networks. Enthusiasm for FTTH construction was low for a number of reasons.

Coaxial and wireless carriers also began competing with FLOs, with multi-service operators (MSO) claiming that coaxial networks are faster than VDSL2 copper networks. Moreover, mobile operators could deliver high-speed 3G and, in some areas, 3.5G data services.

The VDSL2 17a used by many FLOs theoretically enables download speeds of 150

Mbps, though the reality is much lower due to crosstalk between lines. Simply using a higher frequency band doesn't solve the problem of crosstalk or lift rates, and that's why solutions like VDSL2 30a were ineffective and not adopted.

Vectoring maturity around this time was a lifeline for FLOs because it solved crosstalk. Vectoring can take VDSL2 to up to 100 Mbps, and it's quick, easy, and inexpensive to roll out. In Fiber to the Cabinet (FTTC) solutions, carriers can just upgrade DSLAM in roadside cabinets and customer premises equipment (CPE) without re-laying lines or building new stations. Vectoring, therefore, enabled FLOs to quickly wrestle back the lead in broadband access markets.

Huawei acted quickly to push ITU to set vectoring standards, and brought out the market's first 384-line vectoring product. Vectoring also solved the impact of crosstalk due to a higher frequency band, enabling operators to offer higher speeds on copper networks.

Fiber speeds on copper with G.fast

After ramping up speeds with vectoring, operators set their sights on the next goal – access speeds of 1 Gbps over copper wire.

But was that possible? This question had two parts: First came whether DSLAM could be moved to a Distribution Point (DP) close to user homes in a Fiber to Distribution Point (FTTdp) scenario that, in many cases, could bring DPs closer to homes than roadside cabinets. Even in places without fiber cable at the DP, deployment would be far simpler than with an FTTH solution. Low investment, quick construction time, and enough space for small DSLAMs – the FTTdp scenario was sound.

The second part of the question was whether access rates of 1 Gbps could be achieved in the FTTdp-copper wire scenario. Released in 2011, Huawei's G.fast prototype aimed to open the FTTdp market with Gigabit speeds across 100 meters of telephone wire, after proving fiber optic speeds on legacy telephone wires were possible without an FTTH solution.

In October 2013, Huawei and BT successfully held the industry's first G.fast trial. Then, in August 2014, Huawei and Swisscom signed the first commercial contract for G.fast, with the system going live at the end of 2015.

How does G.fast achieve Gigabit access? First, it brings fiber optic cable closer to the home, shortening the length of the copper wire leg. Second, it uses a wider frequency band – about 106 MHz. Third, improved vectoring cancels out crosstalk and inherits Discrete Multi-Tone (DMT) modulation. Moreover, reverse power feed and time division duplexing (TDD) flexibly adjusts the ratio of upstream and downstream rates, simplifying G.fast rollout.

Tailoring with SuperVector

FLOs plan copper networks using specific construction and maintenance models that can be flexibly formulated. Variations in different networks typically increase closer to the user end of the network, necessitating custom solutions for local conditions.

Developed specifically for a German operator, Huawei's SuperVector is one such solution. When deploying G.fast in Germany, engineers found that the network had no obvious DPs, unlike most operators' networks.

Both possible solutions – a large-scale network upgrade or extending G.fast to between 500 and 800 meters – were not possible. However, Huawei's

With innovative technology and infrastructure, NG-Fast meets operator needs for high bandwidth, low latency, low cost, and ease of deployment.

VDSL2-based SuperVector increases the working frequency band from 17 MHz to 35 MHz, boosting the power of the transmission signal and optimizing vectoring for crosstalk cancellation. SuperVector is two to three times faster for users in FTTC scenarios than vectoring alone, and reuses existing FTTC sites and equipment, with only the service board needing to be replaced.

A future win with NG-Fast

G.fast maturity in 2014 prompted Huawei to start researching the next-gen solution – NG-Fast. With innovative technology and infrastructure, NG-Fast meets operator needs for high bandwidth, low latency, low cost, and ease of deployment.

Each successive generation of DSL is five to ten times faster, and so NG-Fast can meet the ultra-high bandwidth needs of 8K streaming at rates of 5 Gbps to 10 Gbps.

Providing such massive bandwidth over copper in single-pair line access scenarios requires a frequency band of 500 MHz alongside advanced coding and modulation techniques for better spectral efficiency. To use the legacy copper network, Phantom Mode and MIMO crosstalk cancellation can be used in home scenarios that involve multi-pair wiring like Cat5. Phantom Mode creates a virtual third pair from two pairs and seven pairs from four pairs, either ramping up speeds or lengthening transmission at the same speed.

Lower latency is crucial to maximize bandwidth for 4K video over DSL. Single-session TCP/IP throughput is determined by the Round Trip Time of the response packet, as well as physical bandwidth. In turn, DSL latency arises from wide-spread interleaving and DSL code length.

NG-Fast needs to slash transmission latency to carry services such as 8K video, which require lower latency than 4K services; avoid interleaving; and reduce code length to suit ultra-low latency services.

It also has to be cheaper than FTTH or there's no reason to choose it. DSL construction costs are lower than FTTH for equipment as well as deployment, which is several times cheaper. However, NG-Fast brings DP much closer to the home, sharply increasing deployment costs and therefore requiring innovations in technical architecture.

A key aspect of deploying NG-Fast is coping with differences near the user end of the network between the copper networks of different operators. Huawei's virtual DSLAM improves the economy and convenience of deploying NG-Fast, because it requires far less space and moves the digital signal processing module up the network. Therefore, it can be deployed almost anywhere, and doesn't need a pre-arranged location on the telephone network.

NG-Fast's OPEX is lower because, unlike DSL which continuously transmits data, NG-Fast only transmits signals sent by data services, which uses less electricity. The position of the digital signal processing module also means it's maintenance-free.

Since ADSL arrived in 2000, constant tech and network infrastructure advances and innovations to tailor solutions for local conditions have accelerated broadband rates on copper wire networks.

NG-Fast is poised to take the baton from G.fast, and set new records for ultra-high-speed broadband access on copper networks.

Single-wavelength rates for 100G access

Already a significant optical access node rate, 25G capability on a single wavelength is the next step to 100G PON. To get there, Huawei's research into 4x10G TWDM PON has yielded a number of multi-wave layering solutions.

Li Shengping
Research Engineer, Acess Network, Huawei

Access rates are increasing across the globe to accommodate the ultra-broadband capacity needed by technologies like 4K and 8K UHD video, VR, smart homes, and IoT. More than 50 carriers across the planet are delivering Gigabit broadband, with some even providing 2 or 10 Gigabit services.

In China, the State Council's 2013 National Broadband Strategy set out a plan to deliver broadband access rates of up to 1 Gbps to homes in certain Chinese cities. In Europe and the US, governments are pushing national broadband development schemes.

Fast single wavelength for next-gen PON

Holding true from 1983 to 2014, Nielsen's Law of Internet Bandwidth projects an annual bandwidth growth of 50 percent for each high-end user, taking the figure up to 1.6 Gbps by 2020 – far beyond the reach of current

PON systems and 1x64 splitters.

Operators are already mass-deploying next-gen Gigabit PON (GPON) and Ethernet PON (EPON) networks, while XG-PON1 and 10G-EPON are being commercially deployed on a small scale.

As an evolution of GPON and XG-PON1, the NG-PON2 standard is part of the ITU-T GPON series. NG-PON2 architecture will be implemented with TWDM-PON to provide either four or eight wavelengths per fiber, with each delivering 10 Gbps to yield a total capacity of 40 Gbps or 80 Gbps.

The IEEE802.3 standard series lags behind ITU-T, with NG-EPON still in early days. Objectives for the standard were published in September 2015, with defined schemes including upstream and downstream single wavelength speeds of 25 Gbps (25G) and Nx25G, and major modulation formats like non-return-to-zero (NRZ), duobinary, and four-level pulse-amplitude modulation (PAM-4).

With various mature specifications offering 10 Gbps on a single wavelength, the industry is now searching for a 25G standard. PON architecture delivering 25G on a single wavelength will form the main solution for PON networks and home user access.

Solutions for governments and enterprises, which need faster networks, will include wavelength overlapping to deliver two and four wavelengths of 25G. ITU-T is expected to discuss project approval for the corresponding standard in Q1 2016.

The challenges

Due to the difficulty and cost of building infrastructure, operators prefer to stick with Optical Distribution Networks (ODN) after upgrading to next-gen PON networks. To do so, current ODNs must – at the very least – support an optical fiber range of 20 km and 1x32 splitters. However, the road ahead is bumpy: dispersion, power budgeting, and rate selection hinder high-speed single-wavelength PON.

Dispersion: Current PON networks, including EPON, 10G-EPON, GPON, XG-PON1 and NG-PON2, don't suffer from dispersion. At single wavelength rates of 10G and below, NRZ modulation is simple and inexpensive; but, at 25G or above, NRZ dispersion tolerance is too low for optical fiber spans of 20 km.

There are two possible solutions. The first, zero-dispersion O-band, isn't viable because O-band is occupied by EPON and GPON networks, and is hard to use due to coexisting generations of PON networks. The second, Electronic Dispersion Compensation (EDC), is more feasible thanks to its high-dispersion tolerance modulation formats and electrical equalization algorithms.

Limited power budget: Power budgeting will be a major headache for PON networks due to the high insertion loss in ODN splitters caused by point-to-multipoint architecture.

Two main types of detectors exist for boosting optical transmit power and receiver sensitivity: PIN diodes and avalanche photodiodes (APD).

PON networks mainly adopt APD optical receivers due to higher power budget requirements, but APD receiver sensitivity is strongly linked to signal rate. When this rises from 10 Gbps to 25 Gbps, receiver sensitivity decreases by 4 dB, reducing the power budget of system links unless compensatory measures are applied.

Currently, only a handful of providers offer 25G APD chips and ROSA package technology – a technology which is immature and expensive.

Going forward, there will be a need for cheaper 25G PON optical transceivers.

Rate selection: Single wavelength rates above 10G suffer from dispersion and limited power budgets, with higher rates raising the impact of dispersion on the system and reducing the power budget of the architecture.

Solutions come in the shape of 25G/single-wavelength systems, duobinary, PAM-4, and NRZ+DSP (Digital Signal Processing). Each of these multilevel modulation formats uses relatively simple encoding and decoding, and requires little from equipment. In 40G single-wavelength systems, however, the higher rates need more complex high-order modulation formats or DSP algorithms, placing an even greater strain on power budgets.

Current 10G-EPON power budget levels are insufficient for 40G/single-wavelength architecture, but maturity is on the horizon for 25G circuit technology, which includes laser drivers, trans-impedance amplifiers, and clock data recovery (CDR) circuits.

That's why Huawei is focusing on next-gen, high-speed 25G/single-wavelength technology, and using multi-wavelength overlapping to hit rates of 50G, 100G, and eventually 200G.

Three modulation schemes

NRZ modulation

The simplicity of the NRZ modulation format positions it well for use in EPON, 10G-EPON, GPON, XG-PON1, and NG-PON2 systems. At rates of 25G on a single wavelength, the dispersion tolerance of signals transmitted on the zero-dispersion O-band using NRZ is sufficient for the standard 20-km optical fiber range of PON systems. Using bands with positive dispersion like C-band or L-band results in inadequate dispersion tolerance. In that case, optical or electrical dispersion compensation methods are needed. Contenders include 25G electro-absorption modulated (EAM) lasers on the transmit side, and 25G APD receivers on the receive side. However, 25G optical components are expensive and dispersion tolerance is poor.

These downsides can be remedied by dispersion compensation through DSP algorithms on the receive side. Correctly optimized algorithms means that 10G optical components can replace 25G components on the receive side and compensate for signal distortion caused by insufficient bandwidth.

Duobinary modulation

Duobinary modules generate a three-level electrical signal, halve the spectrum, and give a dispersion tolerance value that's 2.5 times higher than NRZ. There are two kinds of duobinary with different eye patterns: electrical duobinary (EDB) and optical duobinary (ODB).

EDB is a conventional three-level modulation format that forms two eyes. ODB produces a three-level electrical duobinary signal that passes through an electro-optical phase modulator and modulates the two eyes in different phases, producing a similar eye pattern to NRZ. ODB modulation reduces dispersion by forming an inverted optical phase signal, boosting dispersion tolerance.

Two types of symmetrical 25G PON systems can be formed using EDB and ODB. The first type uses EDB modulation for upstream and downstream data. As Optical Network Units (ONU) in PONs are relatively expensive, 10G ONUs and 25G Optical Line Terminals (OLT) can be used at the transmit side to generate EDB upstream signals and carry out EDB modulation,

respectively. A more complex algorithm on the cheaper OLT receive side can compensate for upstream signal distortion caused by device bandwidth limitations.

The second uses ODB modulation for downstream data, forming ODB signals at the OLT transmit side through phase modulation on the three-level signals generated by the Mach-Zehnder Modulator (MZM). Two-level signal judgment can be used on the ONU receive side, much like NRZ. This greatly simplifies receiver circuitry, reducing ONU costs. The upstream modulation solution is the same as the first type's, where 10G ONUs are used on the transmit side to generate three-level EDB signals.

PAM-4 modulation

PAM-4 combines two bits into one baud. It halves the baud rate, doubles frequency efficiency, and gives a dispersion tolerance value that's four times higher than NRZ 25G. PAM-4 modulation uses 12.5G externally modulated lasers (EML) and 12.5G linear drivers on the transmit side, and 12.5G APD linear optical receivers on the receive side. As most optical components are 10G, 10G optical components can replace the 12.5G EMLs and APDs, and electrical compensation algorithms compensate for bandwidth.

The PAM-4 solution enables digital-to-analogue converters (DAC) on the transmit side to generate four-level signals, which DAC decodes on the receive side.

NRZ, duobinary, or PAM-4?

Each of the high-speed single-wavelength solutions has advantages and disadvantages. NRZ modulation has a simple structure, but it needs DSP on the receive side for dispersion compensation and 25G optical components are costly.

The symmetrical EDB modulation scheme uses low-cost 10G receivers and optical transmitters on the ONU side, but 25G downstream receivers require EDB three-level decoding, driving up ONU costs. The 25G downstream ODB and 25G upstream EDB solution benefit from high downstream receiver sensitivity and simplicity; however, 25G optical devices need to be used on the receive side. Equally, the transmit side is more complex due to the phase modulator.

By halving the baud rate, PAM-4 decreases the bandwidth needed by optoelectronic equipment, but increases the required device linearity and yields less sensitivity than the other solutions. Transceiver chips are expensive and heavy power users, though the cost and complexity of PAM-4 transceivers is expected to fall drastically as major chip makers start to launch PAM-4 chips.

To meet PON systems' power budget requirements, all the solutions need expensive, power-hungry optical amplifiers that are hard to integrate. If not addressed, this issue will make high-speed single-wavelength PON unfeasible.

Each successive PON generation depends largely on industry-wide cooperation. At the moment, 25G optoelectronic equipment is maturing, and 25G chips are used in 25G EAM laser drivers, 25G MZMs, 25G CDR, and trans-impedance amplifiers. PIN-receiver-based 25G O-band lasers have been commercially used for a number of years, and component makers are focusing more on 25G APD receivers.

Advances in optical network technology and the development of high-speed optoelectronic chips will continue to drive up single-wave rates so single-wave high-speed PON systems can unlock the promise of ultra-speed broadband.

Gigabit home Wi-Fi coverage is on the horizon

With Gigabit Wi-Fi bundled into new FTTH services, broadband operators know how important Wi-Fi quality is for revenues.

Gao Xiang
Senior Marketing Manager,
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Home Wi-Fi: A cash cow

In 2014, global shipments of Wi-Fi-enabled devices hit 5.5 billion units, with 70 percent penetration expected by the end of 2017.

However, Wi-Fi speed is the issue that affects user experience, and is also the problem that hit the Google Fiber Gigabit broadband project. As the access and control point for home broadband, optical modems can increase user and service stickiness, reducing churn and boosting ARPU. This is vital as more carriers integrate Wi-Fi into FTTH services and create new business models for smart home services, including 4K video, video surveillance, smart controls, and home network management – all these services depend on Wi-Fi-capable smart optical

modems. China Telecom and China Unicom are two providers that offer smart home services through such devices.

Below are some examples of new Wi-Fi business models that are driving operator growth.

Wi-Fi boosts IPTV

When it rolled out its IPTV service, China Telecom Shaanxi (CTS) was able to offer the service to 98 percent of its subscribers thanks to 100 percent broadband Wi-Fi penetration – a feat that would have been impossible with wired connections. CTS has been pushing a home broadband package with bundled Wi-Fi since 2012, in part because the yearly growth of IPTV service users averages 14 percent.

China Telecom Sichuan quickly rolled out a 4K IPTV service, quickly attracting 1 million users after aggressively promoting a 100 Mbps FTTH package with bundled Wi-Fi. China Unicom Tianjin also quickly increased user numbers with a bundled Wi-Fi package, including its WO TV Home service, which features multi-screen and multi-media sharing services.

Wi-Fi boosts ARPU

Scenarios where multiple users concurrently access broadband in communal accommodation like university dorms require Wi-Fi's flexibility, and solutions such as Portal authentication that allow operators to bill users individually. This can push the total broadband package ARPU in communal halls to three to five times that of home package customers.

Wi-Fi boosts sales

The increasing adoption of home Wi-Fi drives the sale of wireless routers, Wi-Fi repeaters, Power Line Communication (PLC) adapters, and set-top boxes. Wi-Fi's also good for pushing online payments, indoor networking, telephone relocation, and home wireless network commissioning, with operators able to sell service packages for optimizing home Wi-Fi that include these elements. The Hong Kong operator PCCW markets one such package under its Smart Living brand for HK$8,800.

Say hi to Gigabit Wi-Fi

Infonetics reveals that 40 percent of service providers plan to offer 1 Gbps broadband in 2017, up from 15 percent in 2015. Leading operators already provide high-speed FTTH Wi-Fi services; for example, the US firm Comcast Xfinity launched a FTTH service with Wi-Fi speeds of up to 725 Mbps, and its biggest competitor, Verizon Fios, has introduced America's fastest home Wi-Fi package with speeds as high as 800 Mbps. In the UK, Virgin Media, BT, and Sky have all launched Wi-Fi services that claim to be the UK's fastest. A number of Japanese operators are providing Gigabit Ethernet to their users, with So-net even offering a 2 Gigabit package.

Gigabit broadband rates enable ultra-high-speed services such as HD movie downloads, interactive HD VR games, and multi-angle 4K live sport broadcasts. China Telecom Shanghai trialed the world's first Gigabit FTTH broadband on May 17, 2015, with services including three-way 4K TV, one-way HD IPTV, three-way video conferencing, Global Eye five-way HD home video surveillance, and smart home services. The service offers download speeds of 700 Mbps for multiple applications in concurrent use.

With the rise of 4K and 8K video streaming, VR video, massively multiplayer online gaming, video calls, home video surveillance, and home automation gain traction, FTTH services with

bundled Gigabit Wi-Fi will mean new revenue for high-end operators.

Gigabit Wi-Fi optical modems

Today, bandwidth speeds on optical modems are too slow. Most use a 2x2 MIMO Wi-Fi interface based on the 802.11n standard. This supports maximum air interface speeds of 300 Mbps and actual Ethernet throughput of approximately 140 Mbps.

3X3 MIMO Wi-Fi products based on 802.11n can attain air interface speeds of 450 Mbps, but are too expensive to adopt widely. The successor of the 802.11n standard – 802.11ac – works in the 5 GHz band and supports up to 8X8 MIMO, providing theoretical air interface rates up to 6.9 Gbps. The 5 GHz and 2.4 GHz dual frequency bands that 802.11ac devices work on have advantages such as more optional channels, greater anti-interference, higher speeds, and less delay than the 802.11n 2.4 GHz band. They can also offer better HD video and other high-speed wireless services.

Most 802.11ac optical modem products provide 2.4 GHz 2X2 MIMO and 5 GHz 2X2 MIMO or 2.4 GHz 3X3 MIMO and 5 GHz 3X3 MIMO dual-band air interfaces, with air interface speeds of between 1,166 Mbps and 1,750 Mbps. The industry chain for these products is mature, and equipment manufacturers have begun supplying carriers in bulk. Huawei's Gigabit Wi-Fi-ready 802.11ac optical modems feature a dual-core dedicated chip, with one core exclusively handling Wi-Fi flow. The Wi-Fi Ethernet throughput here is close to 1 Gbps.

Smart Optical Network Terminals (ONT) are now used in more homes and businesses. With Huawei's smart ONTs, high-speed Gigabit Wi-Fi is truly a user-oriented service.

The 802.11ac standard will bring beamforming antenna technology into commercial application for the first time. Beamforming enables directivity and gain enhancement on Wi-Fi signals through accurate sensor array calculations, boosting Wi-Fi transmission speeds by at least 60 percent in specific locations and over specific distances.

Automatic channel adjustment is a new function of Huawei's optical modem that automatically calculates interference on all channels, and connects with the user's device on the channel with least interference, which boosts Wi-Fi speeds.

Huawei's Giga Wi-Fi Anywhere is a complete indoor distributed Wi-Fi solution equipped with PLC and Wi-Fi repeaters. The PLC repeaters are designed based on the ITU-T's G.hn standard, and achieve up to 1 Gbps Ethernet relay capability through power lines. The solution also enables seamless roaming for the user device between the optical modem and Wi-Fi repeaters by automatically configuring Universal Plug and Play (UPnP) on the PLC and Wi-Fi repeaters, giving users an unprecedented Gigabit Wi-Fi experience.

Smart Optical Network Terminals (ONT) are now used in more homes and businesses. With Huawei's smart ONTs, high-speed Gigabit Wi-Fi is truly a user-oriented service. The devices can be managed via a mobile app, giving users full control of their Wi-Fi service. The app includes the following powerful features:

Simple and flexible service provision: quickly provisions Wi-Fi services using XML profiles without changing the OSS side.

Proactive experience management: enables operators to remotely detect home Wi-Fi strength in all directions from the ONT, and push the results to subscribers' mobile phones. Operators can also push Huawei's Wi-Fi solution for enhanced coverage to subscribers.

Health mode: sets timers on the ONT to provide Wi-Fi at certain times only, which reduces exposure to Wi-Fi signals and cuts emissions.

Guest network management: sets up Wi-Fi networks for guest users with specific passwords and time limits for added security on home wireless networks.

D-CCAP: Helping MSOs go Gigabit

A fully digital hybrid solution, Huawei's D-CCAP is a fiber-coaxial technology for Gigabit networks.It enables multi-service operators (MSOs) to plan and build networks so they can get agile and stay competitive over the next five to ten years in the multi-service market.

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Wang Qin
Senior Marketing Manager, Access Network, Huawei

MSOs deliver TV and communication services on high-quality hybrid fiber-coaxial (HFC) networks using Data Over Cable Service Interface Specification (DOCSIS), a standard that was introduced 20 years ago.

But, with ultra-fast HD and OTT video on Gigabit broadband and consumers expecting more, MSOs need the power to hurdle capability obstacles and reach new opportunities.

Converged IP services: The next big thing

Stable and fast broadband plus Internet apps are now a basic need, and the Internet is disrupting profit models in many industries – each year sees new records for online sales.

MSOs have forged ahead with spectrum and bandwidth improvements over the past decade thanks to Cable Modem Terminating System (CMTS), a centralized resource sharing solution with wired broadband speeds exceeding 100 Mbps. But, CMTS is behind the curve when it comes to Gigabit, and a pricey medium for upgrading bandwidth. Potential bottlenecks include broadband limits on analogue equipment, massive hub equipment space requirements, and high energy use.

IP-based video services are thriving. It is estimated by 2016 over 72 percent of Internet users will adopt OTT video, and giants like Netflix will serve 70 million users. Netflix's OTT video services alone account for more than 30 percent of operators' bandwidth traffic, while HD video content on YouTube streams at an average of 20 Mbps. Clearly, IP-based video and interactive experiences are here to stay.

The triple-network convergence of telecom, TV, and the Internet is also driving network transformation towards a full IP-based model coupled with service and terminal integration.

MSOs have the sharpest edge when it comes to content. They're pushing strategies for the cross-penetration of different services, seamless connection in multiple scenarios, and personalized services for users in different sectors. Packet-based and best-effort delivery IP technology is the best option for carriers to bear multiple services.

MSOs need to safeguard existing investment when building networks they can smoothly upgrade to IP and transmit both traditional services plus IP video.

Transforming network architecture

HD IP video services like 4K are ready to dive into the mainstream, and so MSOs are building high-bandwidth IP-based converged networks to cope. DOCSIS 3.1 and optical node splitting are the two main solutions to achieve this.

DOCSIS 3.1

Issued by CableLabs in 4Q 2013, the DOCSIS 3.1 standard

uses Orthogonal Frequency-Division Multiplexing (OFDM) modulation, allowing multiple sub-carrier signals at the higher frequencies of 204 MHz upstream and 1.2-1.7 GHz downstream.

The standard's previous incarnation, DOCSIS 3.0, is already widely used in developed countries. Backwards compatible with both DOCSIS 3.0 and 2.0, version 3.1 boosts data transmission efficiency and lowers bandwidth unit costs, enabling MSOs to expand upstream and downstream frequency, and provide Gigabit broadband services. In tandem, equipment vendors are likely to support two upstream and two to four downstream channel capacities to deliver downstream rates of 5 Gbps to 10 Gbps within the next three years.

Despite the welcome jolt to competitiveness, upgrading E2E equipment and reconstructing networks doesn't come cheap when the following are considered: Coaxial Media Converters (CMC), Cable Modem (CM) terminals, HFC components, and engineering costs. Therefore, selecting the optimum DOCSIS 3.1 transformation solution is a must for competitiveness.

Splitting the node

High-quality HFC networks can potentially create huge value for MSOs that own them.

Optical nodes in HFC networks convert optical signals from the fiber optic network into IRF signals for distribution along coax cable to homes. MSOs can split optical nodes, and move them downwards to cut sharing and increase per user bandwidth. For example, splitting a node for 2,000 homes into four nodes further down the network means each node can supply 500 homes. This process "pushes the fiber deeper" by extending the fiber network closer to the user side.

In HFC networks, Fiber To The Last Amplifier (FTTLA) extends the optical fiber along the line to the last amplifier, close to the subscriber. Most MSOs in developed nations are transforming their networks and positioning one to two amplifiers below each optical node.

Choosing the right optical node equipment to maximally benefit from DOCSIS 3.1 will have a huge bearing on the success of MSOs' HFC network migration strategies.

D-CCAP: Reconstructing HFC

Huawei's Distributed Cable Converged Access Platform (D-CCAP) is designed to deploy Gigabit coaxial services and optimize fiber infrastructure, enabling MSOs to deliver future-ready converged multi-service for the Gigabit era.

It combines DOCSIS 3.1 and optic node splitting solutions, digitizes optical fiber architecture via GPON/10G-PON technology, integrates video services, and shares the same platform as FTTx.

D-CCAP complies with the Remote MAC/PHY system architecture under DOCSIS standards. Here, CMC equipment classifies and forwards data traffic to complete MAC framing on the data-link layer, and modulate and demodulate data on the physical layer. CMCs are deployed closer to the user end – usually on optical nodes – to manage control system protocols for module execution, and configure and manage services. The CMC controller handles services aggregation and routing learning. Moreover, integrating EQAM can distribute video.

The CMC controller uses mature, standard interfaces like GPON, 10G-PON, 40G TWDM-PON, and GE to ensure service reliability between the CMC and CMC controller.

Platform-sharing with FTTx allows MSOs to convert their networks into Fiber-to-the-Home (FTTH), while protecting existing investments and driving up competitiveness.

Minimal construction costs

Lack of hub site space and high energy consumption affect future network upgrades. D-CCAP frees up hub space by digitizing analogue equipment and, in a network covering 30,000 users, there's no better solution.

Integrating VOD and BC QAM into remote D-CCAP sites further brings out the solution's advantages. D-CCAP features point-to-multipoint PON architecture, requiring far less optical fibers than traditional point-to-point CMTS/CCAP networks. However, Dense Wavelength Division Multiplexing (DWDM) equipment in CMTS/CCAP networks complicates expansion.

One-step DOCSIS 3.1

While CableLabs' DOCSIS 3.1 standards specify modulation orders of 4K to 16K QAM, most operators cannot currently meet these specifications.

When signals pass through multiple optical-to-electrical or electrical-to-optical converters from the radio frequency interface (RFI) to the optical node, carrier-to-noise ratio (CNR) degradation can be as high as 8dB.

However, very few coaxial broadband users meet the CNR requirement for 4K QAM modulation, which the standards define as a minimum of 41dB. Most lines can only support 1K QAM modulation. Huawei D-CCAP solves this problem with digital fiber optic transmission, which improves CNR and delivers 1Gbps services to 80 percent of users, eight times more than a traditional CCAP.

MSOs are expected to commercially deploy DOCSIS 3.1 in 2016. It takes three to five years to roll out a new standard on a large scale, and MSOs still need to prepare for it. Given the technical and platform limitations of CMTS architecture, upgrading to DOCSIS 3.1 will be expensive and involve several steps, including replacing CCAP platforms and downstream and upstream line cards.

Huawei's comprehensive one-stop solution provides DOSCSIS 3.1 hardware-ready technology and upstream and downstream software capabilities for DOCSIS 3.1 upstream/downstream full service deployment.

Integrated FTTH platform

The trend for full-service operations means more telcos and MSOs are choosing FTTx-compatible FMC strategies. These require platforms that can concurrently support copper Gigabit broadband technologies like DSL, vectoring, and G.fast; Gigabit fiber optic technologies such as GPON, 10G-PON, and 40G TWDM PON; and coaxial Gigabit technologies like DOCSIS 3.1.

Huawei's D-CCAP solution provides three different MSO network construction scenarios on one OLT platform: deploying FTTH through GPON or 10G-PON in new properties, reusing DOCSIS 3.0 cable modems (CMs) to increase speeds over existing coaxial networks, and upgrading CMs to DOCSIS 3.1 so coaxial networks can achieve ultra-broadband capabilities in high-value areas.

The three different scenarios can be delivered on the same OLT platform, ODN network, and CMC equipment. The same management system and OSS can also manage each, helping MSOs build flexible networks and quickly deliver competitive services.

SDN architecture

The software-defined D-CCAP architecture can virtualize the access network, including OLT and CMC, into virtual CCAP equipment. Like a data center, the equipment can automatically acquire and manage IP addresses, and launch automatic configuration and access network service provisioning processes.

Users can trigger network functions and virtual CCAP service provisioning, and customize these on the web portal, allowing the virtual CCAP controller to automatically generate and distribute virtual network resources and service functions as soon as a user goes online.

In the future, Huawei's D-CCAP solution will be programmable and possible to virtualize, accelerating the evolution of networks into open-network API-based Access Network as a Service (ANaaS) networks without needing further configuration. This cuts the need for physical sites and, therefore, investment.

Fully digital D-CCAP for the win

Huawei's D-CCAP is a fully digital Gigabit HFC network solution that provides digitized, distributed network architecture. It increases service bandwidth, frees up hub space, and reduces energy consumption.

D-CCAP delivers one-stop DOCSIS 3.1 commercial capabilities, and includes FTTx solutions on one platform. Leading MSOs have already deployed the solution, including CBN, Vodafone New Zealand, Monaco Telecom, Brazil NET, and Japan's CNCI. Each uses D-CCAP to provide a rich variety of Gigabit broadband services.

D-CCAP optimizes network planning and construction management so MSOs can control future network construction costs, stay competitive, and keep active in the multi-service market over the next five to ten years.

The view's great with U-vMOS

Huawei's U-vMOS video experience standard enables operators to assess and optimize video services so they can build carrier networks that give users the best experience.

Tao Liufei
Marketing Manager, Fixed Network, Huawei

In a survey by Conviva, 35 percent of users ranked video viewing experience as the top factor when choosing a streaming video service, above even content. Moreover, 84 percent stated they give up on videos in less than a minute if the quality deteriorates.

Video quality is something operators didn't focus on in the past because they regarded the video source and carrier network as separate, with faults possible at any point on the network, from the video server to the user's terminal. Rapid fault demarcation and troubleshooting were incredibly difficult.

Enter U-vMOS

When developing the Unified Video Mean Opinion Score (U-vMOS) standard for video experience, Huawei considered a huge quantity of user research. The result was a series of engineering tests based on a modified and improved version of the ITU-D's existing vMOS standard.

An objective measurement, U-vMOS considers three things: video quality, viewing experience, and interactive experience. Rated on a 1 to 5 scale, sub-categories include video definition, quantity of video sources, screen size, usage experience, and streaming smoothness.

Analysis by Huawei iLAB on 4K video viewing experience shows that quality drops considerably when bandwidth falls below a certain threshold or when latency and packet loss exceed certain levels.

Better networks with U-vMOS

U-vMOS collects real-time network indicators and corresponding U-vMOS scores. It uses big data analysis to determine the key network indicators that affect video experience, and outputs recommendations for network optimization and O&M.

The minimum key network

indicators for an optimal 4K video experience are 100 Mbps bandwidth, 30 ms latency, and 0.002 percent packet loss. These indicators correspond to a U-vMOS score of 4, a "good" experience, which requires operators to ensure E2E bandwidth of at least 100 Mbps.

Operators have historically deployed multi-layer aggregation to avoid buying more network ports when user numbers grow. However, as network traffic models have changed due to the rise of video, more operators are flattening network layers and reducing the concentration ratio from 10:1 to 2:1. The reason is that multi-layer aggregation networks cannot multiplex the bandwidth, and the cost of expanding network capacity is high. This kind of network architecture is set to become mainstream in the future.

Operators' video services will go through three stages of development, with each characterized by particular service features, experience guarantees, and challenges that need specific approaches:

Stage 1: (4K) video services emerge. With few users, the main concern of operators is ensuring E2E traffic throughput for single users and that bandwidth access capability can support video services.

Operators should implement Fiber-to-the-Home (FTTH) to increase access rates to between 100 Mbps and 1 Gbps. If that's not possible, they should consider Vectoring or G.fast to increase copper rates to fiber-equivalent levels. Replacing copper with fiber or shortening the distance of the copper line to the home reduces latency and packet loss.

Other techniques can improve experience, like deploying TCP accelerators to increase TCP throughput and improving the TCP-based VoD experience. Tests show that TCP acceleration is highly effective against random packet loss due to poor copper line quality, guaranteeing a TCP throughput of 80 percent bandwidth under conditions where latency is less than 100 ms and packet loss is below 10^-3.

To resolve issues with Broadcast TV (BTV) and User Datagram Protocol (UDP) VoD experience, FCC/RET should be deployed on the IPTV platform.

Stage 2: rapid user growth. The growth of video users in key regions can lead to excessive local network loads, so operators must focus on optimizing the user access network and reducing network congestion caused by high user concurrency. Reducing the optical line terminal (OLT) split ratio on the access segment is necessary to build Passive Optical Networks (PON) with zero congestion that support single-channel 4K streaming video for concurrent users on GPON and EPON. This configuration can be upgraded in the future to support single household multiplex 4K video streaming on 10G PON.

In metropolitan area networks (MAN), operators need to plan bandwidth in accordance with peak concurrent user numbers. For network planning, a concurrency rate of 20 percent is recommended; that is, a concentration ratio of less than 5:1.

More users cause the central Content Delivery Network (CDN) loads and backbone traffic to increase. CDNs should be moved down to reduce pressure on MANs and backbone networks.

Stage 3: mass number of active users. MAN users in this stage hit 1 million, with massive variations in maximum concurrency in different regions and at different times. If capacity planning for the entire network is based on a unified average concurrency rate, congestion is very likely in some regions at certain times, leading to lower U-vMOS. At the same time, CDNs and network capacity in other regions

will be lightly loaded. Conversely, setting network capacity according to a maximum concurrency rate will lead to low average network utilization.

In the third stage, operators need to focus on high burst traffic and precise operations. Establishing a collection system that regularly collects data on network loads and quality can provide big data for video service platforms and network synergy. When a user plays a video, the CDN can assign the optimal server, and the network controller can determine the network path.

Better home networks with U-vMOS

According to video O&M departments, home networks cause over 60 percent of user complaints. Most home Wi-Fi equipment currently delivers a maximum bandwidth of 50 Mbps against a backdrop of unstable or weak signals, interference, and multiple walls. Upgrades are needed in three areas: coverage, bandwidth and network quality.

Coverage: Coverage needs to be improved so that users can receive connection speeds of 100 Mbps and above on multiple terminals from anywhere in the home. This requires multiple Wi-Fi APs distributed throughout the home rather than a single router.

Bandwidth: 4K experiences need at least 100 Mbps bandwidth, but the vast majority of homes use 802.11n Wi-Fi routers that deliver speeds of less than 50 Mbps. The newer 802.11ac standard offers a throughput of 1 Gbps and above, and future-proofs home networks so they can support other services requiring high bandwidth.

Wi-Fi signal interference: The G.hn Power Line Communications (PLC) solution use selectrical wiring to carry data across different rooms to reduce interference between APs. One AP will be deployed per room, and each will be set with different frequencies to reduce interference.

Video O&M

The rise of streaming video services has created new challenges for O&M systems. In addition to managing connectivity and traffic, they now need to handle E2E video and rapidly deal with faults.

Traditional O&M tools lack information about service flow paths, preventing operators from detecting quality changes in real time. However, U-vMOS-based O&M systems focus on video experience, and can extend all the way to the user's home terminal to capture service data in real time so operators can deal with faults.

These O&M systems need to sense and manage data originating from every point on the network to gather real-time U-vMOS indicator metrics. Through big data analysis, E2E experience can be predicted, and the network dynamically optimized. In the traditional O&M model, problems are fixed after they're found. But, in the new model, they're anticipated and eliminated in advance. When they do occur, they're dealt with quickly. Real-time O&M systems involve the following processes:

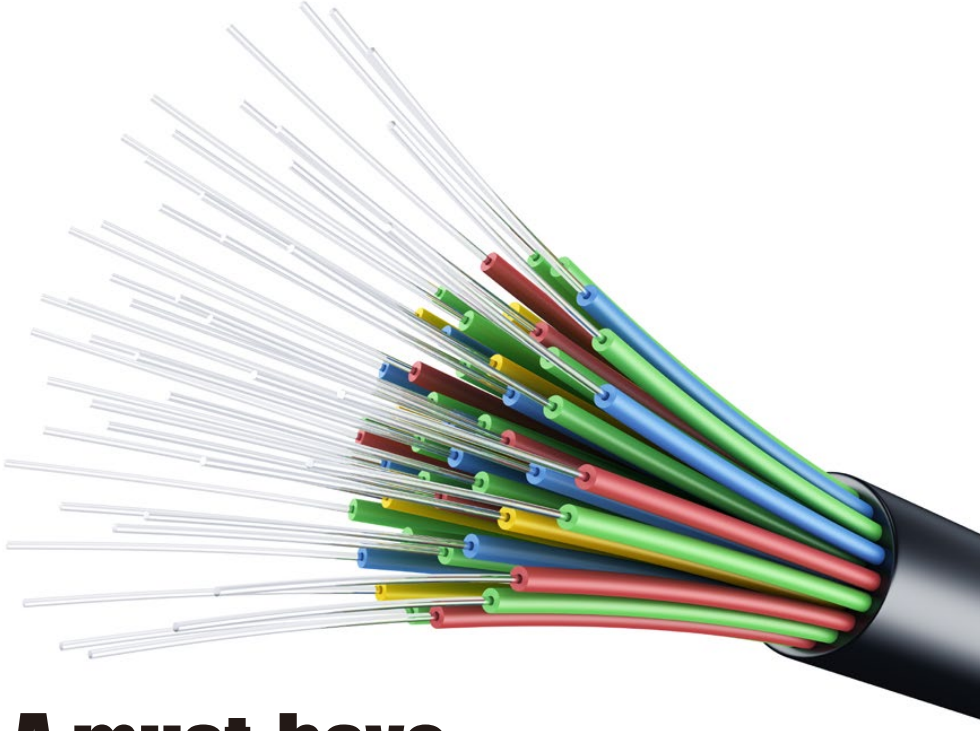
Real-time U-vMOS video experience detection: analyzes video flow in real time using quality-sensing network equipment or U-vMOS sensor modules at the user end, and issues U-vMOS warnings when video indicators deteriorate. This allows operators to be proactive with O&M rather than relying totally on user complaints to detect faults.

Real-time video service path tracking: uses probes to monitor service flow information and restore single service paths in real time based on the combined analysis of service flow and network information.

Real time video fault demarcation: analyzes all links in the network with real-time service path tracking to demarcate faults in real time.

Closed-loop fault handling: resolves non-physical line connection issues with a real-time trouble shooting system, and predicts network-wide changes to U-vMOS indicators based on the O&M system's analysis of individual faults.

Video will become the major medium for a wide range of Internet services and will account for the highest use of network traffic. For operators, a good user experience is the key to success. The U-vMOS video experience standard measures and optimizes video services, and is useful for all players in the video industry. Operators, for example, can use U-vMOS to assess and optimize video services so they can build optimal carrier networks. U-vMOS is a must for the video industry to develop.



FTTH: A must-have for the digital home

To boost FTTH rollout, accelerate digitization, and raise GDP, Fiber-from-the-Home (FFTH) is the best choice for digital buildings and homes.

Wang Huaichun
Marketing Manager, Fixed Network, Huawei

Despite our increasing dependence on broadband networks, broadband doesn't have the same status as electricity and water when it comes to basic utilities.

So, what's stalling digitization and keeping broadband a second-class citizen? Basically, laying optical networks in buildings without FFTH involves lengthy and costly re-construction work that affects users and operators alike.

Three challenges

With slow ROI and high costs, today's mainstream broadband network model – FTTH – can be a tough sell, especially at a time when operators are seeing revenue from legacy services squeezed by OTT services.

Accounting for 10 percent to 20 percent of the total cost, the last mile of FTTH is disproportionately expensive. Equally problematic, property developers often deliberately delay approval times, levy outrageous charges, make unreasonable demands, and even deliberately destroy broadband facilities. Joe Public can also throw the proverbial spanner in the works due to a fear of damage to their homes from cabling or drilling.

The third challenge is a technical one – countless installation scenarios for different

buildings and the prevalence of old buildings massively ramp up complexity and time.

Two prongs

Real estate developers are accustomed to providing conduits and cabling for electricity, telephone, and cable television services for new buildings. They typically cooperate with service providers to connect residences or apartment buildings to existing public facilities outside.

Normally, this involves two telephone, one cable TV, and four electricity conduits. Adding two fiber optic cables to the same trench costs developers very little, and avoids the need to relay fiber optic conduits at a later date, which can take weeks due to license applications, design, coordination, and construction.

Governments should pass standards that require housing developers to provide either FTTH conduits, or actual FTTH connections, when constructing or renovating buildings. Indoor fiber conduits can be laid in the same place as wiring for other facilities, such as electricity, telephone and cable television, to deploy fiber optic cables faster and at lower cost.

FTTH conduits need to follow industry standards like TIA and ANSI, which prescribe bending radius, length, clearance, and termination point location. The correct numbers and sizes of cabinets must also be deployed.

Making it standard

More countries are implementing FTTH policies. China's 2012 code mandates that residential construction companies pre-lay FTTH cables, set aside space for FTTH equipment, and build data communications pipelines, in-wall ducts, and concealed wiring when constructing new buildings. In 2014 and 2015, China laid 50 million and 80 million FTTH lines, respectively.

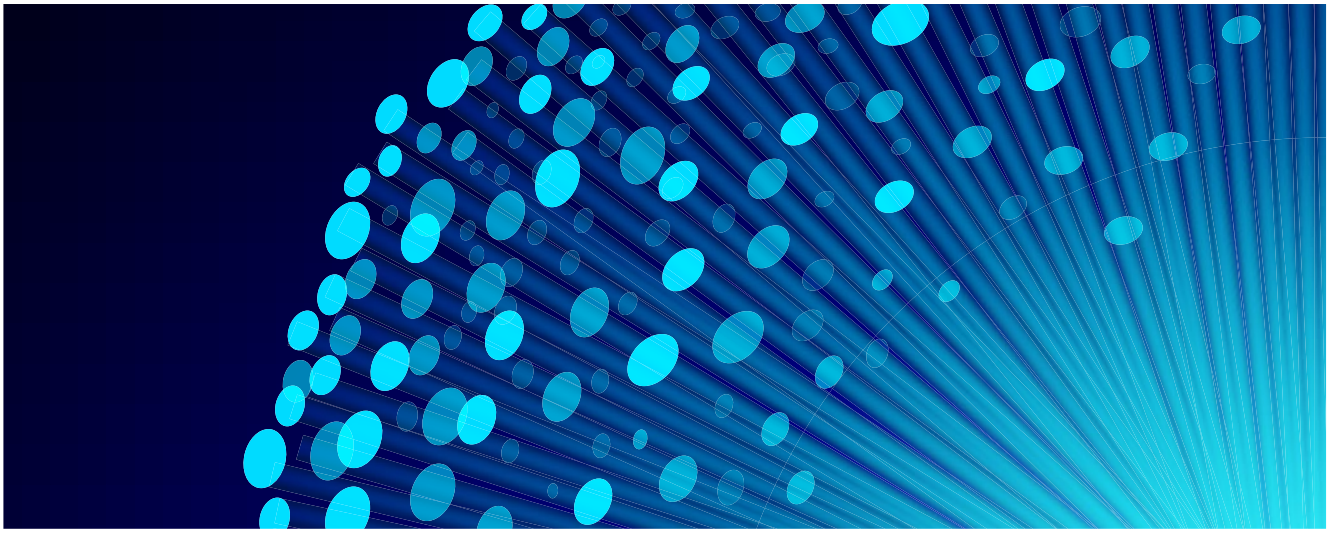
Many US cities have passed FTTH regulations, including Loma Linda in California. The city's Loma Linda Connected Community Standard (LLCCP) requires that, "All new commercial and residential developments (or re-models involving greater than 50 percent of the structure) must equip new structures with fiber-optics interfaces and copper cabling." The developer must install fiber conduits and neighbourhood distribution frames, with data cabinets in master bedrooms, a fiber optic connection to the data cabinet and distribution frame, two Cat 6 connections and one coaxial connection in each room, and a FON solution. All materials must comply with city regulations.

The EU adopted Directive 2014/61/EU in May 2014, which requires all new and renovated buildings to be FTTH-ready from 2017. All permit applications for new and refurbished buildings will need to be certified as high-speed-ready and broadband-ready by inspection. Moreover, facilities in buildings and residential districts will be open to all broadband service providers.

Many other countries including Morocco are preparing to pass FTTH policies, or are in the process of implementing them, such as Indonesia. Some early adopters like South Korea already have high levels of FTTH coverage.

Although FFTH will burden building developers, laying broadband conduits together with other utilities incurs very low cost, but the benefits are immense, especially in areas with a high concentration of new or renovated residences.

To boost the roll-out of FTTH, accelerate digitization, and raise GDP, we believe that FTTH needs to fall under a new standard for buildings and promoted worldwide.



Smartening up fiber optic networks with intelligent ODN

Shaanxi Mobile has deployed intelligent fiber optic networks at the core and aggregation layers of its network, boosting management efficiency and laying the foundations for broadband services.

Wang Guojun
Marketing Manager, Access Network,
Huawei

Despite fiber optic networks (FON) growing in size, many operators still manage a massive number of ports, fiber optic cores, and aggregation servers manually. Poor management in this way seriously restricts the development of fiber optic services.

In 2015, China Mobile subsidiary Shaanxi Mobile got round this problem by deploying intelligent Optical Distribution Frames (ODF) on all its cores and aggregation servers, and upgraded existing ODFs to intelligent ODFs. By building a FON with a smart layer of cores and aggregation servers, the carrier boosted network management efficiency and paved the way for broadband.

The challenges

Shaanxi Mobile began constructing fiber optic broadband in 2010, and has since covered 2.6 million users with its fixed network. But, the increasing complexity began to restrict the growth of its fiber optic service.

Handling data by hand

In the project implementation phase, Shaanxi Mobile engineers relied on paper print outs of engineering drawings and carried out operations manually. All information about the network was recorded by hand or manually entered into a database.

Human error and imperfect resource management processes often led to out-of-date information, with error rates for network resource data topping 30 percent.

Paper labels

Engineers recorded information about fiber optic ports on paper labels that they stuck onto ports after installation, a task that was either forgotten or error-prone, as labels would fall off, become damaged or, when updated, become illegible. Data on port and fiber optic resources was incomplete and unreliable.

Manual O&M

O&M on fiber optic resources involved manually identifying fibers and manual searches on the passive network. Efficiency was very low, and poor FON management had slammed the brakes on Shaanxi Mobile's broadband service.

Lacking an information-based system, all work orders were also handled manually, and tickets took an average of 20 days to close.

Intelligent ODN

Intelligent ODN (iODN) boosts FON O&M efficiency by replacing paper and manual tasks with eID chips, iField site assistance tools, and an NMS for traditional ODNs.

iODN replaces paper labels with electronic tags (eID) on fiber jumpers at both ends. The system automatically reads and collects data on port status, connectivity, and topology for maximum accuracy. iODN uses iField or NMS channels to carry out automatic backhaul and reporting on resource data, eliminating human error and giving 100 percent accuracy.

Intelligent ODN (iODN) boosts FON O&M efficiency by replacing paper and manual tasks with eID chips, iField site assistance tools, and an NMS for traditional ODNs.

To construct the intelligent ODF system, Shaanxi Mobile had to transform existing ODFs and integrate existing processes, but its network used multiple vendors' ODFs and various sizes of ODF equipment arrays. Completing the network upgrade without interrupting services would require a large number of customized products to accommodate these different sizes.

Huawei performed thorough analysis and trials to develop its uniform transformation solution for arrays, which involved adding adjustable telescopic clasps at both ends of new arrays. In this way, the original arrays didn't need to be replaced, and the original fiber optic routing didn't need to be altered – by adjusting the distance between the retractable clasps, the solution easily fit different-sized arrays. Shaanxi Mobile could then upgrade its ODN with intelligent ODFs quickly and economically, without needing a large amount of customized equipment or lengthy service downtimes.

With the ODF transformation issues resolved, the remaining obstacles were integrating service processes into the iODN and overcoming legacy service process problems with offline

With total port shipments exceeding 10 million units, Huawei has deployed iODN in more than 100 networks for national broadband projects for operators including China Mobile, China Unicom, Singapore Telecom, and carriers in New Zealand.

operations, complex work orders, slow ticket transfer, inefficient closed-loop management, and limited quality checks.

Shaanxi Mobile and Huawei designed engineering and embedding processes for intelligent fiber optic cables that automatically generated feedback results on managing fiber optic cable resources, eliminating the need for time-consuming resource comparisons and maximizing accuracy.

To resolve low monthly completion rates on work orders and delayed tickets, the following solutions were added to create a real-time closed-loop system: intelligent fiber core scheduling, network handover processes, unified IT processes, an OI hybrid network for issuing work orders in a unified way, and an automated ticket system.

Shaanxi Mobile and Huawei also worked with an OSS vendor to seamlessly integrate different IT processes into the iODNNMS, including the resource management, work order, and warning systems. The iODN digital O&M process linked disparate network service processes to completely solve problems relating to offline operations and inefficient management.

iODN: Expected results

100 percent fiber port data accuracy

Shaanxi Mobile has built 1,000 new intelligent ODFs and transformed more than 1,000. Optical fiber resource accuracy rate is now at 100 percent. In places where the network has been fully upgraded to the iODN system, all fiber optic equipment uses electronic tagging and automated data reports, making all resources visible in the resource management system and increasing fiber optic accuracy rates to 100 percent.

Higher O&M efficiency

O&M efficiency is expected to rise by more than 60 percent, and ticket closure efficiency by 90 percent. Moreover, the iODN management system has eliminated the manual resource inventory thanks to automated collection and verification. This alone is expected to save Shaanxi Mobile millions of yuan in O&M costs each year.

The electronic transfer of work orders through the iODN makes service provisioning much more efficient, and the closed-loop duration of work orders had dropped from an average of 20 days to 2 – a 90 percent increase in efficiency.

A great team

With total port shipments exceeding 10 million units, Huawei has deployed iODN in more than 100 networks for national broadband projects for operators including China Mobile, China Unicom, Singapore Telecom, and carriers in New Zealand. Standing together with operators, Huawei can rapidly integrate the iODN solution with operators' O&M processes, helping them simplify usage, improve fiber optic management efficiency, and reduce O&M costs.

Smart WO Home
Redefining a happy home life

China Unicom's brand offering Smart WO Home uses cutting-edge IT to make home life smarter, safer, healthier, and happier for its customers.

Chen Pu
Marketing Manager, Access Network, Huawei

Smart home services have created yet another domain where operators are expected to raise service speed and scope without charging more. As Internet companies, home appliance, and e-commerce brands continue to launch new smart home products, operators run the risk of becoming dumb pipe providers in the smart home market as well as in the communications market.

In line with China's broadband and Internet-plus strategies, China Unicom responded to this threat in March 2015 with its integrated platform, Smart WO Home, which its Sichuan subsidiary launched seven months later. With its 21 local networks serving 1.2 million broadband users, China Unicom Sichuan is one of China's most pioneering operators, and thus the

logical choice to roll out its parent company's foray into the smart home world.

At its launch, China Unicom Sichuan General Manager Qiao Guiping explained the thinking behind the brand, "Smart WO Home is China Unicom's full digital service solution for home users to make their lives safer, healthier, and more convenient." According to Qiao, the solution integrates Internet, mobile Internet, IoT, big data, cloud computing technologies, and cutting-edge IT. He believes that, with the home as the hub, Smart WO Home "brings families closer" and represents "a revolutionary change in our thinking and way of life in the Internet-plus era".

Smart WO Home is China Unicom's full digital service solution for home users to make their lives safer, healthier, and more convenient.

1-5-3-1 service architecture

Smart WO Home includes integrated access, information sharing, application services, and interactive control services. The solution's communications package assembles broadband, voice, data, and SMS services under a true 100 Mbps fiber optic full-service sharing package. Home applications include WO Home TV, WO Home Browser, and WO Home Cloud. China Unicom Sichuan also plans to launch WO Home Classroom, WO Home Security, WO Home Doctor, and WO Home Elderly Care.

In readiness for Internet-plus, Smart WO Home is a capability-opening platform that provides practical service support for industry partners and a unified, integrated experience for users. On it, China Unicom Sichuan opens up four of its service capabilities: basic resources, service hosting, central operations, and collaborative innovation.

The 1-5-3-1 service architecture provides:

1 x home integrated communications sharing package

5 x smart home services: WO Home TV, WO Home Browser, WO Home Cloud, WO Home Accelerator, and WO Home Helper

3 x home terminals: a smart router, a smart set-top box, and a smartphone

1 x smart home user interface: WO Bao mobile app

WO Home TV: Bringing happiness

The TV sits at the center of the home entertainment platform in the same way as it does for family life. By making the TV a smart all-round terminal, China Unicom Sichuan delivers computer, mobile, and games to the home through the WO Home TV service.

WO Home TV creates a smart living room entertainment center, so people can enjoy 4K ultra-definition TV shows and do what they like doing online. Logging into the TV service center also lets users pay for their telecom bills, manage device contracts, and buy smart home appliances.

WO Home TV has two pioneering features: One is an online TV shopping service that's run in cooperation with Suning. The second allows users to access the operator's online and mobile service centers so they can check and change their

services, pay bills, and find nearby stores.

WO Home Browser: Managing happiness

WO Home Browser is an integrated full-network, full-terminal, and full-service service solution that uses new tech like hybrid fixed-mobile Internet, IoT, cloud computing, and big data to provide an array of functions including integrated access, information sharing, application services, and interactive control services.

Users can access home automation and security services and check the status of, for example, doors, faucets, air conditioners, and even people. They can also control basic electrical appliances and security systems remotely. The data monitored and collected by WO Home Browser is fed into big data systems that can then provide more services, such as elderly care and health services.

Deputy GM for China Unicom Sichuan Gan Xuejun cites three benefits of WO Home Browser: “First, home security lets people relax when they’re away from home; second, appliance control makes it easier to look after a family; and third, the zero learning curve gives users a headache-free experience.” For industry partners, WO Home Browser leaves plenty of room for innovation.

WO Home Cloud: Sharing happiness

WO Home Cloud lets family members share content like photos and videos across multiple devices, with 500 MB of 4G data free. Unlike Internet companies' clouds, WO Home Cloud connects to the operator’s network through dedicated optical channels for faster upload and download speeds. Content can be shared across any screen – computer, phone, or TV – remotely.

WO Home Cloud communicates with Internet companies' clouds via an open cloud data interface that provides cloud storage and channels on the back end.

Smart WO Home is an incubator for technological innovation, an accelerator of industry growth, and an integrator of happiness.

WO Home Accelerator: Faster happiness

By accelerating broadband with just one click, WO Home Accelerator reduces download times from, say, 45 minutes to 2 minutes. The operator also provides this service for its partners, including Baidu, Thunder, Youku, and various online photo printers, so users can enjoy Internet speeds of 100 Mbps.

As the first Chinese operator to pilot these kinds of services, Gan is keen to point out the importance of partnerships: "China Unicom Sichuan combines forces with many in the industry to meet customer demands for personal services.” According to him, “Smart WO Home is an incubator for technological innovation, an accelerator of industry growth, and an integrator of happiness."

All-optical POL: The new choice for campus network construction

More secure and reliable than Ethernet, high-bandwidth Passive Optical LAN (POL) campus networks simplify cabling architecture and require far less equipment, space, and power.

Gu Xiaofeng
Senior Marketing Manager, Access Network, Huawei

Tang Youguo
Marketing Manager, Access Network, Huawei

Fiber-optic Passive Optical Networks (PON) offer clear advantages over copper networks in terms of bandwidth, access distance, power consumption, reliability, and lifespan.

With operators widely adopting PON, the industry chain is maturing, and PON technology is increasingly common in enterprise campus networks. POL is a new PON-based area network technology that businesses can use to reconstruct the currently prevalent Ethernet-based campus networks or build new Local Area Networks (LAN). POL enables high-bandwidth networks that support integrated services.

Three reasons to reconstruct

Campus network reconstruction is driven by, one, demand for higher bandwidth; two, north-south traffic models; and, three, IoT integration.

Work is getting increasingly smarter and information-based. HD video conferencing, cloud services, massive data switching, mobile office, and CATV are some of the many digital tools that companies now use for business, all of which require greater bandwidth and upgraded LANs.

The campus network service model is also changing, with the widespread use of virtual desktops, BYOD, and cloud computing, causing a data center traffic exchange model to replace multilevel local switching architecture.

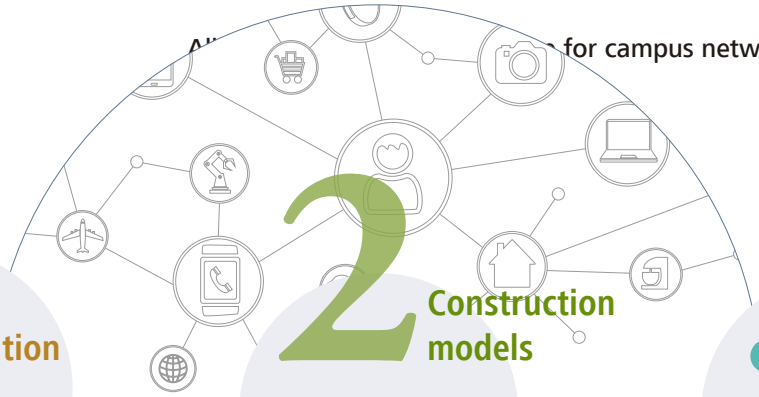
Traffic is starting to move north to south, directly between businesses' internal network terminals, cloud applications, and storage servers. Gartner predicts that by 2016, 90 percent of traffic in enterprise campus networks will flow from north to south.

To smartify and automate campuses, companies need to build campus IoT that connects building management systems with functions like intelligent parking, door control, security, surveillance, fire-fighting, and energy conservation.

Companies also need simple and cost-effective networks to run all their services. They can no longer afford to use separate cabling, equipment, and management systems for voice, video, data, door control, security, and Wi-Fi services. They also need to be able to connect campus systems in an efficient way.

POL: Equipment-lite

The relatively new POL all-optical campus network solution uses single-mode optical fiber, which has the following benefits: greater bandwidth,



1 Solution

Adopts PON technology using single-mode optical fiber; particularly useful for medium and large campuses; has clear advantages over traditional solutions.

2 Construction models

- An operator constructs and runs the network as a service.
- The campus or business builds the POL campus network after managing project bids and contracts.

3 Advantages

- Future-proof, elastic network architecture.
- Saved space can generate profits.
- Centralized management will reduce OPEX.

POL: The New Choice for Campus Network Construction

longer transmission distance, lower volume and weight, and lower cost. POL uses PON, so POL doesn't have the distance constraints of Ethernet and benefits from PON's optical splitting function, which doesn't need active aggregation devices. This saves space in equipment rooms, and cuts power distribution and cooling costs.

Unlike traditional solutions, POL benefits medium and large campuses that need long-distance transmission and passive convergence technologies. Huawei research found that only organizations with more than 500 work stations or connections benefit from POL.

There are two POL models for campuses: One, an operator constructs and runs the network as a service, either providing managed construction and services or leasing the network. The operator can then set and swiftly replicate POL all-optical network standards.

Two – and more common – the campus or business builds the POL campus network after managing project bids and contracts. The POL operation center and server are located on campus, allowing the enterprise to take care of O&M and flexibly expand the network.

One European airport campus provides communication infrastructure services for over 500 businesses. A local operator recognized the need to upgrade the network to meet future demand, and identified POL as the best solution. The main advantages are:

Future-proof, elastic network architecture: PON can evolve to meet future bandwidth needs. Current and future PON standards – including GPON, 10G-PON, and 40G-PON – can coexist and evolve on the same ODN, so bandwidth upgrades can occur without network reconstruction. POL networks can overlay different Customer Premises Equipment (CPE) to connect all major services, such as voice, high-speed data, video surveillance, IoT, and cloud services, on one campus network. POL can then flexibly and elastically expand, which protects existing investment.

Saved space can generate profits: The airport's existing Ethernet-based campus

By offering fast connections and mobility, POL gives businesses the unprecedented power to produce, market, and sell their products from anywhere.

network has more than 200 terminal switch rooms, because of the distance limitations of Ethernet lines. POL's point-to-point technology requires at least 90 fewer rooms, saving rental costs – enough, in fact, to cover the entire cost of the campus network building if the freed up space is rented out for warehousing. The solution will also use up to 70 percent less power as a result.

Centralized management will reduce OPEX: The legacy network required separate maintenance on each of the dispersed active sites. However, because POL is centrally managed and O&M is executed on the Optical Line Terminal (OLT), far fewer O&M personnel are needed, cutting costs by a predicted 60 percent or more.

POL hits the mainstream

POL emerged in North America in 2010, and in 2012, the Association of Passive Optical LAN (APOLAN) was founded. Promotion by APOLAN has seen POL widely deployed in America in campuses and buildings, including the Empire State Building. It's also the solution the United States Armed Forces (USAF) chose for its subsidiaries due to its cost-effectiveness, efficiency, security, and reliability. In 2012, USAF mandated that POL be used in all its new and renovated networks.

Over the past two years, the PON industry has matured, with operators in Europe, the Middle East, China, and the Asia Pacific widely deploying FTTH, which in turn has positively impacted global POL construction. Global PON vendors like Huawei and Alcatel-Lucent have entered the market, and in February 2015, APOLAN set up a European division. POL has become a new choice for CANs around the world, and will soon become a mainstream LAN solution.

For government and enterprise customers, POL satisfies demand for Gigabit networks, reduces OPEX, increases business agility, and guarantees QoS for business-critical services. In hotels, high-bandwidth POL, seamless Wi-Fi, and integrated services improve customer experience, streamline operations, and reduce IT expenditure. Property developers can take advantage of POL's quick fiber optic connections to provide smarter operations for homes, offices, and shopping centers, while schools can use POL technology to support video learning.

The Huawei Xi'an Institute houses 16 office buildings and 15,000 employees over 285,000 square meters. Huawei selected POL because it supports multiple services, including voice, broadband, Wi-Fi backhaul, video conferencing, CATV, video surveillance, and building management automation. Completed at the end of 2015, overall project delivery was twice as fast and 50 percent less expensive than a Cat 5 LAN solution, and the cost of optical cables and transporting equipment was a staggering 70 percent lower.

Elastic, reliable, and cost-effective networks are vital for productivity. POL lets companies and organizations smoothly upgrade to next-gen optical communication standards like PON to XG-PON. By offering fast connections and mobility, POL gives businesses the unprecedented power to produce, market, and sell their products from anywhere.

Breathing new life into copper networks

Huawei's integrated service for modernizing fixed networks spans the full network lifecycle with three core capabilities, powerful tool platforms, and customizable migration solutions. It accelerates broadband speeds, reduces TTM for new services, and lowers TCO.

Liu Anzhen
Marketing Manager, Access Network, Huawei

Wu Ke
Senior Engineer, Access Network, Huawei

Operators face a dual threat: new emerging services like 4K are stretching network bandwidth, and competition from multi-service operators (MSOs) is squeezing profits.

Three questions

Legacy copper networks are huge both in physical size and in terms of the decades of investment they've sucked up.

Breakthrough solutions such as Vectoring and G.fast can deliver 100 Mbps and even Gigabit bandwidth on copper networks, meeting operators' requirements to keep using legacy copper networks and offering existing services. To do so, three questions must be asked:

What network plan will yield high ROI?

Re-using copper networks and sites to meet new business needs and higher bandwidth demands can maximize ROI.

How can legacy networks be integrated to speed up delivery, reduce costs, and shorten ROI?

Modernizing fixed networks involves cutting over a large number of ports and migrating service data. Legacy networks are structurally complex, network error rates during reconstruction are high, and cutover windows are always tight.

Operators need to consider a series of "how to" questions when it comes to reconstruction. These include integrating existing networks, optimizing delivery, automating processes, minimizing old and new network coexistence, reducing OPEX, and accelerating TTM so that new services hit the market at the right time.

What will smooth out migration?

Enterprises, in particular, don't want services interrupted during a network upgrade, and so cutover solutions must be accurate with minimal service downtime. With two tool platforms and three core capabilities, Huawei's customizable migration solution yields zero-awareness cutover.

Two tool platforms: uNetBuilder and GNEEC cloud (Global Network Evolution & Experience Center Cloud) are the two Huawei tool platforms for network reconstruction.

uNetBuilder is a network consulting and analysis tool that offers efficient data collection capabilities, experiential network evaluation and consulting, and characteristics analysis. Its one-click network report function provides the complete status of network resources and bottlenecks, while TCO and TVO analysis tools show pre- and post-reconstruction trends, which can be used to form investment recommendations.

GNEEC Cloud provides integration services for IP, microwave, optical, and fixed access networks. Its standardized processes streamline data and task flows, reduce data transfer and operating errors, and simplify the delivery process.

Three customizable core capabilities

On-demand planning for precision investment

Huawei's on-demand planning service helps customers increase network competitiveness. The service uses intelligent site planning tools integrated on GNEEC Cloud, for example, tools for identifying unique value areas and smart site selection, so operators can reuse legacy networks and provide competitive bandwidth.

Value area identification is a scientific model analysis process that classifies low-, mid-, and high-value areas based on factors such as pipeline resources; user density; zone type, for example, commercial or residential; geographical location; and economic profile.

Target area data is analyzed, converted, and displayed on a Geographic Information System (GIS) map. One-click automatically outputs site selection maps, new site information, equipment configuration lists, and TCO and TVO estimates. Embedded knapsack algorithms carry out site planning based on achievable bandwidth, and ensure the accuracy, reliability, and cost optimization of suggested locations.

Telekom Srbija was the first operator to use Huawei's smart site planning tools. With an initial project budget of €40 million (US$44 million) and 10 work days allotted for designing each CO, Huawei helped the carrier reduce the projected construction costs by €10 million, increase planning efficiency to one work day per CO, and boost reconstruction efficiency by 30 percent. The scheme provides differentiated bandwidth while protecting the customer's investment and shortening service TTM.

Fast TTM

Slow delivery lengthens TTM for new services, hijacks competitive opportunities, and drives up OPEX because operators are running two networks.

GNEEC Cloud's range of integrated migration tools includes capacity reduction, site planning, and mobile call tests. Functions for service analysis, data conversion, service cutover, and integration acceptance streamline task and data flows, boost migration efficiency, and reduce human error. Unified task management and visual scheduling management enable a real-time overview of the delivery schedule and risks.

Huawei's one-stop cabinet satisfies more than 10 kinds of major customer requirements in a single cabinet, minimizing customization needs, leaving existing network services unaffected, and quickly expanding capacity.

Telecom Italia (TI) chose Huawei for its broadband and narrowband synergy network reconstruction project. With a tight deadline and 6 million lines, its previous partner lacked the automated tools and delivered just five sites in nine months – a feat that Huawei equaled in just two and a half months, which then led to further cooperation.

Leave those services alone

Access networks are structurally complex, provide multiple services, and use equipment from different vendors; however, minimal service impact during reconstruction is not just expected, it's essential.

Huawei's solution for modernizing fixed networks supports data conversion on more than 50 types of access equipment from more than ten manufacturers, enabling all old services to be migrated across zero-awareness cutover schemes like jumper wire duplexing. Simultaneous cutover takes place around-the-clock for data and port migration, slashing service downtime.

Huawei's site customization solutions maximize the utilization and reconstruction of legacy networks and equipment, minimizing changes to current networks, decreasing costs, and speeding up delivery. Re-shell and Topbox use existing sites, while others reuse legacy cable bundles. BT, Saudi Arabia STC, and Telefonica Chile have all successfully used these solutions.

Huawei's solution for modernizing fixed networks helps operators assess their existing copper networks to maximize ROI, reduce errors during reconstruction, and boost delivery efficiency in different scenarios for different types of network users.

Smiling with Huawei's OpenLife for smart homes

Network pipelines, massive user numbers, and business services – these are the three features that set telcos apart in the smart home market. Huawei's smart home solution brings these strengths to bear in the smart home arena.

Zhou Bo
Senior Marketing Manager,
Access Network, Huawei

The global smart home market will be worth US$235.8 billion in 2016, and so it's no surprise that telcos, device manufacturers, and content providers are all rushing for a piece of the action.

China's major telcos have all launched smart home services in the shape of China Telecom's Happy Me, China Unicom's Smart WO Home, and China Mobile's Home Harmony. Further afield, major players like AT&T, Verizon, and Telefonica are doing the same. And, telcos aren't alone – big-name hardware manufacturers, Internet companies, and application developers are eyeing a slice of the smart home pie, including Apple, Samsung, Haier, Google, Xiaomi, LeTV, and Alibaba.

Telcos' triple edge

Telcos have three main advantages. First, before anything else, smart home services need a strong network infrastructure, something which only telcos can offer. Second, telcos already have a large customer base to whom they can promote smart home services, and also boost ARPU and loyalty with high-bandwidth VAS services. Third, they have mature support systems and enough personnel to run these services well.

The challenges

Despite the rosy outlook, four main issues hinder telcos' foray into smart home services:

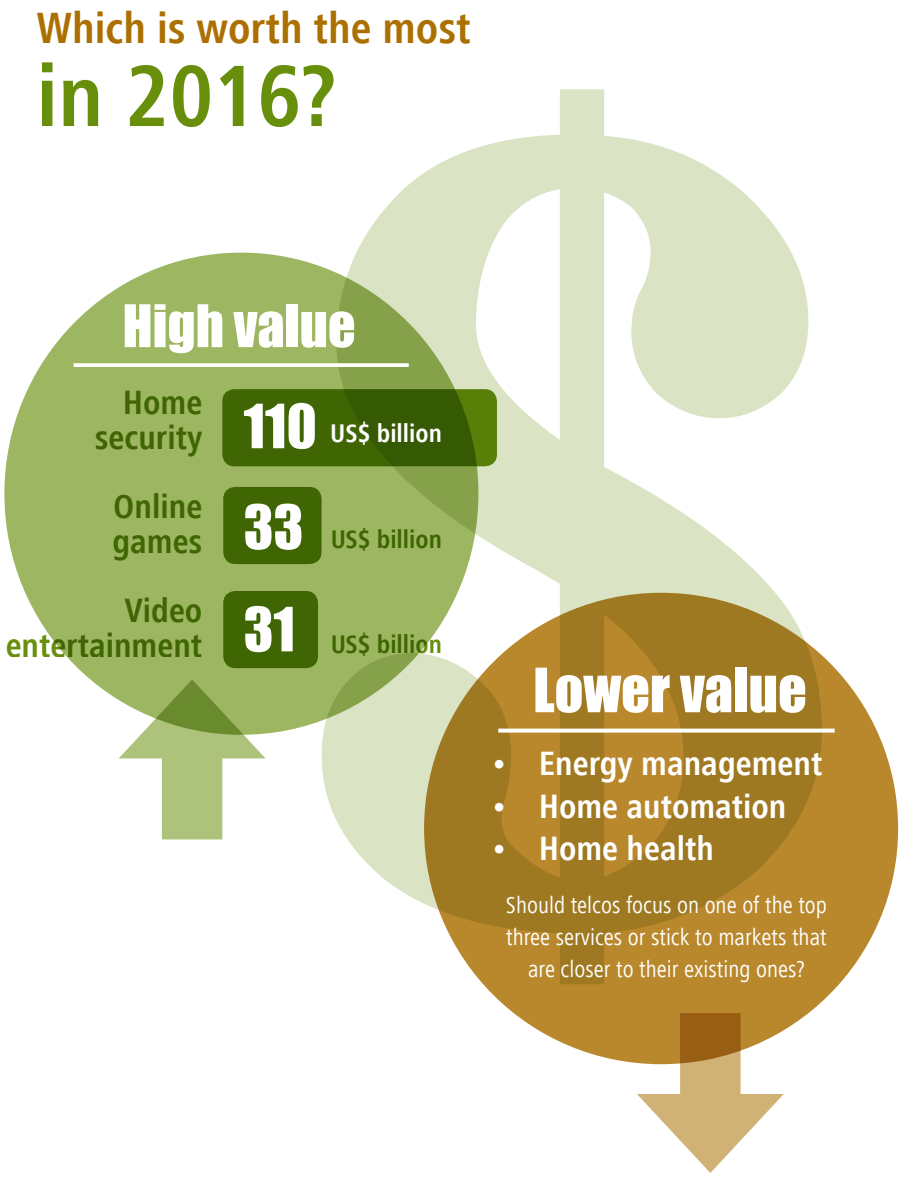
Issue 1: creating unified interfaces and control points. Major vendors offer multiple versions; for example, Apple's HomeKit is accessed by iPhones or iPads, Haier's smart hardware is controlled remotely by a smartphone app and home gateway, and Philips' smart Hue lighting is controlled by a ZigBee control gateway and mobile app.

So, things get complicated for users – they have to buy multiple gateways and install numerous customer terminals, greatly diminishing QoE.

Operators have two control points in users' homes: one, home gateways like xDSL modems and ONT Internet terminals, which closely integrate with their pipelines; and, two, smartphones.

Issue2: interworking between different vendors' hardware. Operators need to consider which control support systems they need at the backend, how to integrate them with legacy service platforms, and how to achieve interoperability with other manufacturers' smart hardware on the backend. They also need to consider support systems for new service rollout, provisioning, deployment, authentication, and billing.

Issue 3: choosing the right service focus



Issue 4: finding the best industry partners for provisioning and integration. This is far from easy – in one horror story, a Western European carrier accepted a tender for smart home services, but the bid-winner couldn't integrate and consolidate different vendors' services. Costing huge amounts of time and money, the operator was forced to re-tender the project.

Getting smart with Huawei

Huawei's smart home solution comprises three components: one, the **cloud**, NetOpen; two, the **pipe**, a smart home gateway; and, three, the **device**, a mobile app. These come under Huawei's OpenLife business development plan. Utilizing telcos' legacy network pipes, the solution smoothly develops smart home services for telcos.

NetOpen platform (cloud): Huawei's NetOpen comprises a cloud management platform for smart homes (IoT Platform), an IoT gateway agent (IoT Agent), and an intelligent home gateway management platform (NetOpen).

NetOpen opens network capabilities to enable intelligent network evolution. It packages operators' network bandwidth, latency, QoS, and billing capabilities into APIs, enabling operators to provide differentiated smart home services for different broadband users.

It unifies the control and encapsulation of the bandwidth acceleration capability of Metropolitan Area Network (MAN) service gateways (BRAS), and provides API interfaces for flexible on-demand scheduling by upper-layer service platforms.

NetOpen unifies the management of smart home services, such as provisioning, billing, and reconciliation, to provide services like home security, video, and online education. It controls mobile app widgets from different hardware vendors, allowing them to work together, and provides standard open API interfaces for integrating third party systems.

NetOpen invokes APIs so the network pipeline can protect bandwidth for services, greatly improving user experience and solving limited bandwidth issues. This function can be applied in scenarios like 4K videos, which are prone to freezing, or video surveillance, which tends to be affected by image delays and

pixelation.

Smart home gateway (pipe): The entry point to the user's home, the pipe integrates with services in two network scenarios: new and legacy. For new networks, Huawei suggests an all-optical smart ONT as the smart home gateway. For legacy networks, Huawei's LAN gateway enables smart home services by connecting to xDSL modems or ONTs that lack smart gateway functionality.

Huawei's smart home gateway uses an OSGI open platform, and doesn't need service plug-ins for integration. It supports MIMO Wi-Fi and 1 Gbps Wi-Fi access for rapid smart hardware access.

The gateway enables home entertainment, video storage, and in-home photo storage and sharing services on USB 3.0 storage interfaces. Supporting ZigBee, Z-wave, and Wi-Fi protocols, the gateway can accommodate large appliances like air conditioners and fridges that connect to Wi-Fi, and others such as light bulbs, smoke alarms, thermometers, and water sensors that use ZigBee or Z-wave.

Mobile app (device): With vendors using different apps, a good experience is impossible without a single app acting as a unified entry point. Huawei's LinkHome app uses the NetOpen management system to integrate and enable interoperability between different vendors' applications under a unified interface. This gives a consistent experience for managing things like smart appliances and home security.

Imagine you've finished work and arrive at home. You open the app on Wi-Fi, and the home gateway detects you're at the front door. The door opens, the lights come on, and your favorite tunes start playing. When you need to pop out, the system turns off the music, lights, and other appliances you set to come on. The app can also remotely connect to the smart home gateway and perform tasks such as controlling smart hardware, performing remote video surveillance, and sharing photos and videos.

OpenLife: Providing a resource pool via NetOpen, which integrates vendors' services and plug-ins, OpenLife helps telcos choose suitable smart hardware vendors so they can smoothly launch new smart home services. OpenLife partners include application content developers and individual developers (Internet-plus); IoT hardware manufacturers and integrated service providers (Smart-plus); and channel service operators (Smart Broadband-plus).

If a partner's service works well, the smart hardware can be brought into the OpenLife resource pool and released to operators worldwide. Companies that have joined Huawei's OpenLife include Tencent, Hikvision, Haier, Dahua Technology, Nanjing Wulian, Netvox, Fibaro, Aeonlabs, Galaxywind, Orvibo and Songshu Hulian.

A smart business plan

Users only pay for products that provide a good user experience in terms of content, service acquisition, and use. OpenLife is user-centric in that it lets operators, smart hardware providers, and platform and service integrators continuously refine user experience.

OpenLife connects people to people, people to things, and things to things. It focuses on user experience, interoperability, and connection standards. With 100 billion connections predicted for 2025, collaboration and innovation are essential. Huawei is committed to pooling the strengths of all industry players because it knows that no single company can go it alone.

Smart storage, smart analysis, big data, big returns

Storage is getting faster, more efficient, and – coupled with data analysis – more useful. Based on applications, Huawei's intelligent storage platform offers data analysis, processing, and storage for different big data scenarios.

Huang Tao, Li Wanlong & Luo Daxin
2012 Labs, Huawei

Pre-buffered movie recommendations, instant-searches for photos, quick route planning for complicated trips – sounds good, right? Well, we can in fact do all of this today.

The two enablers are big data storage and intelligent analysis. Massive amounts of data are needed to produce results from analysis that are relevant to users, and that data needs to be stored.

The massive amount of data produced by IoT and mobile Internet is increasing by 50 percent year on year, with Gartner predicting a total global data volume of 35 ZB by 2020 – equivalent to 8 billion 4TB hard disks. So, sourcing big data is evidently not the problem – the real issue is how to store and intelligently analyze it.

Big storage for big data

The three main types of big data storage applications are mass data storage, fast data read, and intelligent data analysis.

Mass data storage takes care of traditional features like storage capacity, efficiency, and security.

Fast data read manages, schedules, and processes data streams to quickly handle data, and is an area where technology advances are fast because the Internet and IoT need speed.

Intelligent data analysis provides customizable services under a very rapid update cycle for tools, including machine-learning algorithm libraries and software from companies like Hadoop and Spark.

Instead of integrating these three applications to deeply integrate storage and intelligent analysis, most vendors' products miss the mark by only trying to improve the performance of big data storage technology.

Big data-driven companies like LinkedIn and Facebook focus more on high throughput and constructing efficient data analysis platforms on existing hardware, and overlook traditional big data storage.

This separation of technologies causes problems for customers that need big

data analysis. First, data analysts don't have efficient data storage technology, and moving data from traditional storage clouds to analysis clouds is inefficient. Second, storage technology researchers often lose sight of data application requirements and, by only focusing on access speed and storage capacity, produce technology that's no good for data analysis teams. In effect, this divides big data storage and analysis into two separate teams and platforms.

Today's big data storage needs to go beyond massive storage capacity to integrate data storage, fast data reading, and intelligent analysis.

Let's integrate

Huawei's storage platform integrates mass storage, fast reading, and data analysis capabilities.

Just a 1 percent efficiency increase in the Industrial Internet by using big data analysis can generate up to US$1 trillion worth of value. For example, 80 percent of Facebook's revenue comes from mining analysis on social graphs, while EverString reveals hidden business trends and opportunities for users.

The public are generating huge amounts of data on IoT and social media in areas like entertainment, financial services, and healthcare. Rapid and precise analysis would be a great predictor of flashpoint technologies and events in particular sectors, which could in turn help shape policies.

Today's big data storage needs to go beyond massive storage capacity to integrate data storage, fast data reading, and intelligent analysis.

Key technologies

Combining intelligent analysis and storage will integrate stored data and the information to be mined and extracted.

Huawei's efficient intelligent storage platform adopts the following key technologies:

Integrated intelligent analysis provides popular storage capabilities like HDFS and databases alongside data analysis capabilities such as Kafka and Spark, processing frameworks including Samza and Spark Streaming, and data analysis algorithm libraries such as machine learning and image processing.

By integrating intelligent analysis and storage, Huawei's intelligent storage technology can transform economic activities and sectors – the potential to generate new business and increase market value is huge.

Integrated storage system architecture integrates multiple storage system architectures at the resource and system level, and transfers data between them. The resource level includes unified management and name space, heterogeneous resource management for allocating cluster resources, and isolation guarantees. The system level supports multidimensional semantic data, and flexibly uses different-format storage systems, including KV, relationship, graph, file, and object. It also supports active data flow, and can convert different storage systems, including NAS, OSD, SAN, and Cloud.

Data access semantics and service capabilities includes multiple storage methods such as file, block, object, and cloud storage; content searches and document lifecycle management services; hierarchical SLO for performance, availability, and reliability; and methods for visualizing data value.

Application requirements

Huawei's intelligent storage platform meets the requirements of different applications with its application-driven Data Aware Engine (DAE).

In traditional storage systems, an application generates heterogeneous multi-source data; for example, medical records are processed into different formats and stored in different systems such as a picture database, key value system, relational database, and filing system. However, system barriers complicate data integration and analysis between different systems, so data can't be extracted easily. Data-aware storage engines can solve this problem with the following functions:

Cross Storage System Access includes a unified storage engine that formalizes data when it's written, chooses the best bottom-layer storage systems for different data types, and returns the most appropriate data during queries and processing.

Smart Layout Tier & Transfer supports longitudinal or transverse data flow between hot, warm, and cold layers to facilitate data processing.

Unstructured Data Analysis carries out intelligent analysis decisions and deeper mining.

Integrated Access History Logging records the access behaviour of multi-dimensional and multi-source data, so intelligent analysis decision modules can perform deep analysis, mining, and stream processing line analysis.

Huawei's application-driven intelligent storage platform meets the data analysis, processing, and storage requirements of diverse application content by integrating different types of big data analysis tools to provide different services. Using applications as enablers, Huawei delivers customized, efficient, and more secure storage architectures and models for different applications at lower cost.

By integrating intelligent analysis and storage, Huawei's intelligent storage technology can transform economic activities and sectors such as transportation and communications – the potential to generate new business and increase market value is huge.

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