Huawei E2E 100G Solution
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Introduction

With the development of the IP-based broadband service, the number of fixed and mobile subscribers has been constantly increasing in recent years. Meanwhile, the advancement of the network technology enables people to obtain remote information easily and effectively. Customers in different areas can thus communicate in a face-to-face manner. In addition, network information covers contents from texts and voices to multimedia presentations, and then to videos or even high-definition video, which impel the rapid increase in IP traffic. The latest report shows that in the coming five years, the annual compound growth rate of the IP traffic will reach 50%, in which the growth rate accounts for 62% to the total growth rate. The report also shows that the growth rate of the broadband access for mobile networks reaches as high as 128%.

The rapid growth of the network traffic accelerates the expansion of the forwarding capacity of the LPUs on the transmission devices (such as routers), from 1 Gbit/s, 2.5 Gbit/s, and 10 Gbit/s to 40 Gbit/s and 100 Gbit/s. A single device can provide a large capacity in the case that its LPUs support 100 Gbit/s forwarding capacities. In this situation, the operator's operation and maintenance cost are reduced and users can enjoy fast and effective remote communications.

Figure 1 trend of the IP traffic growth
With the help of years of experience accumulated in the telecom industry (especially in the router and optical transmission application) and the deep understanding of the customers’ needs, in September 2009, Huawei proposed the industry-leading E2E 100G. Cluster router and E2E 100G are the key elements of the IPTime SingleBackbone Solution. With the traffic synergy, protection synergy and O&M synergy between IP and Optical, IPTime SingleBackbone Solution can improve the efficiency and enhance the reliability of the network.

The 100GE LPU is first applied to the core network and will be extended to devices on the edge and metro networks. The core network, consisting of the NE5000E clusters that support the 100GE interface and the OSN6800/8800 OTNs that support the 40/80λ x 100G, supports the long-distance transmission of traffic at the rate of 100 Gbit/s. In this manner, the openness and reliability of the entire network are improved, and the planning, construction, and maintenance of the network are facilitated. On the edge and metro network, NE5000E clusters are directly connected through 100GE interfaces. This simplifies the network structure and allows operators to easily cope with the traffic localization. Figure 2 illustrates the overview of Huawei end-to-end 100G.

Figure 2 Huawei E2E 100G
1. Deployable end-to-end solution

At present, the transmission distance of the 100GE optical module is 10 km. The 100GE interface, however, is first applied to the core network, where the transmission distance is greater than 10 km. In this situation, the core router must closely cooperate with the transmission system to guarantee the long-distance transmission. The Huawei Optical Transport Network (OTN) product, adopting the 100G opto-electronic module and core chips and integrating with advanced code modulation modes (such as sDQPSK ePDM-QPSK), extends its transmission distance to 1,500 km, which improves the transmission capacity of a single fiber to 8 T. Driven by technologies such as OTN switching and intelligent Automatically Switched Optical Network (ASON), the Wavelength Division Multiplexing (WDM) transmission network is evolving towards a more capacious, flexible and efficient, and highly reliable network.

The interoperability between routers and transmission devices is a major concern in constructing 100G networks. Huawei, with its experiences in routers and transport devices leading in the industry and its contribution to the 100G standards, realizes the interoperation between 100GE router and the 100G transmission device, which provides a perfect end-to-end 100G solution.

2. Sustainable Bandwidth Expansion

A sustainable bandwidth expansion cannot be achieved at the cost of increasing power consumption and expenditure. Huawei 100G solution employs multiple low-power consumption technologies to guarantee the sustainable bandwidth expansion. These technologies reduce the power consumption of every G bit/s to less than 4 W, 57% lower than that of the industry level.
3. Enhanced Quality Control

In actual applications on the operator’s network, end-to-end services cannot be guaranteed by only the increase of bandwidth, for example:

(1) Even in the case of sufficient bandwidth, the IPTV service, however, cannot be guaranteed and fault that causes the poor service quality cannot be located.

(2) P2P services now dominate the Internet. The P2P terminal, however, cannot identify the network topology. As a result, over 90% IP traffic flows to the core network rather than being localized as that of the traditional telecommunication services. This prevents the sustainable expansion of the core network and degrades the user experience.

(3) The expansion of the bandwidth and intelligentization of the access terminal bring great convenience to users but create favorable conditions for DDoS attacks, the major threat to the security of the network.

The preceding information shows that both the expansion of the bandwidth and the low-cost deployment of the intelligence are necessary conditions to guarantee the quality of end-to-end services. Huawei names this deployable quality assurance solution Enhanced Quality Control (EQC). EQC is an entire network solution which can be deployed to any position on the MAN or backbone network to guarantee the service quality and reduce the operator’s operation cost. Huawei integrates some EQC capabilities on the hardware and chips, so as to effectively lower the deployment cost. The EQC can provide the following functions:

(1) Support for service expansion: identifies and then satisfies services that have special requirements on quality quality.

(2) Traffic control and evacuation: controls the flow direction of network traffic and optimizes the resource configuration.

(3) Service quality monitoring: monitors the service quality in real time. In this case, the fault can be located and rectified on time.

(4) DDOS attack defense: protects the device and a certain network against DDOS attacks.

(5) Fast fault location: cooperates with service quality monitoring to fast locate the fault on the device or the link.
4. Smooth Expansion of Cluster Router with 100G

To address the blasting internet traffic, cluster router is introduced, and the nature of which is to improve the forwarding capability by connecting multiple routers regarded as a logical one.

Huawei NE5000E cluster router is the super core router which can be deployed in Internet backbone, core of Metro and IDC. With advanced non-block switch technology and Solar series chipset, NE5000E cluster router can support multiple cluster mode, such as B2B cluster, 2+4 cluster, 2+8 cluster, and it can be expanded to 16+64 cluster with 10240 10G interfaces or 1024 100G interfaces, and the capacity will reach 200Tbps. In the 40G era, Huawei achieved the first industry commercial deployment of 2+4 cluster with 5T in China Telecom in 2009, leading the network to T bit Times.

The innovative B2B cluster router can connect 2 NE5000E without CLC. With 100G/slot, it can provide the 6.4 T interface capacity to meet the network expansion requirement of the next 2-3 years. So it can protect the investment.

NE5000E adopts ISHE In-Service Hardware Expansion, which is an innovative orthogonal matrix technology to implement full mesh connection between optical(electrical) switch Fabric and Fabric card, and the traffic will be shared by the switch plane; Furthermore, Flexible Optical Unit can support configuration on demand, and switch mode of switch fabric can be dynamically configured online; So it can implement the smooth migration from 3.2T bps to 200T bps reusing existing hardware, without service broken, which can resolve the network expansion issue and meet the requirement of the flattened architecture, and protect the investment of the operator.
Introduction to the Technologies in Implementing Huawei E2E 100G Solution

Huawei takes the lead in OTN evolution and the 100G standards, which are addressed by ITU-T, IEEE and OIF. Huawei proposes various technical innovations with respect to 100G applications and they have been widely accepted by the leading standardization organizations and industry. Huawei leads the ITU-T development of OTN and DWDM standards while actively contributing to IEEE Ethernet work on 100GE PCS modelling and OTN mapping, as well as OIF 100G long haul DWDM framework, ranging from photonics modules, channel coding, management interfaces and protocols. Besides that, Huawei holds various editorships including ITU-T G.709 and OIF 100G FEC white paper. Huawei makes a number of innovations in the 100G application and applies the 100G standard to its products.
Solar 2.0 PFE2A: 100 Gbit/s Forwarding Engine

Currently, the 20/40G LPUs adopting the Huawei-developed Solar Application Specific Integrated Circuit (ASIC) chip Solar 1.0 are commercially deployed in a large scale and are sold more than 100,000 units. The 100GE LPU, as shown in Figure 2, adopts the Solar 2.0 PFE2A chip and has the advantages of flexible application of services, high performance, and low-power consumption. The Solar 2.0 PFE2A chip is developed based on the Macro Instruction for Packet Processing, a technology specialized in the process of IP/MPLS/ETH packets. Compared with the network processor, the Solar 2.0 PFE2A chip has the characteristics of flexible application of services, high performance, and low-power consumption.

100GE LPU of Router

Based on the IEEE 802.3ba standard, Huawei provides two types of 100GE LPUs, namely, 1x100GE LPUF-100 (Figure 3) and 10x10GE LPUF-100 (Figure 4), which are used in different application scenarios.

The 100GE LPU adopts two Solar 2.0 PFE2As as forwarding engines, one of which processes 100 Gbit/s upstream traffic and the other processes 100 Gbit/s downstream traffic. In this manner, the Solar 2.0 PFE2A ensures the traffic forwarding at the wire speed of 100 Gbit/s, as shown in Figure 5. The Physical Interface Card (PIC) module is based on the programmable 100GE MAC chip that is developed by Huawei, and supports IEEE 802.3ba, S-Eth, IEEE 1588v2, and ODU4. The built-in output Traffic Management...
(oTM) engine enables five-level Hierarchical QoS (HQoS) scheduling of the downstream traffic. The 1x100GE LPU supports a Forwarding Information Base (FIB) with the great capacity, fully meeting the requirement of IP network expansion. The 100GE interface supports Compact Form Factor Pluggable Multi-Source Agreement (CFP MSA), which implements the plug and play function of optical modules.

100G WDM Code Modulation Technology

Advanced code modulation technology is the key to realizing ultra-long-haul and large-capacity WDM transmission technology. Having years of technological experience and industry’s leading experts, Huawei develops and adopts advanced code modulation technologies such as sDQPSK, ePDM-
OTN/ASON

The OTN technology enables WDM equipment to groom wavelengths and sub-wavelengths, with an intention to achieve network-based WDM with enhanced switching and routing capabilities. OTN is compatible with WDM and solves the bandwidth problem. In addition, OTN solves the problem in flexibly providing bandwidth with a large-capacity cross-connect technology. OTN can achieve any-to-any wavelength or sub-wavelength connection, regardless of the physical fiber technology, and every two routers have express optical-layer routes in between. In 100G era, OTN is very important to E2E 100G.

To sum up, OTN is helpful for reconstruction of WDM in the following aspects:
**Improved transport efficiency:**

Currently, ITU-T is making significant advances in OTN standardization, which properly solves the problem of carrying and mapping Ethernet services. For example, the ODU0 granularity is used to carry GE services, ODU2e to carry 10GE LAN services, and ODU4 to carry 100Ge services, and ODUflex is introduced to carry any-rate new services. OTN can map hybrid service to ODUk or ODUflex, and converge them to 40G/100G wavelengths.

**Mesh networking capability:**

Large-capacity cross-connections enable the mesh networking capability for the WDM system. This marks great progress of the WDM system for point-to-point transmission and is also important for a flat backbone network. OTN can cross-connect and groom any services without any block. The cross-connect granularities include wavelengths, and ODU0, ODU1, ODU2, ODU3 and ODUflex sub-wavelengths. Hence, mesh networking becomes a basic requirement for bidding held by mainstream operators.

**Robust network:**

As the WDM network carries mass services, the WDM network must be highly reliable. It is always a meaningful practice to provide survivability for the optical layer. Protection against multi-point faults on the backbone network can be provided by loading the OTN system of the ASON/GMPLS control plane.

**Provision of wavelength and sub-wavelength services:**

Originally, the WDM system provides wavelength services and network nodes are manually bridged with fiber jumpers. Then, the construction schedule may not be kept and reliability may be not ensured. OTN/ASON marks an important step on the evolution path of the transport network. Certain valuable large-granularity private line services can be directly provided on the OTN network.
Conclusion

As the world’s leading provider of telecommunications solutions, Huawei has contributed its efforts to constructing more than 100 backbone networks and more than 600 Metropolitan Area Networks (MANs). In addition, Huawei has delivered over 2000 sets of NE5000E core routers and NE5000E clusters (100+ cluster), and over 16 thousand sets of OTN products all across the world. Huawei has ranked the first place in the world’s WDM market, and has also ranked the first in the world’s router market share increase, remaining one of the industry’s leaders and serving the world’s leading operators, including China Telecom, China Mobile, China Unicom, France Telecom, Deutsche Telekom, British Telecom, Telefónica, SingTel, and Etisalat.