WHITE PAPER ON SDH MODERNIZATION
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1 Introduction

The telecommunications industry continues to evolve, and telecommunications services and network architecture today bear little resemblance to their predecessors from 10 years ago. Recently, services such as data center (DC) interconnection and 4K video have emerged, and time division multiplexing (TDM) private line services pose new challenges on transport network security, latency, and bandwidth. In this ever-changing environment, which bearer technology is best suited for future transport networks? This white paper analyzes synchronous digital hierarchy (SDH), which has been deployed on a large portion of telecommunications networks around the world for some time. This paper will also discuss the significance, targets, and key technologies of SDH modernization.
2 Driving Forces of SDH Modernization

2.1 Service Evolution

SDH networks carry broadband, mobile, and private line services. Private line service ports evolve from E1/E3 to fast Ethernet (FE), Gigabit Ethernet (GE), or even 10GE, but still use exclusive bandwidths, which are highly reliable. Moreover, high-value private line services pose higher requirements on transport networks: low latency and high security.

In terms of service attributes, broadband and mobile access services are basic services, and telecom carriers choose the cost-effective scheme based on user distribution and network resources. However, private line services are designed based on specific customer requirements:

- Government or enterprise private lines: connect government or enterprise headquarters and branches. In the government or enterprise private lines, service security and network reliability are top priorities.
- DC leased lines: connect DCs of Internet Content Provider (ICP). ICP customers need high-bandwidth private line networks, fast service provisioning, dynamic bandwidth adjustment, and private line network openness and customization.
- Private lines for Internet access: apply to Internet access in small and medium-sized enterprises. Customers in these enterprises are sensitive to prices and require one-stop service experience.

Figure 2-1 Private line service market segments
Government and enterprise private line services and DC leased line services will be profitable services in the coming years. High-value private line services have the following requirements: high security, zero service interruption, high reliability, low latency, short time to market (TTM), and dynamic adjustment.

Security is the top concern of VIP customers for private line services. In the past, information leak events have occurred when optical networks were intercepted using fiber bending. For example, telecommunications backbone networks in a European country were intercepted near an airport; hedge fund data in America was intercepted before its quarter data was released; and 1.2 million customer information records were stolen from a financial company. Fiber bending interception is easily and cheaply implemented using a fiber fixture, photodiode detector, optical-to-electrical converter, and laptop.

In the standard definition (SD) and high definition (HD) video era, the bandwidth required by digital TV programs is small, and can be satisfied with basic bandwidth and transmission throughput of home broadband. As 4K video services boom, the required bandwidth increases significantly. However, 4K video services also have stringent requirements for low latency and packet loss rate. Therefore, to provide 4K video services, telecom carriers must improve the entire network to ensure user experience.

Video services feature ultra-large bandwidth, low oversubscription ratio, and high real-time performance. To bring the best video service experience and consider per-bit costs, telecom carriers use the over 10G large pipe technology to optimize traffic paths and build a simplified bearer network, which is the best choice for 4K video services.

DC interconnection and 4K video services require large pipes at a rate over 10G or even 100G, and the bandwidth can be customized and dynamically adjusted. Requirements of government, enterprise, and finance private line services on security and latency remain as least as strong. However, SDH cannot support a bandwidth exceeding 10G. To avoid this bottleneck, a new transport technology is required in place of SDH.

### 2.2 Market Evolution

Based on telecommunications market requirements, low-speed private line services will likely persist for a long time, and high-speed private line services will grow rapidly. The following figure shows the change trend of low-speed private line services provided by telecom carriers in recent five to six years. It can be seen from the figure that TDM private line services such as E1 and STM-1 persist for a long time, while FE and GE services keep growing.
Customers of TDM private line services are from security and finance enterprises, which have stringent requirements on security, reliability, and latency. Therefore, physical pipes are required for data transmission. High-speed private line services attract a small number of government and enterprise customers. The services emerge based on the DC interconnection requirements of ICP customers, which require short service provisioning time and on-demand bandwidth. Transport technologies and bearer networks that meet DC service requirements are important for telecom carriers to attract DC customers.

To remain competitive, telecom carriers must be able to provision services quickly. The network bandwidth can be dynamically adjusted by interval based on DC interconnection customers' requirements. This helps improve channel utilization and achieve higher return on investment (ROI).

According to market data of telecom carriers, TDM private line services make up a large proportion of revenue, multiple times the revenue from private line services using IP and
other technologies. TDM private line services will likely still be profitable for telecom carriers for the next decade or longer.

According to market requirement changes, low-speed high-value TDM private line services will persist for a long time, government and enterprise private line services pose higher requirements on security and latency, and large-bandwidth DC leased line services continuously grow. As private line services and private line market continuously change, telecom carriers urgently need a transport technology due to SDN network restrictions on bandwidth and capability for supporting packet services. The transport technology should inherit SDH features and support large bandwidth and strong capability for supporting packet services. Currently, MS-OTN meets the requirements of telecom carriers.

### 2.3 Legacy SDH Network Reconstruction

Based on the telecommunications device lifecycle, SDH networks gradually enter end of service (EOS), telecom carriers reduce investments on SDH networks, the operating expense (OPEX) increase, and spare parts and services are difficult to obtain. Therefore, SDH network reconstruction and device upgrade are required.

**Figure 2-4 Device lifecycle curve**

![Device lifecycle curve](image)

The lifespan of telecommunications devices is generally 10 years. If the devices on a network are more than 15 years old, the network faces high risks and OPEX. Most SDH devices have reached EOS, bringing serious potential risks to services on the network.

**Figure 2-5 Statistics on global SDH network Investment**

![Statistics on global SDH network investment](image)
SDH investment grew rapidly from 1995 to 2000, peaking in 2000 with annual investment exceeding 22 billion USD. From 2000 to 2003, investment declined rapidly. From 2004 to 2010, annual investment remained stable at about 7 billion USD. SDH investment declined again starting in 2010. Based on the current conditions, SDH devices deployed in 2000 have been running for 15 years, which exceeds the device lifespan, and the OPEX and service risks increase.

The existing SDH networks carry a large number of high-value private line services. Therefore, a suitable transport technology is required in substitution for SDH. To resolve the preceding problem, telecom carriers need to replace old SDH devices with new SDH devices or MS-OTN devices. The replacement cost is offset by a large reduction in OPEX. The following shows the investment and revenue in a specific project.

**Figure 2-6 OPEX of legacy SDH networks**

Take a large core equipment room in a metropolis as an example. The cumulative SDH investment exceeds 10 million USD, and the annual OPEX (including power consumption, equipment room rental, spare parts fee, and maintenance costs) is about 900,000 USD. If SDH devices are replaced by MS-OTN devices, device replacement and network reconstruction costs are around 2 million USD. After the reconstruction, the annual OPEX is around 200,000 USD. The total investment within a 3-year period remains the same, and existing assets are updated. The OPEX is greatly reduced in subsequent years.

If old SDH devices are replaced by new SDH devices, the current available equipment investment is reduced, and insufficient bandwidth and weak capability for supporting packet services still persist on SDH networks. Therefore, mainstream telecom carriers prefer MS-OTN devices instead of SDH devices.

**2.4 Consensus Reached by Global Telecom Carriers**

After 20 years' development, a large number of SDH networks exist in the global telecommunications market. According to third-party statistics, there are 5 million existing SDH devices, and the cumulative SDH investment up to 2009 exceeds 100 billion USD. The SDH investment from 1999 to 2001 ranked at the top. Based on the principle of replacing equipment running for 15 years, SDH devices deployed within this period should have been replaced by 2014. The following table shows the number of SDH devices (excluding the China market) running for more than 15 years. The total number of SDH devices is 800,000. SDH devices invested after 2002 gradually enter the reconstruction period, and the rolling reconstruction cost exceeds 3 billion USD.
SDN modernization is peaking between 2014 and 2020. Mainstream telecom carriers have initiated SDH network reconstruction plans. Mexico Telmex, Brazil Vivo, and Vodafone in India have started to reconstruct their SDH networks on a large scale. Based on the development differences in the global communications market, SDH networks carrying voice services shrink in developed countries with an early entry into the telecommunications market due to the service decrease, but networks carrying TDM private line services will persist. The golden period for reconstruction in these countries is the recent 3 to 5 years. In countries and regions with a later entry into the telecommunications market, the SDH investment time is relatively late. Therefore, the SDH networks still run in these countries and regions, and will be reconstructed later.
3 SDH Modernization Target Is MS-OTN

3.1 Full Inheritance of SDH Advantages Ensures Smooth SDH Replacement

In the past 20 years, SDH technologies have achieved great success. Telecom carriers choose SDH because it provides unified network interfaces, standard and flexible multiplexing structure, comprehensive protection mechanism, and powerful network maintenance and management capabilities. OTN is a transport technology that emerged after 2000. It inherits the desirable features of SDH and provides bandwidth of 100G or higher, multi-wavelength optical-layer systems, ultra-long-haul transmission, line fiber monitoring, and future-oriented T-SDN evolution capabilities. OTN fully inherits SDH advantages and exceeds SDH in technical capabilities.

SDH applies to the transmission and bearer plane of a telecommunications network to carry services, such as voice, broadband data, private line, and mobile services. With service evolution and network architecture changes, IP-based reconstruction and SDN are emerging, making packet services more important than others. MS-OTN is a new transport technology that inherits the kernels of physical pipes, provides packet grooming capabilities, and supports evolution towards T-SDN. MS-OTN is gradually accepted by global telecom carriers and becomes a preferred solution to replace SDH.

Figure 3-1 Various bearer technologies

Based on comprehensive analysis of transport technologies, OTN inherits all SDH advantages in security, latency, reliability, and service support and also provides high bandwidth and direct transmission at the optical layer with lower latency. Therefore, OTN is widely accepted and applied in the telecommunications market.
### 3.2 MS-OTN Inherits and Develops SDH

Similar to SDH technologies, OTN technologies provide unified network interface, standard and flexible multiplexing structure, comprehensive protection mechanism, and powerful network maintenance and management capabilities, and are widely applied in global carrier networks. MS-OTN provides unified cross-connect architecture and supports packet and VC grooming capabilities. It fully inherits SDH advantages and supports ultra-long-haul transmission over thousands of kilometers, single-wavelength 100G or higher bandwidths, Terabit-level packet grooming, and evolution towards T-SDN. MS-OTN further develops both SDH and OTN, and is the mainstream technology to replace SDH.

**Figure 3-3 MS-OTN system architecture**

MS-OTN provides unified architecture to carry multiple services, switches OTN/VC/packet services in a unified manner, and supports comprehensive access capabilities ranging from 2M to 100GE. A single MS-OTN device provides 25.6T capacity, and a device cluster...
SDH Modernization Target Is MS-OTN

3.3 MS-OTN Is Future-Oriented and Provides Better Bearer Experience

MS-OTN enhances network scalability to cater to fast service development, simplifies O&M, and improves network efficiency, network quality, and customer satisfaction, meeting future requirements and protecting customer investment.

MS-OTN has the following advantages:

- OTN/SDH/PKT unified switching platform and universal line boards
- Rich bandwidth resources (80 x 10G/100G/400G) and fast capacity expansion
- Open network architecture supporting evolution towards T-SDN
- Optical and packet synergy, improving network resource utilization
- Unified NMS and simplified O&M, improving efficiency and achieving quick and flexible configuration
- Specific requirement matching for high-value customers, improving network premiums

**Figure 3-5** Unified service bearer of MS-OTN

Unified service bearer is a core value of MS-OTN, and progressive reconstruction and evolution of massive SDH networks are necessary MS-OTN capabilities for inheriting SDH services. Most telecom carriers can evolve their SDH networks toward MS-OTN at the core and aggregation layers, while still using SDH at the access layer. According to future service requirements and port changes, massive SDH devices at the access layer can be gradually replaced by case-shaped MS-OTN devices. The progressive evolution solution has little impact on services, saves device investment, and keeps some existing SDH devices working.

**Figure 3-6** SDH network evolution towards MS-OTN

MS-OTN seamlessly interconnects with existing SDH devices without network topology and service trail modifications, and integrates all protection schemes. MS-OTN fully protects existing investment on the live network and resolves the low SDH bandwidth, legacy device replacement, and technical development limit problems. Huawei provides SDH reconstruction and evolution solutions for every scenario and every service on carrier networks.
Figure 3-7 SDH modernization reconstruction solution
4 Key Technologies of SDH Modernization

4.1 Pain Points of SDH Network Reconstruction

Most legacy SDH networks of telecom carriers run for a very long period and have poor maintenance. Their services in the NMS and resource management system are inconsistent, and service maintenance documents are not complete. Under this backdrop, the following issues haunt telecom carriers during SDH network reconstruction:

- Accurately understand the network architecture and service information about existing network devices.
- Guarantee the reasonableness of SDH evolution and reconstruction solutions.
- Securely and quickly deliver configurations and perform service cutover and migration.
- Minimize the costs of SDH network reconstruction.

Live-network data acquisition and data accuracy are very important. Generally, legacy SDH devices on a live network have been running for 10 or more years. Furthermore, legacy devices from different vendors coexist on a network, causing great difficulty in preliminary analysis and subsequent solution design during network evolution.

In project V in country B, a single SDH device has more than 8000 VC cross-connections, an SDH network of a region carries more than 17,000 services, and the live network has more than 30 types of SDH devices from six vendors. If no SDH reconstruction and migration tool is available for live-network analysis, preliminary design and subsequent delivery of the entire SDH modernization project cannot be implemented.

<table>
<thead>
<tr>
<th>Region</th>
<th>Device Quantity</th>
<th>E1 Quantity</th>
<th>Vendor A</th>
<th>Vendor B</th>
<th>Vendor C</th>
<th>Vendor D</th>
<th>Vendor E</th>
<th>Vendor F</th>
<th>Service Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>315</td>
<td>139885</td>
<td>1807</td>
<td>1804</td>
<td>403</td>
<td>5045</td>
<td>151</td>
<td>610</td>
<td>9820</td>
</tr>
<tr>
<td>12</td>
<td>90</td>
<td>8577</td>
<td>534</td>
<td>138</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>167</td>
<td>848</td>
</tr>
<tr>
<td>13</td>
<td>77</td>
<td>7635</td>
<td>640</td>
<td>122</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>80</td>
<td>860</td>
</tr>
<tr>
<td>14</td>
<td>133</td>
<td>8256</td>
<td>22</td>
<td>417</td>
<td>391</td>
<td>0</td>
<td>2</td>
<td>47</td>
<td>879</td>
</tr>
</tbody>
</table>
Huawei is committed to reconstructing legacy third-party SDH networks since 2008 and fully understands the difficulties in these projects. With experience in a large number of project practices and long-term capability building, Huawei has the capability of parsing multi-vendor devices. The configuration scripts of third-party devices can be parsed to restore network topology, service trail, and port configurations, and to graphically display them. The configuration conversion and delivery tool is used to prevent error-prone and inefficient manual settings.

The SDH migration tool can be used to analyze and reconstruct legacy networks. The following table compares the manual and tool-based methods of migrating and reconstructing legacy networks.

**Table 4-2** Analysis on the efficiency of manual and tool-based legacy network migration and reconstruction

<table>
<thead>
<tr>
<th>Method</th>
<th>NMS-Side Service Configuration</th>
<th>Workday Configuration Capability</th>
<th>Costs</th>
<th>Reconstruction Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>Manual</td>
<td>100 services/person-day</td>
<td>Very high</td>
<td>&gt; 60 days</td>
</tr>
<tr>
<td>Tool-based</td>
<td>Script delivery</td>
<td>Unlimited</td>
<td>Low</td>
<td>&lt; 1 week</td>
</tr>
</tbody>
</table>

**NOTE**

The preceding analysis is based on 8000 E1 services.

### 4.2 GNEEC Guarantees Network Evolution Solutions

The Global Network Evolution & Experience Center (GNEEC) is a one-stop experience center that integrates key project tests, multi-vendor integration tests, and SDN integration tests to test and verify evolution solutions for telecom carriers. The GNEEC focuses on carrier network evolution and service transformation. It provides experience of typical E2E scenarios and presents powerful consultation and integration service capabilities of Huawei, helping customers reduce potential risks and ensuring smooth network evolution.
The GNEEC lab is set up based on the E2E network construction idea, covering eight types of fixed network devices with a network scale of more than 300 nodes. The GNEEC provides the capability of mirroring 300 network nodes within only four hours and supports E2E integration tests. The SDH modernization verification platform of the GNEEC supports the pre-testing of service cutover, service interconnection, and network reliability solutions, guaranteeing secure and reliable SDH modernization.

Figure 4-1 GNEEC lab layout

4.3 Automatic Tools for SDH Evolution and Reconstruction

The Huawei web-based one-stop migration tool provides functions such as third-party data parsing, live-network simulation, network design, TCO analysis, and cutover analysis, greatly improving migration efficiency and accuracy.

4.3.1 Data Parsing and Restoration Tool

Telecom carriers upload collected SDH device scripts to the GNEEC platform. In the scenario where SDH devices from multiple vendors are deployed, device scripts can be imported and parsed by vendor to simulate the entire network topology. Users can view the network topology on the Network Restoration page and the resource utilization of devices and links in Resource Manager to identify the network area where capacity expansion is urgently required.

Regarding service restoration, the data parsing and restoration tool allows users to query service trails on an entire network or within a specified area and restore E2E service
information. According to the service information, users can clearly understand how services enter an area and which port and timeslot are used to exit the area.

**Figure 4-2** GUI of the data parsing and restoration tool

This tool can also be used to distinguish services and enable telecom carriers to identify invalid service in the data restoration phase, thereby reducing the actual service design and cutover workload.

### 4.3.2 Target Network Design Tool

During the design of target network migration, telecom carriers can select migration solutions based on actual network conditions. For example, telecom carriers can migrate only to areas with massive legacy devices. When no spare fibers are available or the migration schedule is tight, telecom carriers can perform single-site migration. When many services are configured at a site, telecom carriers can perform ring insertion migration. When spare fibers are sufficient and a new MS-OTN network is planned, telecom carriers can perform E2E migration.

- **Single-site migration design**

  Site migration can be performed in 1:1 or N:1 mode. In the design phase, the cross-connect capacity and port quantity required by the target NE must be calculated. In the service migration phase, the major problems are inefficient and error-prone manual configurations of service cross-connections.

  Users can adjust the timeslots occupied by cross-connections as required. Users can also generate scripts to be delivered to the NMS and a port mapping table, which describes the mapping between source ports and target ports, facilitating cutover implementation.
• Ring insertion migration design

To maximize the interoperability of SDH standard protocols, an MS-OTN device can be inserted into the original SDH ring in pass-through mode. The target network design tool automatically generates pass-through cross-connections based on port timeslots and provides the automatic cross-connection adjustment function for MS-OTN devices.

• E2E migration design

Huawei supports hybrid planning of SDH and WDM services. This tool supports target network topology adjustment, automatically maps SDH services into ODUk signals, and then performs unified resource allocation and route planning. Additionally, this tool displays and adjusts optical-layer parameters and flexibly selects electrical-layer boards and optical modules, making the entire design process efficient. It also supports outputting construction drawings and bill of quantities (BOQ) to guide engineers through network deployment and implementation.

4.3.3 TCO Analysis Tool

After the target network design is completed, this tool compares and analyzes the network resources before and after reconstruction and performs TCO analysis, achieving the optimal ROI of the reconstruction solution. Telecom carriers can enter OPEX data into this tool, such as annual electricity fees, equipment room rentals, fiber leasing fees, and annual maintenance costs. The tool then automatically analyzes the TCO.

**Figure 4-3 GUI of the TCO analysis tool**

![TCO Analysis Tool GUI](image-url)
4.4 SDH Evolution and Reconstruction Solutions

The evolution and reconstruction solutions for SDH modernization mainly include single-site reconstruction solution, service-based E2E migration solution, and ring insertion reconstruction solution. The most widely applied solution is ring insertion reconstruction.

4.4.1 Single-Site SDH Reconstruction Solution

The basic process of a single-site reconstruction solution is as follows: Use MS-OTN devices to replace legacy SDH devices site by site, and then perform service cutover by site. All services of a site are cut over at a time. The single-site reconstruction solution applies to the sites with small service capacities.

Figure 4-4 Single-site SDH reconstruction solution

1. The operation process is simple, and configuration data is prepared in advance, leaving sufficient time to check the configuration.
2. This solution is recommended when the port cutover quantity is small.

4.4.2 Ring Insertion SDH Reconstruction Solution

The basic process of a ring insertion reconstruction solution is as follows: Configure pass-through services on a new MS-OTN NE, insert the MS-OTN NE into the original SDH ring, and then gradually cut over services at the original SDH site to the MS-OTN NE. The cutover can be gradually performed by service.

The ring insertion reconstruction solution applies to scenarios where telecom carriers do not have spare fiber resources, service traffic is heavy at a site, and the cutover for the site cannot be completed at a time.

Figure 4-5 Ring insertion SDH reconstruction solution
1. All the operations can be performed separately and do not need to be completed within one night.
2. The cutover can be performed for multiple devices on a ring in one day.
3. Jumper connections can be performed on both ends of an important circuit so that the circuit is interrupted only once.
4. To perform a rollback, only fibers and cables need to be connected back to the old device.

### 4.4.3 E2E SDH Reconstruction Solution

The basic process of an E2E reconstruction solution is as follows:

Create an MS-OTN plane and perform the cutover by E2E service according to the service matrix on the original plane. The E2E reconstruction solution applies to the scenarios where spare fiber resources are rich.

**Figure 4-6 E2E SDH reconstruction solution**

1. A thorough test can be performed before the cutover.
2. The service interruption lasts up to 5 to 10 minutes after a hardware jumper connection is performed. The direct circuit is interrupted only once.
3. Service cutover can be completed on different days.
4. The cutover is performed service by service, and circuits are easy to monitor.

### 4.4.4 Values of SDH Evolution and Reconstruction Solutions

MS-OTN is inherently compatible with TDM services. During the implementation of an SDH reconstruction and evolution solution, MS-OTN processes VC overheads, grooms VC granularities, and receives STM-N service. MS-OTN provides multiple SDH reconstruction solutions for telecom carriers to choose. According to service characteristics, telecom carriers can select a single-site reconstruction solution, ring insertion reconstruction solution, E2E
reconstruction solution, or any combination of these solutions, thereby fully satisfying SDH modernization requirements.

The IP bearer evolution solution supports only the E2E emulation method for the packet processing of TDM services, but does not support VC overhead parsing. Therefore, the IP bearer evolution solution can be used only for E2E service cutover, causing high complexity and reconstruction costs. For example, during the SDH migration at the access and aggregation layers for mobile bearer and VIP private line services, the single-site migration solution of MS-OTN can be used, without requiring E2E service cutover or spare fiber resources. This migration solution has high operability and low costs.
5 SDH Modernization Values

SDH modernization applies MS-OTN in bearer networks and builds simplified IP+optical network architecture, bringing the following benefits to telecom carriers:

- SDH modernization helps telecom carriers continuously mine the values of VIP private lines.

TDM private line services account for a large proportion of telecom carriers' revenue, and customers have strict requirements on TDM security, latency, and reliability. Currently, MS-OTN functions as physical pipes to satisfy VIP customers' requirements on private lines. In the coming 10 years, MS-OTN will inevitably become the best solution to mine the values of TDM private lines.

- SDH modernization helps telecom carriers maximize opportunities in large pipes for DC interconnection and 4K video services.

DC interconnection and 4K video services require high bandwidth, low latency, and simplified architecture on transport networks. MS-OTN provides single-wavelength 100G and beyond 100G pipes, automatic bandwidth adjustment using OTN or packet solutions, and direct transmission channels at the optical layer, and achieves lower latency than SDH processing site by site. Therefore, MS-OTN better satisfies the user experience requirements of DC interconnection and 4K video services.

- SDH modernization promotes bearer network transformation for telecom carriers, achieving low OPEX.

Massive SDH networks worldwide gradually enter EOS, causing high O&M difficulty and increasing OPEX. The evolution from SDH to MS-OTN helps telecom carriers optimize bearer network architecture and facilitates "asset-light" operation transformation, simplifying O&M and reducing OPEX.

- SDH modernization promotes transformation towards simplified architecture for Internet of everything (IoE).

MS-OTN provides T-SDN-based bandwidth on demand (BoD) and virtual transport service (VTS), flexible bandwidth provisioning capabilities for end users, and on-demand setup of leased line connections, meeting DC-centric backhaul and interconnection requirements. MS-OTN also shatters the physical location limitation of nodes in NFV resource pools, matching uncertain traffic, flow direction, and service type trends. It adapts to the requirements for differentiated bandwidths, meeting future 5G service backhaul and service
slicing deployment requirements, and smoothly transforming to IoE and simplified architecture.