IP and OTN synergy creates enhanced backbone networks

By Liu Hongli

New transport network requirements

The explosive growth of ultra-broadband services has nurtured continual development of technologies for the backbone bearer network. At the IP layer, cluster routers have enhanced the performance and switching capacity of backbone routers. At the optical layer, the optical transport network has an ultra large capacity and long distance transmission capabilities, plus intelligent functions.

Backbone networks are imposing new requirements on the transport network, including:

- **40G/100G high speed transmission**: With increased traffic, the transport networks require 40G capacity per wavelength and should be compatible with 10G and future 100G. In 2009, leading vendors demonstrated their 100G transport and routing devices, but mass commercial deployment is not expected until later than 2012. 40G has become a must and 10G, 40G and 100G devices are expected to co-exist for a long time.

- **Tbit large-capacity cross-connection**: The transport network is required to provide large-capacity cross connections to fully connect core nodes and establish direct routing between regional nodes. A Tbit OTN cross connection would help to bypass the traffic on IP layers.

- **Intelligent control plane**: Key to a transport network, the ASON/GMPLS intelligent control plane can help realize end-to-end service provisioning through large-capacity cross connections, while enhancing the reliability of backbone networks. It can easily handle multipoint failures of transmission links. With a unified control plane, the optical layer and the IP layer can realize interaction and synergy, creating a high performance, low cost backbone network.

Advantages of IP over OTN

With the ASON/GMPLS control plane, OTN can introduce cross connect dispatching of wavelengths and sub-wavelengths to the point-to-point WDM system, enhancing the routing and switching capabilities and forming an inter-networked WDM system. OTN has the following advantages:

- **Better transport and higher efficiency**

  ITU-T has well-defined OTN standards for the mapping and bearing of Ethernet traffic. The latest standards have added ODU0 to bear GE traffic, ODU2e to 10GE LAN, and ODU4 to 100GE. The future ODUflex can map the traffic of different transmission rates into the OTN frame. All these have enhanced optical network capability in terms of high-speed, multi-service transmission.

  The OTN enhances efficiency and lowers transmission costs. Currently, a 40G wavelength costs less than four 10G wavelengths. Using OTN to converge four 10G channels into one 40G channel is cost-effective. Also, through ODU0, ODU1 and ODU2, the OTN can map traffic over the GE level to ODU3 and ODU4, and then converge into a 40G or 100G wavelength, another enhancement that lowers transmission costs and boosts efficiency.

  OTN can realize efficient traffic dispatching and end-to-end service provisioning. Based on a large-capacity cross connection and the ASON/GMPLS control plane, OTN can provide on-demand flexible bandwidth at any time.

  OTN has the capability for full-service cross connection and traffic grooming, while offering non-blocking switching for granules including ODU0, ODU1, ODU2, ODU3 and wavelength, realizing the “any to any” wavelength and sub-wavelength connections in various optical fiber topologies. Compared to WDM with point-to-point networking, OTN has shown great progress with features like mesh networking.

  By adding direct routes to edge nodes with a larger traffic load or with an IP offload solution, traffic can be diverted to the optical layer, reducing the pressure on core routers while strengthening the transmission efficiency of backbone networks.

More reliable transmission
Optical networks should be able to reliably carry massive amounts of traffic. An intelligent optical network can be formed by introducing the ASON/GMPLS control plane to the OTN, which can also effectively solve multi-point failures on the backbone network. Statistics show that a WDM system extending 600km can reach 99.99% reliability, yet for an OTN mesh network equipped with the ASON/GMPLS control plane, reliability can be increased 10 times to 99.999%.

**Wavelength-based service provisioning**

Traffic on the backbone network mainly comes from enterprise customers instead of individuals. BT’s statistics show that individual consumers generate only 24% of network traffic, with the rest coming from enterprises and wholesale services, using one or multiple wavelengths. Traditionally, these wavelengths are provided by WDM systems and switching is realized manually through patch cords on network nodes, making it hard to ensure reliability and deployment time. In comparison, OTN not only enables an operable optical network, but also wavelength-based private services.

Since 2007, mainstream vendors have introduced various OTN product series, with cross connection capability up to Tbit and most are equipped with an ASON/GMPLS intelligent control plane. The ASON-based OTN has been widely applied worldwide, and backbone networks are transforming from IP over WDM to IP over OTN.

**Backbone network with IP/OTN synergy**

IP over OTN is key to backbone networks. Currently IP over OTN generally uses a static optimization approach, requiring manual operations for network planning and configuration. A better approach is to use real-time optimization, which requires synergy between IP and the OTN. Huawei has launched its SingleBackbone solution, realizing synergy for traffic distribution, co-protection, and network management for both the IP and OTN layers.

**Traffic distribution synergy**

IP/OTN synergy for traffic distribution can help to enhance network performance and lower expansion pressure. If the traffic between any two routers exceeds the set value, the router can request bandwidth through the UNI interface. Receiving the request from IP layer, transport network will establish a direct optical routing between these two routers after routing and wavelength assignment (RWA) calculation. As a result, service providers do not need to expand the capacity as traffic is diverted through the OTN.

An IP interface for routers is four to five times more expensive than an OTN interface. As the optical layer has helped distribute traffic for routers, the number of hops and IP interfaces are reduced and so is the CAPEX for service providers. One leading operator reduced 40% of its CAPEX with the IP/OTN synergy solution, simply by bypassing the traffic from routers to the optical layers.

**Co-protection for services**

Bearing the services for tens of millions of users, a backbone network must be highly stable. In a Chinese operator’s backbone network, the number of line faults makes up 58% of all faults, and time required to attend to them makes up 76% of all time spent troubleshooting. The restoration technology employed by routers is mainly used for network node failures and a fiber failure will cause a large number of label switched path (LSP) failures, endangering the QoS.

Sprint’s research in the USA, shows that during the route convergence caused by line faults, IP traffic loops are generated, which cause delay, jitter and packet loss. Services are greatly affected, and the duration may last for 10 or even 60 seconds in some cases.

For a backbone network with IP over OTN, the optical layer focus is on protecting physical layer devices, while IP layers are mainly protecting network nodes, ports and logical links. The co-protection of optical and IP layers enhance network reliability and efficiency. Thanks to the large number of direct routing paths on the optical layer, an IP network can reduce the number of hops to only one in some cases, simplifying the QoS mechanism and minimizing the impact of network traffic.

**Network management synergy**

Proper network management synergy realizes unified alarms, troubleshooting, and one-stop E2E service configuration.

Alarms from optical layers can trigger more alarms on the router layer. The synergy management of IP and OTN layers can help to locate and troubleshoot multi-layer faults, realizing unified alarm processing. Through correlation analysis, alarms from optical layers are suppressed and irrelevant alarms are filtered. Engineers can then focus on the root-cause alarms for fast troubleshooting and lessening O&M pressure.

With a unified network management system, the PCE and GMPLS UNI, IP and OTN can surpass the separate management and configuration model, realizing E2E service provisioning.

With IP and OTN synergy, backbone networks can remove traffic bottlenecks with unified traffic management, plus the co-protection function can enhance network reliability and performance. The network management synergy also assists in troubleshooting and alarm filtering, which enables E2E service provisioning. Practices show that for a typical backbone network, IP and OTN integration can save over 40% of CAPEX, OPEX and equipment room space.

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