Intelligent optical Mesh network drives All IP

With the emergence of new IP-based telecoms services including 3G, IPTV, triple-play, VoIP and IP SAN, transformation of traditional services to IP services, as exemplified by legacy TDM services to packet services, mobile network’s TDM RAN to IP RAN, there is consensus in the industry that the transformation to IP-based services networks and packetized bearer networks is ongoing.

Requirement for optical transport network in the trend of All IP

China Telecom cited in its development planning that it will focus on developing value-added services like streaming media and multimedia session in the future; by 2012, close to 33 million US households will have broadband services with speeds of 10Mbps or higher, capable of streaming high-definition video; by 2010, 30% of European subscribers will enjoy VoD/IPTV services, with household bandwidth rising from 2-3Mbps to 15Mbps. The upsurge of multimedia data services creates a huge demand for transport bandwidth.

Meanwhile, the inherent burst and uncertainty features of data services cause great difficulty in network traffic prediction and pose higher requirements for fast bandwidth distribution.

Mobile transmission network also confronts the problem of dynamic and burst development of customers and services. The network’s ability to increase system capacity in time and ensure quick response to new services is important for offering stable network communications quality and attracting more customers. In the face of increasing equipment capacity and requirement for maintenance, core switching nodes will converge on few nodes, causing the direct through services between core nodes to increase and demanding higher security.

On the other hand, operators’ revenues weigh heavily on business customers, especially key account private line. Accelerating globalization of network and enterprise and government network applications are stressing bandwidth demand, and survivability of infrastructure network carrying broadband services with critical mission is rising in importance. For example, the financial organizations rely more heavily on global interworking to deliver various critical trading services, which are very sensitive to service disconnection. Traditional data redundancy storage will be replaced by disaster restoration planning at different network layers.

It is an inevitable development trend of network to deliver new services such as broadband (over Tbit/s), high quality (service classification), dynamic (bandwidth-on-demand), agile (automatic switching), controllable (protocol intelligence) services directly over photonic layer. The simplified network hierarchies and reduced core node number enable legacy optical transport network to implement multi-degree Mesh
topology. Furthermore, the introduction of intelligent control plane GMPLS offers traditional optical network with more advanced features, as listed below:

- Simplicity and agility in operation: fast end-to-end service provisioning, eased system upgrade and bandwidth-on-demand distribution;
- Carrier-class network and service flexibility: carrier-class service protection and restoration, which include Mesh survivability, enhanced service classification and support for SLA;
- Bandwidth optimization and manageability: intelligent bandwidth grooming and aggregation and high-level OAM.

Creating intelligent Mesh network

In Mesh network, nodes are interconnected via multiple paths, allowing NEs to share the common control plane information. Intelligent optical switched nodes use standardized optical networking algorithms (signaling, routing) and senior management software to provide network information at node and network levels, and automatically discover the optimal path between two service endpoints according to given routing constraints, such as demanding bandwidth, routing diversity, etc.

The embedded intelligent software of node is the foundation of many senior features in intelligent optical network, such as:

- Automatically discover the connection relationship between network sites and form complete network topology, eliminating complicated manual creation operations;
- Enable click turn-up or disconnection of end-to-end services. It only requires customers to consider the source/sink of service, rather than the route and wavelength used. Route and wavelength resources can be calculated automatically via software, or can be designated manually;
- Network resources are visible in real time, allowing customers to understand current network capacity, and easing network maintenance and service turn-up;
- High-level OAM;
- Dynamic mesh restoration.

WXC (ROADM) and OTN electrical cross-connect matrix is the physical basis of intelligent switched node. ZTE iWDM equipments support multi-degree WSS ROADM, enables dynamic add/drop of any wavelengths at any nodes, as well as agile scheduling of λ-level services at any nodes. Customers can design and configure network based on requirements, the difficulty in network planning and service prediction and early cost of network builds are reduced as a result. WSS ROADM integrates channel automatic power equalization technique, enables rapid installation and turn-up of new services; its remote software configuration and automatic service provisioning features can cut manual maintenance cost and avoid mis-operation, allowing operators to respond to the rapidly growing market and helping them achieve revenue gains and improve customer satisfaction.

The complex dynamic Mesh network has the problems of wavelength blocking and network partitioning. The more nodes the wavelength routing passes, the higher the possibility of blocking will be; additionally, optical damage (signal-to-noise ratio, dispersion, non-linear effect) can restrict optical transport distance. Before the commercial availability of photonic components with enhanced functionalities, cross-connect node integrated by optical layer and photonic layer offers additional agility in terms of wavelength conversion/regeneration. Integration level between optical cross connection and OTN...
electrical cross connection largely depends on the degree between optical transport network nodes, the logic connection between P/PE routing units and the dynamic characteristics of service matrix. Services from IP/MPLS client layer or other static services (e.g., multiple GEs and 10GEs) are aggregated and carried over single wavelength, while the integrated OTN electrical cross-connect matrix is used to provide scheduling and cross connection at ODUk (k=0, 1, 2, 3) granularities, thus implementing add/drop multiplexing of any services (X-ADM) and much finer bandwidth adjustment. Capacity of the cross-connect matrix depends on the traffic terminated locally and the proportion occupied by direct through services after ODUk scheduling, regeneration and wavelength conversion, which are dependent on degree of optical node, wavelength number per degree and service matrix. Therefore, OTN cross-connect node should support smooth capacity upgrade (hundreds of Gbit/s to Tbit/s level), and it should be selectively deployed in the network with full considerations on logic or physical Mesh connection and client service mix and granularity.

Though with limitations on service transparency, optical-electric hybrid scheme can erase the impact of physical transmission damage on signal, enables direct switching of λ-/sub-λ-level services, and implements agile scheduling of services. It allows optical transport network to realize dynamic distribution and flexible control of bandwidth resources, rapid rollout of services, provide Mesh-based protection and restoration, network dynamic extension and capacity expansion and diversified service classes.

Resilient Mesh network

Intelligent optical Mesh network can offer network operators with a couple of protection schemes, including extra agile scheme aside from traditional ring-based schemes. Dynamic Mesh protection and distributed intelligence erase single-node failure in network, while diversified trails ensure network flexibility and survivability. New trail can be selected in real time, or it can be preset in advance. Available protection bandwidth can be reserved, shared or provisioned in real time. Mesh network is applicable to handling multi-node failures. It can provide different levels of protections to serve as a part of hierarchical service model, and select different restoration policies based on failure types. Mesh restoration provides more degrees of freedom to address specific requirements of customers and achieve the best efficiency and benefit.
Leveraging on the diversified protection and restoration capability of intelligent optical Mesh network, operators can configure and deliver differentiated CoS services to enrich IP, Ethernet or TDM service mix and optimize the performance of broadband infrastructure networks. For example, services delivered over 3G core transmission networks include streaming media, session, background services, which have different QoS requirements. Intelligent optical network can offer different levels of services in accordance with security and real-time demands, give strong support for operators to respond to service diversity, and personality, and help boosting user satisfaction and competitiveness, as well as ARPU value. On the other hand, for the large volume of non-real-time data services (FE/GE) in 3G network, shared protection bandwidth of Mesh network can be used to improve bandwidth utilization rate, resulting in 60-70% of bandwidth utilization rate in comparison to traditional ring protection’s 50%. Efficient network utilization rate can save vast core network resources and cut investment cost.

The improvement of Mesh network security also leads to lowered network maintenance cost, as multi-node failure protection is available to allow longer wait-for-repair time.

### ZTE iWDM equipments

Services are inevitably in the shift to be all-IP-based, accompanying by transformation of operators’ network architectures. For example, Telefonica is building the Photonic mesh network. Intelligent optical Mesh networks allow operators to deliver new services, such as bandwidth-on-demand services, wavelength wholesale, wavelength leasing, hierarchical bandwidth services, bandwidth trading and optical virtual private network (OVPN), and help them achieve new profitable growth. ZTE iWDM equipments support ROADM photonic-layer scheduling and OTN electrical-layer cross connection. They adopt GMPLS control plane effective coordinate electrical layer and photonic layer, dynamic resource utilization, simplified network architecture and network management, realize fast service provisioning and Mesh-based network protection and restoration, and help WDM network achieve a qualitative leap in operation ability.