Key technologies and solutions for WSON

Abstract: Due to the competition and development in the present telecom market, the telecom network has to meet increasing demands for bandwidth with lower CAPEX & OPEX and higher QoS. The bearer network at the lower layer of the telecom network is also faced with such a great challenge. As a result of the evolution of IP over WDM bearer network and fast growth of WDM switching technology (large-capacity optical cross and electrical cross) and bearer network application mode (MESH networking and service diversification), the introduction of intelligent control plane into conventional optical network has become a consensus in the industry. WSON, the intelligent control technology of WDM network, has gradually matured and improved relative standards and technologies to find a commercial application. This article describes the WSON-related key technologies and the solutions of ZTE’ WSON platform - ZXUCP A200.

WSON — IP over WDM evolution

In the development and convergence of IP and optical network, IP over WDM optical link offers sufficient bandwidth for IP service. 3G, NGN and IPTV now can be carried at the same time over IP-based route-type multiservice platform. IP-based telecom network trend is ever more obvious. The roles and responsibilities of IP network are different from those a few years. In consequence of IP-based information service and IP-based telecom service bearing, IP network has to bear increasing Internet access services as well as other services such as 3G, NGN, IPTV and VIP VPN. The network is now confronted with severe challenges such as "How to bear high-QoS services?" and "How to become carrier-class integrated service platform?". The following aspects are required:

- Meet growing demands for bandwidth and transmit large granules of services.
- Provide carrier-class high reliability and security.
- Minimize CAPEX and reduce resource consumption.
- Plan network QoS and ETE QoS service (VoIP, VOD, VPN, etc.)

With the development of WDM network technology (large-capacity cross and electrical cross) and network application (MESH networking and service diversification), it is very difficult for a user to just use management plane to manage network resources and dispatch & maintain services. The introduction of intelligent control plane into conventional optical network has become a consensus in the industry. WSON (Wavelength Switched Optical Network), the ASON based on WDM transmission network, is now the intelligent WDM standard proposed by IETF. In addition to conventional
ASON functions, it resolves the problems in automatic fiber/wavelength discovery, online wavelength route selection and loss model-based route selection in the network. ZTE provides ZXUCP A100-A300 software to intelligently control different network equipment. ZXUCP A200, the intelligent control plane of ZTE’s next generation iWDM solution, will resolve the problem in the core-layer intelligent dispatching of metro/local backbone network of overseas and domestic mainstream carriers.

**WSON model**

WSON is one of major concerns in IETF research and discussion. It includes WSON frame, information model information, protocol extension and RWA frame. WSON control plane has many special problems.

- It needs WSON network and equipment information model, including cross limit, wavelength limit and optical loss restriction in nodes.
- It needs protocol extension to spread network topology and resource information and signaling extension to support automatic creation of optical power.
- Route submitting restriction, wavelength restriction and optical loss parameter restriction should be considered for RWA.

It is necessary to create models for restriction factor in WSON path selection and such WDM subsystems as WDM Link, Optical Transmitter/Receiver, Splitter, Combiner, ROADM, FOADM, OXC and Wavelength Converter. It is especially required to provide a control plane model for WSON subsystems and processing, which includes:

- WDM Link model: Created with port wavelength restriction (static information) + available wavelength (dynamic information).
- ROADM, FOADM and OXC cross models: Created with connectivity matrix + port wavelength restriction + indicator.
- Wavelength Converter model: Convert the optical signal of a wavelength at ingress port to the optical signal of another wavelength at egress port.

**WSON routing and wavelength assignment — RWA technology**

As ROADM optical-layer dispatching network, ODUk electrical cross network and optical/electrical dispatching network are still blocking non-full-cross optical networks and there are problems in routing and wavelength assignment in such circumstances, it is required to develop RWA algorithm on the basis of GMPLS protocol stack oriented to non-blocking switching network control plane.

RWA algorithm is static, incremental or dynamic. Optical channel-based static RWA algorithm selects the route and assigns the wavelength for each channel. In the engineering RWA problem is often resolved in two steps: route selection and wavelength assignment. ZXUCP A200 has the following solutions:

**Step 1: Routing (select the route for each optical network service request)**

There are two types of routing: fixed routing and alternate routing.

Fixed routing means that one fixed route is selected for each channel. It usually employs the known shortest path algorithm. Alternate routing means that several routes are selected for each channel. The simplest way is to select k shortest paths. When the wavelengths are assigned for a group of routes of several channels, if there is no sufficient wavelengths, alternate routing will be replaced to select new alternate routing and then the wavelengths will be assigned.
Step 2: Wavelength assignment (assign wavelength/sub-wavelength for each route)

If there is no wavelength conversion for optical network nodes, the restriction for wavelength assignment is that each connection path should always be in the same wavelength and different channels in one fiber should be assigned to different wavelengths. If a node can implement electrical cross, the wavelength can be delivered from optical layer to electrical layer for wavelength conversion and physical-layer signal regeneration. For the consideration of simplification, some heuristic algorithms can be used to assign the wavelengths for several routes one by one.

Table 1 Comparison and analysis on RWA solutions

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Centralized RWA</th>
<th>Distributed RWA</th>
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<tr>
<td>Single-point simultaneous connection request</td>
<td>There is no resource assignment conflict in single-point simultaneous connection.</td>
<td>There is resource assignment conflict in single-point simultaneous connection.</td>
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<tr>
<td>Multipoint simultaneous connection request</td>
<td>It has an advantage if there are few multipoint simultaneous connections.</td>
<td>It has an advantage if there are many multipoint simultaneous connections.</td>
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<tr>
<td>Node resource status</td>
<td>Broadcast node resource information change dynamically to the overall network via LSA.</td>
<td>Get the status from resource management module of the node after the node receives signaling message request.</td>
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<tr>
<td>Node processing load</td>
<td>Processing load of single node increases.</td>
<td>Processing load of single node decreases.</td>
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<tr>
<td>Implementation efficiency</td>
<td>It has an advantage if the network has weak wavelength switching.</td>
<td>It has an advantage if wavelength switching is near to full wavelength switching.</td>
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Restriction technology of WSON optical — layer physical features

ASON design is based on the hypothesis that signal quality of optical channel in network planning is assured and all fiber links and channels are characteristic of standard transmission, but the hypothesis will not be workable for WDM optical network. As O/E/O conversion will be gradually reduced in future network evolution, such physical losses such CD, OSNR and PMD will severely deteriorate transmission performance of optical signals and optical channel will not assure transmission features without distortion. Thus, signal transmission quality in the future optical network will not be assured and network planning & design and engineering will be very difficult accordingly.

ZTE uses the planning software to pre-plan and pre-design the network and introduce physical-layer transmission adaptive processing module to control plane, which will dynamically
adjust relative solutions in the operation and add optical loss check to the existing RWA process to process the optical loss.

The above models are used to optimize and adjust dynamically the performance at physical layer of the created connection: For the created connection, physical-layer performance in the operation often deteriorates (e.g., incremental line aging and wavelength drift), which can be dynamically optimized with system margin through adaptive algorithm).

**WSON application in multilayer and multi-domain network — MLN/MRN and PCE technologies**

Now control plane involves SDH, WDM/OTN and PTN/CE. It is required that control planes of different switching technologies can be interconnected or a unified control plane can control different switching technologies. GMPLS supports PSC, L2SC, TDM, LSC and FSC switching to control all the equipment types in the bearer network. On the basis of ITU-T requirements for basic functions and structures of control plane, ZTE employs GMPLS technology to control multilayer and multi-domain network. ZXUCP A200 provides control plane solution for ROADM+OTN networking.

As telecom network evolves, there rise some new problems in the development of control plane. Firstly, larger network scale and more nodes and network layers lead to more complex path calculation of control plane. Secondly, as no traffic engineering information are offered between network domains in the conventional distributed solution, cross-domain services are difficult to be globally optimized and there also exist problems in creating protection paths.

Therefore, IETF proposes PCE technology to resolve the above difficulties, which gains widespread approval from mainstream vendors and carriers. PCE supports distributed and centralized calculation. The solution distributes PCE calculation unit to physical equipment which has a lot of calculation resources. ZXUCP A200 supports PCE development in the ROADM+OTN networking.

1. In the stage of network planning and design, optical loss of service connection can be controlled to the acceptable range according to equipment characteristics. If linear optical loss is still available after network planning and pre-operation, optical loss compensation (e.g., dispersion compensation) will be introduced.

2. As some optical losses are non-linear and dynamic, the planning cannot completely resolve the problem. Control plane is added with distributed optical loss collection and verification. Thus it can collect optical loss and verify the validity of wavelength channel in the signaling stage.

The transmission adaptive module of ZXUCP A200 control plane equipment has two functions: Optimize and adjust dynamically the performance at physical layer of the created connection based on the verification of GMPLS protocol connection validity; and divided functionally into transmission performance adjustment & control algorithm module, transmission performance monitoring module and transmission performance database.

Selectible implementation models for WSON are centralized models and distributed models. Considering the complexity of OSPF and RSVP signaling extension and the risk of industry standard consistency, ZXUCP A200 transmission-layer adaptive adjustment module adopts the distributed implementation model.