Development trends of GMPLS control plane

The ASON/GMPLS acts as the common control plane of transport networks (OTN, SDH, and PTN) to help operators realize intelligent transport networks. How will ASON/GMPLS be developed in the future?

By Hu Ming

Dispatching different levels of granularity

The SDH-based ASON networks with VC-4 granularity currently enjoy wide commercial application. By the end of 2007, Huawei had already deployed over 40,000 sets of ASON equipment for global operators, and this has applied the ASON/GMPLS control plane to over 100 networks. These intelligent transport networks have achieved statistically flawless stability with no service interruptions occurring at all in 2007. The wide application of ASON optical networks not only improves transport network reliability, but also reduces OPEX for operators. ASON technology has already made its commercial mark.

The OTN-based ASON networks are being increasingly piloted or deployed. They comprise an ASON/GMPLS control plane but use the wavelengths, GE/Any, and ODUk (k = 1, 2, or 3) as their service dispatching granularity, the levels of which are vastly higher than the VC-4. The rapid growth of the IP services coupled with the swift deployment of new services such as 3G, NGN, Multi-Play, VPN, and SAN have necessitated higher requirements for transport network bandwidth, performance, and granularity. Driven by the development of services and technologies, operators must aim for highly flexible, efficient, secure, stable, and intelligent OTN networks.

Transport networks are developing with an IP
service focus that has stimulated the increasing application of packet transport network (PTN) technology. While oriented to packet transmissions, PTN inherits the basic features of transport networks. In addition to packet-based node switching, the PTN also achieves flexible QoS control, broadcast/multicast, end-to-end channel management, and SDH-like management, maintenance, protection, restoration, synchronization, and timing.

The OTN, SDH and PTN can all be loaded with the ASON/GMPLS control plane to realize service dispatching with different levels of granularity (λ/sub-λ/TDM/packet), and hence meet the diversified transport requirements on different network layers.

Common control plane for various transport networks

The OTN, SDH, and PTN network control planes are going unified, and this feature is set to be enhanced by the gradually optimized standards. Currently, the transport network's control plane field forms a key research area for standardization organizations, which spans wavelength switched optical network (WSON), multi-region network (MRN)/multi-layer network (MLN), and path calculating element (PCE).

The OTN and WSON are standards relating to intelligent WDM networks. Proposed by the International Engineering Task Force (IETF), it mainly aims to solve problems with the automatic discovery of optical fibers/wavelengths, the online routing of wavelengths, and impairment aware routing in WDM networks. In June 2007, Huawei submitted its WSON architecture and requirement proposal to the IETF, marking the first formal proposal involving the WSON concept. With the participation and support of ten equipment suppliers and operators, the IETF CCAMP working group formally released the Last Call in May 2008, and ratified the Huawei proposal as an official working group document. It denotes the developmental direction of the ASON/GMPLS control plane dispatching with wavelength granularity, and is greatly contributing to the work of IETF CCAMP.

When loaded with the ASON/GMPLS control plane, the OTN, SDH and PTN can realize service dispatching with different levels of protection, recovery, and granularity for services with various rates. Nevertheless, it is dependent on the development of MRN and MLN technologies, the research for which is mainly covering multi-layer survivability and multi-layer traffic engineering (MTE). Multi-layer survivability comprises a range of features to coordinate and realize, for example, inter-layer protection and recovery, and the effective use of inter-layer recovery resources.

ITU-T completed MLN standardization in 2006 and set it out in ITU-T G.8080. The MLN/MRN requirements provided by IETF CCAMP are soon to be released as a formal RFC draft, which will in turn lead to multi-layer signaling and routing standard optimization.

The PCE forms a key technology that solves the MRN/MLN multi-layer routing problem. In a multi-layer network, the PCE is responsible for route computation. It works out the optimal route based on a multi-layer network's known topological structure and constraints, and accomplishes network-wide trans-domain and inter-layer traffic engineering and path optimization. It yields great value in terms of improving network quality and operational efficiency. The IETF PCE working group has made considerable progress in the MRN/MLN field; the relevant requirements have become stable, and six RFC drafts have already been released. The next step will see the formation of the related solution standard.

In conclusion, the rapid development of standards related to WSON, MRN/MLN, and PCE will realize end-to-end service dispatching and unified control at various theoretical granularity levels (λ/sub-λ/TDM/packet). Currently, the transport network is rapidly evolving towards the ASON/GMPLS common control plane.

Inter-layer interaction and intra-layer interoperability

IP over optics provides a highly reliable and low-cost service bearer solution. However, the interaction between the IP and optical (transport) layers, and the interoperability between multiple vendors' control planes must be further optimized via the cooperative effort of operators, equipment suppliers, and standardization organizations.

As the GMPLS protocol is inherited from the MPLS protocol, the inter-layer interaction of the IP and optical layers can involve the adoption of different standards. Router vendors tend to opt for IETF GMPLS UNI, while transport network vendors are more likely to select OIF UNI 1.0R2 or UNI 2.0.

In terms of the intra-layer interoperability between transport network control planes, since there are two standards coexistent, namely IETF
PCE and OIF ENNI 1.0, transport network vendors have various choices.

Interoperability is essential since it is impossible for an operator to use just one vendor’s ASON equipment. Thus, the OIF organized several control plane-based interoperability tests for the UNI and ENNI interfaces in 2001, 2003, 2005, and 2007. The UNI and ENNI interfaces provided by Huawei, Sycamore, Alcatel-Lucent, Ciena, and Cisco demonstrated the required interoperability capabilities. The IETF has set out the necessary interoperability criteria in the proposed GMPLS UNI draft. However, interoperability does not just embody a functional interface. It is also essential to consider the evolution of technologies, end-to-end management, reliability and convenience. These linked factors may lead vendors to choose different solutions.

The evolution plan relating to interoperability must reflect actual network requirements and the developmental trends of the common control plane. Such an evolution plan needs to be established and specified through the cooperation of operators, equipment vendors, and standardization organizations. Standards must be formed to facilitate implementation and meet the requirements for network evolution. The standards should include: the ENNI trans-domain service level agreement (SLA), and operations, administration, and maintenance (OAM) functions, the UNI inband signaling specification, and the unified network management system. They will help commercialize the control plane interoperability to achieve trans-domain end-to-end dispatching, management, and maintenance.

Until interoperability details are fully specified, the static connection of multiple vendors’ ASON/GMPLS control planes represents a feasible and practical solution. In this case, transport plane interoperability is followed by control plane interoperability via upgraded UNI and ENNI interfaces.

China Telecom boasts the maximum number of commercial ASON networks. In 2007, China Telecom partnered with Huawei and Alcatel-Lucent to perform an ENNI interoperability test in its experimental ASON network to verify functions such as end-to-end service delivery. To consolidate the testing process, China Telecom subsequently organized a forum focusing on trans-domain protection and recovery. ENNI interoperability will be commercialized before 2010.

**OAM mode: controllable, manageable, convenient**

At the OptiNet China 2008, Wei Leping, the general engineer of China Telecom, pointed out that the greatest challenge for ASON arises from the changes of traditional OAM philosophy and process. Some operators are worried that they may lose network control where ASON is deployed, and thus demand a “controllable, manageable, and convenient” control plane.

The key issue is to realize innovations in the traditional OAM mode. Firstly, developments in alarm and performance monitoring technology for the control plane are required. Innovations in the SLA degradation alarm, control link interruption alarm, and rerouting time monitoring will allow OAM personnel to maintain the control plane in the same way as the transport plane. In addition to the convenience this affords, extra staff training costs can be avoided.

Secondly, innovation in resource management technology is necessary. For example, reversion technology can be employed to let a service automatically or manually revert to its original path after fault clearance. Resource shared mesh restoration technology can preset restoration paths, grant a 100% post-fault service recovery rate, and enhance resource utilization. Soft rerouting technology can optimize paths and schedule resources both rapidly and reliably.

The right innovations mitigate operators’ OAM concerns following ASON deployment. The ASON/GMPLS control plane elevates network intelligence and reliability, and acts a catalyst for greater network control, manageability, and convenience.

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**Link**

**Huawei demonstrates its OTN-based ASON at ICC2008**

At the International Conference on Communications (ICC2008) held on 19–23 May 2008, Huawei demonstrated its OTN-based ASON equipment and the related service level agreement (SLA). The equipment was favorably received by over 200 experts and scholars present at the conference.

Integrating ODUk cross-connect dispatching with ROADM, Huawei’s OTN-based ASON equipment is capable of OTN optical-electrical mixed cross-connect dispatching. The equipment uses the ASON/GMPLS control plane to provide the centralized control of packets, time division multiplexing (TDM), wavelength/sub-wavelength, and fiber levels. As a result, the mature ASON/GMPLS control technology is extended from the SDH to the ROAD/OTN.

This is the only ASON OTN equipment that adopts multilayer network (MLN) technology and supports 40G wavelength GMPLS protection and restoration. Loaded with ASON/GMPLS control plane, the equipment meets operators’ core requirements to reduce total cost of ownership (TCO), enhance service dispatching efficiency, and simplify OAM. To date, Huawei’s equipment has been widely used in both backbone transport networks and metropolitan transport networks. In the European Broadband Forum 2007, the International Engineering Consortium (IEC) rewarded Huawei with the InfoVision Award in appreciation of its ASON solution.