ASTN, ASON and Control Plane

Future Oriented Transport Network Architecture

In this article, progress on Automatically Switched Transport Network (ASTN) in ITU-T and other standardisation bodies is introduced. Possible future implementation scenarios are presented. Realisation of the ASTN will help Swisscom to save on operational cost of the transport network caused by unpredictable traffic volume increase and future network complexity.

ASTN stands for Automatic Switched Transport Network. Compared with traditional transport networks, it adds an extra control plane. Worldwide many network operators and manufacturers are developing this technology today.

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Why ASTN?

In recent years, network operators have faced not only increasing traffic volumes, but also growing service diversity. Dense Wavelength Division Multiplexing (DWDM) transport technology has successfully solved the problem of traffic volume explosion. Thousands of kilometres with DWDM systems offering Terabit capacity have been reported [1]. DWDM network equipment has been installed in the Swisscom core transport networks since 1998. As IP traffic is becoming dominant, traditional protocol stack IP over ATM over SDH over WDM architecture is being simplified. To simplify the layers between IP and optical, packet over SONET/SDH appeared with a thin SDH frame. To reduce the latency and inefficiency of IP forwarding, Multi-Protocol Label Switching (MPLS) managed to separate forwarding information (label) from the content of the IP header by adding a MPLS labels stack. Then, Constraint-Based Routing (CBR) and source routing techniques can be used to direct IP packets through a selected path from ingress to egress LSR, which fulfils administrative and QoS (Quality of Service) constraints. Considering that CR-LDP (Label Distribution Protocol) and/or RSVP-TE (ReSource Reservation Protocol – Traffic Engineering) are used to establish the forwarding state along the Label-Switched Path (LSP), MPLS could been seen as "connection-oriented" instead of connectionless.

In figure 1 the IP network (the client) and the SDH/WDM network (the transport network) are managed separately. Here, the SDH/WDM nodes form the transport plane and are symbolised by the coloured WDM de/multiplexers; the network and node management system forms the management plane symbolised by the lower computer. The WDM network is "manually" configured with disjoint links (done with BASKAL at Swisscom). The IP network will perform IP routing and IP/MPLS traffic engineering. The connection of the IP routers and the WDM system is static. Such a static connection is provisioned either by a management system or manually.

However, the growing service diversity causes the traffic volume increase to be more unpredictable. Multi-services, for example IP, ATM, GbE, FC, ESCON, FICON, 3G mobile etc. add network complexity. Also, the number of leased line services with higher bit rates (e. g. STM-1, E3) will also increase. Unlike the traditional telephone services, traffic patterns of these new services are unknown at present. Due to the complexity, operational costs are increasing. In addition, as new service providers emerge, the price per bit is decreasing to be competitive. Operators need to find an intelligent way to integrate and manage these technologies. Therefore, it is proposed to introduce a control plane to the transport network. A control plane has connection controllers and call controllers. Intelligence is distributed to the transport network by the controllers, each of which resides logically in an optical network element. However, they can be physically co-located. In addition to the control plane, intelligence must also be implemented into the transport plane and management plane as well. Through signalling between the control plane, the transport plane and the management plane, the control plane can flexibly set

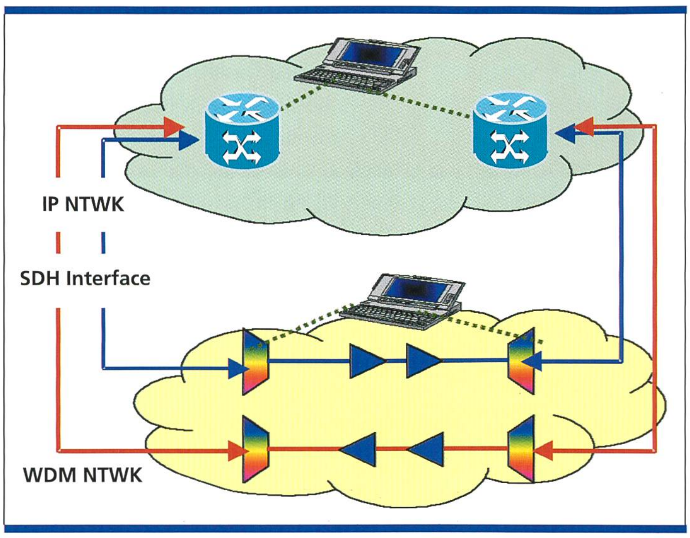

Fig. 1. Today's connection set-up type with separately managed IP and transport networks.

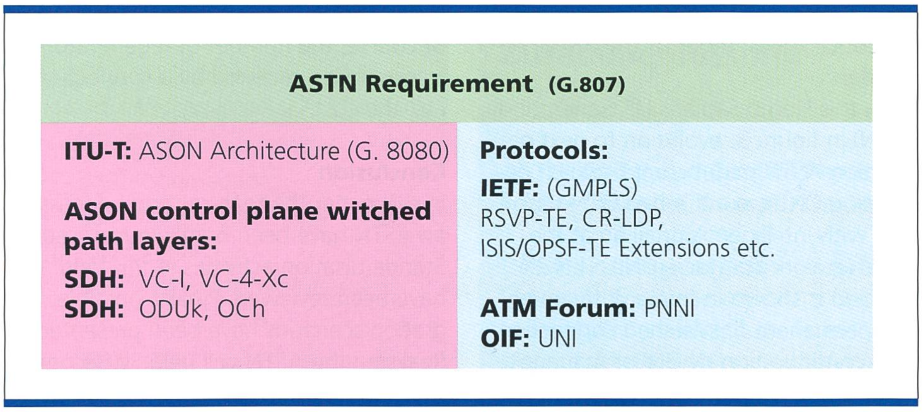

Fig. 2. The promising marriage of ASON and GMPLS in the ASTN family.

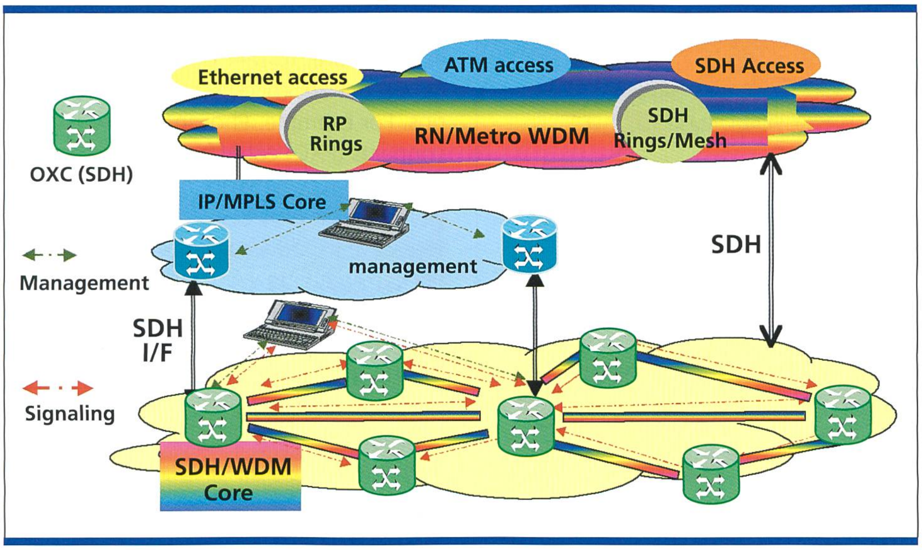

Fig. 3. Migration scenario 1.

up and maintain end-to-end connections between client nodes and may restore a connection in event of a failure. This means that Automatic Switched Transport Network (ASTN) will help to save the operational cost. Then, ASTN will help to increase profit.

Standardisation activities

How can the ASTN be realised? How can call control and connection control functions be performed? Several standardisation bodies, like ITU-T, ATM Forum, OIF and IETF, are working on various aspects of automatic switched transport network specifications.

ASTN activities at IETF

GMPLS [2] is an abbreviation of Generalised Multi-Protocol Label Switching approached by the Internet Engineering Task Force (IETF). GMPLS with extended MPLS aims at controlling multi-layer networks: LSP packet layer (IP), VC-4 layer (SDH), lambda layer (WDM) and fibre layer (physical media dependent). GMPLS incorporates MPLS signalling and IP routing protocol extensions, which use MPLS constraint-based routing, RSVP-TE and LDP protocols. A subset of GMPLS is called MPλS, which is trying to switch wavelengths and fibres with an IP-centric control plane.

GMPLS is a bottom-up approach and opens up interesting architectural possibilities. However, it was felt that the details are missing i.e., a general architecture and detailed routing attributes are not very clearly defined yet. Fortunately, the ASTN architecture provided by ITU-T may compensate for it.

OIF and ATM Forum

The Optical Interworking Forum (OIF) is working on the User Network Interface (UNI). The ATM Forum is working on a Private Network to Network Interface (PNNI) signalling specification [3] for the control of SDH and OTN, since it provides field trialled/deployed signalling solution and PNNI is more resilient than soft state protocols. It is possible that these protocols can also be used in ASTN.

ASTN activities at ITU-T

ITU-T is cooperating with the IETF in the area of signalling and routing protocols for the Optical Transport Networks (OTN). G.807, a technology neutral "Requirements for the Automatic Switched Transport Networks (ASTN)", was approved in May 2001 by ITU-T and forms the umbrella recommendation of the ASTN family. In the G.807 ASTN family, other Recommendations are under development in ITU-T. Another important Recommendation, G.8080 [4], Architecture for the Automatically Switched Optical Network (ASON), was consented in October 2001 in Geneva, which specifies the architecture and requirements for the ASON as applicable to SDH transport networks and OTN. Under the ASON there is a group of Recommendations with details on implementation protocols. Figure 2 shows the SDH and Optical Transport Network (OTN) path layers, which should be switched by the ASON control plane. Also it shows the best possible use of the ITU-T Recommendations and the protocols from other standardisation bodies to fulfil the optical control plane architecture requirements. Here, the management plane is still required to calculate the route for soft permanent connections and provide the control plane with an explicit route.

The SDH path layers are convenient to be switched. To provide a transport infrastructure for other data formats, SG15 has developed a series of Recommendations including G.872 and G.709 [5] for the OTN with framing structure ("digital wrapper"), overhead bytes and payload mappings with an efficiency not expected from current optical transport solutions, and G.959.1 for OTN physical layer interface.

Migration scenarios

From the traditional transport network, the first migration scenario can be to set permanent connections between NE's of transport network and the user NE's, with switched connections between the transport network NE's, as shown in figure 3. With the addition of an extra control plane, set-up and tear-down of connections are carried out quasi-automatically. This is called *soft permanent*

connection. The first connection may be VC-i layer or VC-4-Xc layers, before the OTN appears.
A soft permanent connection has disjoint links, protection and separate IP and WDM management: signalled switched channels in SDH/WDM, but with permanent connection between the client (user) and the network. The SDH/WDM and IP layers will have their own control plane, the so-called *overlay model,* such that the SDH/WDM can also control other non-IP client traffic. Both control planes can also be partly integrated, i.e., cost. Further cost reduction should aim to reduce the number of the 3R transponders.
From this Homo Sapiens (1st Generation ASTN) in figure 3, evolution to next generation ASTN might comprise next generation OXCs in a meshed OTN topology with intelligent signalling at the User-Network Interface (UNI). This 2nd scenario is shown in figure 4. It can be soft permanent or switched connection with configuration by UNI or management and OTN IP traffic engineering. The next generation OXCs contain the OTN

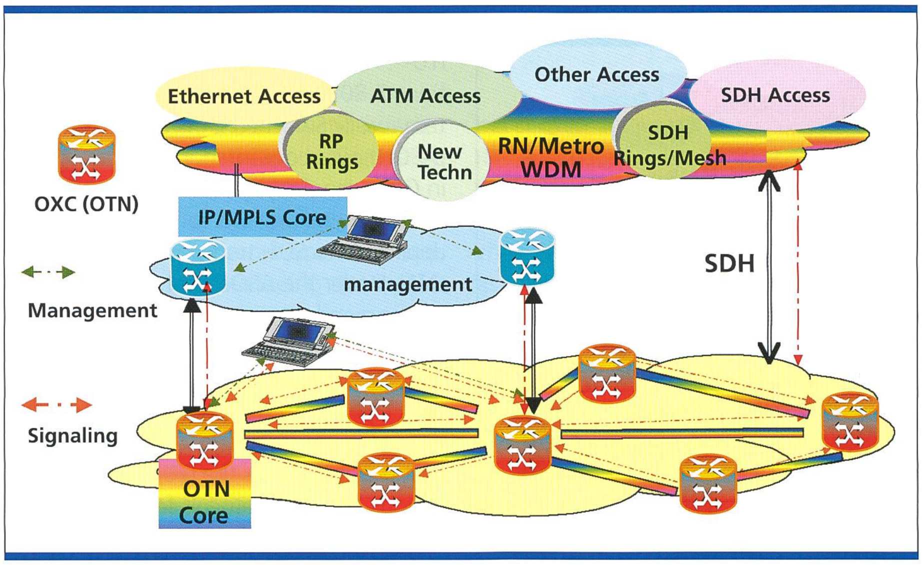

Fig. 4. Scenario 2 switched connection.

a *hybrid model,* with signalling via a UNI. Optical Cross-Connects (OXC) with electronic core will be used. The control plane manipulates the OXC with VC-i or VC-4-Xc layer switching, while protection/restoration and configuration are done by management. The advantages of a soft permanent connection include avoiding the need to develop a new commercial interface, i.e., no new billing system or security system is required between the network operator and the user. When the OXC technologies mature, OXC with optical core might be used to replace the OXC with electronic core in WDM network. An opaque OXC comprises optical 3R transponders or wave length translators. In an optical network it is necessary to use 3R transponders for regeneration, eliminating Polarisation Mode Dispersion (PMD) and Chromatic Dispersion (CD) impairments. However, most of the NE cost is the 3R transponder (wavelength translator) interface. The ASTN in scenario 2 might be a *hybrid model,* with partial signalling between the IP and OTN layers. The reasons are the following: it is commonly felt today that a *peer-peer model,* i.e. common control plane for IP and OTN/WDM layer, was not very practical. Firstly, the network operator may not be willing to let the client know about and control its network resources. Secondly, there are also lots of non-IP clients to be carried through the transport network, for instance, the leased line services.
It is likely that scenario 2 would be realised in many steps. In scenario 2, switched connections will be optimised: the routing protocols will take into consideration the parameters, like Optical Signal to Noise Ratio (OSNR), PMD, CD for multi-span transit traffic, wavelength number, bandwidth, link optical loss, delay time (fibre and NEs) etc. At present, these parameters are still to be defined. Both IETF and ITU-T are working on it. Finally, a not-to-be-neglected parameter is, of course, the number of regenerator/3R transponders required by a connection, i.e., the cost.

Conclusion

In this paper the features and benefits of an ASTN have been briefly introduced. Standardisation activities in this field have been reviewed. Finally, possible migration scenarios have been presented. Realising the ASTN will help Swisscom to save on operational cost of the transport network caused by unpredictable traffic volume increase and network complexity. However, further development and engineering are required, as the ASTN technology is still at an early stage.
In the future, further development would be a more advanced scenario or scenarios. For example, Photonic Cross-connects (PXC) could be used as the layer zero (L0) network node, the IP router and OXC or PXC could be further integrated. Even more radically, optical packet switching would also be a candidate. However, these will depend not only on the technology, but also on the market evolution. 6

Yu Wang *received her Dr. Techn. degree in Electrical Engineering from TU Vienna, Austria, in 1987. After 10 years' R&D on optical communications at Ascom Tech AG, Bern, she started in Swisscom, Fixnet, as Senior Engineer in 1998, being responsible for specification and introduction of WDM and SDH systems, and represents Swisscom at ITU-T SG15 with contributions to the Standards on optical systems and networks. She has published a number of papers in reviewed international technical journals and holds several. She is a member of IEEE ComSoc and LEOS.*

References

[1] ECOC'01 Proceedings, Volume 6, Post-deadline Papers, Amsterdam, October, 2001

[2] GMPLS, homepage: www.ietf.org/internet-drafts, IETF

[3] PNNI, homepage: www.atmforum.com/pages/library, ATM Forum

[4] ASON, ITU-T G.8080, Architecture of Automatic Switched Optical Networks, consented in October, 2001 Geneva

[5] OTN, ITU-T G.709, Network Node Interface (NNI) for the Optical Transport Network, approved in February, 2001, Geneva

Zusammenfassung

ASTN, ASON und Control Plane:
Future Oriented Transport Network Architecture

Dieser Artikel handelt von den Fortschritten, welche die ITU-T und weitere Normierungsgremien auf dem Gebiet des Automatically Switched Transport Network (ASTN) erzielt haben. Ebenso geht er auf die verschiedenen Szenarien ein, die sich für die Einführung dieses Netzes anbieten. Das ASTN wird Swisscom erlauben, die Betriebskosten, die bei einer unerwarteten Zunahme des Verkehrs-0volumens und bei wachsender Netzkomplexität unweigerlich ansteigen werden, in Grenzen zu halten. ASTN steht für Automatic Switched Transport Network. Was dieses Netz von den üblichen Transportnetzen unterscheidet ist die zusätzliche Steuerebene. Heute gibt es weltweit eine Vielzahl von Ausrüstern und Betreibern, die an dieser Technik arbeiten.

FORSCHUNG UND ENTWICKLUNG

Mikrokamera wiegt nur noch 0,3 g

Der Kampf um möglichst kleine und leichte Kameras für künftige Bildübertragung auf dem Mobilfunkgerät ist in eine neue Phase getreten: Seit Anfang Oktober verkauft Fujitsu eine CMOS-Mikrokamera, die 8 × 7 × 5 mm^3 klein ist und nur 300 mg wiegt. Sie ist CIF-kompatibel (Common Intermediate Format), liefert Farbbilder und hat eine eingebaute Kunststofflinse. Zugleich wurde der Bildsensor und der Farbprozessor auf einem einzigen Chip integriert. Bei 15 Bildwechseln pro Sekunde braucht das ganze Kameramodul nur 30 mW bei 2,8 V Versorgungsspannung. Die Bildauflösung wird mit 357 × 293 Pixel (effektiv) angegeben. Als Preis in Japan wurden 42 US-$ genannt. Die Mikrokamera ist derzeit die kleinste und leichteste der Welt.

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Mit Zähnen und Klauen

Der Überlebenskampf der Speicherchip-Industrie beschäftigt jetzt die Juristen: Die amerikanische Micron Corporation und die deutsche Infineon Technologies AG haben vor der Welthandelsorganisation Klage gegen die koreanische Hynix Semiconductors eingereicht. Den Koreanern wird vorgeworfen, mit Hilfe unfairer Staatshilfen die Preisspirale weiter nach unten zu drehen, um sich über niedrige Preise erhöhte Marktanteile zu verschaffen. Solche Wettbewerbsklagen hat es während des letzten Abschwungs schon mal gegeben: Sie zielten ebenfalls auf die koreanische Konkurrenz.

«System on Glass» für Mobilfunkgeräte

Ein erstes Farbdisplay für Handys, das die zugehörigen Treiberschaltungen als ganzes System auf dem Glasträger mit beinhaltet, hat NEC entwickelt. Die Polysilizium-Transistoren werden in einem Niedertemperaturprozess bei der Strukturierung des Displays gleich mit aufgebracht. Das helle LCD-Display bietet ultrafeine Bilder mit einer Auflösung von 230 Pixel pro Zoll (Pixeldurchmesser etwa 0,1 mm), ist 360 × 480 Pixel gross, kann 260 000 Farben darstellen und damit Standard-TV-Bilder nach CIF auflösen. Um Energie zu sparen, bietet es den Partial Display Mode an, eine Eigenschaft, bei dem für eine erste Sichtung zunächst nur 11% vom Bild angeboten werden, bis zu einer Entscheidung des Nutzers über den Vollbildmodus. In diesem Energie sparenden Mode braucht das LCD nur 1,7 mW an Leistung.

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Moleküle mit Metalldrähten

Forschern der Arizona State University ist es nach eigenen Angaben geglückt, Metallelektroden an die beiden Enden eines Kettenmoleküls anzubringen. Damit ist es erstmals möglich, reproduzierbare Messungen an molekularen Bausteinen durchzuführen. Die ersten Messungen hat man an nur 1 Nanometer kurzen «Drähten» vorgenommen. Mit dem Verfahren kommt man der Charakterisierung von elementaren Nano-Schaltelementen, wie beispielsweise Transistoren, Dioden und Logikgatter, einen grossen Schritt näher.

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