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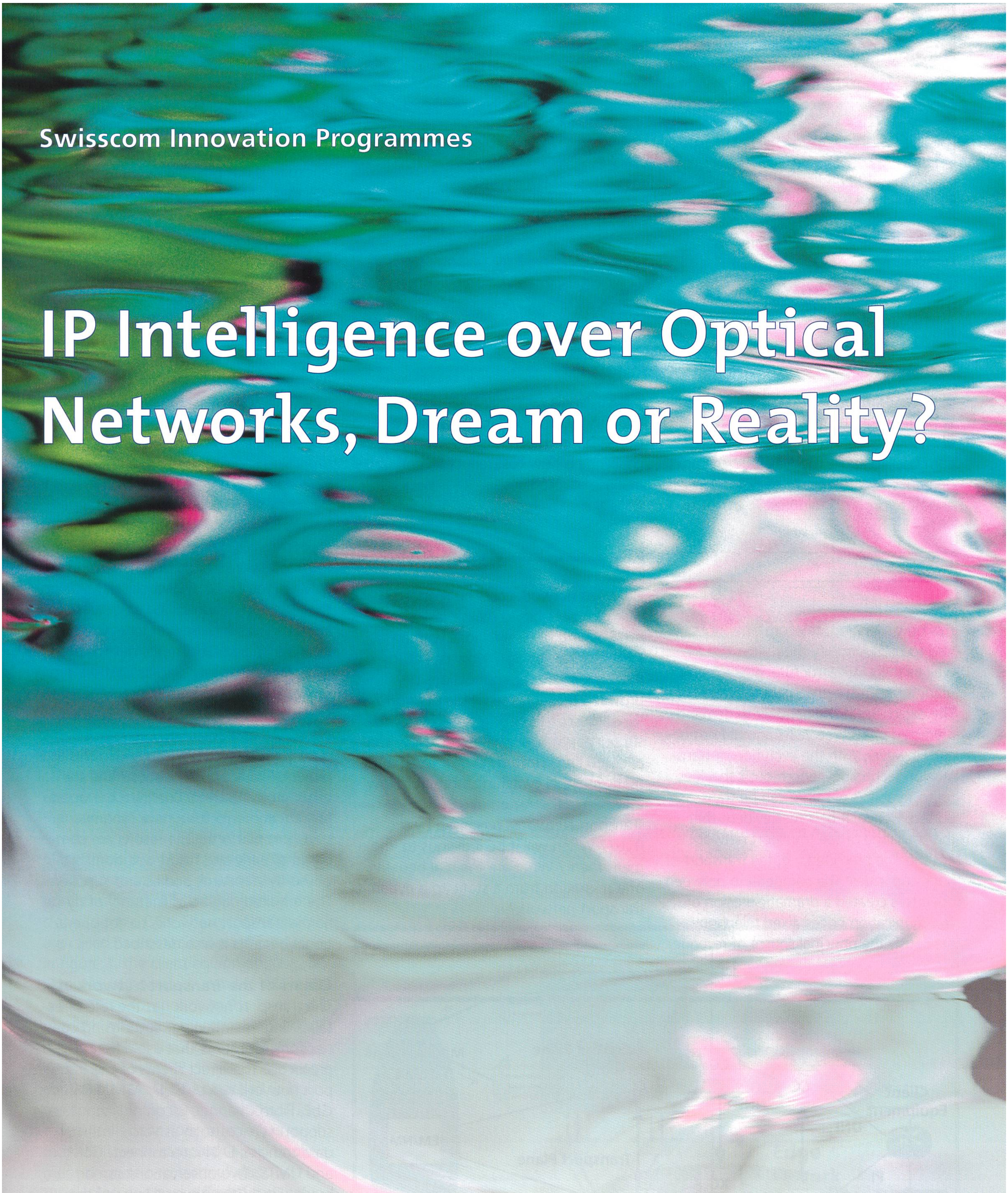
IP Intelligence over Optical Networks, Dream or Reality?



In recent years, data IP traffic showed a strong increase whereas voice traffic grew only slightly. The transport network originally optimised for voice now has to carry an important dynamic and asymmetric data traffic load. Therefore, network operators need a new transport network more adapted to data traffic. Many standardisation units, such as ITU-T, IETF, OIF and even the ATM-Forum are working on the architecture of such new transport networks.

The programme "Future Network Services" explores future network technologies enabling wired and wireless, fix and mobile broadband services. It covers the core, metropolitan and access networks and includes a multitude of access technologies such as DSL, GSM, GPRS, UMTS, WLAN or Bluetooth, and the new services that they can provide.
With its Innovation Programmes, Swisscom Innovations follows the objective of recognising early on the impact of technological developments, finding new business opportunities, promoting technical synergies, and developing concrete innovation proposals. Further, the expertise built up enables active engineering support of business innovation projects.

In less than ten years, the telecommunications industry had to face huge changes: the Internet explosion, telecom liberalisation, mobility, and the appearance of a multitude of new services and network technologies. To adapt to

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this new situation, telecom operators had to partly modify their structure as well as their infrastructure. This is particularly true for the transport network. The explosion of the bandwidth demand predicted until three years ago did not occur. However, with the evolution of transmission technology, enormous capacities up to Terabits/s per fibre can be transported. Hence, it becomes evident that the challenge of the transport network is not the one predicted, i.e. the transport of huge capacities. The competition between operators created a dramatic erosion of communication prices; fixed telephony, previously the principal source of revenue, is becoming a commodity; and data traffic, now more important than the voice traffic, brings much less revenue. The challenge is now cost reduction and optimal use of resources.

How can network costs be reduced? How is it possible to realise fast provisioning of connections with a specified bandwidth? How can automatic switching of connections be provided through the whole network? What kind of signalling is necessary to support automatic switching? How can a leased lines strategy evolve to an automatic channel switching strategy? How mature are the Automatic Switched Transport Networks proposed by the ITU-T? When will it be judicious to implement them? What are the real benefits of a migration from a static to a dynamic transport network?

Above questions sum up the chances and critical aspects of future transport networks. To give an answer to each question is not possible because technology and market are evolving. However, most of the questions point to the short and long-term evolution of transport networks.
In order to remain competitive, operators must drastically reduce the price of their networks. For a future transport network, both CAPEX (infrastructure costs) and OPEX (operational costs) must be strongly reduced. Because it will primarily transport data, the transport platform of tomorrow must be adapted to the dynamic and asymmetric IP traffic. One of the most promising candidates is the Automatic Switched Transport Network (ASTN) proposed by the ITU-T. Other standardisation bodies such as the Internet Engineering Task Force (IETF) propose the GMPLS platform that corresponds to an extension of IP-MultiProtocol Label Switching (MPLS) to the transport network.
In this article, the requirements for the new transport platform, its new opportunities, its maturity, and its cost are presented. Most of the results come from the EURESCOM project FASHION: *Flexible Automatic SwitcHed client Independent Optical Network* [1]. Within this project, Swisscom Innovations and the other project partners defined the operator requirements for a new dynamic transport platform. The results are compared to early and future solutions proposed by standards bodies and suppliers. The required degree of maturity of dynamic transport networks to get operational benefits is also described.

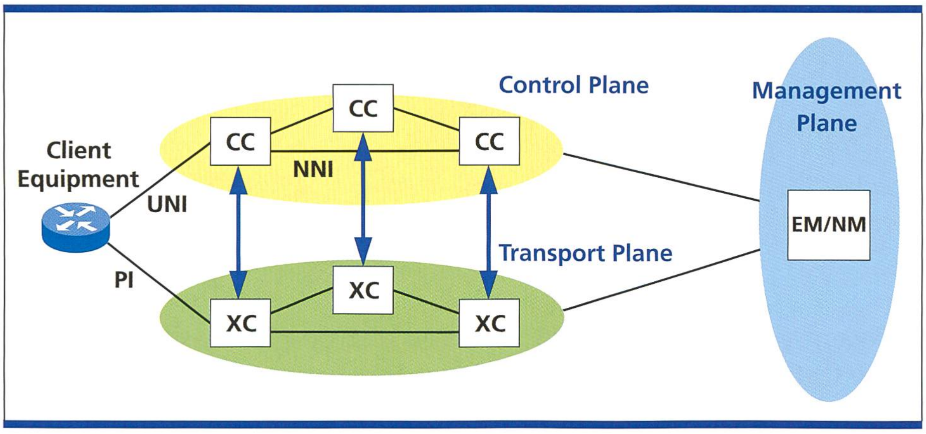

Fig. 1. ASTN model as proposed by the ITU-T with its three planes for transport, control and management. The abbreviations correspond to User Network Interface (UNI), Physical Interface (PI), Network Node Interface (NNI), Cross-Connect (XC), Cross-Connect Controller (CC), Element Manager (EM) and Network Manager (NM).

Clients of the Transport Network

The transport network has the role of establishing, maintaining, and closing connections for clients that use different protocols. The direct clients of the transport network can be SDH, ATM, POS, GbE, Fibre Channel, Escon or Ficon. They support services such as voice, Internet, data transfer, LAN interconnect, GSM, and UMTS. Two observations can be made. Firstly, the physical layer of the network is based on optics and secondly, most of the client services are or will be based on IP.
The important number of direct clients of the transport network gives the first requirement: the transport network must be *client independent*. The importance of the IP client gives the second require-

ment: the transport network must be *optimised for the IP traffic.*

The ASTN Model

To fulfil the transport network requirements of switching flexibility and fast provisioning, the ITU-T proposed the ASTN model [2]. This network model is shown in figure 1. It is made of three planes. The transport and management planes are already present in current transport networks, but the control plane (in yellow) is a new entity. The transport plane is made of Cross-Connects (XC) and fibre links between them. Each XC is directly related to the control plane through a Cross-connect Controller (CC). The control plane uses Network Node Interface (NNI) signalling to distribute the information on topology, bandwidth usage, and connection demands through the whole network. This distributive approach allows fast provisioning of connections between each XC.

To establish or tear down connections, two methods can be used. The first one is performed manually through the management plane and the control plane that distributes the information to open or close the connection. The CCs receiving the information transmit the order to the XCs. This first type of connections is called *"soft-permanent connections"*.

The second method does not need the management plane. An ASTN client can directly send the request to the control plane through a User Network Interface (UNI) shown in figure 1, and the connection is automatically established or closed via the CCs. These connections are called *"automatic connections"*.

In figure 1, the client equipment, e.g. an IP router, is separated from the ASTN network. This corresponds to the *"overlay model"*, where the client makes a connection request through the UNI. However, especially for IP clients [3, 4] a single control plane could be attached to both transport and (IP) client networks. This model, called the *"peer model"*, is much more difficult to standardise and implement because two technologies, two topologies, and two different routing and switching mechanisms must be controlled by the same entity. Furthermore, it is badly adapted to non-IP clients and to multi-operator environments. If it is certain that the overlay model will be the first implemented, the *"augmented model"* that is an enhanced overlay model could come second. For the overlay model, only the connections request is exchanged between client and transport layer. For the augmented model, further information such as bandwidth usage, local topology, and survivability information could be exchanged.

Standardisation and Signalling

Standardisation of the ASTN has been described in detail in a previous COMTEC article [3]. The first ITU-T version of the ASTN was the ASON: Automatic Switched Optical Network, where optical channels (or wavelengths) can be switched. ASTN is a generic model that is primarily defined as an SDH switched network, where VC-x connections can be set up automatically. The IETF standardises a specific type of ASTN called Generalised MPLS (GMPLS). GMPLS is an extension of the IP-MPLS protocol to drive together the IP, SDH, and optical net-

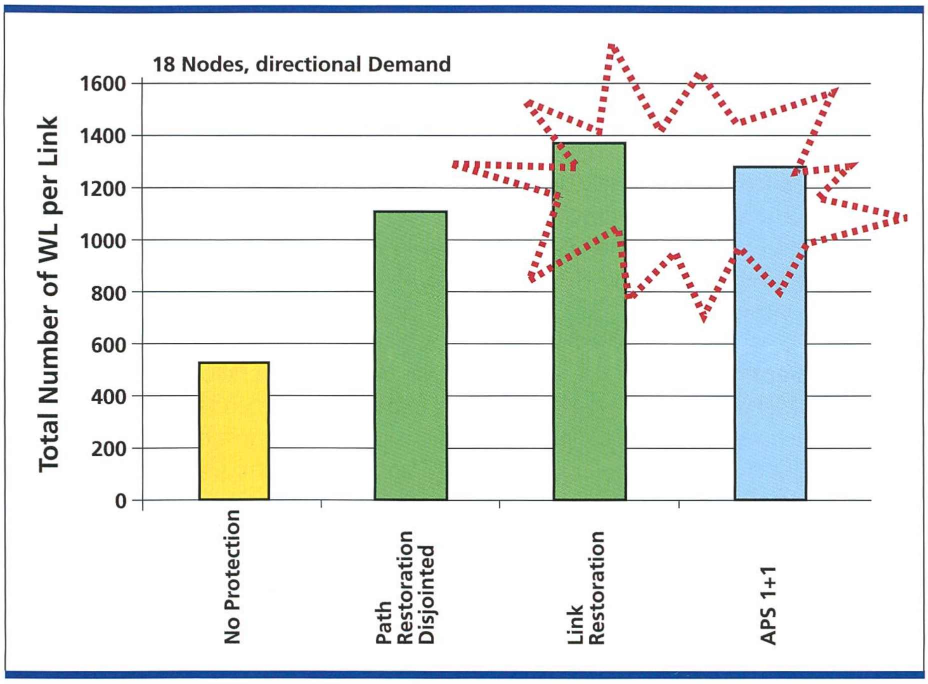

Fig. 2. Required capacity for different protection and restoration mechanisms in an 18-node weakly meshed network. The capacity is shown in number of wavelengths per fibre link.

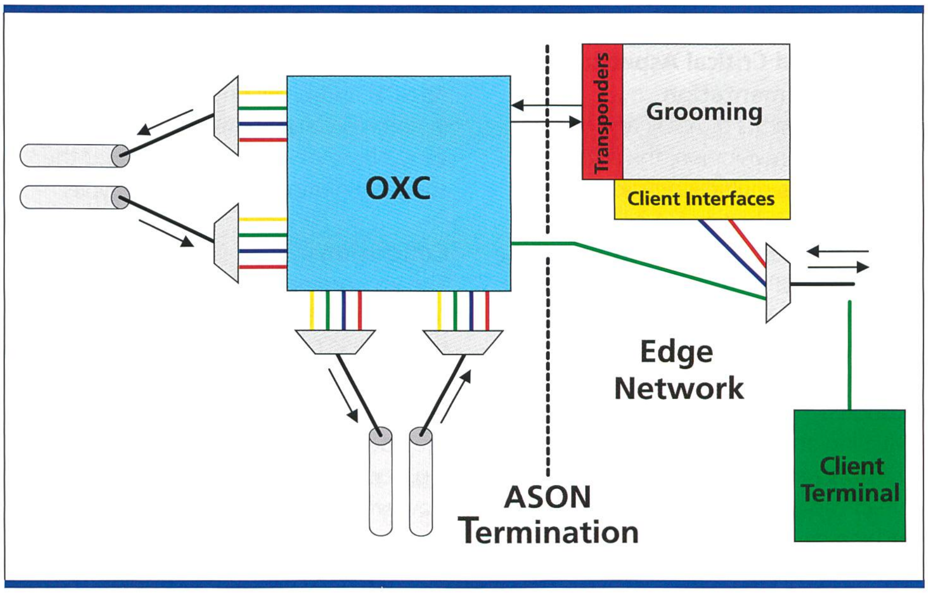

Fig. 3. One possible ASON node. It corresponds to a transparent optical node connected to the edge network through transponders, grooming and client interfaces.

Best Paper Award

The EURESCOM Project «Fashion» received the Best Paper Award at the «Networks 2002» conference in Munich last June. Swisscom Innovations is co-author of the selected paper together with France Telecom, Telecom Italia, Portugal Telecom, OTE-Greece and Matav-Hungary. The jury chose this article due to its rich content and the quality of the collaborative work. The paper called «Network Operator Perspectives on Optical Networks – Evolution towards ASON» can be found in [6].

works. It is much more precisely defined than ASTN. The signalling is described in detail in the IETF drafts [5] and OSPF routing with CR-LDP and RSVP-TE extensions are proposed [4].

Transport Services

In the FASHION project, five types of transport services have been defined for ASTN, or ASON:

1. Permanent connection established directly by the management
2. Soft permanent connection established by the management through the control plane
3. Automatic connection established by the client through the UNI and the control plane
4. VPN and optical VPN services
5. Lambda trunking for high bandwidth connections between the same end nodes

Benefits and Critical Aspects of an ASTN Implementation

The main benefits of ASTN and GMPLS are the fast provisioning, the automatic switching, the multiple protection and restoration mechanisms, a better use of the network resources, a reduction of the CAPEX and OPEX, and an easier network operation. However, some of these benefits are not straightforward. Fast provisioning (but not switching) can also be realised through a TMN management. Automatic switching and signalling permit to establish ASTN restoration mechanisms, but the gain in capacity depends strongly on the meshing degree of the network. In the FASHION project, the ASTN dimensioning has been simulated as a function of the protection mechanisms [6].

Figure 2 shows the results for an 18-node network with a small meshing degree. For a given traffic load, the required capacity is illustrated for connections with (1) no protection, (2) disjointed path restoration, (3) link restoration, and (4) 1+1 Automatic Protection Switching (APS). For this type of weakly meshed network, a 1+1 APS is optimal. The marked area in figure 2 emphasises that it even requires less capacity than a link restoration.

Many critical aspects must still be solved before ASTN or ASON implementation becomes possible. The definition of an optimal ASTN node or XC is in itself a challenge. Which part should be transparent (purely optical without opto-electronic regeneration)? Which part should be opaque (with opto-electronic regeneration)? Which part should be based on SDH? How can different protocols such as ATM, POS, GbE, Fibre Channel, Escon or Ficon be integrated on this node? How can these different channels be groomed over one VC-x or one optical channel? It is important to note that grooming represents one of the most critical features of a transport platform [7]. Figure 3 shows one possible optical node for an ASON. It is evident that this transparent optical node is particularly complex. The connection with the edge network is either optical to very important clients (in green) or is performed through transponders, TDM grooming, and client interfaces to less important clients.

The real benefit of an ASTN will only appear when a stable UNI interface allows clients to establish automatic connections through the ASTN. The UNI has been defined by the Optical Internetworking Forum (OIF) [8]. However, it is only based on SDH and is still not implemented in commercial systems. The ASTN is in its early phase of standardisation and the supplier solutions are still prototypes.

Conclusions

The very promising ASTN and GMPLS transport platforms have been studied in the EURESCOM FASHION project. Important benefits can be expected for telecom operators in reducing costs, simplifying the operation of the network and proposing new automatic bandwidth services. However, ASTN and GMPLS are still in a standardisation process and no stable solutions can be provided yet. Some important signalling aspects are not precisely defined: CR-LDP and RSVP-TE are both accepted by the standards. This could lead to a future multi-vendor incompatibility. As soon as the UNI is commercially available and the NNI signalling is defined, operators could consider a possible migration of their static transport networks to the dynamic ASTN. The FASHION project gave precious indications on the new transport services required in an ASTN. It also showed that resilience, and through that ASTN benefits strongly depend on the meshing degree of the network. 6

Jacques Robadey *studied physics at the ETH Zürich and received his Physicist Diploma in 1991. He then worked on laser physics at the Institute of Micro- and Optoelectronics at the EPFL Lausanne. He received the Ph.D. degree for his work on the fabrication and characterisation of new types of complex coupled DFB lasers. Since 1999 he has been with Swisscom AG, Innovations, where his activity focuses on optical and transport networks, and on ASTN and GMPLS. He contributed to different European EURESCOM projects in this field.*

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