Evolving All-Optical Network Management

Deregulation of the telecommunications market has created a new generation of global carriers: customer focussed; profit driven.

Customer focus requires fast response to client need while providing an ever-increasing portfolio of revenue streams such as Internet, Gigabit Ethernet and native wavelength allocation. Services must be provided on demand with 'point-and-click' capacity provisioning.

This means that today's operators must drive their assets to the limit, making effective use of legacy networks while managing the change from the pseudo-static circuit switched levels of voice traffic to the bursty nature of data traffic due to IP over WDM on tomorrow's transport network.

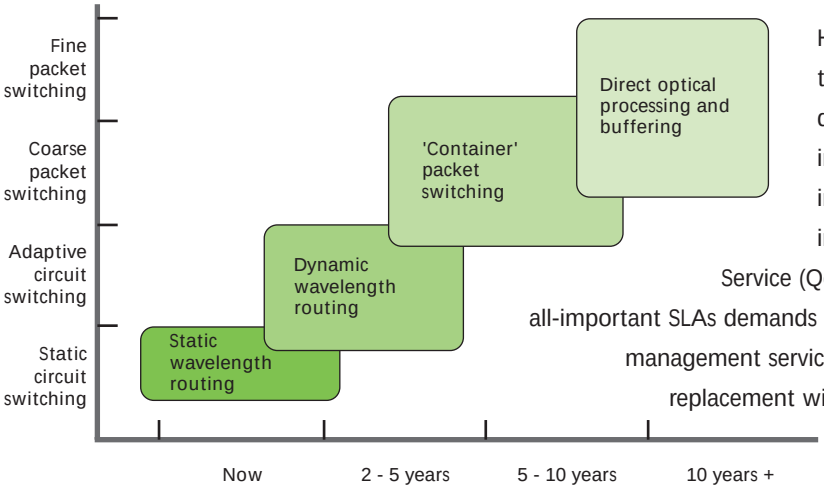


Figure 1: Optical network evolution

However, realizing the future all-optical transport network does not mean dismantling today's management infrastructure. The considerable investment made by incumbent operators in establishing and maintaining Quality of Service (QoS) standards, billing transactions and the all-important SLAs demands advances in existing network management services to meet the optical challenge, not total replacement with a new network management platform.

This white paper looks at the forces driving the evolution of the all-optical network, its shape, and how network management - built on existing TMN-compliant services - will ensure operators reap maximum benefit.

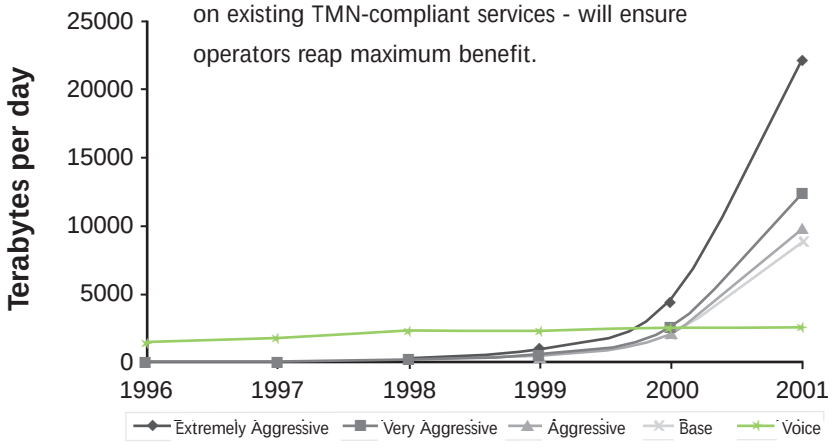


Figure 2: Traffic growth forecast
(Courtesy: Merrill Lynch)

The shape of high-capacity networks is changing.

Metro and long-haul carriers are moving towards all-optical networks to meet the almost insatiable demands for data traffic. Forecasts indicate explosive growth in data traffic driven by the rapid expansion of Internet, CATV and VPN services. This sea change in traffic is creating a dilemma for established operators: how to manage the network.

Massive research into system and component level enabling technologies - DWDM, soliton transmission, MEMS, Raman amplifiers and Bragg gratings - has opened a window of opportunity for the creation of the optical transport layer in next-generation backbone and metro networks. It is now time at look to the systems that will incorporate these components and provide the essential network management services that will make the all-optical network a reality.

Irrepressible force vs. immovable object

Worldwide demand for ever-faster, more robust internet services, including secure intranets and extranets, has put the Internet Service Providers in a powerful position to shape the new network architecture. The inherent resilience and routing capability built into Internet protocols (IP) offers the prospect of a highly flexible robust network but internet routing systems still need to drop from the optical domain into the electronic domain to route packets, constraining throughput significantly. Also, IP does not provide the foundation for billing transactions and Service Level Agreements (SLAs) built on the established QoS foundation inherent in the Telecommunications Management Network (TMN) that major carriers have in place today.

International standard TMN is entrenched within the long haul carriers as the means of establishing QoS performance figures and hence SLAs with major clients. However, as these clients become increasingly data-centric, demanding a fast, flexible approach to capacity provisioning, weaknesses in TMN are exposed. This is where the irrepressible force of exploding Internet service providers (ISPs) meets the almost immovable object - the carriers' legacy TMN-compliant networks.

Evolution to a higher plane

To reconcile this conflict as networks evolve, ilotron has designed a family of optical networking products that operate in the all-optical domain and extend TMN-compliant services to support rapid restoration and point-and-click capacity provisioning. Totally scalable with pay-as-you-grow at wavelength, fiber, through/drop ratio and smart - non-invasive detection and selective regeneration - cleanup levels, and with ITU 709 digital wrapping in all products, ilotron's network solution means operators can evolve their networks to the all-optical plane without impacting their existing TMN-compliant network management facilities.

	IP Layer	ATM Layer	SDH Layer	Optical Transport Layer
Services	E Mail Streaming Video VPN E-commerce	ATM VLAN CATV Private Lines	Private Lines Trunk	Native wavelengths
Features	Interoperability Security / VPN Support	Single format for all services Guaranteed QoS Standards based Service Level Agreements Intelligent distributed provisioning / restoration	High reliability facility transport Distributed high speed facility restoration Bandwidth management TMN compatibility	Independence of hit rate and format Potential for efficient re-arrangement of embedded capacity as demand changes

Figure 3: Services and features of IP, ATM, SDH and DWDM

Network Evolution

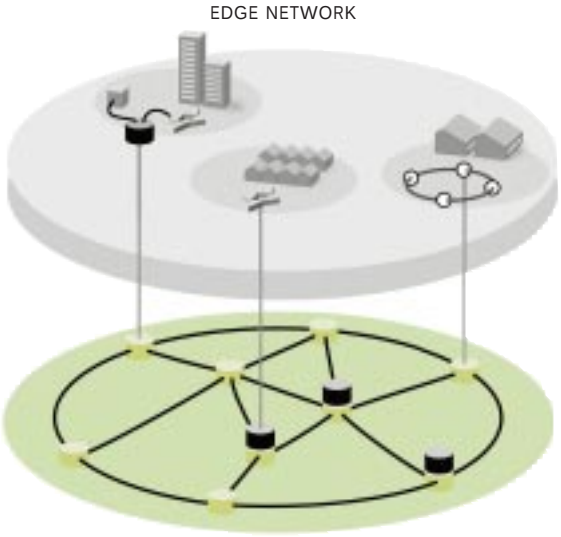
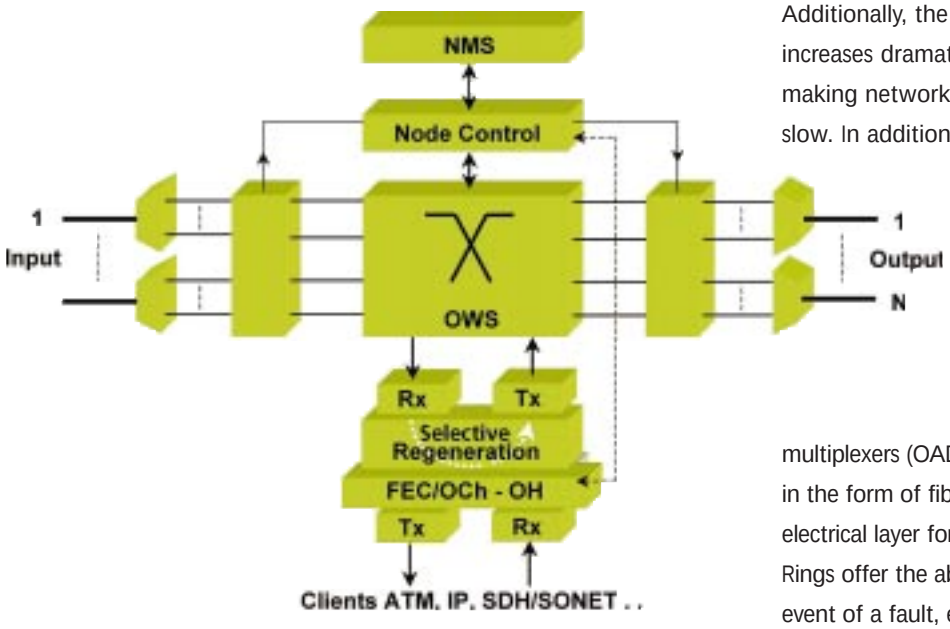


Figure 4: Network evolution

Optical fiber is the transmission medium of choice throughout the telecommunications network, from the transport backbone and eventually to fiber-to-the-home. The immediate increase in available bandwidth and reliability reduces cost/unit bandwidth, fuelling demand for ever more capacity. Initial steps in increasing capacity saw the introduction of Wavelength Division Multiplexing - and then Dense Wavelength Division Multiplexing (DWDM) - enabling many times the current volume to be carried on the same fiber. This supercharged the electrical transport layer and opened the way for operators to market individual frequencies to major clients.

Conventional electrical cross connects route traffic by converting data streams from the optical layer to the electrical layer, extracting the necessary information and then passing to the designated tributary or, by regenerating back into the optical layer, re-routing onto the appropriate circuit. Performance constraints in electronics mean this technique has significant limitations, squeezing throughput at switching and grooming points. Additionally, the amount of electronics required increases dramatically with the number of channels, making network growth very expensive - and hence slow. In addition, operators have traditionally surrounded network elements with costly transponders to enable interoperabilty.

Figure 5: Optical wavelength switch



A true photonic layer...

More recently, the availability of rudimentary optical add/drop multiplexers (OADMs) has facilitated a photonic layer in the form of fiber rings with no return to the electrical layer for routing or regeneration purposes. Rings offer the ability to rapidly recover routing in the event of a fault, enabling operators to maintain QoS

objectives. However, the influence of Internet infrastructure architecture has caused operators to reconsider mesh structures as a means of creating network resilience. Mesh structures call for optical cross connects (OXCs) rather than the use of back-to-back OADMs to create cross connect functionality.

Development of true photonic switching now makes genuine OXCs feasible, allowing operators to create optical superhighways and so market IP, ATM, SONET/SDH services, or raw capacity in the form of native wavelengths. This all-photonic layer, with cross connect throughputs up to a Petabit, will be completely transparent to the client.

... with many edges

An immediate consequence of true photonic switching and routing is the migration of other services - SONET/SDH, IP, ATM - to the edge of the network where islands of lower speed transport and grooming occur. It is at the network edge where the opportunities for high revenue voice and data services exist. Data-centric services such as IP and ATM require framing to carry these services across the new all-optical network; the ITU 709 digital wrapper - standard in all ilotron products - is rapidly becoming the framing technology of choice.

As data traffic overwhelms voice traffic volumes, so the characteristics of the overall traffic changes. At the edge of voice-centric networks, traffic is no longer pseudo-static but now exhibits an asymmetric and bursty nature. Although smoothed out naturally as it is carried towards the backbone, the levels of bursty/asymmetric traffic are likely to increase substantially over the next few years, creating the need for service providers - particularly ISPs - to want to provision facilities directly on to the transport network to meet uneven demand. Similarly, CATV content providers will require additional capacity to deliver pay-on-demand services over the network.

However, realizing the future all-optical transport network must not mean dismantling today's infrastructure, particularly the proven investment in TMN, the cornerstone of QoS standards, billing transactions and the all-important SLAs. IP, ATM, SONET/SDH and CATV all contribute important services to structuring tomorrow's network management.

Protocol cherry-picking

SONET/SDH provides the basis for big revenue earning services such as frame relay and leased line, the underlying transport layer of many global intranets and extranets. Today's TMN concepts have been developed in parallel with SONET/SDH standards, creating a solid foundation for today as well as providing much of the functionality required for managing the future all-optical network.

IP is a very powerful protocol, offering exceptional levels of interoperability and ubiquity but it does not provide support for SLAs, billing transactions, QoS and general network management. Furthermore, IP does not support high volume applications such as CATV, nor - despite much hype - high revenue voice services (VoIP) at a quality equal to today's terrestrial services.

The introduction of ATM as an intermediate layer rectified some of these deficiencies. ATM appears to be the technology of choice of the CATV industry and - since the CATV industry is likely to become the content provider of choice, displacing ISPs and terrestrial voice service providers - this creates a legacy constraint that cannot be ignored.

Managing the all-optical network

Operators rely on their TMN-compliant network management investment to meet the exacting SLAs imposed on them by clients. The logical layering of the SONET/SDH electrical transport network laid the groundwork for interconnectivity across heterogeneous systems, creating today's international networks. It is only as a result of TMN through SONET/SDH that operators are today able to achieve QoS targets, service monitoring, SLAs and bandwidth provisioning - and have a suitable structure for the all-important billing transactions.

Existing TMN infrastructure does what it does well; however, it does suffer from two major deficiencies: fast circuit restoration and rapid provisioning and breakdown of services to clients. MPLS (Multi-protocol label switching), developed within the Internet community to carry IP over the ISP domain, does not suffer from these deficiencies; but is it logical to replace proven TMN with a completely new system?

Whither MPLS?

MPLS is synonymous with backbone packet switching and current realizations still resort to the electrical layer to achieve this objective. This is not desirable from performance or cost/unit bandwidth perspectives.
To realize network efficiency and enable operators to provision high bit-rate bursty traffic, the optimum intermediate solution is a hybrid optical cross-connect/packet switch node. ilotron will introduce optical packet switch (OPS) functionality into their OXC nodes, allowing operators to mix the ratio of circuit and bursty traffic according to local needs. Packets will be 'containerized' rather than bit-by-bit switched to sustain traffic efficiency; fine packet switching is not needed to realize full network efficiency. This will be the preferred solution for metro and long haul operators as it offers the lowest cost and highest bandwidth solution while maintaining complete TMN-compliant network management.

It is clearly beneficial to simplify metro and long haul transport but not at the expense of network management and all that it implies: SLAs, billing transactions, QoS, etc. Management functionality

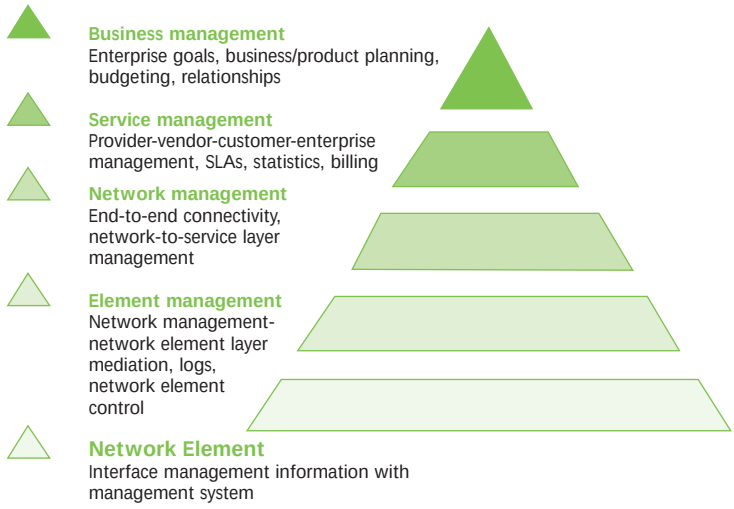


Figure 6: The TMN pyramid

distributed across all network elements - the lowest level of the TMN pyramid - is the key to fast restoration and provisioning. By providing OADMs and OXCs with the required Q interface and SNMP capability - and the planned CORBA interface - the optical layer gains fast protection and provisioning as well as full integration into the legacy TMN structure. As SONET/SDH and ATM retire to the edge of the transport network - and optical-based packet switching is introduced - operators benefit from the seamless migration of network management.

The ilotron approach

ilotron's approach to network management allows operators to grow their networks gracefully, providing point-and-click provisioning where appropriate without compromising their existing TMN facilities. OXCs provide optical superhighway circuit switching and enable operators to supply IP/ATM and SONET/SDH services and native wavelengths to clients. As networks scale, ilotron's unique 'clean up' feature optimizes the use of transponders on a needs-driven basis. Hybrid OXC/OPS nodes allow operators to accept more bursty traffic on a pay-as-you-grow basis.

Ilotron is carrying out field trials of its OXC and OPS products throughout 2000/2001 to prove both the technology and network management approach, and to demonstrate that its products offers the lowest cost/highest added-value solution.

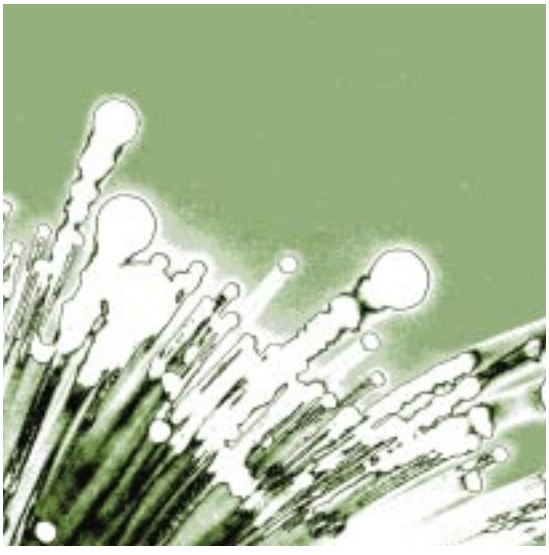
ilotron

ilotron, headquartered in West Malling, UK., develops and markets optical wavelength and packet switches for the evolving data-centric optical transport network. ilotron exploits leading-edge all-optical technologies to provide scalable, carrier-grade, manageable transport solutions for service providers to fundamentally change the cost and speed of provisioning high bandwidth wavelength services.

By specializing in network simplification, ilotron helps carriers:

- *scale their networks to meet the huge growth in data/IP traffic*
- *reduce operating and capital expenditure to cope with collapsing bandwidth prices*
- *offer superior customer service through efficient network management*
- *provide turnkey network management solutions - TMN, MPLS*
- *increase profitability*
- *win new business while maintaining working relationships with existing customers*
- *minimize network layers*
- *conserve floor space and power consumption*
- *lower lifetime ownership costs with shortening product lifecycles*

Experts predict that photonic network transport technology will blow away the bandwidth bottleneck, eliminating delays and creating simpler, faster connectivity. As incumbent suppliers adopt these new technologies, ilotron's optical solutions satisfy the requirements of legacy and evolving network environments, turning this vision into reality.



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