DEVELOPMENTS IN OPTICAL SEAMLESS NETWORKS
Invited paper

Andrea Spaccapietra[1],Giovanni Razzetta[2]
[1]*VicePresident Optical Core Networks, Marconi Corporation,*
New Century Park, Coventry, West Midlands, CV3 1HJ,United Kingdom,
andrea.spaccapietra@marconi.com
[2]*Photonics System Design Manager, Marconi Communications,*
Via A. Negrone 1A, 16153 Genova, Italy
giovanni.razzetta@marconi.com

Abstract: This paper give a view on key technologies that are emerging as the enabler for evolving Core Transport Network towards the delivery of the customer experience expected by the service users community. Optical technologies will be dealt with first, explaining how they are fitting in the medium and long term evolution of commercial optical transmission systems. Hardware and software technologies involved in the shift toward data centric services are addressed, identifying the path to a full integrated transport and switching core network, with the ultimate objective of maximizing the user benefits and reducing cost.

1. INTRODUCTION

National incumbents, large fixed line second operators and some key Mobile operators have spent significant time and Capital building large, highly reliable, resilient, carrier-class Networks to support Voice and leased lines services. This had been a stable business model for well over a decade, with the largest challenge being how to scale.

As we know the existing model is being challenged. It is anticipated that the revenue our customers will generate from traditional voice services will be flat at best, with growth expected to come from the provision of new broadband data services (i.e. triple play: voice, data and video).

Residential broadband services typically consume 10 times the bandwidth of narrowband users, but are offered at no more than twice the existing narrowband subscription rates. Equally the increasing requirement for Enterprise businesses to store, protect and retrieve information and records is doubling data traffic in the Wide area every two years.

Broadband services dramatically increase capacity demands on the network but do not return a proportional increases in revenue. Therefore network operators need to substantially reduce network operational costs, provide capacity at much lower cost per bit and deliver new revenue generating services.

In the following the enabling technologies for achieving such objectives are illustrated and placed in the context of new generation core transport network, delivering seamless services to network operators and their customers.

1.1 Optical seamless network

Optical Seamless network is a key component in building service infrastructures that deliver a delighting customer experience, innovative products, rapid time to market for new services and transform the cost base for the network. An example can be found in Figure 1.

The goal of the service infrastructure is to provide a "simple and complete" communications service to customers, regardless of time or place.

The pillars of this network vision are:

- an high performance, integrated, cost effective transport infrastructure, evolving from current transport networks;
- new platforms for services based on the delivery of content and applications, supporting both multi-media and mobile services;
- OSS increasingly becoming part of the service, and ultimately converging with the network intelligence components;
- standards to define the architecture components.

The optical seamless network is a rationalized optical transport enabling an ultra broadband data network. Access networks will be converging onto a multi-service platform.

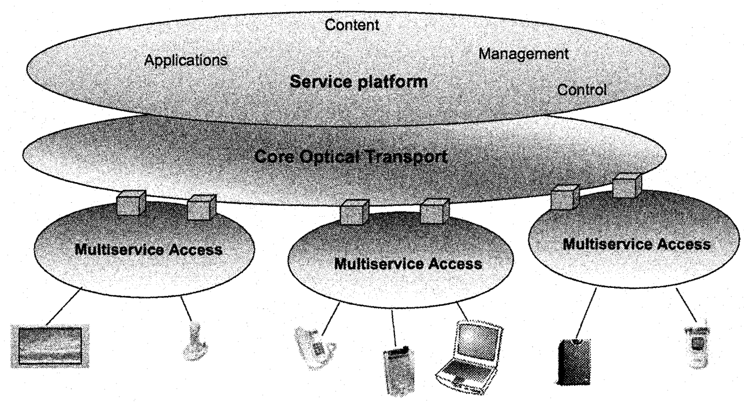

Figure 1- Service network architecture

2. THE REQUIREMENTS FOR THE OPTICAL SEAMLESS NETWORK

After positioning the Optical Seamless network in the bigger picture of overall service network, we need to identify the requirements that service objectives set to the transport network and how they can be best addressed using emerging technologies. Requirements can be better understood if the transport network is logically divided into a data plane and a control plane. From the technological point of view the data plane can be further divided into three technology layers: the optical plane, the electrical plane and the data plane in strict sense (i.e. packet/cell based).

Key requirements and related technologies for the optical plane enabling the seamless operation can be identified in transparent bypass of wavelengths (OXC, ROADM, EDFA and Raman amplifiers) and compatibility with existing fibre plant (dispersion resistant modulation schemes for combined 40Gbit/s/10Gbit/s transport).

Emerging technologies for the electrical plane ready for a massive roll-out in the electrical plane are integration of SDH and wavelength (ODU) switching, standards compliant mapping of data into transport frames (GFP/LCAS/VCAT).

The data plane will be initially provided by separated plug-in cards and ultimately a protocol agnostic transport switching can allow further integration with the electrical plane.

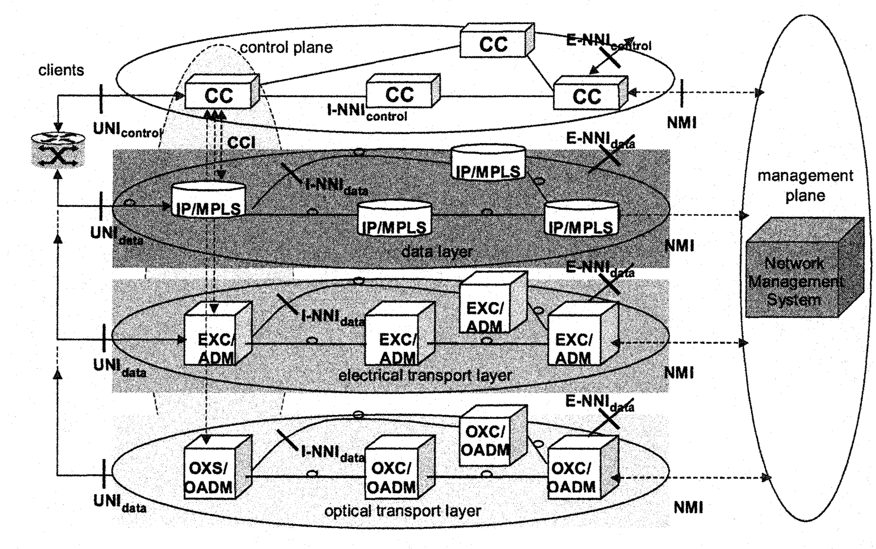

Figure 1 – Network planes

The control of the network will progressively migrate from centralized operation support systems or network management system to a distributed control plane (the same way large data networks are managed today), although functions like Alarm Supervision, Performance Monitoring and Inventory will remain under the TMN domain.

A common control scheme for data and transport simplifies operational processes and ease the convergence of data and transport.

2.1 Optical plane

After the massive investment in the "Holy Grail" of optical technologies during the years of the "Telecom bubble", we are now in a situation where components suppliers are bringing selected optical technologies to the marketplace for being usefully utilized in the design of optical system. The economical benefit of the so called "optical bypass " is now recognized in the transmission community and a number of component and system technologies are available. Some of them are well established, such as dynamic power management, dispersion management, error correction, some of them are being developed and will become common in the near future, such as electrical distortion compensation (EDC), innovative modulation formats and sophisticated methods for optical performance monitoring & fault localization. All of these ingredients are preparing current transmission infrastructure for scaling towards high channel bit-rates (i.e. 40G), that has already been experimented in the field, both in Europe and US.

All the above needs to be achieved through a "platform concept", in order to deliver inexpensive unlimited bandwidth with the maximum flexibility. For example a single common chassis type that has multi function slots that can accommodate the relevant transponders, amplifiers or optical switching unit.

2.2 Electrical plane

If we look at today SDH layer of a Core transmission network we can see that we have a potential like for like element replacement of 16:1 or greater. The high capacity OCS nodes can consolidate multiple 1st generation ADM Elements into one element. This results in considerable infrastructure savings with the associated benefits this brings. This allows significant improvements to be made at all levels of a core implementation. It also allows simplification of potential co-located elements which are interconnecting to other Access rings bringing operational and real estate benefits.

Moving to the layer above SDH we can see savings gained through integration between layers of the core Network. The recently standardized Optical Transport Network frame structure (OTN/ODU) is now integrated in optical cross-connects, that now can handle wavelength bandwidth granularity.

Along with the evolution toward larger granularity and massive integration, the capability of handling data streams by simply mapping them in transport structure is now being deployed. Bandwidth optimisation through aggregation and dynamic bandwidth allocation enhance the competitiveness of the solutions with respect to pure data networks. This identifies a definite trend for transport networks to encompass layer 2 and even layer 3 functionalities, but with the carrier class availability performance that transport network only can deliver.

This provides a base architecture that can adapt to accommodate any service mix.

2.3 Control Plane

The "Seamless' attribute of new generation transport network is associated with an increased level of intelligence that is inherent within the network elements and is realised via the implementation of an ASTN/GMPLS control plane, which simplifies network operation and optimises network resources.

Via the neighbour discovery function newly added network elements and nodes are automatically recognised by the network. The additional capacity and route diversity becomes automatically part of the network resource pool and can immediately be used. Long and cumbersome manual configuration processes belong to the past. The end user can requested new services directly via the standardised user-network-interface (UNI). The network automatically finds the best and least expensive route through the mesh and protects it according to the selected grade of service. New services are provisioned at a fraction of the time and cost compared to today's manual processes. Additional flexibility can be offered to the end-user, optical virtual private networks (OVPN) become a compelling reality.

Mesh based restoration schemes increase the resilience of the network against any type of failure. Therefore new survivability schemes can be offered in addition to the well-known SDH/OTN protection mechanisms and guaranteeing comparable switching time.

2.4 The convergence of data and transport

The reality of an optical layer capable of dynamic provisioning and restoration of optical circuits offers the opportunity for an architecture where a reconfigurable SDH/OTN network delivers connectivity to the nodes of a packet backbone. The reconfigurable optical layer can be shared among other service networks such as ATM, Frame Relay or leased lines.

User to Network Interface between IP and transport systems is standardised and interoperability between the two has been demonstrated and tested. IP over transport network approach is key to guarantee the scalability of the switched optical backbones and the cost-effectiveness of this approach has been demonstrated by network modelling studies.

The final convergence step will be represented by a unique Core Node where the Core Data functionality (IP/MPLS) is fully integrated inside the Transport Node. As mentioned before the availability of protocol agnostic switching fabrics will surely enable this evolution

3. CONCLUSIONS

Optical Seamless network developments are based around four key elements which combine to deliver against the requirements outlined

- Integration
- Flexibility
- Intelligence
- Standardisation.

The consolidated of network elements by increasing switching capacity and vertical layer integration, simplifies the network and improve the efficiency of the core network, enabling simpler operation due to fewer elements.

The flexibility of a single platform, Multi-application, next generation solution also simplifies the core network, significantly reducing the operational expenditure due to reduced Maintenance, powers, space, spares and training. Modular & Scalable platforms enables the network to scale with traffic requirements whilst also ensuring low first in cost.

Through implementation of intelligent switching and software mechanisms, the implementation of products with "change aware" hardware enables Dynamic TMN capabilities to the network allowing on the fly provisioning of services and restoration. This dynamic network environment can be utilised for creating competitive advantage by introducing new enhanced differentiated dynamic services.

Open interfaces conformant to the standards developed by the telecom industry ensure inter-operability between different layer networks and between different vendors equipment in the same layer.

By the evolution path outline, significant and measurable benefits of the optical seamless network are realised.

ACKNOWLEDGMENTS

The authors wish to thank the technology strategy team of Marconi for the useful discussions and for their encouragement and support.

REFERENCES

[1] Stefan Bodamer, Jan Späth and Christoph Glingener: "Impact of traffic behaviour on the planning of multi-layer transport networks." OFC 2004
[2] Stefan Bodamer, Jan Späth, Ken Guild, Christoph Glingener: "Is dynamic optical switching really efficient in Multi-Layer Transport Networks?." ECOC 2003
[3] Jan Späth: "Impact of traffic behaviours on the performance of dynamic WDM transport networks." ECOC 2002
[4] L. Blair et al.: "Impact of switch node architecture upon capacity efficiency in Williams North American network." ECOC 2002.
[5] Sudipta Sengupta, Vijay Kumar, Debanjan Saha: "Switched Optical Backbone for Cost-Effective Scalable Core IP Networks." IEEE Communications Magazine, June 2003
[6] Agostino Damele, Andrea Spaccapietra: "Telecom Network Architecture: Multi-Layer Switching Solution." FITCE 2002
[7] Joerg-Peter Elbers: "High-capacity DWDM/ETDM transmission." OFC 2002
[8] L.M. Gleeson, M.F. Stephens, P. Harper, A.R. Pratt, W. Forysiak, D.S. Govan, B.K. Nayar, I.D. Phillips, B. Charbonnier, M.D. Baggott, H.S. Sidhu,

I.E.Tilford, P.M. Greig: "40×10.7 Gb/s meshed ULH network with remotely managed all-optical cross connects and add-drop multiplexing." ECOC2003
[9] Stefan Herbst, Heinrich Lücken, Cornelius Fürst, Silvia Merialdo, Jörg-Peter Elbers, Christoph Glingener: "Routing criterion for XPM limited transmission in transparent optical networks." ECOE 2003.
[10] Silvia Merialdo, Jörg-Peter Elbers, Cornelius Fürst, Stefan Herbst, Christoph Glingener: "Path tolerant dispersion management for transport optical networks." ECOC 2003
[11] Helmut Griesser, Joerg–Peter Elbers, Christoph Glingener: "A generalised concatenated error correcting code for optical fibre transmission." ECOC 2003
[12] Cornelius Fürst, Roman Hartung, Jörg-Peter Elbers, Christoph Glingener: "Impact of spectral hole burning and Raman effect in transparent optical networks." ECOC 2003
[13] G. L. Jones, W. Forysiak, J. H. B. Nijhof : "Economic benefits of all-optical cross connects and multi-haul DWDM systems for European national networks." OFC 2004
[14] A. R. Pratt, P. Harper, S. B. Alleston, P. Bontemps, B. Charbonnier, W. Forysiak, L. Gleeson, D. S. Govan, G. L. Jones,
[15] D. Nesset, J. H. B. Nijhof, I. D. Phillips, M. F. C. Stephens, A. P. Walsh, T. Widdowson and N. J. Doran: "5,745 km DWDM transcontinental field trial using 10 Gbit/s dispersion managed solitons and dynamic gain equalization." OFC 2003
[16] A. R. Pratt, B. Charbonnier, P. Harper, D. Nesset, B. K. Nayar and N. J. Doran: "40 x 10.7 Gbit/s DWDM transmission over a meshed ULH network with dynamically re-configurable optical cross connects." OFC 2003