White Paper

Breaking the physical barriers with electronic Dynamically Compensating Optics (eDCO)

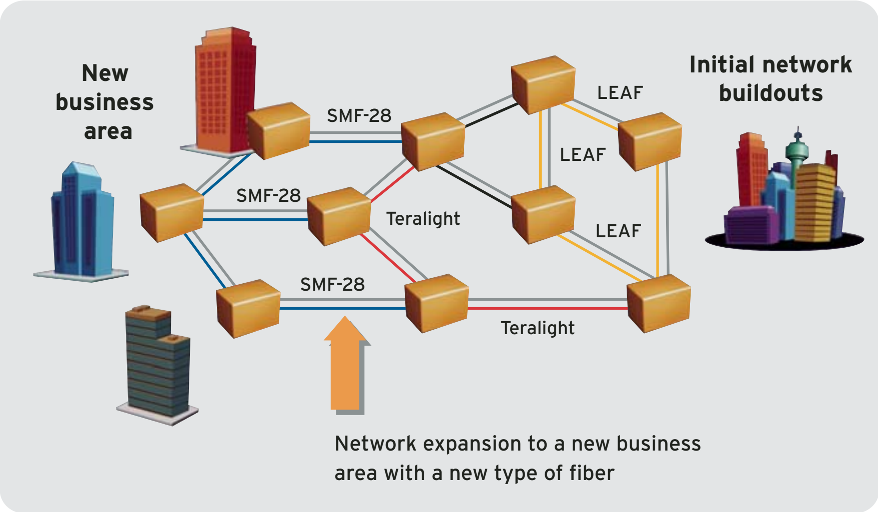
Introduction

Business and residential broadband services are without a doubt fueling service providers' and cable operators' positive momentum. However, their deployment requires the implementation of emerging technologies (such as Passive Optical Networks, ultra high-speed Digital Subscriber Line (DSL), Resilient Packet Ring, etc.) and the use of multiple network topologies to meet subscribers' (residential or business) expectations to access 'on demand' content at any time and from anywhere. Many of these new services, such as video on demand (VOD), VoIP, content sharing, etc., on top of their stringent requirements for a high level of quality of service, are difficult to forecast in terms of bandwidth demand and traffic routing patterns. As a result, traffic patterns are becoming diversified and unpredictable, thus creating a new operational challenge for service providers and cable operators to effectively forecast bandwidth requirements at the numerous sites spread across the network.

Furthermore, the intense competition between the various types of service providers is dictating a higher level of flexibility, faster service turn-up and most importantly, new service economics. The network delivering these broadband services must be agile and adaptive to the ever-changing business factors (e.g., expansion of served areas, introduction of new services, etc.).

Today's network consists of a mix of new and old build-outs (Figure 1), where wavelengths travel across different distances and sometimes over different fiber types from source to destination. Therefore, service providers use bulk optical dispersion compensation to ensure maximum signal integrity. However, this method (bulk optical dispersion compensation) significantly reduces network flexibility as modifying and expanding the network become extremely complex tasks, thus slowing down service providers' and cable operators' deployment of broadband and other emerging services.

Figure 1. A typical network consists of many fiber types



The disadvantages of bulk Dispersion Compensation Modules (DCMs) can be summarized in the following bullets:

- Fixed dispersion maps must be used, therefore service providers and cable operators must pre-plan the ultimate network length and topology, forecast where OADM sites will occur, select DCM values individually for each span and re-engineer after repairs or rerouting. Furthermore, a network with fixed dispersion maps can hardly evolve to support next–generation photonic switching capabilities such as enhanced Reconfigurable Optical Add/Drop Multiplexers (eROADMs).
- Additional amplification is required to compensate the link budget loss caused by bulk DCM. This will require two line amplifier stages (instead of one), capital expenditure, and significant real estate and power consumption, thus increasing the network complexity and creating new failure points.

The next paragraph describes a new disruptive technology that solves all the issues related to bulk DCM while setting the network on the evolution path towards adaptive, all-optical intelligent networking.

Electronic Dynamically Compensating Optics

Electronic Dynamically Compensating Optics (eDCO) is a breakthrough technology that provides pre-compensation of each wavelength before its transmission, thus enabling service providers and cable operators to deploy systems that span in excess of 2000 kms while eliminating the need for in-line DSCMs (Dispersion Slope Compensation Modules) and their associated additional amplification requirements.

How does eDCO work?

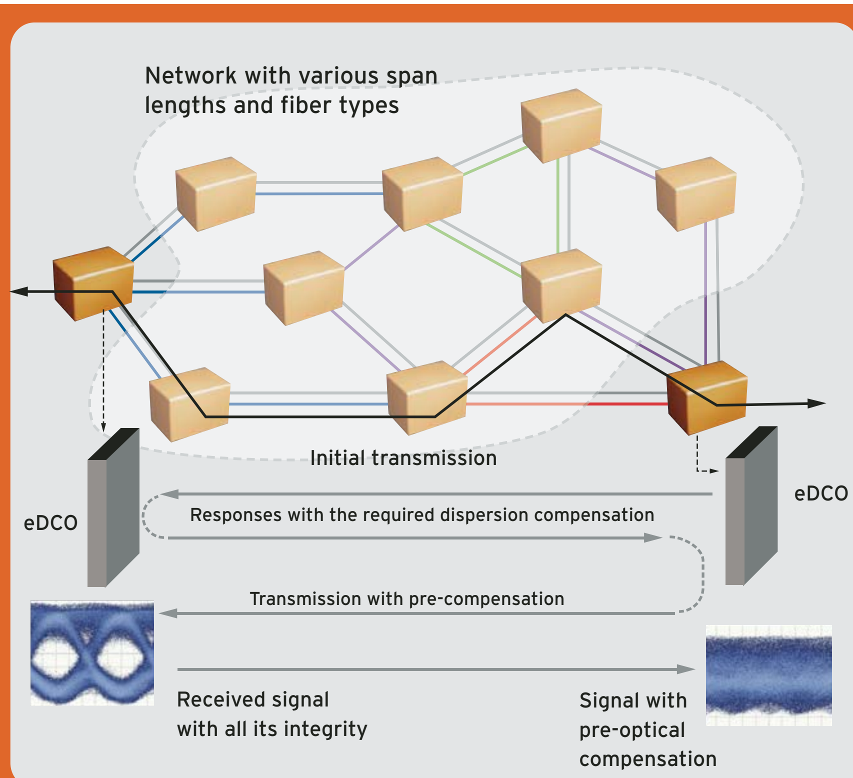
During initial system setup, a dispersion scan is invoked in order to determine the amount of dispersion to be applied by the transmitter. The eDCO encapsulates the aggregated traffic into standards-based G.709 OTU-2 frames, in which special feedback messages are inserted in the overhead. At the other end, the eDCO receiver translates these messages and adjusts the appropriate transmitter. Once the dispersion scan is complete, optimization takes place such that the pre-FEC errors are minimized. Figure 2 describes briefly how eDCO communicates to determine the required compensation dispersion for every wavelength.

Figure 2. A brief description on how eDCO operates

Step 1: The eDCO transmitter sends special messages in the G.709 frames.

Step 2: The eDCO receiver at the far end translates these messages and adjusts the appropriate transmitter with pre-compensated signal.

Step 3: Once the dispersion compensation has been determined, transmitters at each end pre-compensate the signal to establish flawless broadband connectivity over 2000 Km without any DCMs and their associated amplifiers.



Example

The scenario

A service provider is planning to extend its offering of broadband and triple play services into a new territory. However, the available fiber outlay providing connectivity to the new territory is a mix of various old and new fiber types (LEAF, LS-DSF, SMF-28, etc.) as depicted in Figure 3.

The challenge

To extend the offer of broadband and triple play services while addressing the following business and operational requirements:

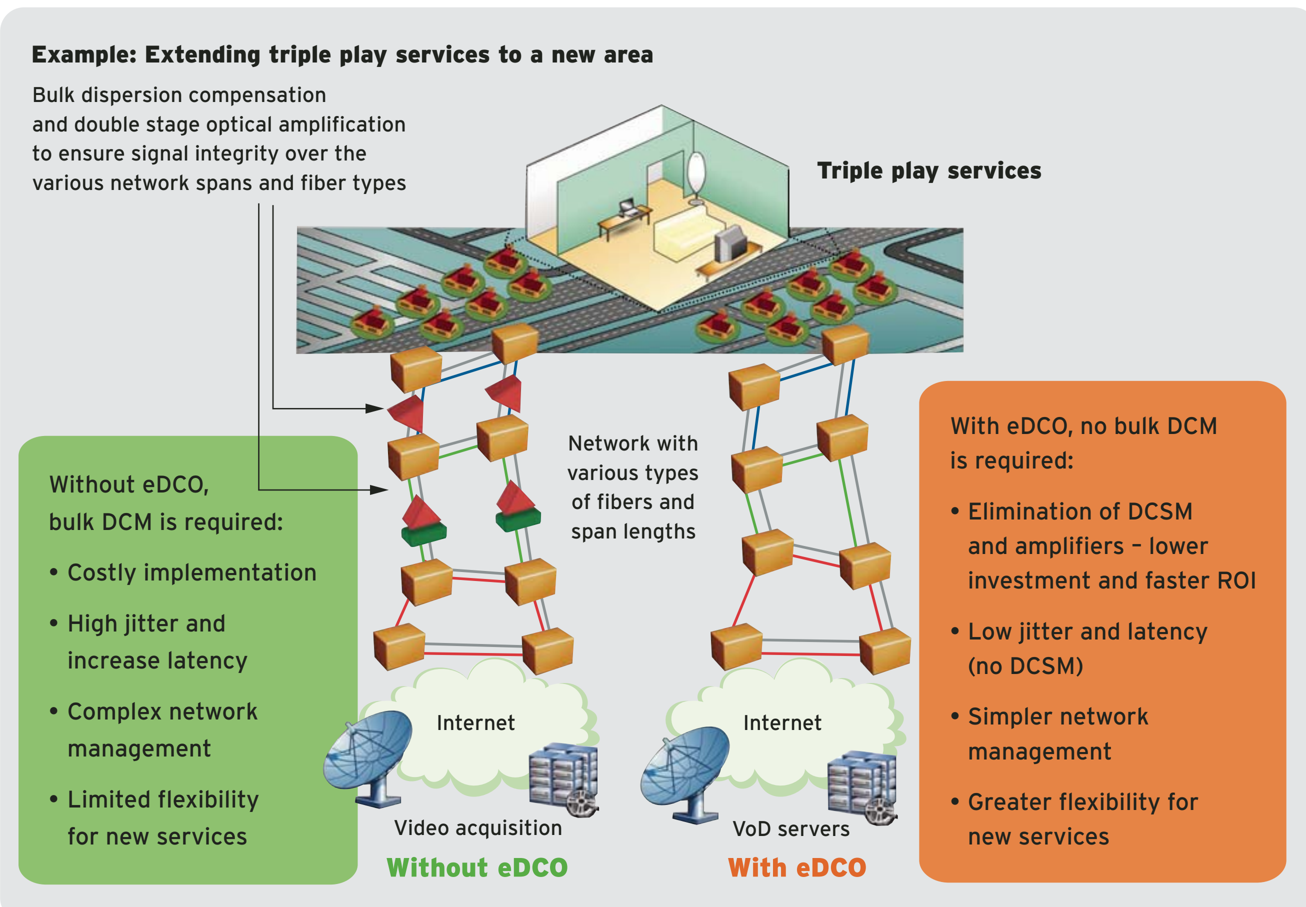
- Ensure a minimum capital expenditure for faster return on investment (ROI)
- Maintain service integrity even during network changes as triple play services (e.g. IPTV, VoIP) have stringent quality requirements (low jitter and latency, etc.)
- Avoid at any cost increasing network complexity
- Provide future-proofness for emerging services
- Ensure seamless network and service scalability

The solution

Prior to the introduction of eDCO technology, the service provider had no option other than to implement bulk dispersion compensating modules to provide wavelength connectivity to the remote territory, which results in an extensive capital investment, significant increase in network complexity and limited network agility for future services.

The disruptive technology of eDCO is the solution. The service provider can extend the service offering to the new territory despite the mixture of various fiber types without the need of DCM

Figure 3. Service extension with eDCO



and their associated amplifiers, thus allowing the service provider to reduce capital investment and accelerate ROI. Furthermore, the elimination of DCM removes a major source of jitter and latency. The following paragraph describes how eDCO meets and exceeds the service provider's business and operational requirements:

The benefits

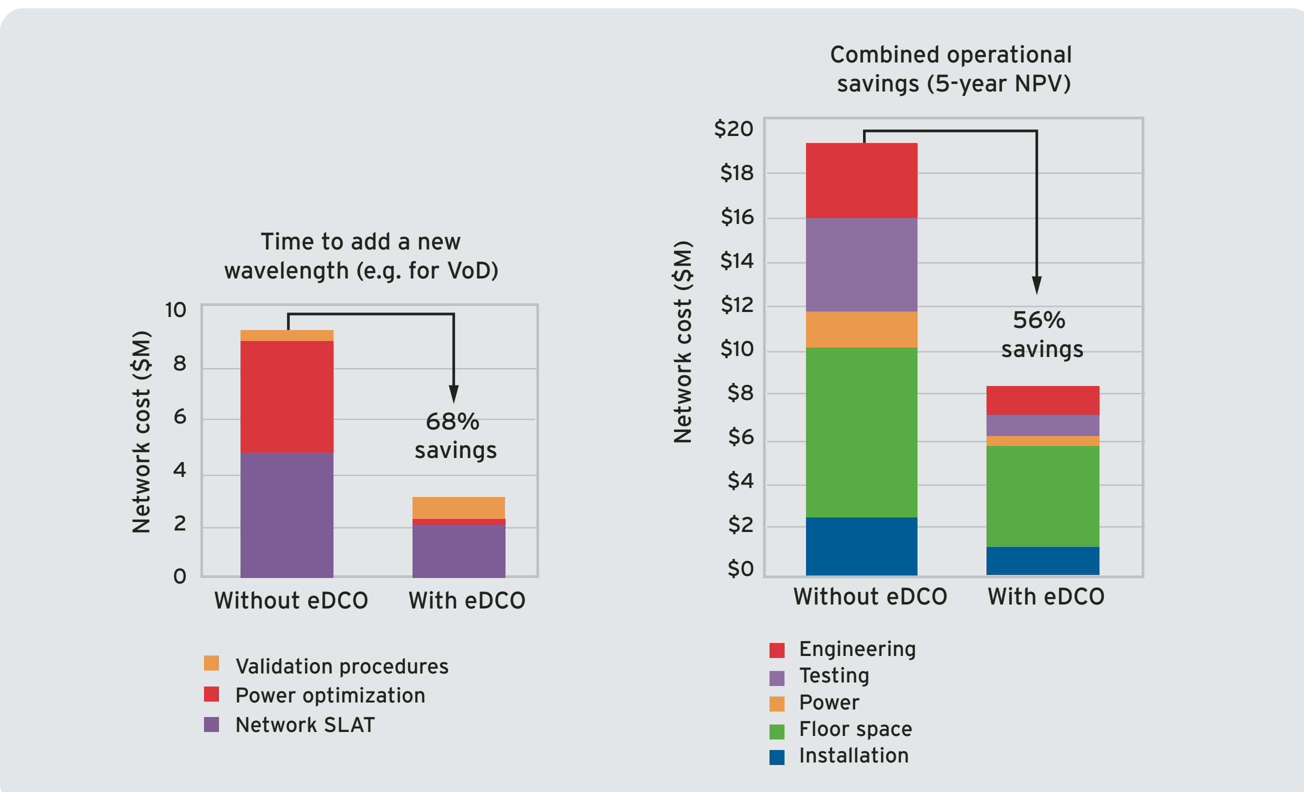
The added value of the eDCO interfaces lies in their dramatically reducing the transport cost of high bandwidth signals through the elimination of in-line DSCMs and the additional amplifiers. The benefits can be summarized in the bullets below:

- Enable wavelength agility throughout the network without the need for pre-planned dispersion maps
- Provide a day one DWDM optical layer which does not need to be engineered with a complex DSCM design
- Reduce overall network latency due to the elimination of in-line DSCMs
- Extend the service reach (2000+ km) at a minimum cost while maintaining signal integrity (through enhanced Forward Error Correction)
- Increase security against signal tapping due to pre-compensation (prevent video piracy)

The eDCO performs dispersion compensation directly on the transmitter interfaces and provides real-time performance optimization on a per-wavelength basis while eliminating the need for pre-placement of optical dispersion compensation modules in the optical DWDM line.

In addition to benefits highlighted earlier, the implementation of eDCO translates into significant reduction in capital and operational expenditures. As a matter of fact, the results of a real-life case study performed on a North American service provider's network demonstrate the positive impact of using eDCO on various factors that constitute operational expenditures (Figure 4).

Figure 4. Cost savings achieved through the implementation of eDCO



What products support eDCO?

The eDCO technology has been initially implemented on Nortel's flagship, the Optical Multiservice Edge 6500 (OME 6500) depicted in Figure 5 and will be extended to other key products in the optical portfolio as part of Nortel's strategy of evolving the network to adaptive, all-optical intelligent networking.

Conclusion

Electronic Dynamically Compensating Optics (eDCO) is a leading edge technology that breaks the physical barriers to enable reliable and cost-effective broadband connectivity across 2000+ km and over any fiber build-out while ensuring simple network management, flexibility and scalability to meet the requirements of future growth.

Figure 5. The Optical Multiservice Edge 6500

Acronyms

ATM: Asynchronous Transfer Mode

DCM: Dispersion Compensation Modules

DSCM: Dispersion Slope Compensation Modules

DSL: Digital Subscriber Line

DWDM: Dense Wavelength Division Multiplexing

FC: Fibre Channel

FEC: Forward Error Correction

GigE: Gigabit Ethernet

IPTV: IP-based Television

IP: Internet Protocol

IR: Intermediate Reach

LAN: Local Area Network

LEAF: Large Effective Area Fiber

LS-DSF: Lambda-Shifted Dispersion-Shifted Fiber

MUX: Multiplexer

NPV: Net Present Value

OADM: Optical Add/Drop Multiplexer

OEO: Optical – Electrical – Optical

OME 6500: Optical Multiservice Edge 6500

OTN: Optical Transport Network

OTU: Optical Transport Unit

ROI: Return on Investment

RPR: Resilient Packet Ring

SDH: Synchronous Digital Hierarchy

SLAT: System Line-up and Test

SMF: Single Mode Fiber

SONET: Synchronous Optical Network

SR: Short Reach

VoIP: Voice over IP

VSR: Very Short Reach

WT: Wavelength Translator

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