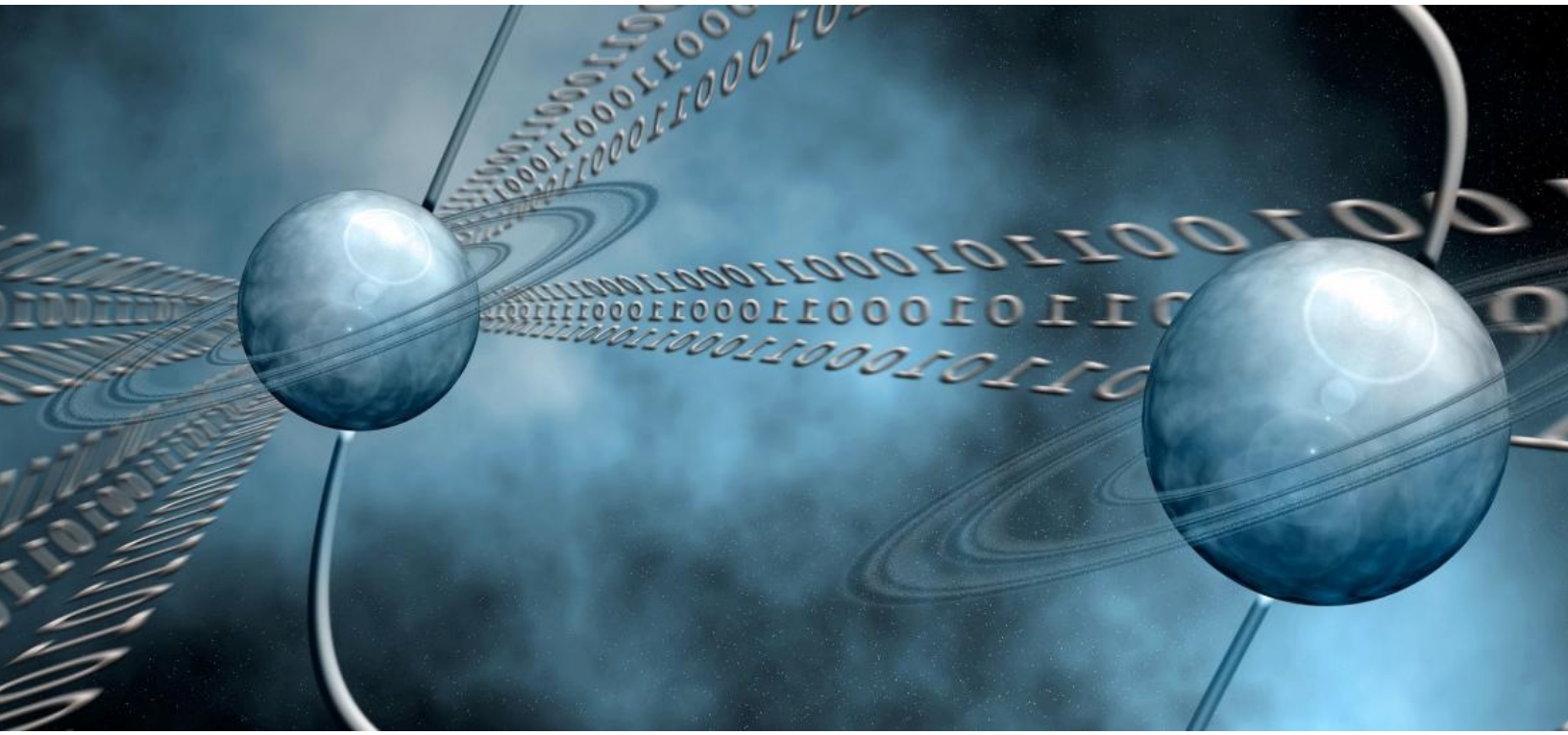
Why Service Providers Should Consider IPoDWDM for 100G and Beyond



Executive Summary

The volume of traffic on service providers' networks is growing dramatically and correspondingly increasing cost pressures. To meet demands, the core network is evolving from 10 Gbps standards to 100 Gbps and beyond at both router interface and optical wavelength levels. To do this economically, a tighter integration between the packet and optical layers is required.

Many service providers want to integrate packet and optical using IP over DWDM (IPoDWDM) technology. For starters, IPoDWDM allows service providers to eliminate the capital expense (CapEx) and operations expense (OpEx) costs of unnecessary transponders. Moreover, service providers are increasingly looking at coherent technology to further improve economics. Coherent technology enables service providers to drive 100G speeds and beyond over existing fiber infrastructure. This allows them to leverage existing sunk CapEx costs and maximize investment protection. The overall result is a clear reduction in total cost of ownership (TCO).

ACG has investigated how a specific vendor, Cisco Systems, is delivering solutions to help with these challenges. The Cisco IPoDWDM (IP over DWDM) 100 GE core network solution combined with Cisco's coherent detection technology provides the transmission capacity required in service providers' core networks while also minimizing TCO. From an operations perspective, convergence does not have to compromise levels of performance, manageability, and functionality characteristic of existing optical transport solutions. The overall system protection is more responsive when IP and optical are united than that of separate router and DWDM system configurations.

ACG Research analyzed the TCO of the Cisco IPoDWDM 100 GE solution. The results can be significant. The IPoDWDM 100 GE optics are shown to have 15% and 29% lower TCO for short-reach and long-reach configurations, respectively, when compared to traditional grey 100 GE optics. The benefits of Cisco's coherent detection technology eliminate the costly and extensive Raman amplification or regeneration required of other vendors' solutions. On a traditional 20 wavelength system, for example, Raman amplification would add a 20% higher cost, and regeneration would add an 81% higher cost than Cisco's solution.

Key Takeaways

Cisco's 100 Gbps IPoDWDM integrated optical solution, the only one in the industry, features:

- IPoDWDM optics with 15% to 29% lower TCO than grey optics.
- Coherent detection with 1,000 Km greater reach than the competitors' reach; yields 20% to 81% lower cost when serving 20 wavelengths on a 3,000 Km optical span.
- OAM&P capabilities that exceed those of SONET/SDH DWDM by integrating packet and optical protection.

Introduction

The scale of providers' networks is increasing dramatically. New services such as content-rich digital media, cloud services and mobile broadband are driving IP/MPLS core network traffic to massive scale. For example, the Cisco Visual Networking Index finds that global IP traffic increased eightfold over the last five years and projects a threefold increase over the next five years. It estimates that in 2016 global IP traffic will total 1.3 zettabytes[1] per year, challenging network scale and profitability.

The problem is service providers' revenue and profit growth are not keeping pace with traffic growth and customers' increased quality expectations. This puts tremendous cost pressure on network operations and infrastructure. Network scale and service velocity must increase while simultaneously minimizing the total cost of ownership. The core network needs to move to 100 Gbps to meet scale and capacity needs; however, this must be done economically. Service providers can use integrated optics (IPoDWDM) to do this.

The business case for two elements of Cisco's approach to integrated optics is examined:

1. Cisco CRS core router with 100 GE IPoDWDM (IP over DWDM): Integrated optics reduces cost by eliminating system redundancies in the router and DWDM systems.
2. Cisco's coherent optical transmission technology: Cisco's coherent technology extends the reach of signal transmission without signal regeneration. This eliminates expensive regeneration or costly amplification on long network links and enables greater reuse of fiber installed to support 10 Gbps transmission on new 100 Gbps systems.

Business Case for CRS Core Router with 100 GE IPoDWDM

Cisco is the only vendor offering an IPoDWDM solution for 100 Gbps. IPoDWDM reduces CapEx and associated space, power, and cooling expenses by eliminating the grey optics and the transponder used in separate router and DWDM systems. The business case analysis begins with a TCO comparison of two approaches to linking the CRS core router to the DWDM system. The approaches are:

1. IPoDWDM: A 100 GE DWDM transceiver is integrated into the CRS router.
2. Grey[2] optics on the CRS and in the DWDM system: Grey optics is used to link the CRS to the DWDM system.

Figure 1 shows the IPoDWDM interface, and Figure 2 shows the grey optics interface.

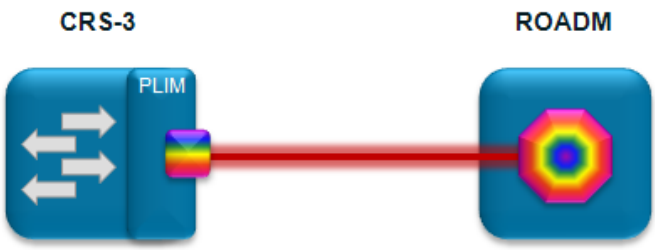


Figure 1 – IPoDWDM Optical Interface

[1] 10^{21} bytes
[2] Grey or "uncolored" wavelength typically 1550 nm

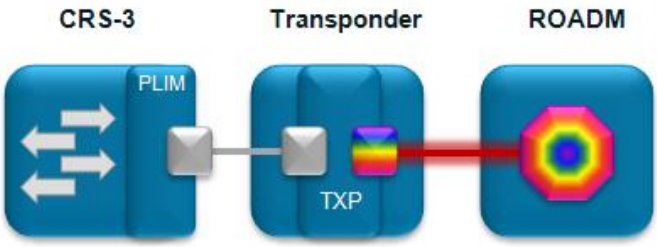


Figure 2 – Grey Optics Interface

IPoDWDM reduces CapEx by integrating the optics and the ROADM into a single interface. Figure 1 shows that a single IPoDWDM optical element is used for the IPoDWDM interface. The grey optics interface (Figure 2) consists of four elements: the grey optics Physical Line Interface Module (PLIM), a pair of short-reach (or long-reach) optics, and a transponder.

A comparison of the TCO associated with the optical elements of the IPoDWDM interface versus the grey optics interface is made for a single CRS and ROADM pair. The optical interface encompasses 10 wavelengths. Figure 3 shows the TCO comparisons for short-reach and long-reach optical connections between the router and the ROADM. The comparisons are for the initial CapEx and one year of OpEx).

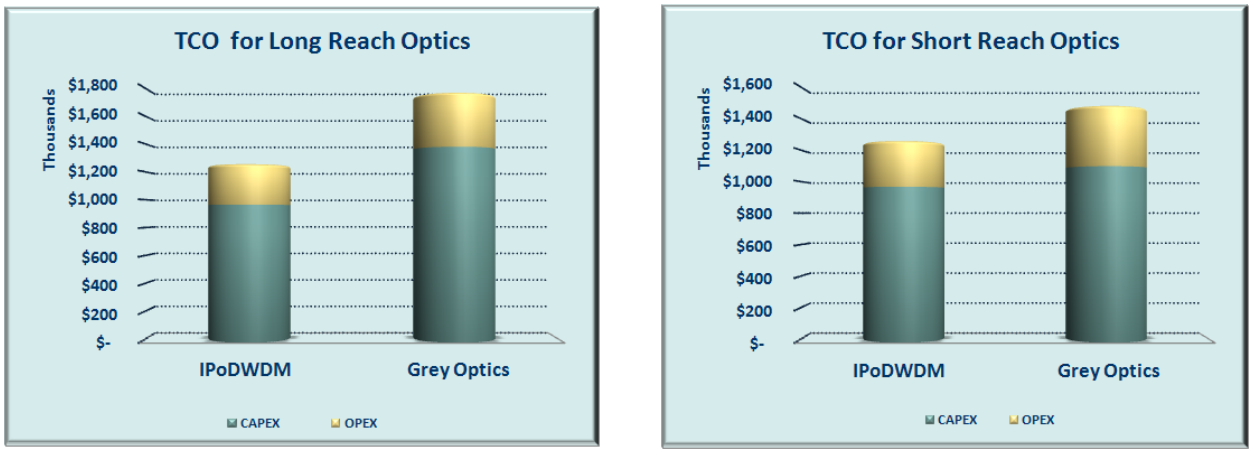


Figure 3 – TCO Comparison IPoDWDM versus Grey Optics

The IPoDWDM optical interface has 29% and 15% lower TCO for the long-reach and short-reach optics, respectively, when compared to the grey optics interface. CapEx is 30% and 12% lower for the long- and short-reach optics, respectively; OpEx is 25% and 24% lower. The vendor's service fee cost component of OpEx decreases because it is closely aligned with CapEx. Consequently, the primary source of the TCO savings of the IPoDWDM is its integrated functionality, which reduces the equipment required to connect the router and ROADM.

Benefits of G.709 Operations, Administration, Maintenance & Provisioning (OAM&P) Capability of the IPoDWDM Solution

The IPoDWDM solution includes the OAM&P capabilities of the ITU G.709 (Optical Transport Network) recommendation. Transport organizations have relied upon these capabilities to manage SONET/SDH networks for many years. They are essential to timely and precise location of network faults on large networks and help to eliminate costly truck rolls. Cisco's IPoDWDM solution provides G.709 OAM&P

capabilities that are equivalent to those provided on SONET/SDH 10 and 40 Gbps systems. However, the solution leverages IPoDWDM optical integration to go beyond the capabilities of separate router and DWDM systems.

Pre-FEC Proactive Protection is a Cisco innovation that ensures near hitless protection of packet traffic during a physical layer failure. By monitoring pre-FEC (uncorrected) bit errors within the G.709 overhead, the CRS 100G IPoDWDM PLIM can notify the upper layer protocol (OSPF, IS-IS or MPLS) of an impending failure, allowing traffic to be rerouted before the actual failure occurs. For example, when a backhoe accidently digs into a fiber cable the fibers are stretched before they are cut. The FEC monitoring system detects the signal degradation caused by stretching the fiber, immediately initiates the upper layer reroute process, and diverts traffic before the fiber is cut. In a traditional system the Layer 3 reroute process is not initiated until after the fiber is cut and a service affecting delay is incurred.

Cisco's Coherent Detection Technology

Coherent detection lowers the optical signal to noise ratio (OSNR) limit so that signals can travel farther without expensive regeneration or specialized signal amplification. This reduces CapEx on new construction and also allows reuse of fiber designed for 10 Gbps on shorter routes. Fiber reuse reduces engineering/planning OpEx and time and the need to replace fiber, DCM, repeaters, etc.

The Cisco IPoDWDM 100 GE solution supports optical transmission in excess of 3,000 Km without signal regeneration. This is at least 1,000 Km more reach than competing solutions.

Cost Savings of 3,000 Km Optical Transmission without Raman Amplification or Regeneration

Unregenerated 100 Gbps transmission over 3,000 Km is significant for three reasons.

1. 3,000 Km represents the extreme of terrestrial network transmission requirements (trans-continental distance).
2. Optical transmission of 3,000 Km using "standard" Erbium Doped Fiber Amplifiers (EDFA) avoids the use of more complicated and costly Raman amplifiers.
3. The capability to reach 3,000 Km without regeneration or more costly amplification also allows reuse of older fiber on shorter routes.

For vendors without advanced coherent technology, compensation must be engineered or bought for the network. If the required optical transmission reach is too short two options are available to span the required distance:

1. Raman amplification: Optical signal amplification that exploits the Stimulated Raman Scattering phenomenon. It is a more complicated and expensive approach than EDFA. This drives up both CapEx and OpEx.
2. Optical to electrical to optical regeneration: The optical signal is transformed into an electrical signal, regenerated, transformed back into an optical signal and then retransmitted. This is done on each individual wavelength and is a costly process as it requires the use of two 100 G transponders per regenerated wavelength.

The relative cost of Cisco's coherent technology is compared to the first and second options, which competitors must use for an optical span of 3,000 Km handling up to 80 wavelengths (Figure 4 shows results between 1 and 25 wavelengths). Relative cost is measured and the cost of any solution is divided by the cost of Cisco's solution for a one wavelength span. Costs are calculated for a Greenfield deployment.

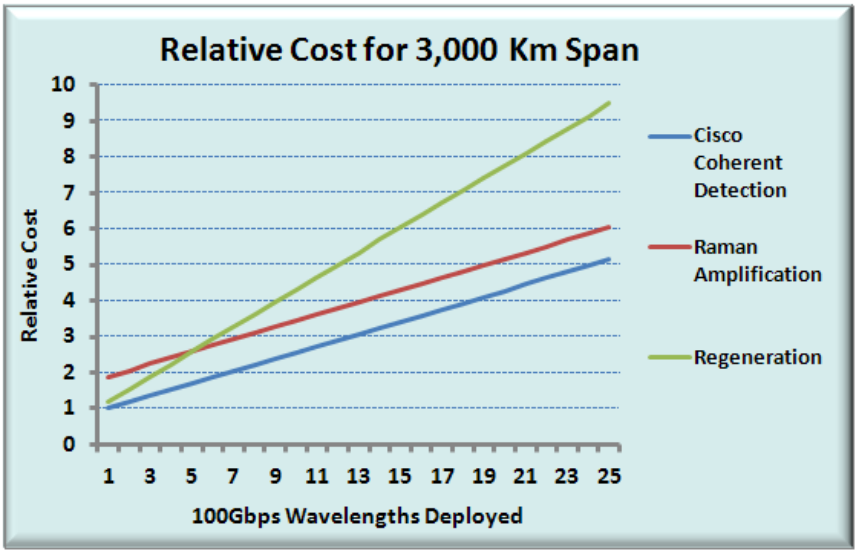


Figure 4 – Relative Cost for 3,000 Km Optical Span

For one wavelength the Raman amplified solution is nearly double of the cost of solutions that do not employ Raman. As additional wavelengths are deployed, the Raman network does not incur any additional costs compared to the network that is not Raman; however, it still retains a 20% total cost premium even with 20 wavelengths deployed. The EDFA-only (not Raman) network represented by the green line requires signal regeneration at one location along the 3,000 Km path. Although its initial deployment cost is comparable to the Cisco EDFA-only unregenerated network, its cost rapidly increases with each new wavelength deployed:

- The regenerated EDFA-only network becomes more expensive than the Raman network at six wavelengths and is 57% more costly than the unregenerated Cisco EDFA-only network.
- At 20 wavelengths deployed, the regenerated network is 81% more expensive or nearly double the cost of the unregenerated Cisco EDFA-only network.

Cisco's coherent detection technology also eliminates the lengthy delays (18 months) that would be associated with upgrading shorter routes to work with 100 Gbps transmission.

Conclusion

The scale of providers' networks is increasing dramatically and driving costs higher. Network scale must increase while total cost of ownership is minimized. IPoDWDM reduces cost by eliminating equipment redundancies found in separate router and DWDM system designs. Coherent detection reduces cost by enabling longer optical reach without regeneration or specialized amplification. It also reduces cost by allowing more reuse of older fiber.

A TCO analysis of the Cisco IPoDWDM 100GE solution for the core network found:

- The IPoDWDM 100 GE optical interface when compared to the grey 100 GE optics interface plus 100G transponder has 15% and 29% lower TCO for the short-reach and long-reach optics, respectively. CapEx is 12% and 30% lower for the short- and long-reach optics, respectively. OpEx is 24% and 25% lower.
- The manageability and quality control of the optical network is substantially increased by incorporating the OAM&P capabilities of the ITU G.709 recommendation into the IPoDWDM interface. This reduces OpEx and substantially increases network availability, resiliency, quality, and service provisioning velocity.
- By tightly linking the protection schemes of the router to the FEC capabilities of the DWDM system (Cisco's Pre-FEC Proactive Protection), overall system protection is more responsive than that of separate router and DWDM system configurations.
- The relative cost benefits of Cisco's coherent detection technology that extends optical signal reach to more than 3,000 Km is compared to competing solutions that require either Raman amplification or regeneration at that distance. On a 20 wavelength system the Raman amplification has 20% higher cost, and regeneration has 81% higher cost than Cisco's solution.

Cisco's 100 Gbps IPoDWDM solution and coherent detection technology allow the network to scale and service velocity to increase while simultaneously minimizing the total cost of ownership.

For more information on Cisco IPoDWDM, 100G or Convergence Solutions visit www.cisco.com/go/optical.