The Economics of Cisco's nLight Multilayer Control Plane Architecture

Executive Summary

Networks are becoming more difficult to plan and optimize because of high traffic growth, volatile traffic patterns, changes in network architecture and more stringent service level agreements (SLA). Because the IP and optical control planes are not integrated, service providers' networks are always over-engineered and underutilized with 50–75 percent of the network capacity deployed for network resiliency, not for passing traffic. A more economically efficient and effective network resiliency solution is needed.

Cisco has addressed this problem with nLight: a multilayer routing and optimization architecture that focuses on IP and DWDM integration, increasing network agility and flexibility while improving network utilization. By enabling information flows between the routing and optical layers, nLight provides an end-to-end protection and restoration approach that meets performance constraints, such as 5 9s availability, at much lower total cost of ownership (TCO) than present methods, such as the widely used 1+1 optical protection scheme or IP protection alone. Cisco's broad portfolio of DWDM enablers, such as colorless, contentionless, and omnidirectional add/drop, Flex Spectrum transmission, and an impairment-aware optical control plane, enable nLight.

ACG Research compared the nLight approach to protection and restoration to the widely used 1+1 optical protection scheme. A sample 12 node core network was used to make the comparison. The study showed that by enabling the two-way flow of information between the routing and optical layers the number of transponders was reduced by 63 percent and the number of router interfaces was reduced by 26 percent. nLight improvements in the capacity planning process resulted in a TCO savings of up to 50 percent.

KEY FINDINGS

nLight enables information flows between the optical and routing layers, which deliver an end-to-end protection and restoration solution. Compared to 1+1 optical protection nLight delivers savings of:

- 26% fewer router interfaces
- 64% fewer optical transponder interfaces
- Up to 50% savings in TCO for capacity planning

Introduction

Network requirements are becoming more demanding in response to explosive and more volatile network traffic growth, changes in network architecture, and increasing performance expectations by subscribers. Cisco's Visual Networking Index (VNI), for example, projects that annual global IP traffic will surpass the zettabyte[1] threshold by 2016. High traffic volume growth, however, is only one dimension of changing network traffic. Traffic patterns are becoming more volatile in at least three ways. First, the difference between peak and average traffic volumes is increasing. Second, new traffic flows among multiple servers and storage devices (called east to west flows) are emerging as part of the move to the cloud computing business model. Finally, large event-specific traffic surges are occurring more frequently. The iPhone 5, for example, prompted a surge in traffic volumes the day after its release as its new owners downloaded apps.

New applications and the increasing importance of IP networking to both consumers and enterprises also are making networking requirements more demanding. SLA requirements are more stringent for availability and latency, which are now at the microsecond level. Shorter network provisioning time is another dimension of more demanding network requirements. Increasingly, demanding availability requirements include:

- Reduced risk of failure
- Improved protection times
- Recovery from multiple successive failures
- Improved network monitoring

In addition to these more challenging network requirements service providers are facing expanding cost pressures because the growing requirements are not being monetized. Consequently, a more agile and efficient network is required.

nLight Control Plane

nLight[2] control plane is a multilayer routing and optimization architecture that focuses on IP and DWDM integration. It links the intelligence of the packet network with that of the optical network to provide end-to-end optimization. This increases network agility and flexibility.

Figure 1 illustrates the network optimization problem.

[1] One zettabyte is about 10^{21} bytes.

[2] Cisco is working within the IETF to create a standards-based solution.

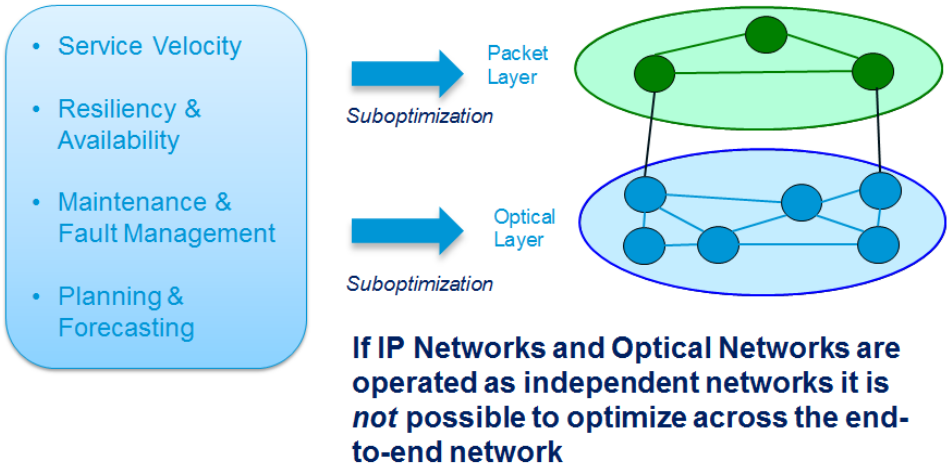

Figure 1 – The Network Optimization Problem

Today, IP and optical networks are typically operated as independent networks by separate network operations departments. Each department optimizes its network to satisfy its own service velocity, resiliency and availability, maintenance and fault management, and planning and forecasting requirements. Consequently, it is not possible to optimize the entire end-to-end network. Furthermore, the communications links between the packet and optical layers shown in the figure are usually manual processes. These links are very slow and subject to errors and misunderstandings between the two network operations departments.

Figure 2 illustrates end-to-end optimization using nLight.

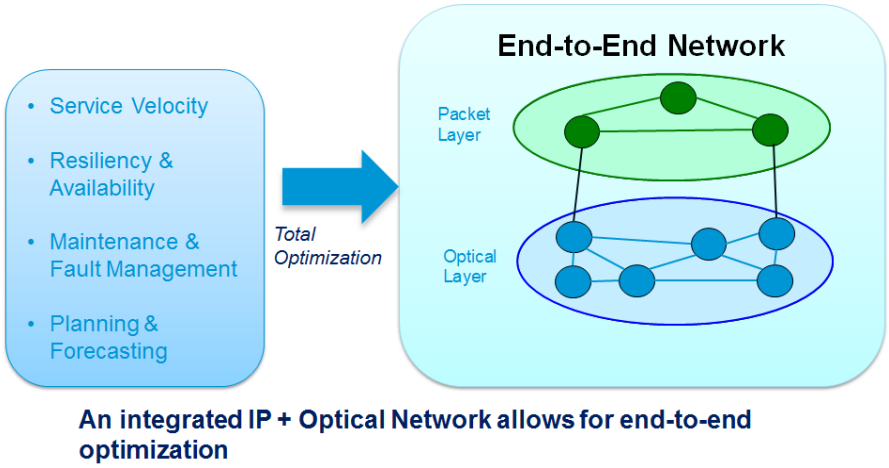

Figure 2 – End-to-End Network Optimization using nLight

Cisco Open Networking Environment (ONE)

nLight is the forwarding and transport layer of Cisco ONE, a portfolio of Cisco's technologies and open standards that provides programmatic control of the network. nLight provides layer interfaces between the routing layer (L3) and the optical transport layer (L1). Figure 3 shows where nLight resides within the overall Cisco ONE framework.

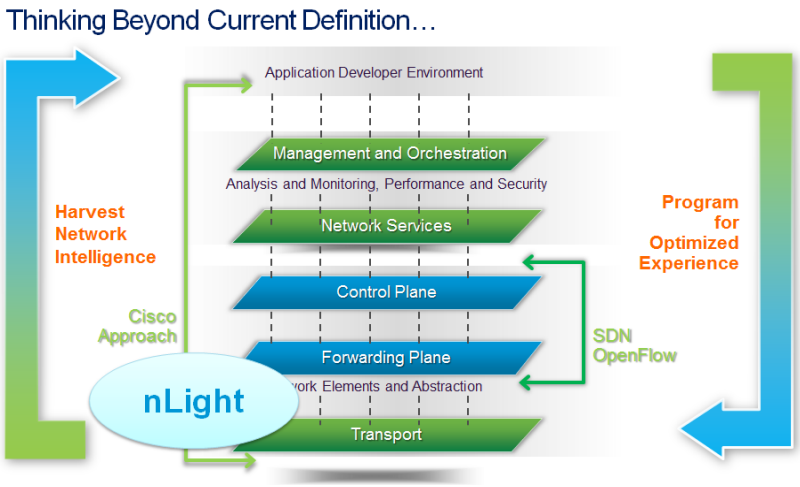

Figure 3 – nLight Control Plane

As shown in Figure 3 nLight provides an integrated optical and IP control plane. The integrated control plane produces a virtual and agile IP and optical topology. Using the integrated control plane it is possible to simultaneously optimize optical and IP total cost of ownership subject to constraints such as:

- Latency
- Shared Risk Link Groups (SRLG)
- Diversity
- Restoration
- Protection

Optimization of the IP and optical topology is further enhanced by the Cisco ONE controller, which analyzes network traffic, topology, and failure conditions and uses this information to run optimization algorithms to provide the lowest cost network that satisfies network resiliency and performance constraints. The controller architecture, which enhances the capabilities provided by nLight, is an optional component of the Cisco ONE architecture.

Optical Enablers of nLight

Cisco provides comprehensive optical capabilities that are required to enable complete control in software with no manual intervention. These capabilities include:

- Tunable laser: A transmit laser can be software provisioned to any frequency in the C-Band.
- Colorless: ROADM add/drop ports are not frequency specific. Any frequency can add/drop from any port.
- Tunable receiver: A coherent receiver can select any channel from of a composite (unfiltered) signal.
- Restoration: The ability to reroute a wavelength at the optical layer.
- Flex spectrum: The ability to allocate a granular amount of spectrum to each wavelength or group of wavelengths.
- Contentionless: The ability to add/drop the same frequency from multiple ports in the same add/drop device.
- Omnidirectional: A wavelength can be routed from any ROADM Add/Drop port to any direction.

- WSON: An impairment-aware GMPLS optical control plane.

In addition, Cisco's 100 Gbps coherent technology is used for packet and optical transport systems. This supports higher scale and reduces cost by extending reach without the need for costly regeneration.

nLight Economics

nLight integration of the IP and optical layers provides for end-to-end network optimization. Two areas of economic benefits are examined in this paper:

1. Benefits due to efficient network resiliency
2. Benefits due to efficient capacity planning

Economic Benefits due to Efficient Network Resiliency

nLight provides a resilient optical and packet network at lower cost by using multilayer intelligence to allocate resources more efficiently. Figure 4 illustrates the resiliency problem as it exists today when the optical and packet layers are protected separately.

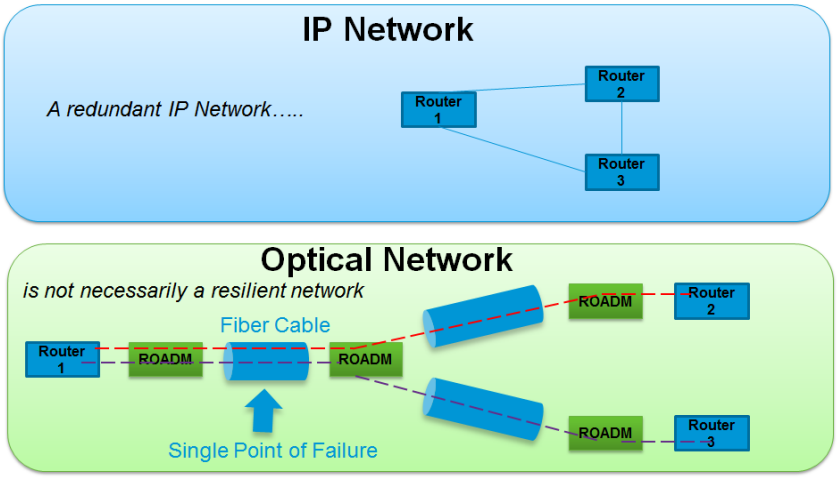

Figure 4 – The Resiliency Problem

The top portion of the figure illustrates a redundant IP network where two network links have been provided from each router, thus, delivering apparent protection for the failure of any network link. However, the bottom half of the figure shows that both fibers reside in the same cable for one span of the physical route. This represents a shared risk link group. Router 1 is not protected by diverse links. Since information is not passed between the IP and optical networks, routers lack sufficient information to instruct ROADMs to route circuits across paths that do not share the same SRLG.

Under the present mode of operations the resiliency problem is resolved by using 1+1 Y-Cable optical protection (See Figure 5).

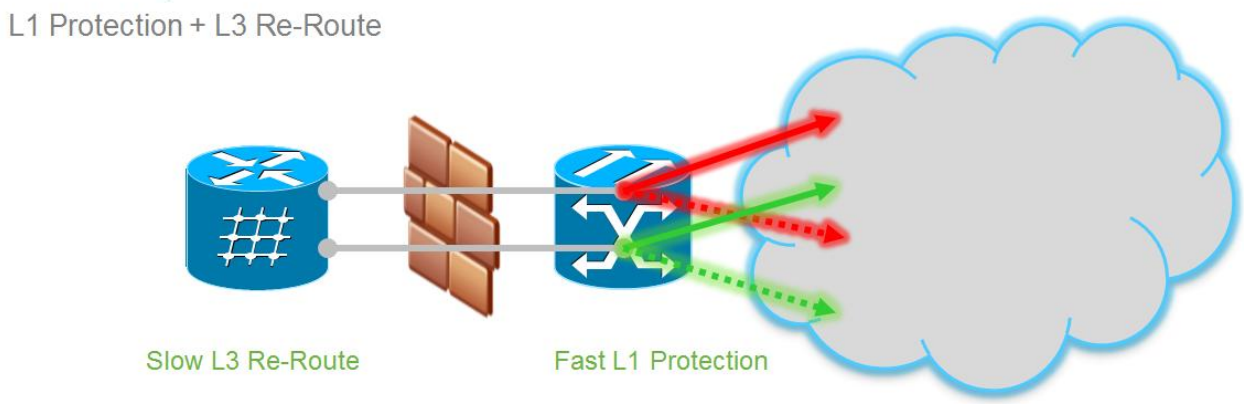

Figure 5 – Traditional Network Resiliency Relies on 1+1 Protection

1+1 optical protection uses two optical transponders to send a single packet interface in two directions. The output of the L3 interface is split in two directions and one signal is selected at the far end. This approach doubles the optical transponder requirement and uses half of the true capacity of the DWDM system.

Figure 6 shows a pure L3 network resiliency solution.

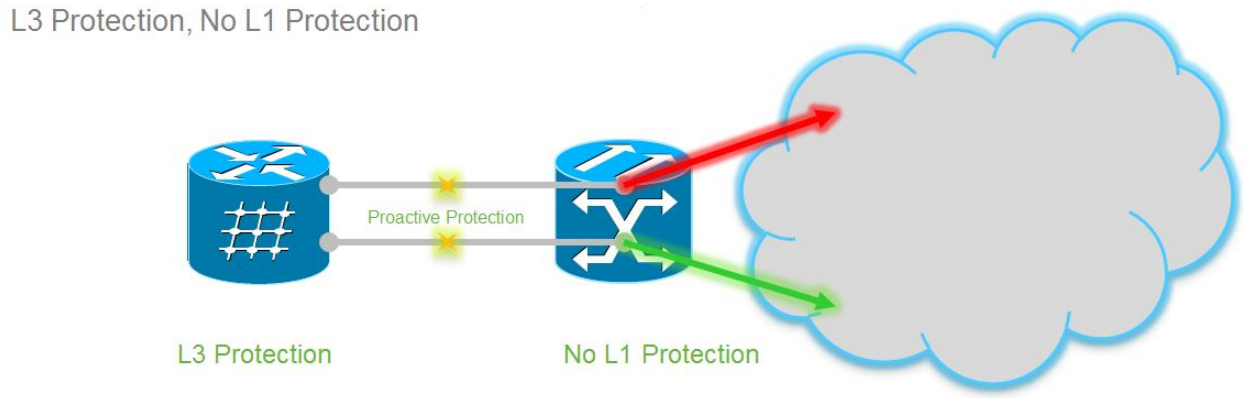

Figure 6 – Pure L3 Network Resiliency

This solution provides network protection at layer 3 only. L3 network rerouting can be much slower than optical layer protection, and the L3 network has no visibility into optical layer SRLGs.

nLight optimizes the network, providing protection via the IP layer and restoration via the optical layer (See Figure 7).

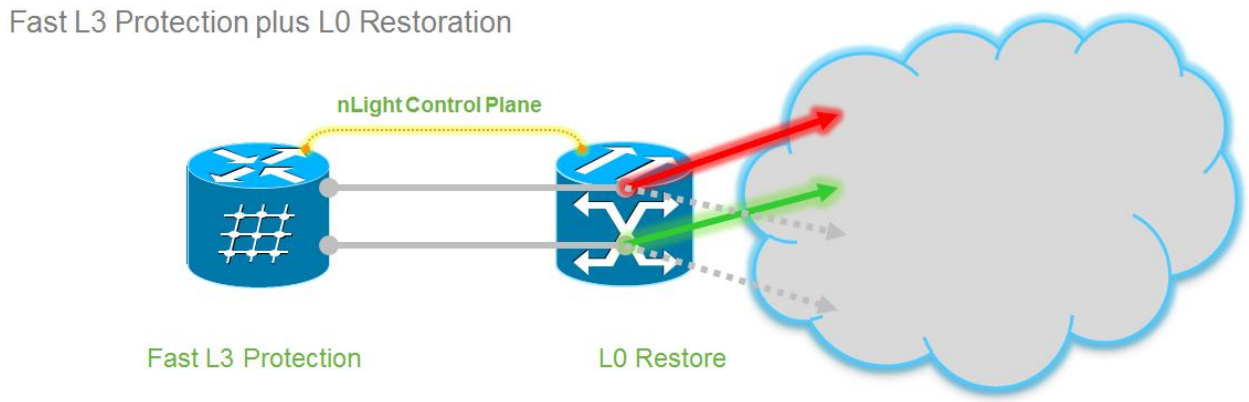

Figure 7 – Multilayer Network Resiliency Is Achieved via nLight Protection and Restoration

The IP layer is aware of the actual payloads, the priority and the constraints on the traffic. It uses this information to decide how to reroute traffic, over what interfaces, and what level of priority each circuit/service requires.

The integrated IP optical network delivers savings in two dimensions. First, by providing resiliency at the IP layer without the risk of redundant links traversing the same SRLGs, there is a 50 percent reduction in transponders. With pre-FEC proactive protection combined with fast Layer 3 reroute protocols, 1+1 protection at the optical layer is no longer needed to ensure sub 50 millisecond protection switching times. Second, by providing multilayer circuit restoration at the optical layer the router interfaces can be run at higher average utilizations. If a failure occurs in the optical network, affected traffic can be rerouted over alternative links while the optical circuit is being restored. Quality of service (QoS) provides a guarantee that high-priority traffic will be delivered without problems. There is some chance that best- effort traffic could be dropped while the optical circuit is being restored; however, because the restoration time is fairly short (30 seconds) and the probability that a failure occurs during a peak traffic time is small, there is only a small chance of dropping best-effort traffic.

Sample Network Study

The benefits of nLight resiliency are studied on a 12 node core network using Cariden Mate, Cisco's industry standard network simulation and planning tool.

Three scenarios are compared:

1. No nLight: 1+1 Optical Protection used for resiliency
2. nLight: L3 protection using nLight to ensure L3 links do not share SRLGs
3. nLight: L3 protection and dynamic optical restoration allowing higher utilization of IP links

Figure 8 shows the results of the analysis.

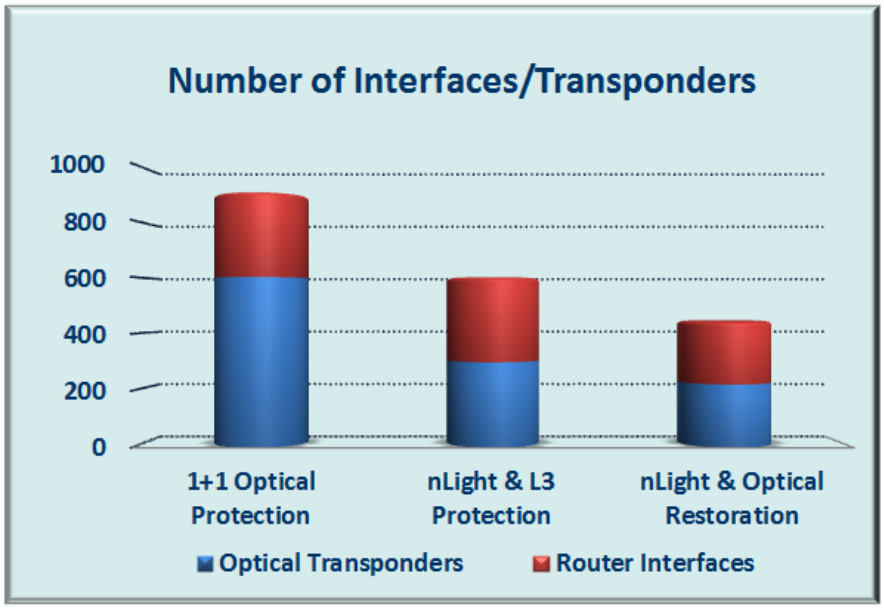

Figure 8 – Number of Interface Comparison 1+1 versus nLight Protection

In scenario 2 nLight provides 50 percent savings in transponders because of moving protection from L1 to L3 and ensures that L3 circuits do not share SRLGs. In scenario 3 nLight provides an additional 26 percent savings by increasing the normal utilization of router interfaces while leveraging router QoS to protect high-priority traffic during the optical circuit restoration interval.

The total nLight savings if we consider the benefits of L3 resiliency and dynamic optical restoration are:

- 63% reduction in transponders
- 26% reduction in router interfaces

Economic Benefits due to Efficient Capacity Planning

The information sharing capability of nLight enables creation of a unified and automated capacity planning process for the IP and optical layers. This increases the timeliness and accuracy of data shared between the IP and optical layers as part of the capacity planning process and consequently reduces total cost of ownership.

Today, without nLight large service providers divide the IP and optical layer management roles into separate routing and transport organizations. Figure 9 schematically shows how this organizational separation causes delays and overestimation of bandwidth requirements.

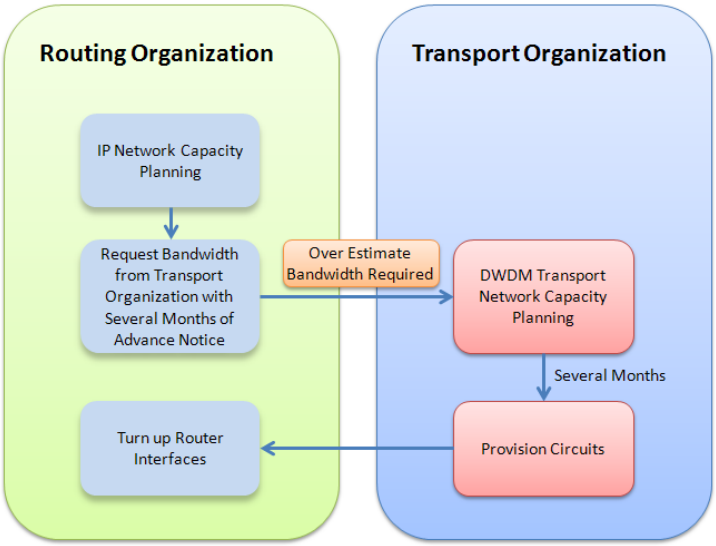

Figure 9 – Capacity Planning Process without nLight

Each organization hands off data by manually entering it into spreadsheets or databases. Each spreadsheet or database is a function of the expertise of each organization and typically requires coordinating activities among organizations or in some extreme cases there is no coordination or information sharing. Each organization performs its own capacity planning activities according to an internal schedule subject to the priorities and objectives of the organization. Consequently, the routing organization makes its bandwidth requests to the transport organization several months in advance of its need for circuits required to turn up router interfaces.

The bandwidth requests of the router organization must necessarily be overestimated because the traffic load is volatile and growing rapidly. The overestimation is made as a hedge against the risk of being caught with inadequate circuit capacity over the next planning cycle. Figure 10 shows the capacity planning process that is enabled by nLight.

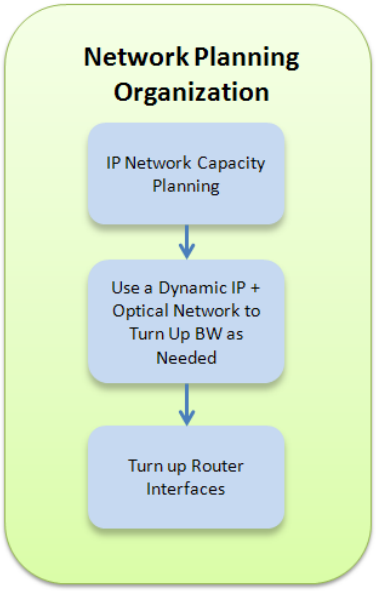

Figure 10 – Capacity Planning Process with nLight

A dynamic packet and optical network allows for end-to-end provisioning of capacity as needed. This provides just-in-time capacity management and optimizes the utilization of network resources.

TCO Modeling Results

The TCO benefit of using nLight to eliminate bandwidth overestimation is modeled for a typical core network. Figure 11 shows the results of the modeling exercise.

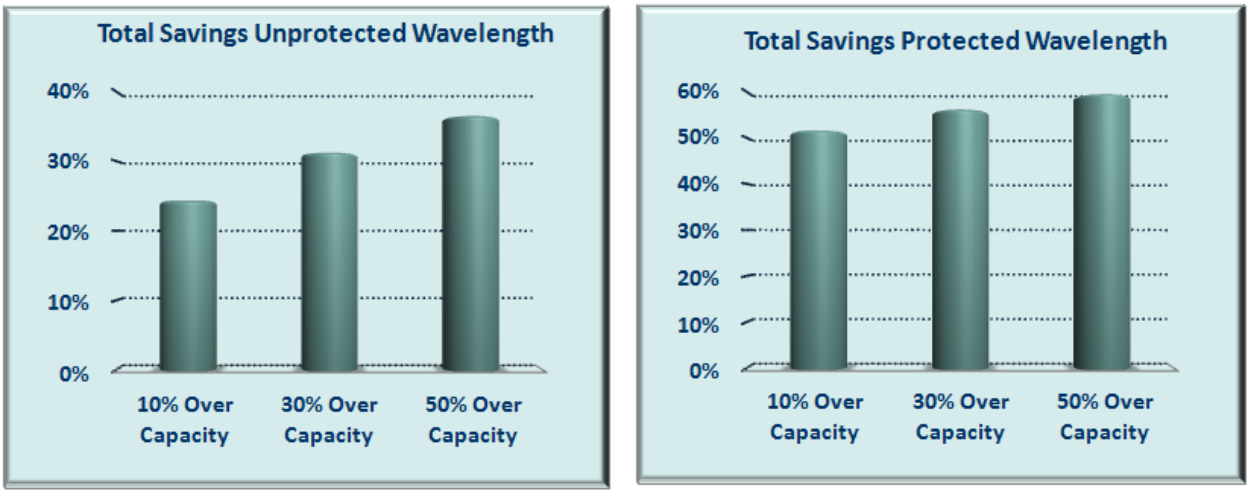

Figure 11 – Percentage of TCO Savings with nLight versus Capacity Overestimates

nLight significantly reduces TCO by eliminating even small overestimates of required bandwidth capacity. For example, in a design using unprotected wavelengths nLight produces 24 percent reduction in TCO by eliminating 10 percent overestimation of required capacity. The deployment of nLight on a network with protected wavelengths produces more than 50 percent TCO reduction by eliminating 10 percent overestimation of required bandwidth capacity. These savings are achieved because nLight enables a just-in-time capacity provisioning process that reduces the risk of being caught with inadequate circuit capacity.

Conclusion

Network requirements are becoming more demanding in response to explosive growth and volatile traffic patterns, network architecture changes, and increasing performance expectations from subscribers. In addition to these more demanding network requirements service providers are facing increasing cost pressures because the growing requirements are not being monetized. Consequently, a more agile and efficient network is required.

nLight is a multilayer routing and optimization architecture that focuses on IP and optical integration. This increases network agility and flexibility and dramatically reduces the need for overengineering and underutilizing service providers' networks. By enabling information flows between the routing and optical layers nLight provides an end-to-end protection and restoration approach that meets performance constraints, such as 5 9s availability, at much lower total cost of ownership than present methods, such as the widely used 1+1 optical protection scheme.

ACG's economic analysis shows that nLight optimizes the resiliency of IP and optical networks, resulting in:

- 63% reduction in transponders
- 26% reduction in router interfaces

Additionally, nLight improves the capacity planning process, which can result in 50 percent savings in network TCO.

ACG Research

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