The Business Case for ROADM Technology

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Executive Summary

Recent developments in the telecom market are leading to rapid growth of traffic in metro networks. Among the key applications that are driving this growth are:

- Residential triple-play services (IPTV, video-on-demand, VoIP, and high-speed Internet)
- Commercial Carrier Ethernet services

As a result of this growth, service providers are deploying DWDM transport networks in metro areas. One of the key questions facing service providers is:

Should we deploy a Fixed OADM or a Reconfigurable OADM (ROADM) DWDM network architecture in our metro areas?

This paper provides an ROI analysis demonstrating that a Fixed OADM solution could be less expensive than a ROADM on day one. However, in many cases over several years the Fixed OADM is *more expensive* then the ROADM. The higher cost associated with the Fixed OADM is a result of additional CAPEX and OPEX due to inefficient network designs and equipment configurations, inefficient sparing, and increased labor costs. In networks with high growth and uncertainty of future demand, the longer-term cost savings of the ROADM solution is more pronounced.

Our analysis compares both the capital network equipment costs and labor costs of a traditional Fixed OADM network with a Cisco® ONS 15454 ROADM network. In this study we use two approaches to make this cost comparison:

1. **TCO Model** – A total cost of ownership (TCO) model is used that compares two hypothetical networks (a ring and linear topology) for both the Fixed OADM and ROADM systems.

2. **Case Study** – A customer that has already deployed the Cisco ONS 15454 ROADM and has realized CAPEX and OPEX savings was interviewed and the results of that interview are presented.

Our conclusions from this analysis are that the deployment of the Cisco ONS 15454 ROADM system results in both CAPEX and OPEX savings as compared to a traditional Fixed OADM. These savings are realized to a greater degree in networks with:

- Uncertain demand and network changes
- High growth
- High capacity
- Mesh demand characteristics

Network equipment CAPEX savings in ROADM networks are primarily due to more efficient deployments of OADMs and transponders in the network and the reduction of spares.

Labor and OPEX savings are due to the following factors:

- Bandwidth can be turned up on demand without the need for accurate, long-term forecasts.
- More intelligence, automated discovery, automated signaling, and power conditioning functions are used in a ROADM network.
- Circuit provisioning and activation time is significantly faster in a ROADM network.
- Maintenance and network care are improved.
- There is a more efficient deployment of line cards due to any-to-any connectivity.
- Bandwidth can be deployed much more quickly than with fixed DWDM technology.
- With a ROADM network, technicians are only needed at origin and destination points to install line cards – all other provisioning is automatic. In the fixed system, more experienced engineers are needed at each intermediate site (multiple truck rolls) to install wavelength add/drop multiplexers to prepare for uncertain future demand and to manually readjust tuning for power and signal variants resulting from configuration changes.
- Adding additional wavelength channels in Fixed OADM networks is intrusive and service-affecting, and therefore must be done during scheduled maintenance windows.
- Faster provisioning time means faster time to revenue.

In the case study, CAPEX savings were 50% and OPEX savings were 70%. This resulted in a high ROI and a payback of less than 12 months for the Cisco ONS 15454 ROADM.

In addition to CAPEX and OPEX savings, the flexibility of the ROADM provides strategic competitive advantages including:

- Faster time to revenue due to reduced circuit provisioning times
- Reduced churn due to reduced provisioning times and greater flexibility in service offerings
- Ability to win the contract in competitive bidding situations due to increased flexibility and accelerated service deployment

The following sections of this paper present a brief overview of Fixed OADM and ROADM technology, a TCO comparison of these technologies, and a case study of a large cable service provider that has deployed the Cisco ONS 15454 ROADM technology.

Overview of Fixed OADM and ROADM Technology

First- and second-generation DWDM networks were built with Fixed Optical Add/Drop Multiplexer (OADM) technology. While these systems have enormous capacity and are in wide use worldwide, they are complex systems to design, configure, and install. Fixed OADM systems are also extremely complex to change. More recently, Reconfigurable OADM (ROADM) technologies have been introduced to the market, allowing service providers much greater flexibility in network design and installation and, most importantly, have allowed for flexibility in moves, adds, and changes.

Fixed OADM Technology

While there are many different DWDM vendors and system architectures, there are some basic components that are used in all Fixed OADM systems. These components are depicted in Figure 1. In a Fixed OADM system, multiple optical wavelengths are used to create separate optical transport channels. Terminal filters are used at the end points of a linear (point-to-point) network or at the hub of a ring to originate or terminate optical channels. The terminal filters operate at fixed wavelengths and can only originate or terminate optical channels operating at those *fixed wavelengths*. At any point along the ring, channels can be added or dropped by an optical OADM. These OADMs are also *fixed to specific wavelengths* and typically allow add/drop of a *fixed number* of channels. In our TCO model, a fixed OADM system that drops increments of four optical channels is analyzed. Electrical-optical transponders are used to convert standard service interfaces to ITU DWDM optical signals for transport on the DWDM network. Transponders have many service interfaces (Gigabit Ethernet [GbE], 10 GbE, OCn, Fiber Channel, etc.) and come in two fundamental data rates: 2.5 Gigabit and 10 Gigabit transponders. Another fundamental component of all DWDM systems is the Erbium-Doped Fiber Amplifier (EFDA), which is used to amplify the optical signal for medium to long-haul fiber links. In Fixed OADM systems, EFDAs need to be manually adjusted so that the amplification accounts correctly for the number of channels that are added or dropped at a particular site. Manual adjustments need to be made on all EDFAs in the network as new channels are added or dropped.

An example of a Fixed OADM network is illustrated in Figure 2. In the Fixed OADM network, channels are interconnected using fixed filters/OADMs. Because all channels and wavelengths in the network are fixed, it is essential that network planning and engineering account for traffic growth and changes as the network evolves. Adding capacity and/or making changes to the network is difficult and can cause service outages because there is very little flexibility in a Fixed OADM system.

Some of the problems with Fixed OADM systems are:

- Inefficient sparing – A large number of spares are required because each filter and transponder is unique to a specific set of wavelengths.
- Fixed channel filters are unique and require specific part numbers – This makes inventory management quite difficult.
- Dynamic traffic management is not supported – Fixed wavelengths require that channels and transport interconnectivity be fixed.

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