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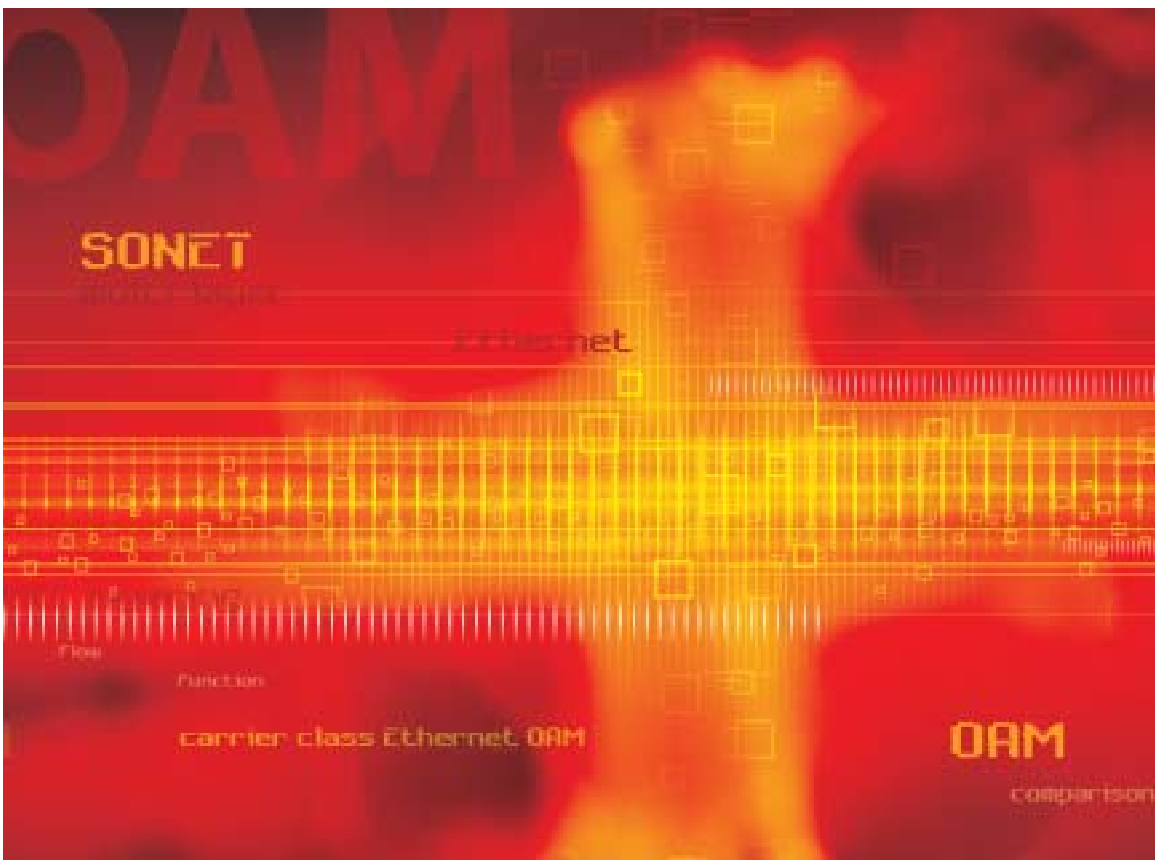
A Survey and Economic Analysis of Metro High-Capacity Central Office Approaches



Introduction

The CO is the core of the metro network, providing all the features and functions to support service delivery, transport, operations, provisioning and maintenance. As networks continue to grow and new services are introduced, the CO becomes interconnected with more and more equipment to provide these functions.

CO equipment provides transport optics, service interfaces, ring protection, STS and VT grooming, and interconnection. Traditionally, these functions have been provided by separate equipment. SONET ADMs provide the transport optics, local drops, ring protection and STS grooming within rings. DCSs provide STS and VT grooming for interconnecting rings and service delivery features. Other equipment provides specialized services and transport for Ethernet and other services. In high-capacity central offices, the costs of many separate pieces of equipment to provide these functions quickly add up. Also, costs and complexity to interconnect the different ADMs, DCS and other equipment quickly add up.

The focus of this paper is to address a type of next-generation SONET ADM (MSPP) that provides multiple ring termination, high-capacity STS and/or VT grooming, along with multiservice capability. These new features have created a lot of interest among network operators. Our intention is to present an unbiased economic analysis of the capital cost savings for different architectures and applications in the areas of multiple ring termination, multiservice delivery and combined STS and VT grooming.

The Economics of Multiple Ring Termination

An MSPP with multiple ring terminations, as compared to an ADM with only one ring termination, makes good economic sense in the following two cases:

1. Multiple ring termination capability best fits in a CO that warrants a certain number of OC-48 rings. Our research with a variety of available equipment cost information indicates the minimum number of OC-48 (or OC-192 equivalent) rings in the CO is between 8 and 12 to justify such an MSSP.
2. The more rings that are interconnected in the CO, the more cost efficient multiple ring termination capability will be when combining multiple rings on a single system.

The Economics of Multiservice Delivery

In a CO with mixed traffic of Ethernet, DS1, DS3, OC-48 and OC-192, a system with only optical interfaces will require a two-tier configuration: a smaller system to interface the low-speed electrical traffic such as DS1/DS3 and 10/100Base-T Ethernet and a larger system to interconnect the optical rings and aggregate the traffic from the lower speed systems. This two-tiered approach generates extra interconnection requirements between the two layers and limits grooming at the site. A system that supports multiservice delivery can provide all the interfaces from DS1 to OC-192 in one platform.

Analysis has proven that the system with scalable multiservice delivery has a greater economic advantage over the two-tiered approach, resulting in equipment cost savings that range from 15% to 40%.

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For your convenience, a list of acronyms can be found on page 12 of this document.

The Benefits of Combined STS and VT Grooming Capability

The benefits of having DS1-level cross-connect capabilities along with STS capabilities come from the fact that ports used to transport DS1-visible traffic between the system and a DCS will be eliminated, saving DCS ports and intraoffice connections. Some of the add/drop traffic will have been converted into inter-ring traffic on an MSPP or MSSP.

The Economics of Multiple Ring Termination

With the advent of new technologies such as higher density VLSI chip sets, a ring switch capable of terminating multiple OC-48 and OC-192 SONET rings and cross-connecting large amounts of bandwidth has emerged. A typical ring switch can have a switch fabric with the capacity of more than 300 Gbps in a single system. One interface card can have 16 or more OC-3/OC-12 ports, up to 16 OC-48 ports and up to four OC-192 ports. A typical ring switch has only optical interfaces. With some help from low-speed interface MSPPs, one can configure a central office with a ring switch as shown in Figure 1.

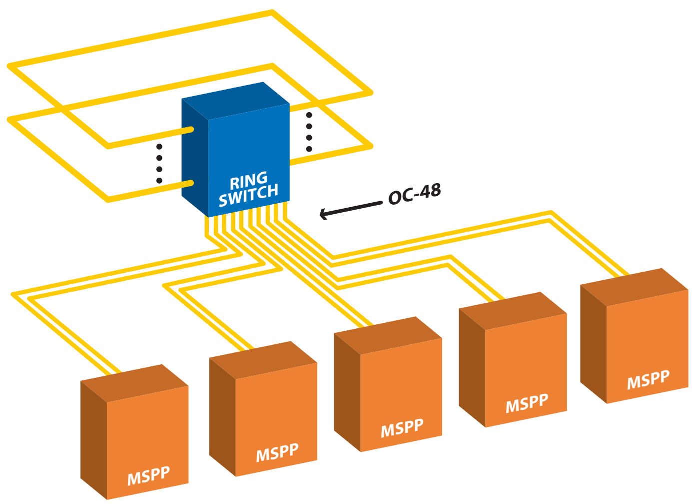

Figure 1: Configuration of Ring Switch in a Central Office

Network operators must determine if it is more economical to deploy a ring switch at one particular CO (or for a particular application) than to deploy a number of regular MSPPs. Two aspects must be investigated:

- Overall traffic volume at the CO
- The traffic between interoffice rings that terminates at the CO

CO traffic volume can be characterized by the number of rings terminating at the CO. Interoffice rings are usually OC-48 or OC-192 rings. For simplicity in our analysis, we will use OC-48 rings only (NOTE: one OC-192 is equivalent to four OC-48s). The number of OC-48 rings determines the traffic volume at the office. As traffic demands increase, a ring switch becomes a more favorable choice. A ring switch is a large system and usually incurs a larger initial cost than a regular MSPP. The breakeven cost point between an MSPP and a ring switch (without taking into account inter-ring traffic) is the total common equipment cost of a number of such MSPPs that is equivalent to the common equipment cost of a single ring switch (assuming interface-per-port prices are the same). However, the inter-ring traffic will require more interface ports for the MSPP only solution (as shown in Figure 2). The additional cost of interfaces for inter-ring traffic increases the cost of an MSPP solution. The breakeven point depends on both the common equipment costs and the cost of interfaces for inter-ring traffic. Inter-ring cost effects will be further discussed later.

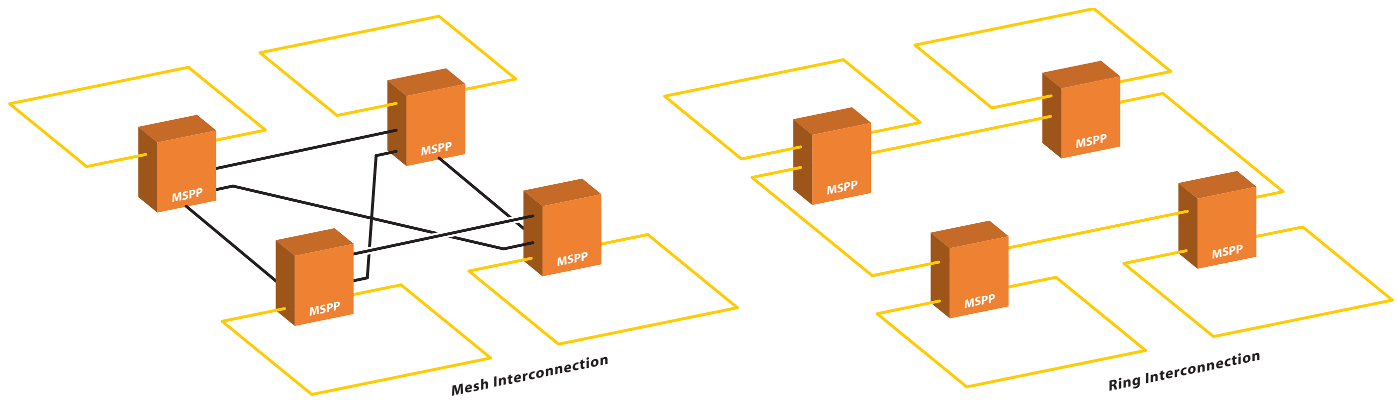

Figure 2: Intraoffice Connections for Inter-ring Traffic using Regular MSPPs

Our analysis shows, based on a general assumption on the cost of interfaces and common equipment, that at least 8 to 12 OC-48 rings must terminate at a CO to justify the deployment of a ring switch.

As mentioned earlier, the inter-ring or ring-to-ring traffic in the CO is also a determining factor of how well the ring switch will perform at the CO. In the following analysis, we assume a CO with three typical types of traffic flows:

- **Add/drop traffic—**traffic that is carried by the interoffice rings and terminates at the CO with low speed interfaces of DS3 and OC-3
- **Inter-ring traffic—**traffic that switches from one ring to another in the same CO
- **Pass-through traffic—**traffic that passes through the CO untouched

Note that these three types of traffic add up to 100% of the entire CO traffic load. We assume the pass-through traffic is fixed at 30%. We then use the add/drop and inter-ring traffic as two variables to test the sensitivity of the crossover point and the economics of deploying ring switches versus small MSPPs. We will examine the three options of 45% add/drop & 25% inter-ring, 30% add/drop & 40% inter-ring and 15% add/drop & 55% inter-ring. The third variable, which is the most important one, is the traffic volume at the CO in terms of the number of OC-48 rings. We will let this variable change from 4 to 36 with an increment of four.

For the equipment cost assumptions, we assume the per-port costs are the same for all interface cards and the cost for the ring switch's common equipment (shelf, control and processing cards) is about 6–7 times that of other MSPPs.

In the first of the following three figures, the result is that, when the inter-ring traffic is low (even if there are several rings in the CO), deploying ring switches in that location is not economical. The second and third figures show that the efficiency of the ring switch improves when the inter-ring traffic increases.

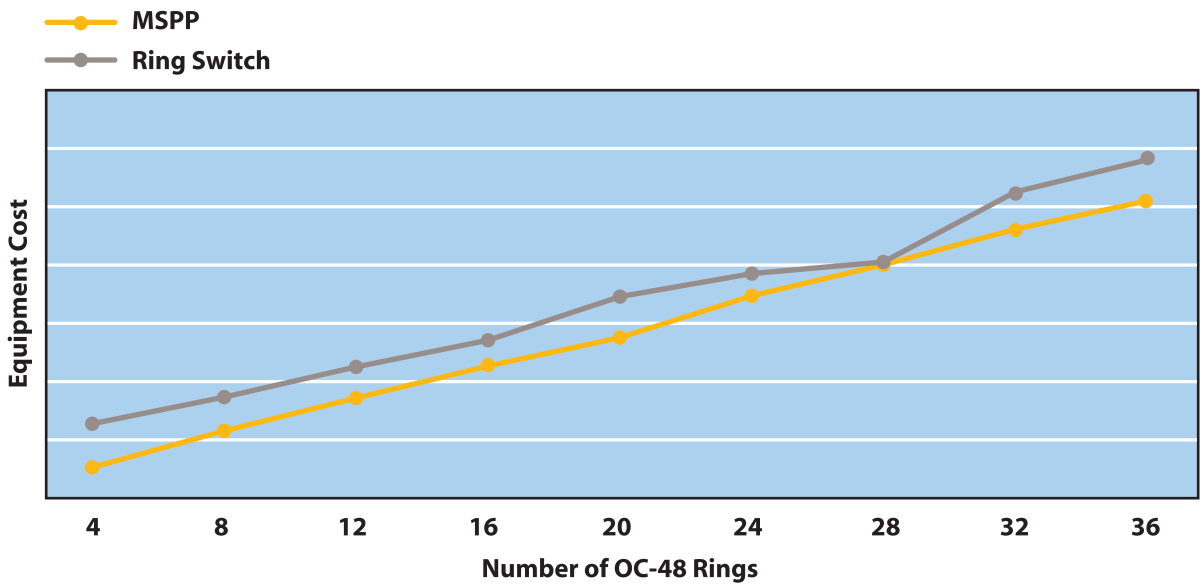

Figure 3: Economic Comparison with Add/Drop = 45% & Inter-Ring = 25%

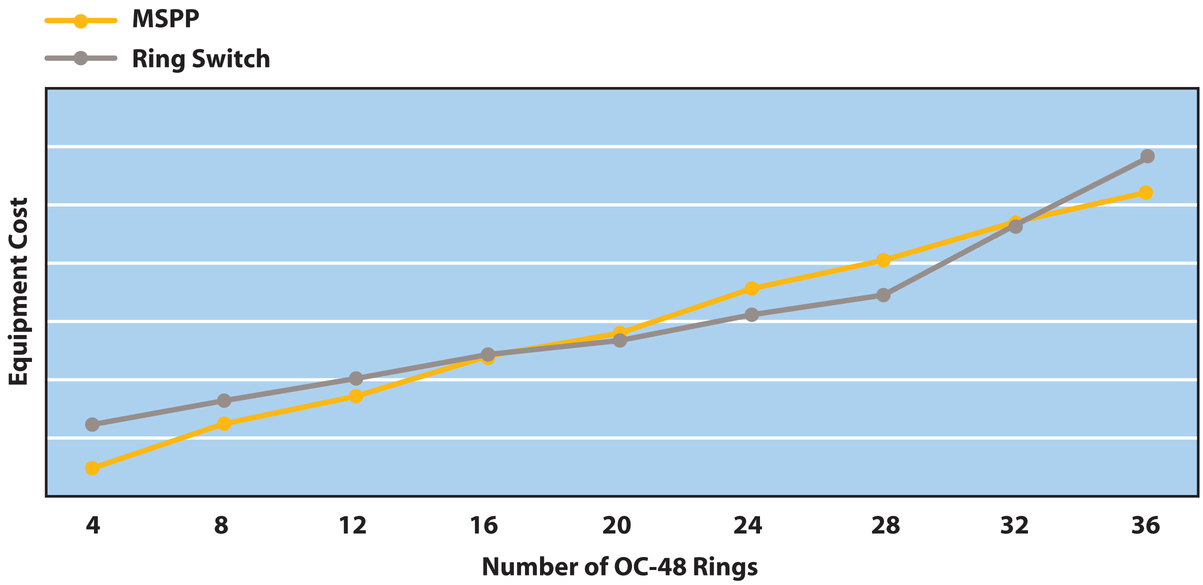

Figure 4: Economic Comparison with Add/Drop = 30% & Inter-Ring = 40%

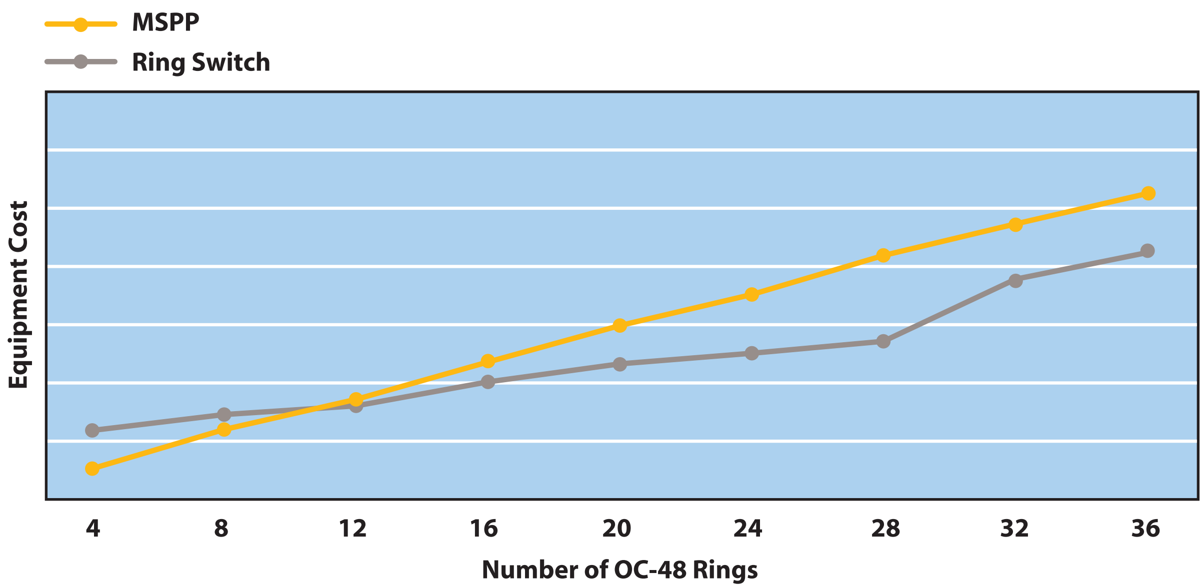

Figure 5: Economic Comparison with Add/Drop = 15% & Inter-Ring = 55%

Since the add/drop traffic and the inter-ring traffic complement each other, the business case becomes worse for the ring switch solution when the number of add/drop interfaces increases. This approach causes the two-tiered ring switch solution to carry the traffic from the low-speed service tier to the high-speed service tier. At the same time, the MSPP-only solution is already very efficient and cost effective in taking the low speed traffic from the inter-ring activities.

The Economics of Multiservice Delivery

As indicated in the previous section, the two-tiered ring switch approach has a cost penalty by the inter-connection between the two tiers, because every low-speed traffic flow from the lower tier requires three ports (one for the customer interface and two for the interconnection). Our multiservice delivery concept is to collapse the two tiers into one to save interconnection costs and reduce management complexity. Figure 6 shows a system that provides services from DS1 to OC-192 while providing multiple ring terminations. This system combines the functions of the ring switch and the MSPP to create an MSSP.

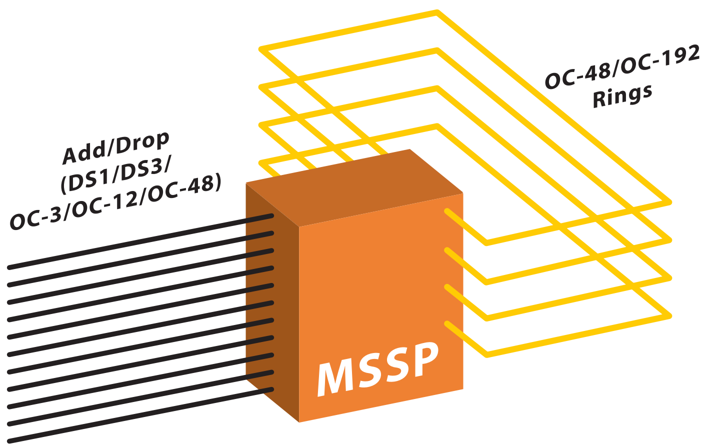

Figure 6: The MSSP Approach

For the equipment cost, we assume the per-port costs are the same for all interface cards and the cost for the MSSP common equipment (shelf, control and processing cards) is about 6–7 times that of a MSPP.

Figures 7, 8 and 9 show the economics of MSSP deployment. For reference purposes, we added the MSSP performance curves into the charts to compare the ring switch and the MSPP from the previous section.

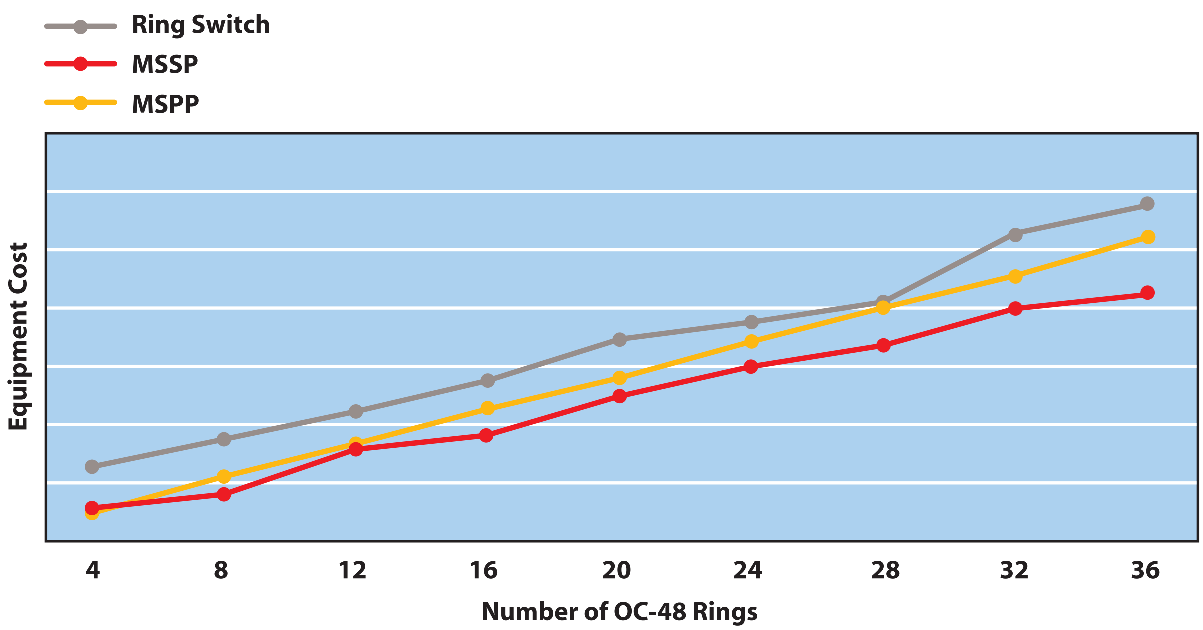

Figure 7: Economic Comparison with Add/Drop = 45% & Inter-Ring = 25%

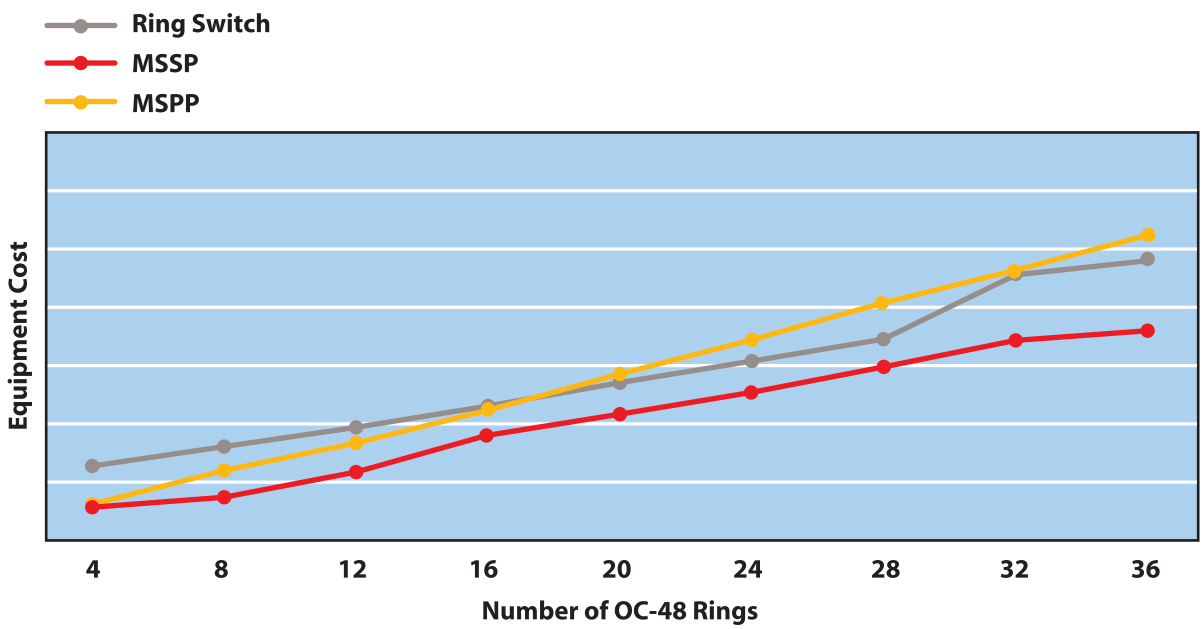

Figure 8: Economic Comparison with Add/Drop = 30% & Inter-Ring = 40%

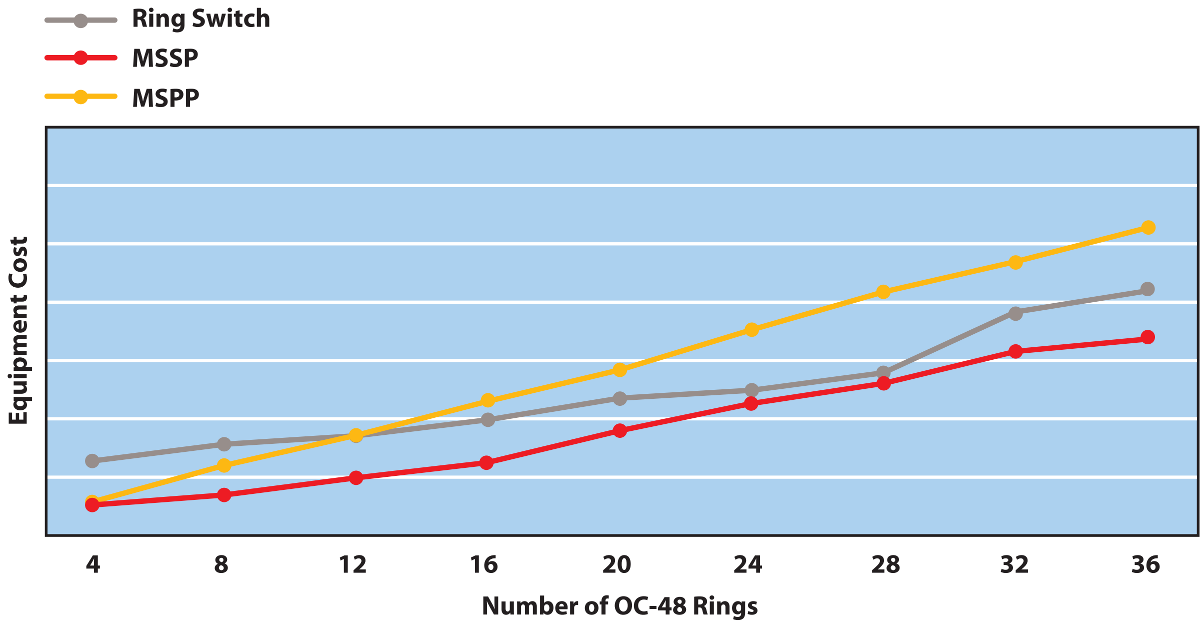

Figure 9: Economic Comparison with Add/Drop = 15% & Inter-Ring = 55%

Key findings include:

- The starting cost of the MSSP is much lower than the comparable ring switch approach
- The crossover point against MSPP is earlier (4 or 5 OC-48 rings, instead of 8–12)
- The inter-ring traffic does not erode much of the cost savings

The Benefits of Combined STS and VT Grooming Capability

In today's COs, a lot of traffic is dropped from an ADM for traffic management or grooming at the STS-1 level and at the DS1 level by a Wideband DCS.

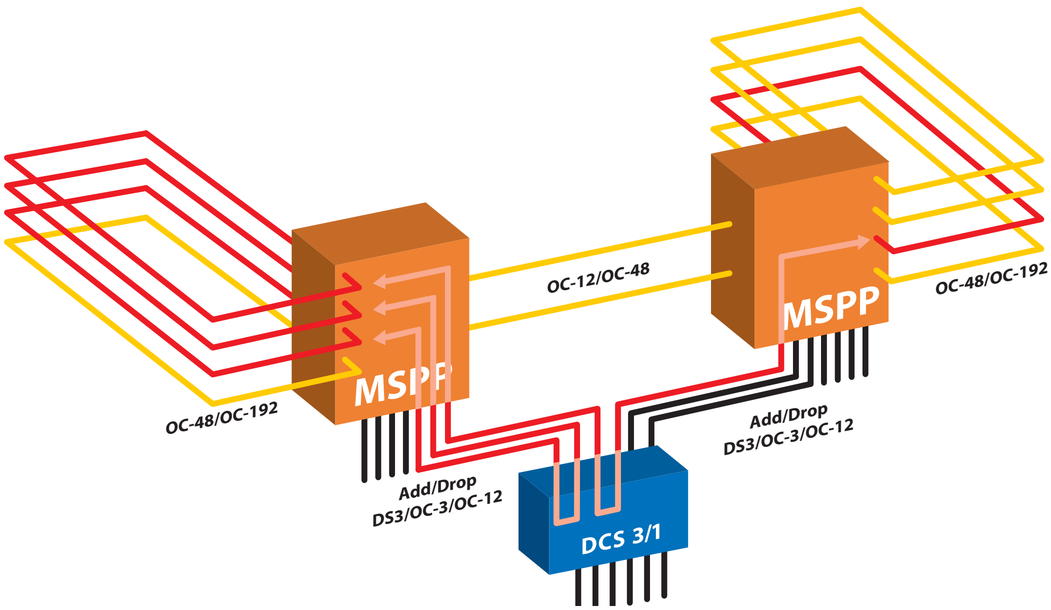

Figure 10: DS1 Grooming through a Wideband DCS

In metro networks, a DCS is deployed at hub sites to optimize the trunk usage of transport facilities. STS-1 timeslots filled with only a few DS1/VT1.5 connections are sent from access sites to hub sites. At the hub sites, these STS-1s are sent to the DCS so that the STS-1 pipelines coming out of the hubs are more efficiently filled with DS1s going to the same destination.[1] The cost of the process is the extra ports required to carry these STS-1s in the forms of DS3, OC-3 or OC-12 connections from the ADM to a DCS and back. This configuration may not necessarily take four ports for every STS-1, depending on how many poorly utilized STS-1 timeslots can be combined into one highly utilized STS-1. However, many ADM and DCS ports will be consumed strictly for this grooming purpose.

If the MSSP itself had DS1/VT1.5 grooming power, this kind of aggregation activity could take place inside the MSSP with no external ports required.

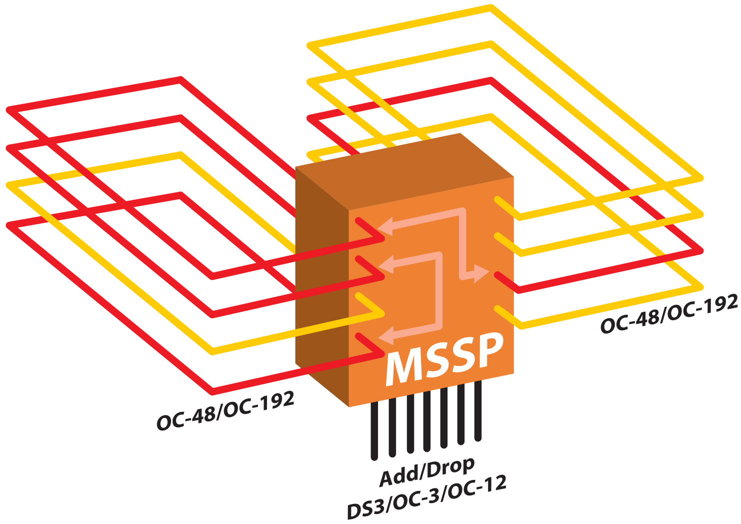

Figure 11: MSSP with DS1/VT1.5 Fabrics

Going back to the ring switch case again, having a VT1.5 fabric on the ring switch not only saves the ports between the ADM and DCS, but also serves to convert the add/drop traffic into inter-ring traffic. Add/drop traffic going to the DCS for grooming purposes is now going directly from one ring to another via an internal fabric, not consuming any external interface ports. As described earlier, the impact of the inter-ring traffic on the economics of deploying ring switches, the more inter-ring traffic that exists in the CO, the more economical it is to deploy ring switches.

Summary

SONET network elements continue to grow in feature density and service delivery capability. A next-generation SONET platform that provides multiple ring terminations, a ring switch, saves costs in large COs with multiple interoffice ring terminations and heavy inter-ring activities. Additional costs are saved if all interfaces from DS1 to OC-192 are terminated in one platform, saving the interconnections on smaller ADMs for aggregation. This process leads to the multiservice MSSP concept for the next generation of SONET equipment.

References

[1] Sunan Han, *Economics in Deploying Next-Generation SONET Equipment in Metro Networks,* Proceedings of National Fiber Optic Engineers Conference 2002, Vol. 1, September 2002, pp. 526-536.

Acronyms

Acronym	Descriptor
ADM	Add/Drop Multiplexer
CO	Central Office
DCS	Digital Cross-Connect System
MSPP	MultiService Provisioning Platform
MSSP	MultiService Switching Platform
VLSI	Very Large Scale Integration

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