

EMC Smarts Optical Transport

A Manager of Managers for Ensuring Service Delivery over Optical Networks

Abstract: The optical sector continues to show solid growth, based largely on steady private-line use and burgeoning Ethernet demand. However, the optical domain with its wide range of devices, systems, and vendors poses many management challenges. This white paper helps carriers identify and understand the key issues associated with managing their optical networks, and determine what solution best addresses those challenges.

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Introduction

The optical sector continues to show solid growth, based largely on steady private-line use and burgeoning Ethernet demand. In particular, the advent of Ethernet-over-Optical has reinvigorated Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH), as carriers seek new revenue-generating service opportunities that also allow them to distinguish their offerings.

However, the optical domain poses many challenges to carriers, including:

- Numerous vendors offering a range of Layer 1 products with varying capabilities and attributes.
- Carriers populating their growing optical networks with an unwieldy assortment of devices.
- Most devices using different approaches to how they send signals up through the layers of the Open Systems Interconnection (OSI) stack.
- Legacy element management systems (EMSs) and network management systems (NMSs) offering no end-to-end visibility into the optical transport environment, which burdens service provider networks.

As a result of these challenges, management of optical networks has become labor-intensive and costly. This white paper helps carriers identify and understand the key issues associated with managing their optical networks, and determine what solution best addresses those challenges.

The Optical Network

After several years of decline, worldwide sales for optical equipment have rebounded. Sales in 2003 were \$8.6 billion, and 2004 sales likely will exceed \$9 billion (Infonetics, Oct 2004). This growth stems from a combination of burgeoning enterprise demand and maturing technologies whose annual growth rates exceed 100 percent, such as:

- Ethernet-over-SONET/SDH.
- Coarse Wave Division Multiplex (CWDM).
- Resilient Packet Ring (RPR).
- Fiber to the X (FTTx).

Representing Layer 1 of the OSI stack, metro and long-haul SONET/SDH networks offer an open architecture for overlaying technologies such as Asynchronous Transfer Mode (ATM), Frame Relay, Ethernet, and Internet Protocol (IP). As deployments grow, so does the need to broaden the optical backbone to carry the additional traffic.

Optical networks also represent the cornerstone for earlier voice traffic. Successful long-distance telephony required high-speed transmission with exceptional Quality of Service (QoS); as a result, nearly all DS0-DS3 voice circuits were transported over optical networks (see Figure 1).



Figure 1: Applications for an Optical Network

T1 and E1 private-line services further buoyed optical sales, followed by the integration of Ethernet services directly onto SONET/SDH boxes. The bandwidth capability and resilience associated with optical networks has led to their wide-scale deployment with numerous other technologies. From a management perspective, these dual deployments have two consequences:

- Failures in the optical domain can generate hundreds—even thousands—of alarms and events. These sheer numbers make it difficult for carriers to sift through the extraordinary level of data to quickly pinpoint the exact cause of a failure.
- Failures in the optical domain ripple into other layers of the OSI stack. For example, signal degradation or a cut optical fiber can create outages in the overlaying ATM and IP/Multi-Protocol Label Switching (MPLS) domains, which in turn adversely affect virtual private network customers.

These conditions create a need for management solutions that can fulfill two basic requirements:

- Correlate optical failures to the related infrastructure.
- Determine the impact of those failures on customers.

Managing Optical Networks

The OPEX-to-CAPEX ratio for managing optical networks is arguably the highest of all infrastructure technologies.

Optical by nature is a multi-domain environment, offering SONET, SDH, integrated SONET/SDH in international carrier networks, CWDM, and Dense Wave Division Multiplex (DWDM) architectures. A significant level of IT expertise is required at the carrier network operations center (NOC) to interpret and analyze optical failures.

At the EMS and NMS levels, management of optical networks remains disjointed. Equipment vendors avoid introducing into their own management systems capabilities that could manage other equipment vendors' products (see Figure 2).

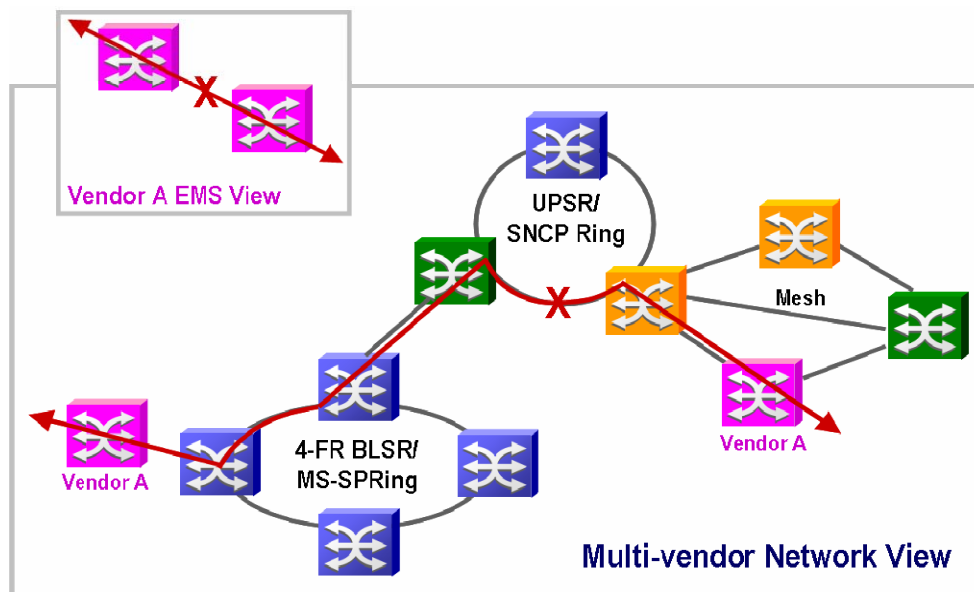


Figure 2: Typical Multi-vendor Network

Failure on the circuit as shown in Figure 2 is often difficult to pinpoint and troubleshoot due to the disparate views provided by the management systems of the different equipment vendors.

Most carriers have deployed anywhere from tens to hundreds of optical EMSs and NMSs—more than any other technology in the overall infrastructure—which exacerbates the management problem. When an issue arises, IT personnel must examine and attempt to interpret data from numerous different EMSs. This effort extends the length of outages and delays time-to-repair. Although some carriers have developed in-house manager of manager (MoM) solutions in an attempt to consolidate data, varied implementation of the TL1 protocol by equipment vendors has made such efforts costly.

A management solution's ability to distinguish between root-cause problems and mere symptoms of those problems addresses two key concerns by:

- Pinpointing the exact problem that needs fixing—whether it occurs in the optical network or in the ATM, Frame Relay, IP, or another related domain—dramatically decreases the length of the outage.
- Distinguishing failures that occur in other carrier networks. For example, a cut fiber in one carrier's network may cause a circuit outage in another carrier's network. From a service assurance perspective, carriers must discern exactly where the root cause is so that they can correct the problem as quickly as possible.

Managing SONET/SDH Devices

This category includes a large family of devices, including Add-Division Multiplexers (ADMs), Multi-Service Provisioning Platforms (MSPPs) and Digital Access and Cross-Connect Systems (DACs). These optical switches offer a wide variety of interfaces, ranging from asynchronous (DS1/E1/T1, DS3/E3) and optical OC-3/STM1 to OC-192/STM-64 and Ethernet (10/100/1000MbE).

The legacy asynchronous circuits were developed to support Public Switched Telephone Network (PSTN) voice circuits. As the number of voice circuits increased, it became more viable to carry these services over an optical backbone. The growth of data services propelled interfaces such as 2.5G, 10G, and DWDM technology, enlarging the optical backbone. Core optical switches emerged, offering higher capacity. Greater emphasis was placed on optical protection schemes (ring, mesh, and dual-redundancy).

Yet a new series of challenges faced carriers:

- What SONET/SDH alarms are critical to our business?
- Which alarms requires immediate corrective action?
- What level of IT personnel must be available to troubleshoot SONET/SDH failures?
- How can automation minimize outages and operating expenses?
- How can we determine what circuits have been impacted by protection switches or outages?

Managing DWDM Devices

DWDM devices range in optical reach (ultra-long haul systems offer reach of thousands of kilometers) and multiplexing capability (single-lambda to more than 100 lambda). The result is a complex association of optical devices offering dispersion compensation, multiplexing, and pulse amplification. Failures that occur in the DWDM domain can cause hundreds—even thousands—of DWDM and SONET/SDH alarms (Figure 3).

This potentially high number of alarms makes DWDM fault management extremely difficult. Not only must IT professionals comb through a flood of raw data to pinpoint exact causes, but failures that appear to occur in the SONET/SDH domain may have actually taken place in the DWDM domain. This Layer 1 dependency creates the need for cross-correlation between SONET/SDH and DWDM so that a carrier can ensure proper diagnosis of failures.

Event	Severity	Ack	Source	Description	Count	NE Facility	Equipment	Time	Date
1	Minor	No	Nortel OPTera LH	Signal Change Alarm	1	2322 1-2-33-1-2	OC48	5:03:05	12/15/2004
2	Major	Yes	Ciena CoreDirector	LOS	1	433 1-12-23-1	OC192	5:03:05	12/15/2004
3	Minor	No	Cisco 15454	Loss of Protection	2	1013 1-23-1-5	OC192	5:03:05	12/15/2004
4	Warning	No	Lucent DMX	Invalid Removal of Circuit Pack	1	10311 1-7-5-32	1000MbE	5:03:05	12/15/2004
5	Critical	No	Lucent Lambda Unite	Circuit Pack Fail	1	New York 1-5-3-8-2	DS3	5:03:05	12/15/2004
6	Minor	No	Nortel OPTera LH	RDI	1	Baltimore 1-2-33-1-2	OC48	5:03:05	12/15/2004
7	Major	No	Ciena CoreDirector	LOS	1	1323 1-12-23-1	Amplifier	5:03:05	12/15/2004
8	Warning	No	Nortel OPTera DX	LOF	2	Dallas 1-23-1-5	Amplifier	5:03:05	12/15/2004
9	Critical	No	Lucent DMX	Holdover	1	54555 1-4-2-6-4	OC192	5:03:05	12/15/2004
10	Minor	No	Lucent DMX	AIS-L	5	2045 1-5-5-55-4	Timer1	5:03:05	12/15/2004
11	Major	No	Cisco 15454	AIS-P	1	Chicago 2-1-5-3-5	OC192	5:03:05	12/15/2004
12	Major	No	Tellabs 5500	Loss of NE	1	St. Louis 3-1-1-3-4	OC192	5:03:05	12/15/2004
13	Warning	No	Tellabs 5500	Signal Degrade	2	Albany 3-2-4-44	1000MbE	5:03:05	12/15/2004
14	Critical	Yes	Tellabs 5500	Loss of Working	1	Miami 1-66-3-5	DS3	5:03:05	12/15/2004
15	Critical	Yes	Tellabs 5500	Loss of Working	4	Miami 1-7-8-3	OC48	5:03:05	12/15/2004
16	Critical	No	Alcatel Flashwave	Amplifier Failure	1	San Antonio 3-5-2-4	Amplifier	5:03:05	12/15/2004
17	Critical	No	Alcatel Flashwave	Amplifier Failure	1	Kansas City 1-23-1-5	Amplifier	5:03:05	12/15/2004
18	Warning	No	Alcatel Flashwave	UNEQ-P	2	Atlanta 1-4-2-6-4	Amplifier	5:03:05	12/15/2004
19	Warning	No	Ciena CoreDirector	Signal Degrade	1	New York 1-5-5-55-4	OC3	5:03:05	12/15/2004
20	Minor	No	Nortel OPTera LH	AIS-L	1	Dallas 2-1-5-3-5	OC48	5:03:05	12/15/2004
21	Major	No	Lucent Lambda Unite	Loss of Switch Card	1	San Diego 3-1-1-3-4	SW	5:03:05	12/15/2004
22	Major	No	Lucent Lambda Unite	Loss of Protection	1	San Diego 1-3-7-5	DS3	5:03:05	12/15/2004

Figure 3: Excerpt of Consolidated Optical Alarm View

Managing Ethernet Services

The introduction of Generic Framing Protocol (GFP) and Virtual Concatenation (VCat) protocols has enabled the integration of Ethernet onto SONET/SDH interfaces. Ethernet VLAN traffic can now be mapped directly onto an optical network. This ability creates a new set of services that carriers can offer their subscribers—as well as a new potential source of failures that can directly impact users throughout the optical domain. As a result, management solutions must apply cross-domain correlation from the optical network into the Ethernet services that depend on that network.

The MoM Criteria

Based on the management needs of these devices, one can develop a set of criteria that addresses the need for improved fault management in optical networks:

- Offer complete monitoring of all possible Layer 1 (SONET and SDH) and sub-Layer 1 (DWDM) alarms.
- Accurately pinpoint the location of a network failure.
- Perform root cause analysis of all known network failures.
- Determine the impact of optical failures on:
 - Overriding circuits.
 - Dependent applications.
 - Business services.
 - Customers.
- Reduce the level of human intervention required for network troubleshooting.
- Provide end-to-end optical network management.
- Minimize the number of actionable events that require intervention by the IT staff.

EMC Smarts Optical Transport Manager

EMC® Smarts® Optical Transport Manager (OTM) offers the industry's leading-edge solution for managing optical networks. Like other Smarts solutions, Optical Transport Manager leverages the EMC Smarts Common Information Model™, which places all network entities and events in the proper topological and business context.

EMC Smarts Optical Transport Manager uses a different approach from those taken by all other vendors. Instead of starting with the events that can occur and defining rules to process them, Smarts starts with the *authentic problems*™ that must be detected to protect service delivery. This approach is based on the fact that not every event is a service-affecting problem—in fact, a flood of events could occur without there being any problem that needs to be fixed.

Identification of *authentic problems* focuses on a unique set of symptoms, known as the problem signature. EMC Smarts Optical Transport Manager constantly monitors for symptoms of *authentic problems*. When a match between events and the signature of an *authentic problem* occurs, EMC Smarts Optical Transport Manager sends a notification that the problem occurred and invokes an associated action.

EMC Smarts Optical Transport Manager automatically discovers the logical and physical objects in the environment as well as their relationships, behaviors, and interactions. Examples of physical objects include network elements, interfaces, and optical links. Examples of logical devices include Common Transport Protocols (CTPs) and protection groups. Based on the results of auto-discovery, EMC Smarts Optical Transport Manager automatically builds a comprehensive repository, or topology, and traverses the repository to automatically calculate the signatures, mapping problems to symptoms.

To illustrate this example, consider the simple 3-node 4-fiber Unidirectional Path Switched Ring/Sub-Network Connection Protection (UPSR/SNCP) network shown in Figure 4.

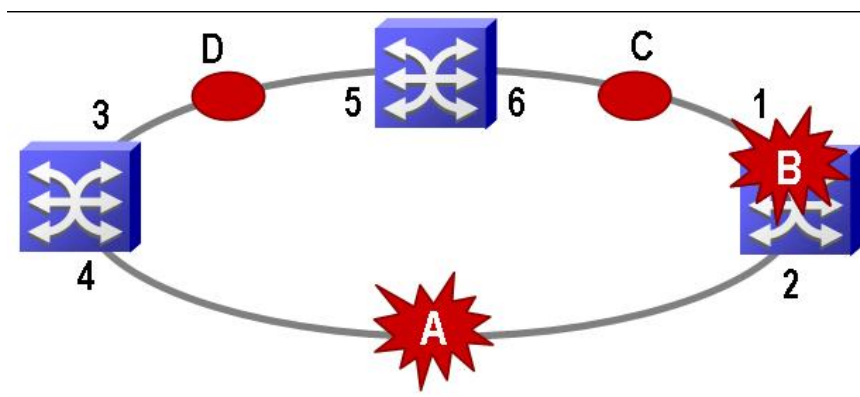


Figure 4: An Example of a SONET/SDH Ring

EMC Smarts Optical Transport Manager discovers the optical network devices and their attributes (such as name, vendor, location, and ports) as well as the circuits (or cross-connects) associated with each device. This discovery is key for correlating infrastructure to circuits. The topology and physical connectivity of these devices is also collected, allowing Optical Transport Manager to manage the entire network—not just one vendor's part of it. After it fully discovers the network, Optical Transport Manager builds a repository of the environment and begins monitoring. In Figure 4, a failure at point A occurs in a 4-fiber ring protection switch. This failure will typically produce a large inflow of events, including loss of signal, alarm indication signal, remote defect indication, and circuit-level alarms. Optical Transport Manager collects the inflow of events, matches symptoms to signatures, identifies the root cause, and provides a list of circuits impacted by the initial failure (see Figure 5). This model can be extended to failures at points B, C, and D in the example in Figure 4 as well.

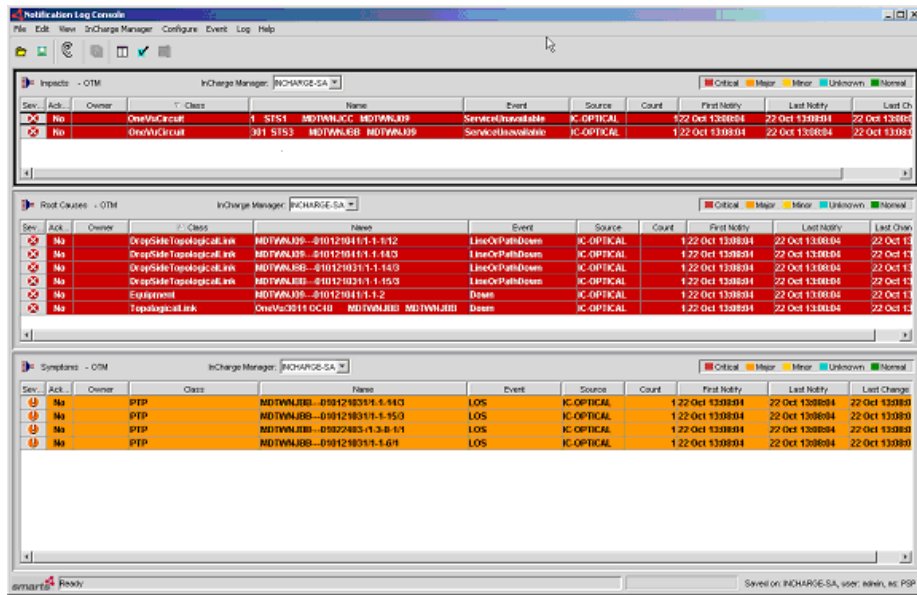


Figure 5: Optical Transport Manager Distinguishes Root Causes from Impacts and Lists the Impacted Circuits

One of the key benefits in adopting Optical Transport Manager as the MoM for optical networks is its end-to-end network management. The UPSR/SNCP network shown in Figure 4 can easily consist of products from numerous vendors along the same ring—complexity that can make troubleshooting network failures using a mix of vendor EMSs and NMSs difficult. Optical Transport Manager collects all information pertinent to the network topology (linear, ring or mesh) and builds a unified topology.

Correlation

As already discussed, SONET/SDH failures can correlate to impacted circuits. Correlation with Smarts also extends to other key areas:

- Because of the nature of the Smarts repository, Optical Transport Manager can correlate failures that occur in the DWDM domain into the SONET/SDH domains (see Figure 6).
- Smarts inherently can correlate underlying infrastructure failures to the application and business layers.

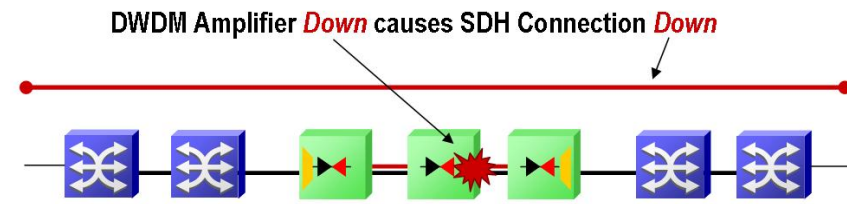


Figure 6: Correlation of DWDM Failures to SONET/SDH Circuits

Alarm Management

EMC Smarts Optical Transport Manager offers the most comprehensive SONET/SDH and DWDM alarm management in the industry. Optical Transport Manager provides root cause and impact analysis for physical failures such as equipment malfunctions, as well as logical failures such as line and path. Optical Transport Manager also determines if failures in the carrier network stem from external-domain failures. This critical distinction allows carriers to determine if outages in their network are actually the result of failures in a neighboring network. All alarms listed in Figure 7 are monitored by Optical Transport Manager.

Problems	Symptoms
Equipment Failures	Circuit pack and common equipment failures
Line-level Failures	Line failure (e.g., fiber cut) Signal failure Signal degradation
Path-level Failures	Path-level failures due to: UNEQ-P, LOP-P, AIS-P, TIM-P, PLM-P Common equipment failures
External Failure	Detection that a problem is outside managed network when the following alarms are received from an external network and do not correspond with a known problem inside the managed network. Alarms processed indicating line problems are: LOS, LOF, AIS-L, RDI-L Alarms processed indicating path problems are: RDI-P, LOP-P, UNEQ-P, TIM-P, PLM-P, PDI-P

Figure 7: List of Failures Monitored by EMC Smarts Optical Transport Manager

Conclusion

EMC Smarts Optical Transport Manager provides carriers a powerful means to minimize the length of outages in their optical networks. Optical Transport Manager offers the same value proposition of other Smarts products, leveraging the EMC Smarts Common Information Model to discover and dynamically manage a SONET/SDH and DWDM architecture. Optical Transport Manager distinguishes failures from impacts associated with those failures, and notifies the user what circuits the failures have affected. The use of EMC Smarts Application Services Manager and Business Impact Manager extends correlation to the impacted applications and business services that depend on this infrastructure. The result is a highly efficient fault management system that gives IT personnel the edge they need to manage their optical networks efficiently and cost-effectively.