Ensuring Intelligent Optical Network Interoperability, Reliability and Performance

Intelligent Optical Networks are set to replace SONET/SDH transport networks. While intelligence brings new levels of scalability and manageability to optical networking, it also poses a threat to reliability. New methods are needed to verify interoperability, reliability, and performance before deployment.

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Introduction

Today's traditional SONET/SDH networks provide high levels of reliability based on mature and stable technologies, however these networks are unsuitable for the impending bandwidth revolution. Intelligent optical mesh networks promise to deliver new levels of optical network scalability, manageability and efficiency. These new optical transport networks take routing and signaling technologies from the data networking industry and adapt them for use in optical transport networks. While these new technologies bring many benefits to optical networks, they also introduce new risks that threaten to compromise the reliability and performance of a core optical transport network. New methods are required by equipment developers and service providers for verifying interoperability, reliability, and performance of new optical networking elements before deployment. These new methods are proposed and discussed in this paper.

Today's Reliable SONET/SDH Networks

Today's optical network architectures, based upon SONET/SDH, have provided us with a highly reliable foundation for the world's voice and data networks. The need for high levels of reliability has been driven primarily from voice networks that in many cases guarantee 99.999% service availability. With healthy revenue streams generated by voice traffic, network operators cannot afford outages. Outages can cost millions of dollars per minute in lost revenue, as a result, redundancy has built into SONET/SDH networks from the ground up.

It should also be noted that voice networks have very predictable traffic patterns and growth requirements. With such predictable growth, it was possible to forecast provisioning of new optical circuits many months in advance. Consequently, optical transport networks could afford to be managed in a very labor-intensive manner.

New Intelligent Optical Transport Networks

The success of the Internet has placed extreme pressure on all aspects of a service provider's network. Technologies such as xDSL and broadband cable modems have risen to the challenge, giving users high-speed access connections. The introduction of Gigabit and Terbit IP Routers allows this traffic to be efficiently forwarded. DWDM technology provides high capacity "fat pipe" core networks for interconnecting routers and access devices in the metro and long haul.

Service providers are facing the challenge of managing fast growing networks while reducing operating costs and improving provisioning times. Consequently, service providers are finding traditional SONET/SDH network architectures and management solutions inappropriate for future needs. A new architecture is required.

Intelligent optical networking, enabled by high capacity Optical Cross Connects (OXCs) with software intelligence, grants new methods for managing high capacity core optical networks.

Important innovations that OXCs bring to optical networking include;

- Switching capacities matching the bandwidth needs of DWDM technologies,
- Automatic topology and resource discovery supporting large random mesh topologies,
- Software driven route selection and inventory management,
- Efficient protection and restoration schemes with user selectable priority and preemption levels,
- Automatic provisioning via a standard user-to-network interface.

First generation OXCs generally deploy an electronic switching fabric; these systems are often referred to as OEO. Future all-optical OXCs may deploy an optical fabric using bubble switch or MEMS technology, referred to as OOO. All-optical devices have the advantage of bandwidth transparency and switch complete fibers carrying multiple wavelengths. Regardless of the core switching technology deployed, both generations of OXC will utilize software intelligence to automate management and provisioning.

The heart of this intelligence is the optical control plane. The optical control plane consists of tightly coupled routing and signaling functions. Each instance of an OXC in an intelligent optical network contains an instance of the control plane. Control plane instances communicate with each other either "In Band" or "Out of Band". In band control plane messages are carried in the SONET/SDH overhead of one wavelength in the fiber. Out of band messages are generally transported via a separate data network, usually an IP network.

Presently most control planes are proprietary, with most vendors developing and deploying their own protocols. In most cases, these protocols are adaptations of existing data networking protocols that already support concepts such as topology discovery and signaling.

Existing control plane protocols are mostly concerned with communications between OXCs; thus, there is currently no method of interworking across different vendors.

The first step of interworking will be to standardize the optical user to network interface (O-UNI). The O-UNI will allow devices such as IP routers to signal for additional optical circuits when required, and tear down circuits when traffic levels subside.

Barriers to Deploying an Intelligent Optical Network

It is important to put into perspective the role of intelligent optical core networks. These new networks are set to become the core of core networks, deployed by carriers-carriers, and handling the traffic of nations. Software glitches can halt industries, destroy reputations and generate billion dollar law suits. In such circumstances, network operators cannot afford outages.

We have seen several highly publicized network outages in the data and voice networks we rely on today. In many cases these outages can be attributed to software corner cases, system limitations or interoperability problems. Like a small spark that lights a large forest fire, a negative stimulus to a single element can ripple through and impact an entire network.

Consider also that optical network control plane software components have been mostly adopted from the data networking industry. Reliability of data networking devices has improved over recent years, however these devices have not yet achieved availability close to the 99.999% provided by SONET/SDH equipment.

Before deploying production networks, network operators and equipment manufacturers alike must be convinced beyond doubt that the technology is reliable enough to stake their future on.

A New Testing Regime

Testing and verification of networking devices can typically be broken down into a series of stages. Each stage involves building a level of confidence that allows progression to the next stage. This is no different for optical networking devices, only a higher level of confidence is required. Below is a high-level overview of typical testing stages. These stages are not normally sequential, but are usually run concurrently with results feeding back down the chain. For example, a failure identified during Alpha trial can result in further stress testing.

All stages in this test regime are essential to improve network reliability and confidence. The Conformance, Interoperability and Stress stages could be considered the most important of all stages.

Functional and Regression Testing

Even before component design has been completed, a functional regression test campaign can be well under way. Such a campaign allows evolutionary product releases to be tested in a test harness environment. As the functionality of the design is built up, so too can the regression test harness. Defects can be detected and resolved well before a design is complete. This is often the most effective and efficient way to eliminate most defects early in the design cycle.

Conformance and Interoperability Testing

Ensuring functional conformance to standards is the first real step to interoperability and reliability. Protocol specifications are never perfect and are always open to interpretation.

Many network failures can be attributed to a difference in the implementation of a control plane protocol that causes two network elements to interoperate in an unpredictable way. A conformance test suite provides a means of aligning the interpretations of protocol specification.

If the aim of standards is to promote interworking, then interoperability is the catch-all final test to prove interworking. In situations where multiple vendors are required to work together in a single network, interoperability testing is essential. This is especially the case at the edge of the network, where service is terminated by an O-UNI, or within a network where elements from different vendors are required to peer with one another via an O-NNI. Ideally interoperability testing should be conducted with stress applied, to simulate worse than real world conditions.

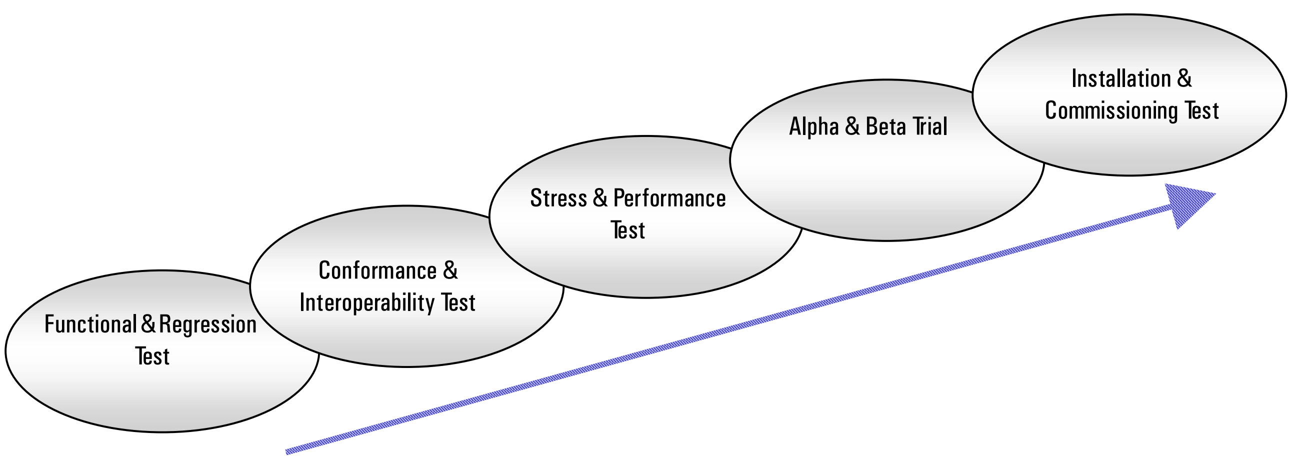

Figure 1:Testing and Verification Stages for optical devices.

Stress and Performance Testing

Applying stressful conditions to a network element allows one to discover weak links in a design. Stress conditions should replicate conditions much worse than those experienced in a real network. Stress can be described as "Worse than real world testing" and involves exploring dimensions of scalability and performance simultaneously and over extended periods of time. Stress must be applied in an environment that is as close to real world as possible, including all system components as they will be deployed in a network. Stress testing may involve surrounding an element with virtual peers who each inject topology and topology change information, whilst also signaling for resources. Such a test would provide answers to the following questions well before deployment:

- Does the Routing software handle large, complex topologies?
- How do dynamic changes to the topology affect routing software stability?
- What is the response to connection request floods?
- How quickly does the network respond to fiber cuts and element failures?

Conclusion

With such huge revenue streams dependent on core optical transport networks, reliability has become the key concern to the success of any core optical network operator. It has become apparent that a rigorous program of testing is required to prove reliability before operators will feel comfortable enough to deploy these new intelligent devices. Such a program should exist from the earliest stages of development focusing on regression, stress, conformance and interoperability.

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Agilent IP Routing Test Solution

Agilent's IP Routing Test Solution product family includes Agilent QA Robot and Agilent RouterTester and the test software that runs on these platforms. The QA Robot provides all basic IP routing test capabilities, plus conformance, stress and functional testing. The RouterTester is enhanced with wire-speed traffic generation that enables comprehensive performance metrics and integrated routing protocol support.

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