OTN Testing With the NetBlazer Series

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INTRODUCTION

The dramatic increase in bandwidth demand has forced carriers to change their infrastructure. Since carriers are now focusing on reducing their operating expenses (OPEX), maintaining their old networks (SONET, SDH, WDM) is no longer a viable and efficient option.

The optical transport network (OTN) was created with the intention of combining the benefits of SONET/SDH technology with the bandwidth expansion capabilities offered by dense wavelength-division multiplexing (DWDM) technology. Today, OTN is not only used in core networks to transport high-speed rates of 10, 40 and 100 Gbit/s, it is also starting to be used in edge networks.

OTN BENEFITS AND CHALLENGES

OTN standard G.709 was primarily developed to add SONET/SDH features like performance monitoring, fault detection, communication channels and multiplexing hierarchy to DWDM technology. The primary benefits of OTN include:

› Enhanced OAM (operation, administration and maintenance)

› A universal container supporting all service types

› Standard multiplexing hierarchy

› End-to-end optical transport transparency of customer traffic

› Multi-level path OAM

OTN has mostly been used in core networks for long-haul and ultra-long-haul transport. However, an increasing number of carriers and service providers are now implementing OTN because of the benefits above. Having OTN in edge networks or at the customer premises has many advantages:

› The network becomes transparent to any underlying services and protocols

› The network maintains end-to-end optical performance and alarm monitoring

› The traffic is efficiently groomed

Extending OTN deployment to edge and metro networks creates challenges for technicians who are used to working with Ethernet, IP, Fibre Channel, SONET/SDH and other technologies. In most cases, they will require training. However, carriers and services providers want to reduce their costs and avoid spending money on training. This presents a serious dilemma to carriers and service providers.

OTN TECHNOLOGY

In addition to further enhancing the support for the operations, administration, maintenance and provisioning (OAM&P) functions of SONET/SDH in DWDM networks, the purpose of the ITU G.709 standard (based on ITU G.872) is threefold:

1. It defines the optical transport hierarchy of the OTN.
2. It defines the functionality of its overhead supporting multi-wavelength optical networks.
3. It defines its frame structures, bit rates and formats for the mapping of client signals.

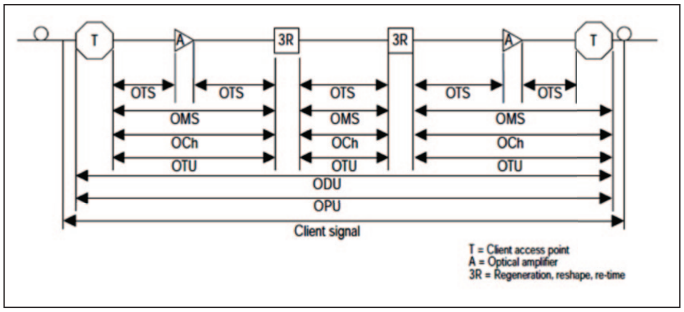


Figure 1: OTN layer termination points

As shown in Figure 1, the OTU also encapsulates two additional layers—the ODU and the OPU—which provide access to the payload (SONET, SDH, etc.). These layers normally terminate at the same location.

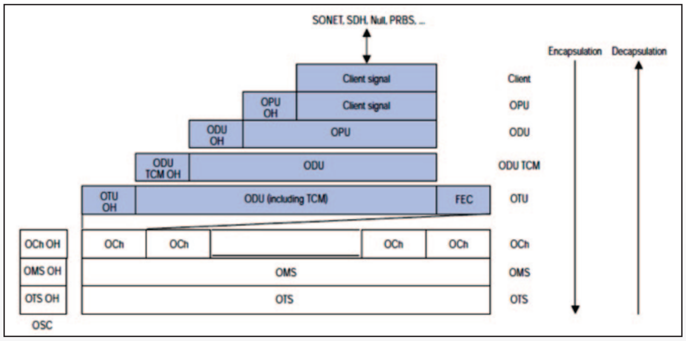


Figure 2: Basic OTN transport structure

As depicted in Figure 2, to create an OTU frame, a client signal rate is adapted at the OPU layer. The adaptation consists in adjusting the client signal rate to the OPU rate. Its overhead contains information that supports the adaptation of the client signal. Once adapted, the OPU is mapped into the ODU. The ODU maps the OPU and adds the overhead needed to ensure end-to-end supervision and tandem connection monitoring (up to six levels). Finally, the ODU is mapped into an OTU, which provides framing as well as section monitoring and FEC.

Based on the OTN structure presented in Figure 2, OTUks (k = 1, 2, 3) are transported using the OCh; a specific wavelength of the ITU grid is assigned to each channel. Several channels can be mapped into the OMS and then transported via the OTS layer. The OCh, OMS and OTS layers each have their own overhead for management at the optical level. The overhead of these optical layers is transported outside of the ITU grid in an out-of-band channel called the optical supervisory channel (OSC).

When the OTU frame structure is complete (OPU, ODU and OTU), ITU G.709 provides OAM&P functions that are supported by the overhead.

OTU Frame Structure

The OTU frame is comprised of the following components:

› Framing

› OTU, ODU, OPU overheads

› TCM

› FEC

Framing

The OTU framing is divided into 2 sections:

› The frame alignment signal (FAS) is used to provide framing for the entire signal.

› The multiframe alignment signal (MFAS) is used to extend command and management functions to several frames.

Overheads

There are three overhead areas in an OTN frame: the Optical Payload Unit (OPU), the Optical Data Unit (ODU) and the Optical Transport Unit (OTU). These overhead bytes provide path and section performance monitoring, alarm indication, communication and protection switching capabilities. One additional feature is the inclusion of a Forward Error Correction (FEC) function for each frame.

Tandem Connection Monitoring (TCM)

TCM enables the user and its signal carriers to monitor the quality of the traffic that is transported between segments or connections in the network. Whereas SONET/SDH allowed a single level of TCM to be configured, ITU G.709 allows six levels of tandem connection monitoring to be configured.

In large networks constructed over vast geographical areas, it's very common for multiple carriers to transport a signal; each providing transport services across their respective geographical areas. These carriers monitor the path layer as the signal enters and exits their network in order to provide service assurance to the end-to-end carrier.

OTN enables path-layer monitoring at multiple, user-defined endpoints, which is one of the more powerful OTN features. TCM bytes provide this user-defined path-monitoring function. There are up to six different levels of TCM bytes available in the OTN overhead, labeled TCM1 through TCM6. These bytes allow carriers to define their own path layers.

Assigning monitored connections is currently done manually and it requires an agreement between the different parties. There are various types of monitored connection topologies: cascaded, nested and overlapping.

Forward Error Correction (FEC)

FEC provides a method to significantly reduce the number of transmitted errors due to noise, as well as other optical phenomena that occur at high transmission speeds. This enables providers to support longer spans between optical repeaters.

An OTU frame is divided into rows, sub-rows and interleaved bytes. The interleave is executed so that the first sub-row will contain the first overhead (OH) byte, the first payload byte and the first FEC byte, and so on for every remaining sub-row of each row in the frame.

The FEC can correct up to eight (bytes) errors per sub-row (codeword) or detect up to 16 (bytes) errors without correcting any. Combined with the byte interleave capability included in the ITU G.709 implementation, the FEC is more resilient to error burst, where up to 128 consecutive bytes can be corrected per OTU frame row.

TESTING OTN

As previously mentioned, carriers and service providers are faced with a serious challenge with the deployment of OTN in the edge/metro networks and to the customer premises: reducing OPEX while increasing the efficiency of their technicians in a multiservice and multiple technology environment.

Service turn-ups and troubleshooting of OTN networks by non-experienced technicians is the reality carriers and service providers are faced with.

Testing OTN with the NetBlazer Series

EXFO's NetBlazer Series makes testing OTN very easy and efficient thanks to an intuitive GUI that virtually eliminates the learning curve. The NetBlazer features multiservice testing: Ethernet, Fibre Channel, SONET/SDH, PDH as well IPTV and VoIP. Since one technician could be asked to test all these different services, having all the services in one tester increases efficiency. Once the tests are done, EXFO Connect allows technicians to send results, configurations and other relevant files to a secure server to be analyzed and shared by other colleagues.

The OTN feature of the NetBlazer allows the user to test OTN in the core as well as in edge/metro networks. The application provides the test functions and features technicians need to install, commission and troubleshoot OTN.

The OTN BERT application facilitates the validation of the OTN transport protocol by performing a bit-error-rate test in order to check traffic or payload stability over a network facility. To facilitate the interpretation of results, pass or fail verdicts are generated independently for both BERT and SDT (Service Disruption Time) measurements.

The OTN testing feature allows technicians to test both in-service or out-of-service.

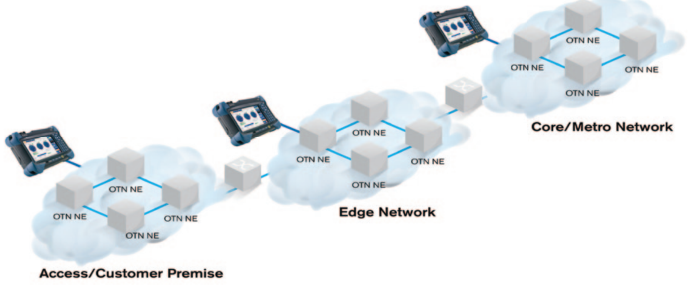
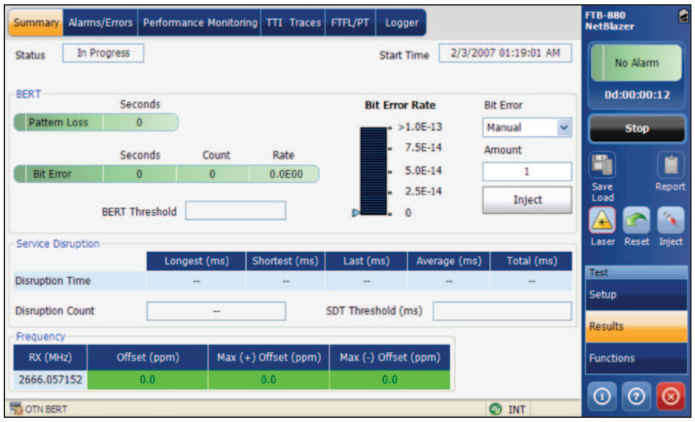


Figure 3: OTN testing

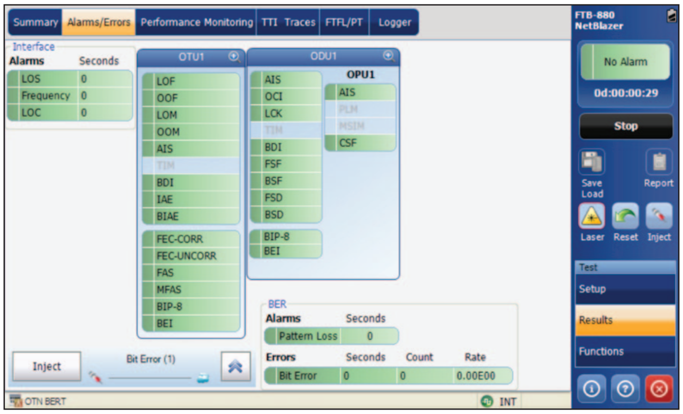
Out-of-Service Testing

During this testing phase, technicians can use the NetBlazer to validate OTNs before transmitting live traffic. The OTN BERT allows users to monitor errors and alarms as well as collect performance statistics. Errors and alarms can also be injected to simulate network conditions. To enhance the troubleshooting experience, the OTN BERT application also offers the ability to monitor and manipulate the OTN overhead and perform service disruption time (SDT) measurements. In this scenario, the NetBlazer tester can be placed in terminated or through mode.



In-Service Testing

While services are running on the network, technicians can monitor errors and alarms, and collect performance statistics. All overhead bytes are captured and displayed. In this scenario, the NetBlazer tester is used in terminated mode.



CONCLUSION

The combination of CAPEX (capital expenditures) reduction by carriers, which manifests itself by using existing network infrastructures (SONET, SDH, WDM), the increase in bandwidth requirement and the inherent benefits of OTN will all contribute to the expansion of OTN technologies within the core as well as to metro and edge networks. The need to test OTN networks becomes not only important for new deployments but also for existing networks. EXFO's NetBlazer Series is the perfect solution to address OTN testing needs. It also enables technicians to test all the other services such as Ethernet, Fibre Channel, SDH/SONET and DSn/PDH at every stage of OTN deployment, from service turn-up to troubleshooting. The multiservice testing features, the many connectivity options, the intuitive GUI and EXFO Connect make the NetBlazer the best fit for all field testing applications.

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