Application Note

OTN – Advance Testing & Dividing the Network

MT1000A Network Master Pro

MT1100A Network Master Flex

MU100010A 10G Multirate Module

MU110010A 10G Multirate Module

MU110011A 100G Multirate Module

MU110012A 40/100G Module CFP2

Contents

Background

As operators migrate from legacy (SDH/SONET/PDH/DSn) networks to the current or future (10 GigE/1 GigE, MPLS-TP/PBB-TE) networks, today's test equipment must be able to test OTN (Optical Transport Network) as well as legacy and future networks running over OTN. Operators' Metro to Core networks are evolving and must support all technologies both future and legacy. Testing these networks must confirm the "five 9s" performance on the OTN layer as well as from the Access to Core network—the focus of this Application Note.

Recommended Reading

We have published several White Papers on OTN, starting at a basic level and moving up to the engineer level; for details, refer to the Further Reading section. There is also an Application Note called OTN Basic Testing offering advice about the best way to test across the OTN layer.
We also offer a free OTN wall poster as a quick reference guide; for details refer to the Free OTN Wall Poster section.

OTN Network

Figure 1 shows an end-to-end network across OTN, highlighting different key areas. The customer connection is often completed over Ethernet and VLAN (Virtual Local Area Network), which is then connected to the operator access point commonly over Stacked VLAN and MPLS (MultiProtocol Label Switching) after entering the OTN network.

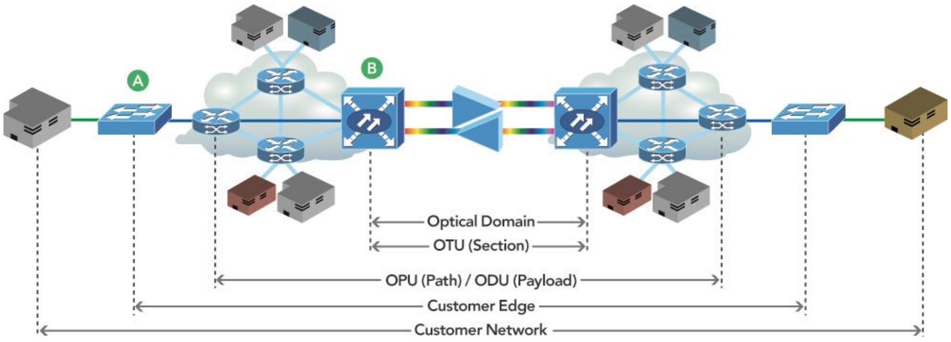


Figure 1. Network Diagram

Testing OTN Layer

Since OTN is a transport layer, it's important to have the flexibility to test all the standard OTN layers for Alarms and Errors. This is often done using a PRBS (Pseudo Random Binary Sequence) payload, allowing test equipment to determine whether or not there is an error in the payload while still effectively randomizing the information; this is commonly referred to as a BERT (Bit Error Rate Test).

For more details about OTN BER (Bit Error Ratio) testing, refer to the OTN Basic Testing Application Note.

Dividing Network

When looking at the network from a testing perspective, it's important for an engineer to be able to divide the network into logical sections, supporting both testing from end- to-end as well as section-to- section and between different sections or end points. Once an engineer can divide the network, issues can be quickly isolated and identified. A simple view of the network is:

- Core to Core
- Metro to Metro
- Customer to Customer,

as well as any combination of the above: Core to Customer, Metro to Customer, Core to Metro. Figure 2 shows a diagram of this view.

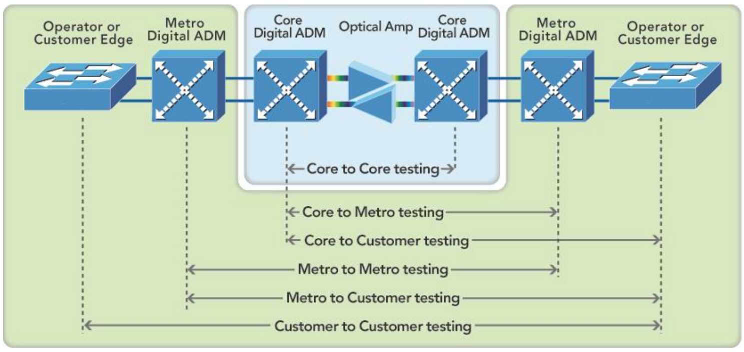


Figure 2. Divided Network

Testing Customer Circuit

End-to-end circuit testing is not only the most common test completed by an operator, but is also often a requirement for commissioning a customer circuit. Usually, this test is run by generating the same type of traffic as a customer would generate (commonly Ethernet) and is completed from Customer Edge to Customer Edge. The most common tests completed across this area of the network are RFC 2544 or Y.1564. The two test procedures work in different ways, but can be summarized as:

RFC 2544

- Completes multiple tests sequentially to confirm the network maximum throughput, latency, frame loss, and burstability. Test times can be quite long because the RFC 2544 test is serial.

Y.1564

- Completes multiple tests per stream very quickly sequentially to test connectivity and then completes a longer test by combining all earlier streams into one combined stream, while searching for network maximum throughput, latency, frame loss, burstability, etc.

Network Divide and Locate Issues

There are several cases when it's not possible to test a customer circuit end-to-end, or (more importantly) there are times when network troubleshooting is required to find an issue. Non-technical areas cause the largest testing issues, such as gaining physical access to a customer's premises during non-business hours. As a result, it's often simpler to test a network end-to-end from the operator's premises rather than the customer's premises. Although this doesn't provide a final commissioning report for the customer, it often allows for quicker troubleshooting and fault resolution.

There are many situations where accessing the network at different locations is required. Some examples and suggested solutions are described below.

Modern Advance OTN Testing

If a customer's site has a larger contracted data rate than other offices (e.g. head office has a 1 Gbps connection while regional offices have 256 Kbps to 512 Kbps connections), it can be difficult to run a commission test from the head office connection. However, it is quite simple to test from each regional office to the head office by emulating multiple traffic streams for each regional office via Y.1564. This allows the operator to confirm they can supply the contracted throughput to the regional offices. Confirming whether the contracted throughput to the head office is possible or not has been quite difficult historically for an operator to document until recently. Testing is complicated mainly because the customer side of testing must be connected to an Ethernet interface while the operator side is completed on an Ethernet over OTN interface. It is important to be able to set-up a Y.1564 or RFC 2544 test on one part of the network and receive it on another i.e. Customer Edge to Core. Consequently, testing from the customer side (Figure 1 point A) is completed using a Y.1564 test over Ethernet, while testing on the operator side (Figure 1 point B) is completed using a Y.1564 test over Ethernet over OTN. It's also very important that the tester supports testing over a multistage OTN as shown in Figure 3 because the tester must support connection to any possible network configuration. This type of testing will be required more as operators continue moving their OTN network closer to customers, because the operator's network will very likely be a 10 Gbps OTN or higher and the customers' circuits are likely to enter the operator's network at the ODU0 (Optical channel Data Unit) level or via a direct 1 GigE connection. An example of mapping a signal from 10 Gbps (OTU2) down to a 1 GigE signal is shown in Figure 3. This type of test setup is required when connecting on the operator's side of a Core network.

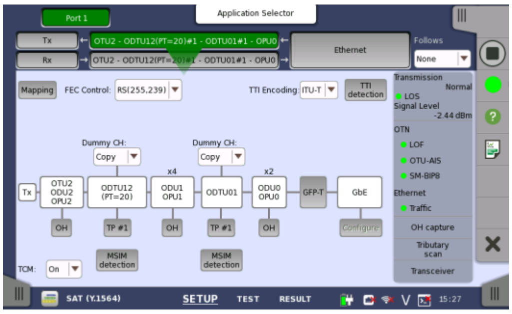


Figure 3. Multistage OTN Mapped Path

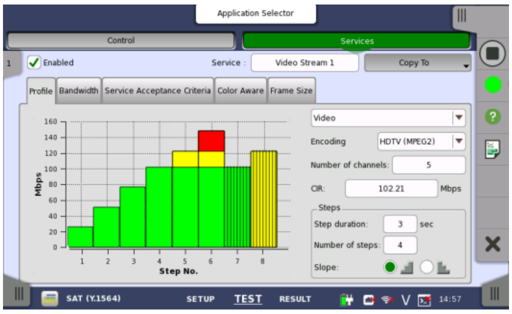


Figure 4. Y.1564 Configuration

Figure 5. OTN Error/Alarm results

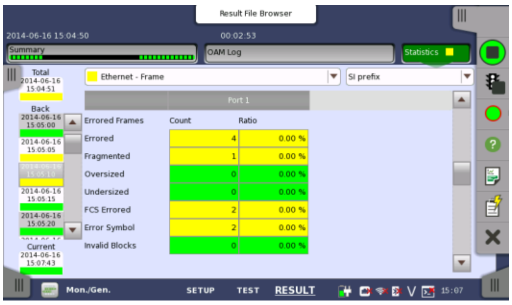


Figure 6. Ethernet Frame Results

In the above situation, the setup on the customer side of the network would look like standard Ethernet, or it could require VLAN, Stacked VLAN, MPLS, MPLS-TP (– Transport Profile) or PBB-TE (Provider Backbone Bridges – Traffic Engineering), depending on the protocol the operator is supplying to the Customer Edge point. The Y.1564 test would then be placed on top of the required protocol stack to carry it across the Core network on both ends, meaning an OTN transport layer for the operator and Ethernet for the customer.

This type of configuration allows the operator to confirm the throughput the customer is paying for (and not more) at the head office location. This is possible although testing is from the Access or Core network and transport is over different protocol layers. After completing this type of test, the operator can deliver test results to the customer proving delivery of the paid-for service.

If there is an issue, it is also important to have the ability to troubleshoot the network emulating end-customer traffic; at this point, the operator often completes a test using multiple traffic streams. Being able to test on the operator's side of the network while still having the ability to see all the way to the customer's traffic layers gives an engineer much more insight, because he or she can correlate errors on the OTN layer with errors on the Ethernet or customer traffic layer, allowing viewing across network layers and confirming the real cause of any errors. This not only simplifies testing for the engineer, but is also key to ensuring less downtime for end customers. An advanced tester should allow the user to drill down to alarms and errors on any layer of the network and connect at any point on the network to view and manage both Transport Layer protocols, OTN, MPLS-TP, etc., while simultaneously viewing and managing client protocols, Ethernet, PDH (Plesiochronous Digital Hierarchy), Fibre Channel, etc. An example is shown comparing Figure 5 and Figure 6; in the same 5-second time interval, there are several SM-BIP-8 (Section Monitoring - Bit Interleaved Parity-8) errors and one Uncorrectable FEC error (Figure 5). These errors are the root cause of all the Ethernet frame errors (Figure 6). By understanding this, an engineer not only understands the lowest layer causing the problem but also can get a clear idea about where to start troubleshooting.

From understanding how to complete the above testing, an engineer can re-task these processes for different circumstances, depending on the network and customer configuration. Some examples could be:

- Commissioning or troubleshooting a customer network with a faster head office data connection than regional offices
- Bringing a new office into service without taking down or affecting other offices of the same customer
- Troubleshooting and re-commissioning an office without affecting or overloading other offices of the same customer
- Completing Core network end-to-end troubleshooting in parallel to a customer without taking down their network
  In this case the operator could run a parallel circuit from the ODU/OPU (Optical channel Payload Unit) point (or Customer Edge if access is possible) along the same path as the customer to confirm there are no Core network issues over time. It is important to emulate the end-user data over the testing period in addition to completing a simple BERT because this might highlight possible issues related to end-customer concerns as well as allowing an engineer to check the lower OTN layers in more detail.

Other Important Testing Across Layers

Using the above testing depth, it's easy to see both the importance of generating OTN-to-client traffic as well as being able to generate errors in the different layers to ensure the network equipment is responding correctly. Within the OTN overhead, upon detection of a loss of client signal by the GFP (Generic Framing Procedure) source adaption processes, it will it will report a CSF (Client Signal Fail) as shown in Figure 7, which is then reported back as a BDI (Backward Defect Indication) error on the lower order ODU (Optical channel Data Unit) level. For more details on how alarms and errors respond to each other, refer to the Maintenance Signal Interaction section in the free OTN Wall Poster. Inserting an error into the higher layer makes it possible to confirm the OTN network element is reporting this correctly, and testing from the client traffic all the way to the CSF alarm to the BDI alarm confirms all network layers are working and interacting correctly.

Figure 7. CSF Alarm Caused by Higher

Summary

OTN offers a modern telecom operator large advantages, and the movement of the OTN closer to the end user (Access network) is happening quickly today. Due to this movement, it's important for operators to test methods and advances in equipment as the network changes to ensure the same QoS and fault resolution time. For more details on OTN, refer to our White Papers on OTN and Free Wall Poster.

Ordering Information MT1000A

Mainframe	
MT1000A	Network Master Pro
Test Module	
MU100010A	10G Multirate Module
Options	
MU100010A-001	Up to 2.7G Dual Channel
MU100010A-051	OTN 10G Single Channel
MU100010A-052	OTN 10G Dual Channel

Ordering Information MT1100A

Mainframe	
MT1100A	Network Master Flex
Test Modules	
MU110010A	10G Multirate Module
MU110011A	100G Multirate Module
MU110012A	40/100G Module CFP2
Power Supply Module	
MU110001A	Power Supply Module AC/DC
MU110002A	High Power Supply Module AC
Options	
MU110010A-001	Up to 2.7G Dual Channel
MU110010A-051	OTN 10G Single Channel
MU110010A-052	OTN 10G Dual Channel
MU110011A/12A-053	OTN 40G Single Channel
MU110011A/12A-054	OTN 40G Dual Channel
MU110011A/12A-055	OTN 100G Single Channel
MU110012A-056	OTN 100G Dual Channel

Further Reading

White Papers on OTN

OTN – What is it and Why is it Important?

Technical Level 1 (Basic)

Introduction to P-OTS, its different components and a basic overview of OTN.

OTN – What is it and How does it Work?

Technical Level 2 (Engineer)

How OTN works; breaks down and explains the five major frame sections. Written for engineers, but readable by all.

OTN – The deep dive into details that make it tick. (coming soon)

Technical Level 3 (OTN Engineer)

All you need to know about OAM, TCM, FTFL and FEC. W written for OTN engineers, but readable by anyone with a keen interest in OTN technology.

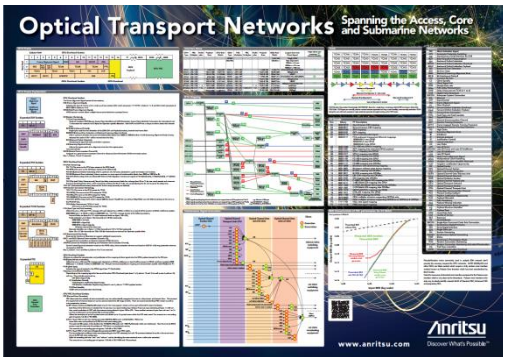
Application Notes on OTN

OTN – What's Important to Test.

Different types of BERT over an OTN.

Free OTN Wall Poster

Many of the above details are shown in an A1 size wall poster.
Simply register online to get your free copy mailed directly to you.



References

ITU-T G.709 (Interfaces for the optical transport network)
http://www.itu.int/rec/T-REC-G.709
ITU-T G.7041 (Generic framing procedure)
http://www.itu.int/rec/T-REC-G.7041
ITU-T Y.1564 (Ethernet Service Activation Test Methodology)
http://www.itu.int/rec/T-REC-Y.1564/en
IETF RFC 2544 (Benchmarking Methodology for Network Interconnect Devices)
http://datatracker.ietf.org/doc/rfc2544/

List of Acronyms

Acronym	**Definition**
ADM	Add/Drop Mux
BDI	Backward Defect Indication
BER	Bit Error Ratio
BERT	Bit Error Rate Test
BIP-8	Bit Interleaved Parity-8
CSF	Client Signal Fail
DSn	Digital Signal n
FEC	Forward Error Correction
FTFL	Fault Type Fault Location
GFP	Generic Framing Procedure
GigE	Gigabit Ethernet
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
MPLS	MultiProtocol Label Switching
MPLS-TP	MultiProtocol Label Switching – Transport Profile

Acronym	**Definition**
ODU	Optical channel Data Unit
OPU	Optical channel Payload Unit
OTN	Optical Transport Network
OTU	Optical Transport Network
PBB-TE	Provider Backbone Bridges – Traffic Engineering
PDH	Plesiochronous Digital Hierarchy
PRBS	Pseudo Random Binary Sequence
RFC	Request For Comment
SDH	Synchronous Digital Hierarchy
SM	Section Monitoring
SONET	Synchronous Optical NETwork
TCM	Tandem Connection Monitoring
VLAN	Virtual Local Area Network

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