AN INNOVATIVE SOLUTION FOR IN-SERVICE TROUBLESHOOTING ON LIVE FTTH NETWORKS

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When service is activated on a passive optical network (PON), telephony, high-speed Internet and video signals are sent from the optical line terminal (OLT) at the central office (CO) to various optical network terminals (ONTs) at different residential customer locations. In this situation, if one of the ONTs goes down and cannot restart its synchronization with the OLT, this branch of the PON becomes inactive and the customers associated with this branch lose service. The result: A technician is called in to troubleshoot and restart the service. Once at the inactive location, the technician must measure the optical power level to determine if it is sufficient to allow the ONT to synchronize with the OLT. In order to do this, several things must be considered.

Specific Location of the Problem—Before or After the 1xN Splitter?

From the network operation center, the technician can determine if it is only one subscriber who does not receive the service or if others are also experiencing problems. If numerous ONTs in the neighborhood are down, then either the 1xN splitter serving this neighborhood has failed or the problem relates to the feeder fiber located before this splitter. If only one ONT is inactive and the other ONTs served by the same 1xN splitter synchronize with the OLT at the CO, then the problem relates to the distribution fiber located between the inactive ONT and the 1xN splitter.

Following this simple rationale, the technician, with the help of the network operation center, can quickly determine if the problem is located before or after the 1xN splitter. When in doubt, it is always easier to go directly to the customer's site and troubleshoot directly from this location. One thing is certain—from this location, the technician cannot use a standard 1310/1550 nm OTDR.

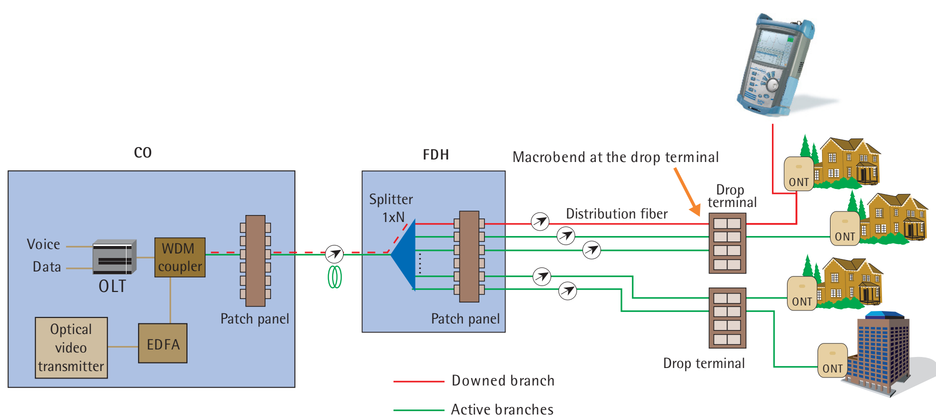

Figure 1: A technician launches an OTDR test from the out-of-service ONT. The red line denotes the OTDR test on the faulty branch of the 1xN splitter (malfunction caused by a macrobrend), while the other branches of the same splitter (green lines) are still in service. In this situation, there is no fiber break; therefore, the OTDR signal can go up to the OLT, pass the macrobend and possibly interfere with the lasers of the transmitters operating at 1490 nm and 1550 nm wavelengths. In addition, these incoming signals may blind the avalanche photodiode of the standard OTDR, which will stop the OTDR analysis.

The Effect of Sending Standard OTDR Wavelength Signals on a Live FTTH Network

An OTDR using standard 1310/1550 nm signals from one particular ONT location will interfere with the live video signals sent by the transmitters at 1550 nm, as well as with the live 1490 nm data and telephony signals going through the feeder fiber (F1) between the 1xN splitter located at the fiber distribution hub (FDH) and the OLT. In addition, the transmitter lasers emitting these signals from the CO may be destabilized, creating unwanted bit error rate when the dynamic range of the OTDR is enough to reach the CO. This extra bit error rate will affect the quality of the transmission to the other ONTs served by the same 1xN splitter. Moreover, the OTDR trace will get corrupted by the presence of traffic on the line because the traffic power is much stronger than the weak backscattering signal used by the OTDR for its measurement.

Testing through Splitters with a Standard OTDR

When using a standard OTDR unit to test through a splitter, many factors can prevent valuable link characterization, such as:

- Lack of dynamic range at intermediate pulse widths (100 to 500 ns)
- Lack of resolution at longer pulse widths (1000 ns)
- Heavy distortion in the step response (splitter drop) created by any of the following:
  a. Marginal stability of electronics
  b. High-tailing effect
  c. Un-adapted gain stitching and design for PON links

With the PON-optimized OTDR, distortion after the splitter drop is greatly reduced and the result is highly repeatable and reliable. The user can measure the loss of the splitter and the cumulative link loss, as well as identifying whether any unexpected physical event occurred before—or after—the splitter.

The PON-optimized OTDR also has a high value in construction: testing at 1310/1550 nm can significantly reduce the number of problems that occur after customer activation by certifying end-to-end link integrity. For additional details, refer to application note 201: OTDR PON Testing: The Challenges–The Solution.

Instruments for In-Service PON Troubleshooting

EXFO has created an OTDR designed specifically for in-service PON troubleshooting. This OTDR features a dedicated port for testing at 1625 nm or 1650 nm and incorporates a filter that rejects all unwanted signals (1310 nm, 1490 nm and 1550 nm) that could contaminate the OTDR measurement. Only the OTDR signal at 1625 nm or 1650 nm is allowed to pass through the filter, generating a precise OTDR measurement. In-service OTDR troubleshooting of optical fiber should be done in a way that does not interfere with the normal operation and expected performance of the information channels. Testing with the1625 nm or 1650 nm wavelength does just that.

EXFO's PON OTDR does not interfere with the CO's transmitter lasers because the 1650 nm wavelength complies with the recommendation ITU-T L.41 (Maintenance wavelength on fibers carrying signals). This ITU-T recommendation suggests a 100 nm difference between the OTDR wavelength used for in-service maintenance and the closest transmission wavelength (i.e., in this case, 1550 nm). The addition of a broadband filter, acting as a 1625 nm or 1650 nm testing port at the CO's WDM coupler, may also be beneficial. As a result, the quality of service provided to other subscribers serviced by the same 1xN splitter is not affected. Armed with this technology, the technician can connect the OTDR's 1625 nm or 1650 nm port to the ONT and send the signal toward the CO. If a 1625 nm or 1650 nm testing port is added to the CO, it is also possible to perform tests from the CO down to the ONT, but 1625 nm or 1650 nm filter may be needed at each ONT.

As seen above, the main advantage of this is its two-port versatility. The first port features a broadband filter and is dedicated to in-service PON trouble-shooting at 1625 nm or 1650 nm, while the second port operates at the more common wavelengths (1310/1550 nm). This allows users to perform in-service PON troubleshooting, as well as standard 1310/1550 nm OTDR testing, saving valuable time.

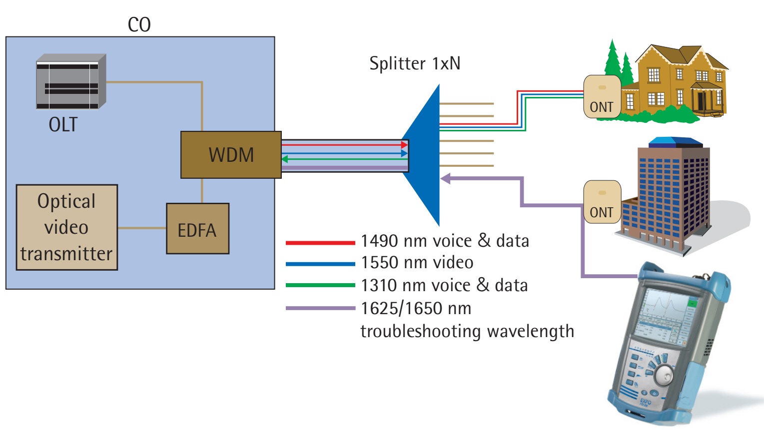

Figure 2: In a typical FTTH network, data and voice signals are transmitted from the OLT at 1490 nm, while analog video signal is transmitted at 1550 nm. Therefore, when a standard 1310/1550 nm OTDR is used at the ONT to troubleshoot the network, it cannot transmit because the OTDR's internal avalanche photodiode is blinded by the incoming signals (1550 nm for video and 1490 nm for voice and data). In addition, the Rayleigh backscatter of its 1310 nm wavelength may interfere with the other active ONTs serviced by the same 1xN splitter. When OTDR troubleshooting is performed on an inactive branch at 1625 nm or 1650 nm, there is no interference at the OLT or at the other active ONTs.

Testing Situation

Here is an example of a typical troubleshooting situation.

- Two macrobends have been induced. One at a drop box and the other on the feeder fiber due to careless fiber-loop manipulation during routine service activation, causing a different ONT serviced by the same splitter to go down. The second one is on the feeder fiber (F1) caused by a clamp that has not been installed properly.
- The loss is higher than typical loss budget headroom available on a PON transmission line for one ONT, it is just a question of time before the second macrobend affects the other ONTs. Temperature will vary, causing stress on the fiber and increasing the loss due to the macrobend.
- Only one branch of the 1x32 splitter is reported to be down at the network operation center, so the technician knows the problem is located between the ONT and the FDH.
- A technician is called to troubleshoot the faulty link. The technician knows that only one branch is down, but does not know if the fault is related to a fiber break, a macrobend, water freezing in an enclosure (freeze-outs), a poor connection or by something else.
- The technician's challenge is to qualify the fiber link between the ONT and the FDH as fast as possible for this particular inactive PON branch.
- The quickest and safest procedure is to go to the inactive ONT and launch a 1625 nm or 1650 nm OTDR trace to identify and position the fault.

The 1625 nm or 1650 nm wavelength is so sensitive that a typical macrobend of 0.1 dB at 1550 nm will create a 1 dB loss at 1625 nm or 1650 nm, and a 1 dB loss at 1550 nm could create a loss of 2 dB at 1625 nm or 1650 nm. Macrobends can be created when a technician manipulates fiber loops in drop boxes or at an FDH, pinching the fiber loops or bending them too hard. Another frequent cause of macrobends is water infiltrations that freeze in an enclosure, creating significant loss. Macrobends are very common in active PON systems because fiber loops have to be manipulated frequently at the FDHs or at the drop terminals.

With a normal OTDR operating at 1310/1550 nm, macrobends are identified by measuring a loss difference between the 1310 nm and the 1550 nm wavelengths at a specific location. With 1625 nm or 1650 nm wavelength OTDR testing, a macrobend will be visible directly on the OTDR trace (see the trace below, acquired at 1625 nm with EXFO's PON-optimized OTDR).

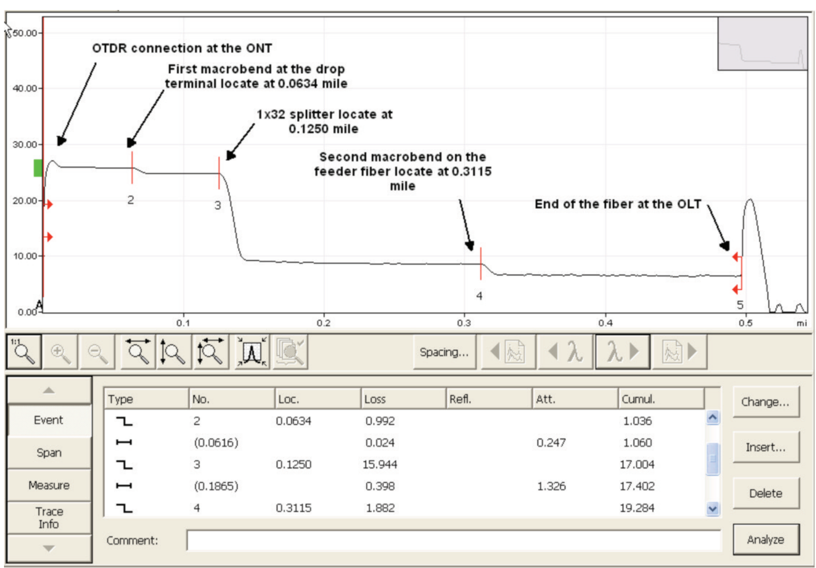

Figure 3: The link qualification of an inactive branch of a 1x32 splitter using a 1625 nm PON-optimized OTDR test from the ONT allows a technician to quickly identify and locate the two macrobends that caused the outage of this branch. Moreover, he can prevent any problems on the other ONTs that would have happened down the road since the second macrobend is on the feeder fiber (F1). Should there be no break along the distribution fiber, EXFO's PON-optimized OTDR provides enough dynamic range to reach the 1x32 splitter and validate the loss of the splitter and up to the CO. If the loss would not have been in a range of 16 dB, the technician could then have identified that the problem was in the FDH. A standard 1310/1550 nm OTDR test is not possible because the 1490 nm power received from the OLT blinds the internal APD of the standard OTDR.

FTTH Network Testing: Stage-by-Stage Solutions

Anyone involved in the deployment of an FTTH PON system should be aware of the testing requirements required for each and every deployment phase. Below is an overview of the main testing phases–installation/construction, activation, maintenance and troubleshooting–as well as the equipment that corresponds to each of the phases. For more information on our products, visit www.EXFO.com.

FOT-930 MaxTester OLTS

Installation/Construction Phase

With eight integrated instruments, the handheld FOT-930 MaxTester multifunction optical loss test set (OLTS) and its platform-based equivalent, the FTB-3930 MultiTest OLTS, are the ultimate PON-installation test solutions.

Installation phase could also be achieved using the FTB-7300E, PON-optimized OTDR module in a FTB-200 platform. Since the FTB-200 can house two modules, the FTB-3930 and the OTDR could be in the same platform. The technicien can then accurately measure the insertion loss and the optical return loss of the total link using the FTB-3930 on one end and the FOT-930 on the other end. The PON-optimized OTDR, FTB-7300E could then caracterize the loss and reflectance of any components on the link (splices, connectors and splitter).

PPM-350B PON Power Meter

Activation and Maintenance Phase

The handheld PPM-350B PON Power Meter allows simultaneous upstream/downstream measurement of all signal types–voice, data and video. It provides pass/warning/fail indicators for quick, accurate testing across the entire network.

FTB-200 Compact Platform, OLTS and OTDR

Troubleshooting Phase

Precisely locate the position of the macrobend or the fiber break responsible for major loss. Troubleshooting can be required at the construction phase, when there is no light on the network. When the PON is in service and troubleshooting is required, it is recommended to launch a signal through the inactive PON branch at 1625 nm or 1650 nm, with a dedicated port, so that it does not interfere with OLT lasers using 1490 nm and 1550 nm wavelengths or 1310 nm lasers used by the other active ONTs. When there is no light on the PON and troubleshooting is required, it is possible to test at 1650 nm, but the 1310/1490/1550 nm transmission wavelengths can also be used. All of these tests are possible by using the FTB-200 with the FTB-7300E PON-optimized OTDR. EXFO also offers a handheld version of a PON-optimized OTDR: the AXS-110. If testing through the splitter is not required, the AXS-100 is the recommended solution.

AXS-100 Series OTDR

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