VIAVI Solutions

White Paper

Evolving ODN Management Methodology

Abstract

With the growing number of subscribers and the increased need to work/study-from-home, reliable FTTx networks are becoming more crucial. In today's tough business environment, maintaining customers' satisfaction is a top priority for service providers. Hence to enable these, a strategy for managing fiber assets must be considered to avoid disruption to fiber broadband services.

This white paper introduces an evolved methodology to manage FTTx Optical Distribution Network (ODN) performance. A centralized OTDR-based solution is the core of this evolved methodology, which greatly improves the visibility and operation efficiency in maintaining ODN quality and resilience.

Traditional Method for ODN Performance Auditing and Monitoring

ODN Performance Auditing

On a live ODN with xPON and RF Video overlay services, the best practice is to perform a periodic test at primary and secondary fiber concentration points where the optical splitters are normally located. However, providers often tend to prioritize handling growing service activation demands, overlooking the ODN network performance, especially the feeder cabling and distribution cabling infrastructure.

For auditing the ODN's performance, a field test engineer visits the primary and secondary fiber concentration points at the customer's premises during a new service activation. An xPON power meter is used to investigate if the signal level is out of tolerance. To locate any faulty network elements (such as high loss splitter/splice/connector, macro-bending issue) or any fiber breaks, a PON optimized OTDR with a live testing port will to be used.

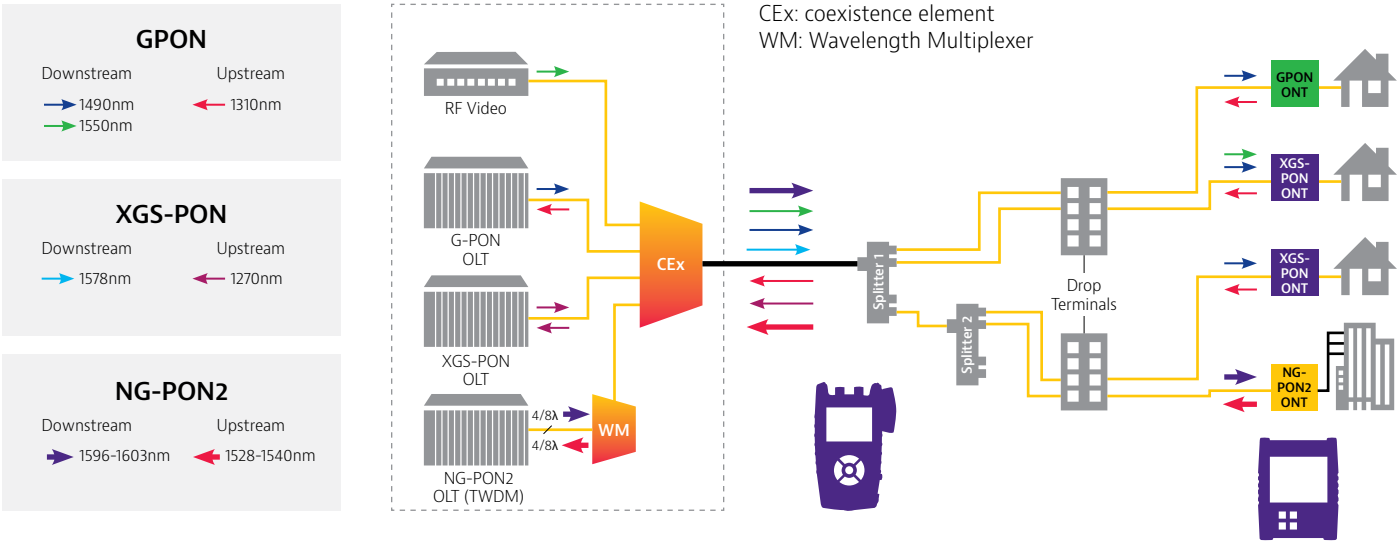

Figure 1 – Auditing ODN performance with xPON Power Meter and PON OTDR

This auditing methodology has been adopted by providers since the beginning of FTTH deployment despite several drawbacks.

- Time consuming and high truck roll costs as the tests must be carried out at several locations
- No test point access since some splitter-to-fiber connections are fusion spliced
- Reactive maintenance since the auditing process tends to be done during a new service activation

xPON Service Monitoring

The xPON element management system provides a good service monitoring capability, as shown on Figure 2.

This approach enables Service Providers to verify and carry out troubleshooting in case of service failure on ONUs. The service monitoring is performed through OLT-to-ONU real-time communication checks and ONU's status against each provisioned xPON service. Any raised alarm(s) reported by the element management system might indicate there is a fiber continuity issue.

However, this service monitoring capability has some limitations;

- Unable to demarcate if the fault is caused by equipment failure or fiber issue which results in sending incorrect field tests to engineers
- Unable to pin the exact location of the fiber issue which results in sending test engineer for further manual troubleshooting

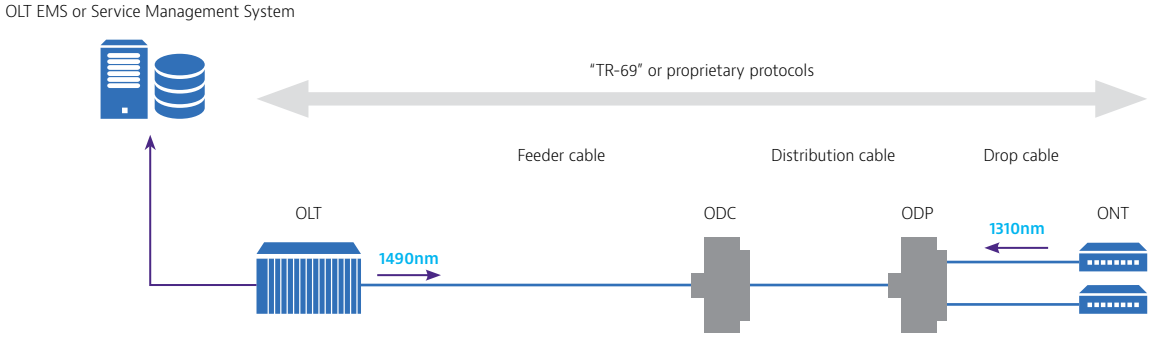

Figure 2 – FTTH Service Monitoring

New Approach with Greater Visibility and Operation Efficiency

The new ODN Management methodology is developed on top of the existing fiber monitoring method. A centralized OTDR-based solution and passive optical Reflectors are at the core center of this evolved methodology which will greatly improve the visibility and operation efficiency in maintaining ODN quality and resilience.

Optical Test Unit is placed at a Central Office. OTDR maintenance wavelength (1625/1650nm as per ITU-T recommendation) is multiplexed with xPON traffic signals thru a passive Wavelength Coupler element, as shown on Figure 3. An automated, in-service OTDR testing is performed in 24x7 schedule that provides a continuous performance visibility testing across feeder cabling, distribution cabling, drop cabling and any network elements along the OLT and ONUs.

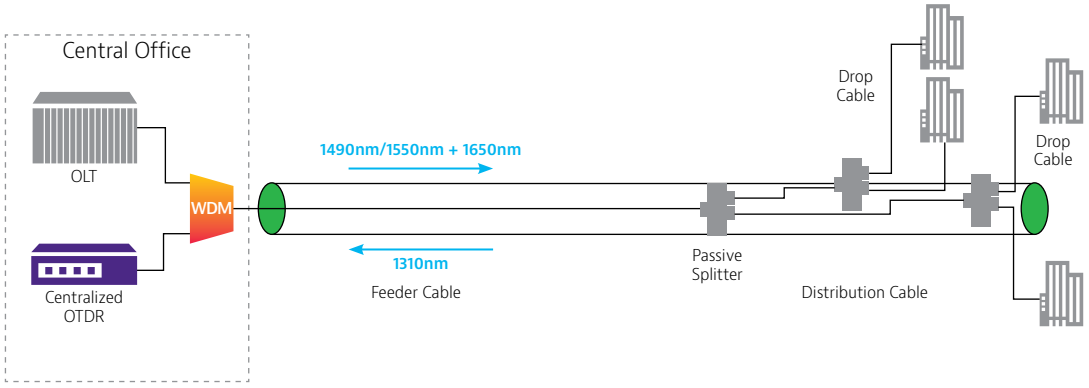

Figure 3 – Centralized OTDR with In-service Monitoring

Passive Optical Reflectors are placed at strategic splitter location(s) and/or ONU(s) to function as demarcation devices. Its signature reflection is used to measure the location distance to test point and end-to-end insertion loss.

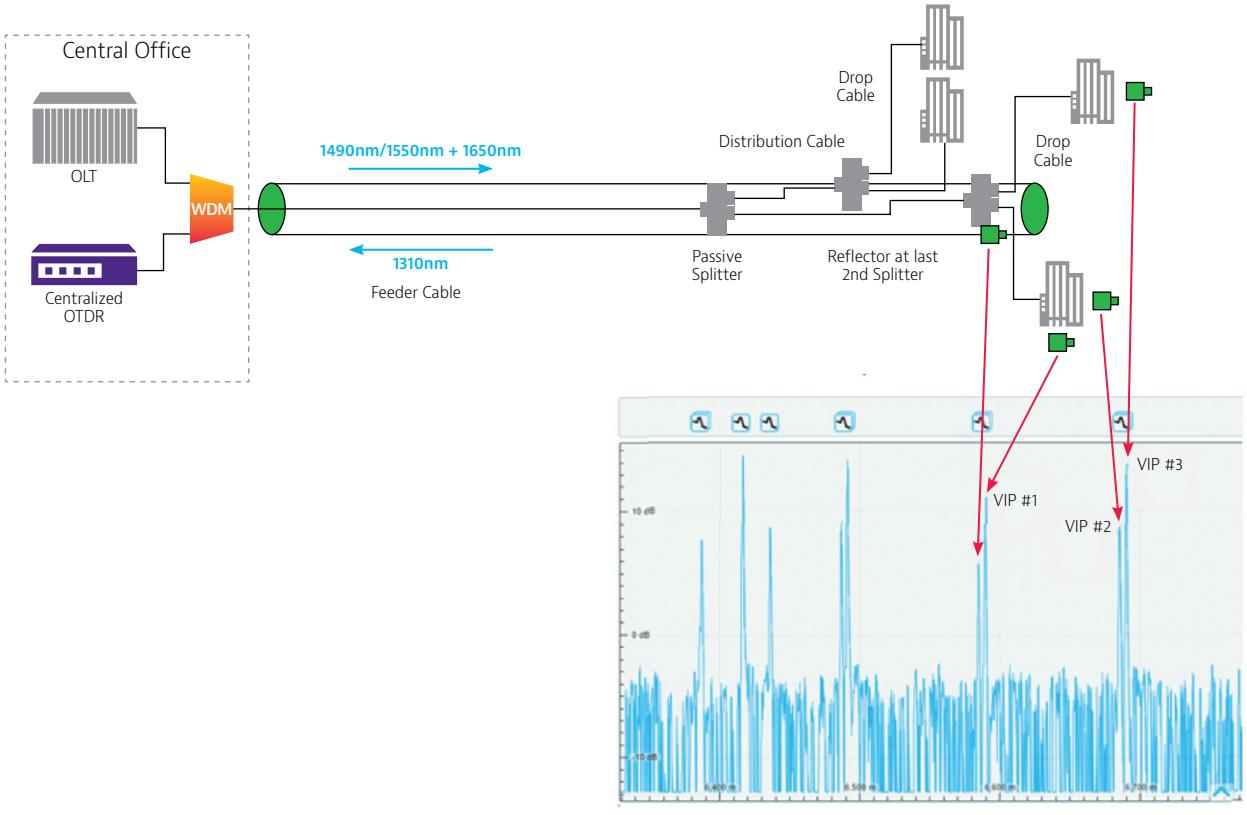

Figure 4 – Reflections generated by Reflectors at different demarcation points

Below we will further discuss more about the new improved ODN Management Methodology on ODN monitoring, VIP/Premium customers monitoring and Proactive ODN performance auditing.

ODN Monitoring

FTTx Service providers design and deploy fiber networks with maximum area coverage, at the most efficient cost to serve different xPON services and customers. The ODN is typically formed with primary cables (with large fiber distribution capacity), secondary cables (with medium/low fiber capacity and large drop cable capacity), passive splitters and other optical components.

The described ODN Monitoring Methodology allows flexibility to choose monitoring routes to maximize the coverage and focus on critical links: Primary cabling only, primary and secondary cablings, or primary and secondary cablings that serve VIP/ Premium customers.

End of ODN monitoring shall be located at longest fiber on primary cabling or last second splitter of primary/ secondary cabling of the chosen fiber route to maximize the monitoring coverage, as shown on Figure 5.

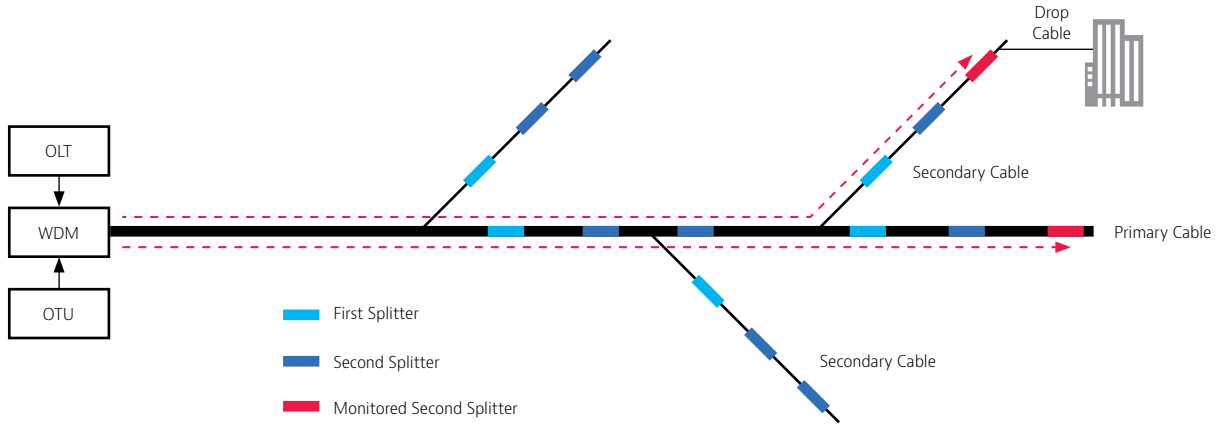

Figure 5 – Selecting monitoring routes to maximize monitoring coverage

OTDR trace between first splitter and last second splitter can be noisy and distorted due to insufficient OTDR Dynamic Range or reflections of UPC/dirty connectors, respectively, as shown on Figure 6. Therefore, a passive optical Reflector must be placed at a strategic location to serve as a demarcation point. More Reflectors being placed will provide a greater ODN performance visibility. A balance between performance visibility versus investment costs (number of Reflectors) should also be considered.

Figure 6 – OTDR trace between 1st splitter and last 2nd splitter

Two tests were performed on the monitored fiber route.

1. Fiber Continuity Test: Detection and localization/demarcation of fiber continuity issue up to the demarcation point(s). For example, fiber cut at feeder section and/or distribution section.
2. Fiber Performance Test: Detection and localization/demarcation of network elements issue up to the demarcation point(s). For example, fiber degradation, splitter/splice/connector degradation.

VIP/Premium Customers Monitoring

The ODN monitoring coverage can be extended further to monitor fiber continuity of selected links, especially those that serve VIP or premium customers. As shown on Figure 7 below, a Reflector was installed at the demarcation point between the Service Provider and Customer. Once installed, the Reflector's signature will be tagged and referenced for monitoring purpose. Multiple reflections can appear on one ODN.

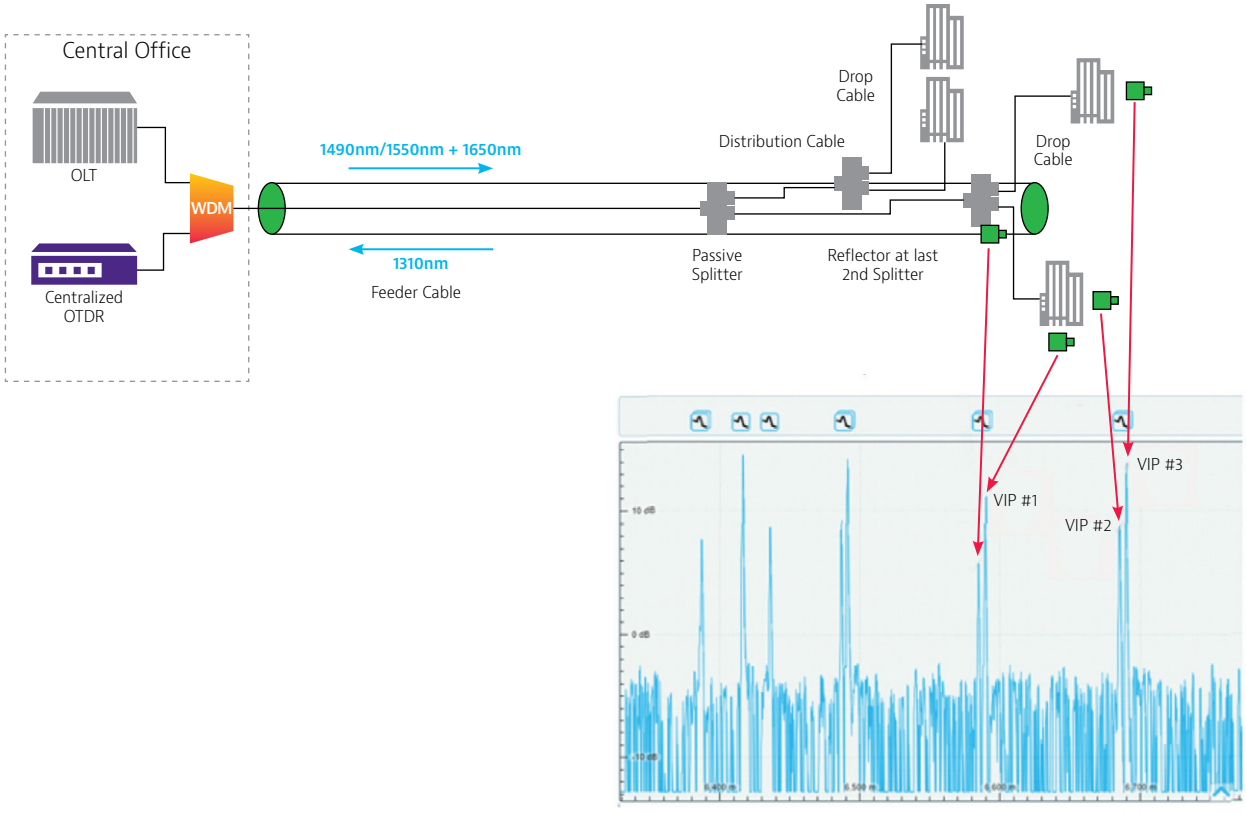

Figure 7 – Using Reflector's Signature for VIP/premium customers monitoring

Two tests were performed on the monitored fiber link.

1. Fiber Continuity Test: Detection and demarcation of fiber continuity issue of the VIP customer(s) link. For example, fiber cut at drop section.
2. Fiber Performance Test: Detection of network elements issue of the VIP customer(s) link. For example, fiber degradation, splitter/splice/connector degradation.

Proactive ODN Performance Auditing

Since the ODN is being tested on a 24x7 schedule, proactive ODN performance auditing and troubleshooting can be performed. This allows Providers to ensure that the link is always ready and within expected performance threshold for new subscriber service activation at any time.

OTDR testing is performed from the Central Office to a demarcation point direction. A single OTDR test result can provide detail analysis of the ODN performance, avoiding time consuming process and high truck roll costs of traditional testing method.

The Reflector signature's level value is being used to measure ODN's Insertion Loss (IL) between Central Office and a demarcation point, as shown on Figure 8. This provides ODN performance visibility along the particular link.

IL = Reference Level (R_L) - Absolute Peak Level (P_L) + Constant (**K**)
Constant (**K**) depends on the reflector value.

Figure 8 – Using a Reflector to measure ODN's insertion loss

In addition, OTDR trace from the Central Office and a demarcation point provides a visibility of first splitter's loss performance.

Figure 9 shows a list of links which Reflectors were placed at strategic locations and their respective ODN performance. Two critical measurements will assist the ODN performance auditing and troubleshooting process, which are IL between Central Office and Reflector(s), and Loss of first splitter.

Splitter Name	Reflector Ser. No.	Fiber Length	Theoretical End to End IL Value	Measured End-to-End IL Value	End-to-end IL Difference	Theoretical 1st Splitter Loss with 4 legs	Measured Loss Of First Splitter
MNL005-L60-N1	1911-3682	2545	18.36	23.29	-4.93	4.5	3.48
MNL005-L60-N2	1911-4129	2643	18.39	21.95	-3.56		
MNL005-L61-N1	1911-3730	2349	18.30	19.32	-1.02	4.5	3.52
MNL005-L61-N2	1911-3980	2408	18.32	18.66	-0.34		
MNL005-L82-N1	1911-3817	1939	18.13	25.17	-7.04	4.5	4.56
MNL005-L82-N2	1911-3837	2013	18.20	18.7	-0.50		
MNL005-L147-N1	1191-4347	2108	18.23	23.42	-5.19	4.5	7.5
MNL005-L147-N2	1191-3734	2204	18.26	22.42	-4.16		
MNL005-L177-N1	1911-3896	1331	17.95	15.53	2.42	4.5	3.88
MNL005-L177-N2	1911-3920	1342	17.95	31.56	-13.61		

Figure 9 – ODN Performance of Monitored Links

An analysis was done on MNL005-L60-N1 and MNL005-L60-N2, which second splitter #1 and second splitter #2 were under same first splitter. As shown on figure 9 table, both locations have a significant IL discrepancy from the theoretical IL value at those locations. As the measured loss of first Splitter was still within the theoretical threshold, one can deduce that the distribution cable is troubled and requires a fix.

Another analysis was done on MNL005-L82-N1 and MNL005-L82-N2, which second splitter #1 and second splitter #2 were under same first splitter. MNL005-L82-N1 has a significant IL discrepancy from the theoretical IL value at its location; whereas, the IL of MNL005-L82-N2 is within the theoretical threshold. These could signify a trouble at MNL005-L82-N1 port and requires a fix.

Last analysis was done on MNL005-L147-N1 and MNL005-L147-N2. Both locations indicated a significant IL discrepancy from the theoretical IL value at those locations. As the measured loss of first Splitter was higher than the theoretical threshold, one can deduce that the first splitter was troubled and requires a fix.

Figure 10 proposes an auditing and troubleshooting process flow that can be performed from a centralized OTDR- based test unit, with the readings performed from the Central Office to demarcation points where Reflectors are placed.

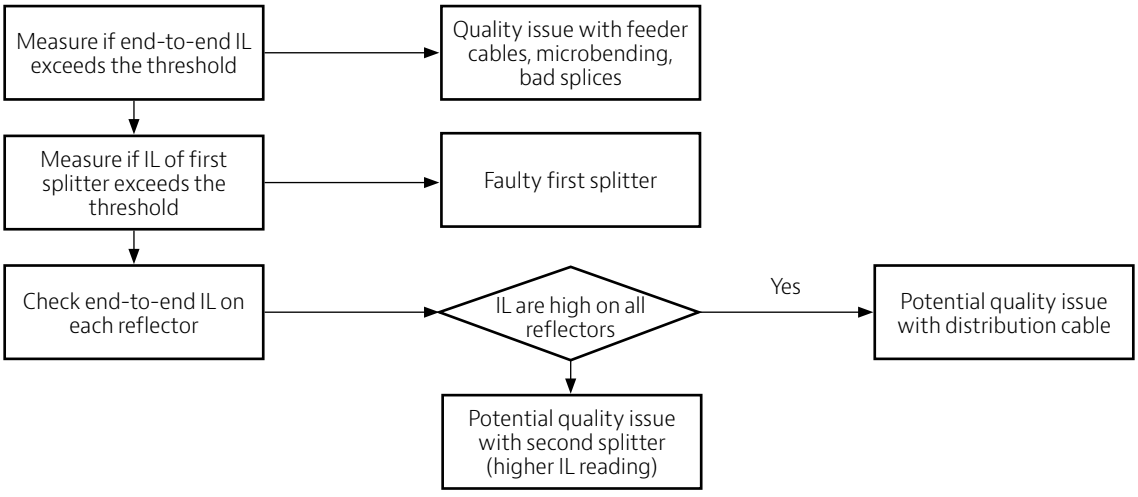

Figure 10 – ODN auditing and troubleshooting flow

To provide another perspective on ODN performance, a Reflector can also be placed at the first splitter location. Providing better visibility of feeder section Insertion Loss performance.

Conclusions

This evolved ODN Management Methodology greatly improved the visibility and operation efficiency in maintaining ODN quality and resilience. It enables Providers to perform in-service fiber link monitoring to achieve a fully automated ODN cable fault detection and demarcation, provides fiber continuity monitoring for premium customers, and enables a proactive auditing and troubleshooting for fiber quality assurance.

References

[1] Optical Network Monitoring System by VIAVI Solutions

[2] FTTH Handbook by D&O Committee, FTTH Council Europe FTTH Network Troubleshooting

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