Fiber Optic Troubleshooting and Monitoring

Field Testing Best Practices and Diagnostics Tools

Introduction

Driven by demand for more bandwidth and faster speed, fiber optics are replacing copper wire communications because of its many advantages over copper. Cable based methods for data transmission can't provide the bandwidth of fiber, and is limited in the distance that signals can be sent due to power loss. Fiber optics offer greater bandwidth capacity, and the ability to transmit signals over longer distances with very little power loss. Fiber's resistance to magnetic interference can make transmissions nearly noise free. Coupled with the low security risk of transmissions via light and the ease of installations with smaller size and lighter weight cables, fiber is bringing convenience and monetary advantages to the broadband operator.

Fiber also has an advantage in better signal quality and less plant maintenance. Maintaining a clean signal can be a challenge in a plant using Hybrid Fiber Coax (HFC) precisely because of the "coax" portion of the plant. The longer those coax runs are and the more active and passive devices along the way, the more likely it is that ingress, micro-reflections and group delay will impact the signal. Cable operators are reducing this issue by extending fiber as close to the subscriber as possible without have to replace the last mile infrastructure connecting their subscribers. In addition to improving potential speeds delivered, this reduces the chance that the signal will be impaired along the way.

While fiber has many advantages, there are also some disadvantages in fiber optic transmission that shouldn't be overlooked.

Fiber on a pole
Photo by Doc Searls

Fragility

Since it's made of glass, fiber can't take the abuse or bending that a piece of coax or twisted pair can. It must be handled much more gently, making installations slower. Splicing fiber optic cable is also not as easy as copper, as bending will break it.

Cost

Fiber installation costs are dropping every year, but the cost of laying fiber optic cable is still higher than copper cable, especially considering the extra care required when installing. Even so, fiber is still advancing into the limelight, and despite its disadvantages is still the industry choice for communications.

And, while there are fewer signal problems associated with fiber deployments, there are still issues that need to be addressed. In this paper we discuss some of the things which can cause issues on fiber networks, and some of the tools that can be used for troubleshooting.

Fiber Troubleshooting and Best Practices

A big factor to be aware of when searching for the cause of a poor signal over fiber optics is the physical cable itself. We already mentioned the disadvantage of a cable made of glass, and obviously if the glass gets broken then no signal will get through, but even too much bending of the fiber can interfere with the signal.

If you're seeing just one subscriber with an issue, there may be a problem in the fiber between the subscriber and the splitter closest to the home, a problem with the ONT equipment at the home or a problem in the subscriber's home wiring inside the house or a combination of these. When you're seeing all customers on the same splitter without service, but others connected to the same OLT are ok, the source could be a problem with one of the splitters or a fault in the fiber link between the two splitters. If all subscribers are affected whether on one splitter or two, the cause could be a problem in the splitter closest to the OLT, in the feeder cable of the fiber network, or a problem in the originating OLT equipment.

In addition, signal loss can be caused by dust and scratches on the fibers themselves, and even fingerprints and humidity. You also need to consider the length of the cable span, even though fiber can transmit longer distances, it's not an endless span and the longer the distance the more attenuation will occur.

Besides the cable itself, troubles can result because of bad or contaminated connectors, faulty connections at the patch, poor quality splices, or too many connectors or splices in the fiber run. Finally, there is the possibility that there is insufficient signal strength from the transmitter.

The Number One Cause

Installers have established that the number one cause of issues or failed transmissions is dirty connections. Fiber is smaller and thinner than a human hair and unfortunately you can't just look at a fiber strand with the naked eye and tell if it's clean. If the strands become dirty, it can affect the transmission to the point that it stops working altogether.

When installing and connecting the fiber, natural oil from the installer's fingers will contaminate the fiber, and dust will cling to that oil. These nearly invisible specks of dust will block the delivery of light through the fiber. And any brush of clothing can put static charged particles in the air or tiny traces of debris can settle on and damage the end faces of the fibers when they're connected.

Think of the dust motes you occasionally see floating in a band of sunlight beaming through a window. These same dust specks are heading toward your fiber and you won't see these on the fiber strands just by looking. And dirt on the fiber connectors themselves can contaminate the other connections, and then you've added to the problem and made testing to discover the problem even more challenging. Keep the unused fiber cabling connectors covered at all times, even when not in use, to avoid this complication.

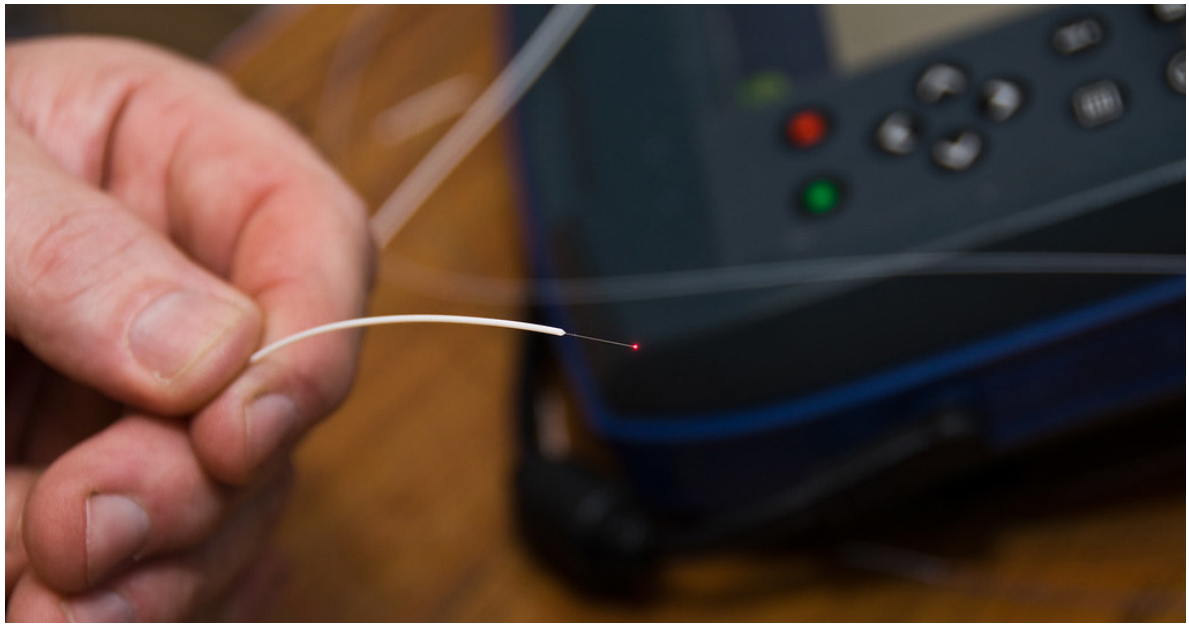
To ensure a clean connection, it's a good practice to clean the end faces to get rid of oil and dust particles. A package of lint-free wipes and a bottle of rubbing alcohol will work well. This process will clean the oils and residue and eliminate static charge. When cleaning the end faces don't use canned air or blowers. These just end up blowing particles around and adding more dust to what's already there.

And if you are making a repair and a patch is unavoidable, the leads can easily become scratched or dirty during the handling. Patch leads should be cleaned every time.

Save yourself some headaches by cleaning fibers every time you connect them. Whenever fiber is being handled, following a "keep it clean" mantra will go a long way in controlling the problems that crop up. With this cleaning and inspection practice in place you won't have to put in as much time searching for issues at a later time.

Once cleaned, you can use a scope to verify the fiber end faces are clean. A fiber optic microscope is designed specifically for inspecting fiber optics. A scope with a high magnification level will show you more detail when inspecting the cable.

Next, running a quick test with an inexpensive fiber optic tracer can verify if the fiber is clean and capable of transmitting light. A fiber optic tracer is a low power troubleshooting tool that uses a LED source to inject light into the fiber to provide tracing of the light in the fibers. If the light does not shine through the fibers, first, make sure it is a problem with just that fiber, not the entire cable. If only one fiber isn't transmitting light, this usually means a bad connector. Using the optic microscope to look at the fiber at the connector, look for dirt, dust or cracks in the fiber and clean if required. After cleaning, check the scope again. If both connectors now look clean, the problem is most likely internal. At that point you'll need additional testing equipment such as visual fault locator (VFL) or optical time domain reflectometer (OTDR).



Thin fiber
Photo by Savannah River Site

Zeroing in on the Problem

A Visual Fault Locator (VFL) is needed in establishing if the problem is a bad connector by applying a bright red laser. When a fiber connector that is plugged into the VFL and a lot of visible red light displays, that indicates the connector is bad and should be replaced. If you look from the other end and see light coming only out of the fiber strand that indicates a good connector.

On the other hand, to measure each segment of a PON network and expose all "events" along the fiber from the beginning point at the OLT, and down to the subscriber and their devices, a traditional Optical Time-Domain Reflectometer (OTDR) can be applied. An OTDR can detect, locate, and measure at any location along a fiber optic link. To test the fiber link, the OTDR injects a sequence of pulses into the fiber which are used to detect faults, such as breaks. It is also the only way to know the exact location of a fault or a break.

OTDRs are small, light and easy to use. The latest OTDRs run software that automates the evaluation of the light trace. These OTDRs can automatically show where instances of reflectance and loss are. However, correct operation and interpretation of an OTDR trace requires special technical training. Operating an OTDR is not especially difficult, but it requires familiarity with fiber testing best practices in order to test correctly. Advanced software applications in the instrument, can help technicians use an OTDR without the need to understand or interpret OTDR traces.

Testing the fiber system with an OTDR can determine the causes for excess loss and check that splices and connections are clean and dependable. It is also the only way to know the exact location of a fault or a break.

Software-based Diagnostics Tools

Element Management Systems

As FTTx and PONs become mainstream for subscriber broadband connection, there is a need for accurate diagnostics tools for troubleshooting and maintenance of the network. While these field diagnostics tools are helpful and a necessary part of fiber troubleshooting, software-based tools that collect data from the OLTs and ONTs on the network can provide a wealth of information right from your desk, and in some cases right from your mobile device.

Diagnostics are the key for accurate and speedy troubleshooting of fiber optics. And even though troubleshooting a PON network differs from copper cable troubleshooting, the fundamentals are the same: cables are damaged, devices are faulty, and installations need best practices.

If you're already managing a GPON network, you may be using the element management system (EMS) that came with your equipment to run diagnostics data. The element management layer manages a specific part of the network and can play an important role in overall network management, but usability issues can mean an EMS may not be the optimal system for troubleshooting certain problems.

The primary trouble with an EMS is that each equipment vendor has its own proprietary management system for its equipment. To automatically see and track multiple and various manufactured device changes in real-time is not possible with the typical EMS since the device diagnostics are solely for that particular vendor's equipment. This means you may end up with multiple EMS diagnostics systems that have to be observed and monitored simultaneously. And each of the various systems will also have different methods and processes for operation. Struggling with these various systems results in swivel chair management and requires extra training for your network operators to have skills on different systems instead of just one.

This typical EMS setup also makes troubleshooting extremely complex. A troubleshooting tool's interface should have customer information, device status, and other metrics that will help your call center staff and engineers troubleshoot subscriber devices and network issues. EMS software generally doesn't have any customer information. And, it can also take drilling down through multiple, complicated screens to find the information you are looking for, In addition to increasing the amount of time to get the information you need, the inherent complexity of the system reduces the number of people who can make use of it.

Even if the information in the EMS were more user friendly, the EMS also exposes anyone using it to the OLT configuration screens, which is not a good thing to hand over to your customer service representatives or other departments that might be able to benefit from the diagnostics data in the system. Those who are troubleshooting a problem should only have access to the functions they are assigned to, and should only be able to execute management functions corresponding to their assigned permissions.

Third-party Diagnostics Solutions

A better alternative to managing your fiber network is with a third-party diagnostics tool that is vendor agnostic. Unlike an EMS, a tool of this type is specifically designed to collect and present diagnostics data to better troubleshoot the OLT, the fiber network, and the connected ONTs, In addition, they will include the customer information, and diagnostics data is presented on concise, screens that are organized in a way that makes it easy to find the information the user is looking for. With a network-wide view of your system you can automatically see and track all alerts, device changes or problems in real-time, and if supported you can see historical information. And, since they are not tied to one vendor, you can deploy equipment from multiple vendors and your staff will be accessing one, familiar interface, This single pane of glass and multi-vendor support significantly reduces the time to identify, isolate and resolve network and end user issues.

What is your diagnostics system showing you? Without an advanced diagnostics system that incorporates multi vendors, seeing complete information in a timely manner is difficult and makes troubleshooting a tedious process for you, not to mention your subscribers who are expecting a quick resolution.

The ideal diagnostics management system should be designed and focused on making the job easier and faster for your staff. The information showing a problem should be clear, and data should be useful and meaningful to everyone from the network operations to the end user support personnel (perhaps especially for the end user support personnel). They should have sufficient information in front of them to guide them in what questions to ask, what steps to take, and that will help them determine if it is a local issue or one extending over a wider segment of your operational area that would need to be escalated.

When you're experiencing problems in your fiber, your diagnostics system should show you if only one or multiple subscribers are affected by an issue and you should see this along with subscriber info such as name and address/ location on the same screen without drilling down into multiple screens.

Armed with this knowledge up front, your customer services reps can instantly begin the discovery process to find the cause of a fiber service disruption. For example, if your rep is seeing just the single subscriber without service, having her ask the caller a few questions about any changes that might have been made prior to the issue could save your field techs a lot of find-and-fix time. Often the simplest of things such as disconnecting and reconnecting the cable to a new computer or moving the desk can cause the connection to be loose or the cable stretched. If the cable becomes stretched too tight, the quality of light down the cable becomes compromised. This results in poor performance or even complete failure of the transmission.

Rolling a chair over the cable is a very common occurrence, especially for those subscribers who are working in a home office. And sometimes utility or telephone workers can pull or cut cables and fail to repair or reconnect them. Any number of things can affect the fiber performance and only by asking your subscriber some questions will you be able to narrow down what might have happened. This process of identifying the location of the problem can be shortened by having access to diagnostics information that is ideally is quickly and easily and accessible, and understandable for everyone involved in the process of troubleshooting the issue.

In short, a robust diagnostics tool that provides a single pane of glass to view the network and connected devices is the goal. Dashboards should be available that have the information that is most relevant to the groups that will use them. With summary and detailed views that provide easy access to live and historical diagnostics data, you will have a tool that will make your operations staff, call center and techs in the field more efficient and productive as they support your network and subscribers.

Additional Resources

For more information on ZCorum's TruVizion Diagnostics for Fiber networks:

Download a Product Sheet for TruVizion Fiber Diagnostics.

Watch a Video Demonstration of TruVizion's Fiber Diagnostics features.

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