How good is your fiber, or
Are you ready for increased bandwidth?

Greg Stearns, TTP-US

Most of us are bitten by the technology bug. We like our smart phone and iPad and Wi-Fi connectivity and Bluetooth technology. We even like it more when those technologies come packaged in a new car. Smart people have found a way to include in new cars the technology that we surround ourselves with on a daily basis. We do not have to stop being connected to the information highway even when we are speeding down the highway. The one item we take for granted, though, is the road system on which we plan to operate that new car. We like to believe that every road upon which we will travel will be smooth and uncongested. However, the reality of the situation is otherwise. Hence, it does not make any sense to buy a Corvette if you live on a ranch at the end of a rutted dirt road. A four-wheel drive Jeep may be better suited to get you to your ranch because you will not be able to optimize the capabilities of that Corvette.

The same concept can be applied to your single mode fiber backbone. It does not make any sense to try to increase your bandwidth (i.e., increase transmission speed) through your fiber unless the condition of that fiber is such that it can handle the increase. Networks have been running up to1Gbs speeds for some time now. However, as we crave more information and chew up the existing bandwidth, the need for 10G, 40G, and above bandwidths, along with using transmission techniques such as WDM have become critical to satisfying our cravings. As this happens, it becomes apparent that our fiber backbone must be capable. Installing new fiber is certainly an option, but it may not be cost or time effective. Additionally, there may not be available pathways. A more cost effective solution is to characterize (test) existing fiber to determine its capability.

Using existing fiber is not without risk since there are many potential problems. However, it is usually much less expensive to test the fiber to determine if there are problems than to completely ignore the fiber. Some fiber issues may have easy fixes. If the existing fiber is determined to be capable, it can be used in house, or in some cases, the fiber can be leased to another entity for a recurring revenue stream.

So how do we determine if fiber is capable of handling increased bandwidth? The answer is fiber characterization and is defined by ITU-T G.650.3 as “A comprehensive suite of measurements that is carried out on an optical fiber cable link to determine the key performance attributes of that link which may affect current or future applications that operate over that link…Full fiber characterization includes connector end face inspection, insertion loss measurements, return loss measurements, OTDR testing, chromatic dispersion testing, polarization mode dispersion measurement and spectral attenuation.” Let’s look closer at those items.

Connector end face inspection

Many fiber problems can be fixed after an inspection of each connector end face. Two issues will become readily apparent during that inspection. First, the inspection will reveal if the end face is damaged, and second, the inspection will reveal if the end face is dirty. Prior to conducting an end face inspection, it is imperative that you clean the connector. If during the inspection the connector can pass an end face connector inspection test such as the EXFO ConnectorMax2 test, you can continue with other tests. If the connector cannot pass, then the solution is to replace the connector.

Insertion loss (IL) measurements

Prior to testing for insertion loss, you will need to calculate your link loss budget. Insertion loss includes loss associated with connectors, splices, and fiber attenuation. By using the minimum and maximum loss values for wave length to be tested (e.g., 1310nm or 1550nm), loss for connectors, and loss for splices you will have a number to which you can compare your test results. You can get insertion loss numbers from OTDR testing and from power meter testing.

Optical return loss (ORL) measurements

As optical networks increase bandwidth or use WDM, optical return loss testing becomes more important. This is due to the fact that lasers have a lower tolerance for reflectance. An easy to understand definition of optical return loss is the difference between the power at the source and the power that is reflected back to the source. It is expressed as a positive value and the higher the number (e.g., 45dB) the better. Optical return loss can be measured by an OTDR and a power meter.

OTDR testing

Information gathered from OTDR testing includes fiber length, location of connectors and the associated loss, location of splices and the associated loss, and fiber attenuation. While OTDR testing is done in one direction, it is imperative to do bi-directional OTDR testing an analyze the trace information from both directions. EXFO has developed iOLM software that is effectively a GUI version of the OTDR trace. It can be used to complement OTDR testing.

Chromatic dispersion (CD) testing

While the previous tests are a significant part of fiber characterization, chromatic dispersion testing is a critical test. The easy definition of dispersion is a spreading or broadening. Applied to the lasers used with fiber, it means that the optical pulse contains multiple wavelengths (colors) and these colors travel down the fiber at different speeds and arrive at different times, thus spreading the optical pulse. The longer the fiber link, the greater is the spreading. There are a number of methods to control this spreading depending on how the fiber will be used. Chromatic dispersion testing can only be done with a CD tester.

Polarization mode dispersion (PMD) testing

Polarization mode dispersion testing is also a critical test with respect to fiber characterization, however, there are very few ways to control it. Specifically, PMD is a consequence of certain physical properties the result in the distortion of optical pulses. Of note, PMD can change over time. For example, an aerial fiber link may be subjected to high winds or cold temperatures in January, and no winds and high temperatures in July. A PMD test conducted at those separate times will reveal different test values. PMD testing can only be done with a PMD tester.

Fiber characterization is a phased process and is not just testing. A simple explanation of those phases follows:

- The first phase is to determine what the customer is trying to do (e.g., increase bandwidth to 10G or implement WDM) and the customer's required performance criteria. If you do not know what the customer wants, you will not be able to do the analysis and provide the recommendations that will get them there. In this phase, you will determine the number of fiber to be tested.
- In phase two a fiber inventory must be conducted across the span that the customer wants to use. This will enable you to determine types of fiber (e.g. aerial or underground), manufacturer and year of manufacturer, category of fiber (e.g. G.652, G.655, G.657), connection points, distances, type of connectors, and fiber count.
- The third phase is to develop a test plan that may include connector end face testing, OTDR testing, iOLM testing, power meter testing, chromatic dispersion testing, polarization mode dispersion testing, and bit error rate testing. A meeting with the customer is critical here so that you can get the assurance that you will have their support (e.g., access to facilities, customer preparation for testing such as providing new patch cords).
- The fourth phase is to implement the test plan. This starts with inspection of each and every connector and concludes after all testing is complete.
- The fifth phase is to analyze all of the data obtained. This is by far the most critical phase. The analysis involves cross-referencing each of the test results from connector end face inspection, the OTDR, the power meter, the CD tester, and the PMD tester.
- The final phase is to provide recommendations and a final report to the customer.

When the testing and analysis is complete, it should be very apparent how good the fiber is and if it is capable of handling increased bandwidth or WDM applications. At that time you will know if you can optimize that “Corvette” because the highways are smooth and uncongested, or you will have to stay with a “Jeep” to navigate the rough roads.

Greg Stearns
CEO
TTP-US, 393 Enterprise Street, San Marcos, CA 92078
(c) 760-533-2110 - (o) 760-510-8552 - (f) 760-510-8559
gstearns@ttp-us.com - www.ttp-us.com