Fiber best practices for the wireless world

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The most recognizably familiar components of the cellular network are the cell towers and the antenna installations mounted on tall structures such as multistory buildings and municipal water towers. Thanks to these large cell sites, which are often referred to as macro-cell sites, wireless service providers are able to deliver voice, text, and broadband communications. Because of the height at which the antennas typically are mounted and the high power levels at which they transmit radio-frequency (RF) signals, macro-cell sites effectively cover large geographic areas with relatively high capacity. They're also capable of hosting multiple wireless service providers. But even though tower or building-mounted macro cells are upgradable, their coverage areas can't be expanded. In fact, the coverage radius of the cell actually shrinks as it becomes more heavily loaded with traffic.

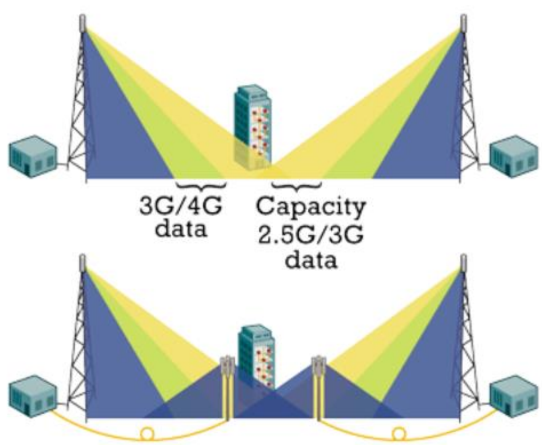

FIGURE 1. A fiber-optic network foundation can significantly add to the capacity of a wireless network

That wasn't a problem in the early days of cell-phone technology, when networks were used for voice services and therefore designed more to provide large coverage area than capacity. However, today's bandwidth-intensive use of mobile phones for a wide range of Internet-based applications has transformed cell-phone usage, contributing to an ever-growing set of coverage and capacity challenges.

Continuously building and rebuilding the network to meet growing demand for instant, interrupted service is an expensive and lengthy undertaking. As network capacity needs increase continuously, a quicker fix is in order for the network infrastructure. But simply adding new micro sites – or micro or pico cells – is no longer a feasible solution. Instead, the existing macro layer must be expanded and enhanced using various low-power nodes such as femto cells, remote radio heads/units (RRHs/RRUs), and distributed antenna systems (DASs). This integration of the macro cellular network with DAS networks and various small-cell approaches has been dubbed the "heterogeneous network" (or HetNet for short).

Increased fiber connectivity and penetration provides the foundation for these HetNets, as they feed the required bandwidth to the entire wireless infrastructure (see Figure 1). Because so much is riding on this optical infrastructure in terms of bandwidth, profits, and investment, good fiber testing practices are critical. We'll outline the fiber-optic infrastructure requirement and the best practices needed to ensure the effectiveness of the wireless antennas.

Testing the fiber infrastructure

Fiber infrastructure represents a significant investment, especially in urban areas. Proper installation of the optical physical layer during the construction phase clearly is essential to setting up an easy-to-maintain system with a high return on investment (ROI). To maximize ROI, figure out exactly what fiber you have and where. You also need to know how good it is, i.e., whether the fiber can support current and future requirements and whether it meets testing and troubleshooting requirements.

Confirmation of these key elements depends on complete and accurate data and documentation – and the more information you have, the better. Comprehensive testing during construction will ensure detection of problematic splices, dirty or damaged connectors, and other faulty components before they lead to service disruption. Such testing also will reduce costly and time-consuming troubleshooting during the commission phase. Implementing best optical testing practices during this phase is therefore key to ensuring a successful network that will be easy to maintain in the future.

Insertion loss is the most important validation parameter for ensuring signal integrity. In addition to the insertion loss from dirty and damaged connectors, loss resulting from low-reflectance splices or kinks, microbends, macrobends, and defects in the fiber must also be taken into consideration.

To this end, tests should be performed at two wavelengths, for example, 1310 nm and 1550 nm for singlemode fiber and 850 nm and 1300 nm for multimode fiber (e.g., in certain indoor DAS instances). These tests should be performed using a reflectometry-based system like a standard OTDR or an intelligent link mapper, the latter providing greater speed and accuracy while greatly reducing human error in interpretation before and after testing.

Bidirectional testing is recommended in the presence of splices due to the significant loss or gain (dependent on the test direction) that can appear when splicing different fiber types with different core sizes. This test should be performed after the fiber installation but before commissioning.

OTDR and automated link mapper tests are out-of-service tests that enable qualification of each element of the system to determine the presence of the weakest link; they also make it possible to implement effective mitigation before revenue-generating traffic reaches the link. Inspection probes are another must-have tool because the vast majority of network issues are caused by dirty and damaged connectors. Once again, use of an automated fiber inspection probe will reduce test time and increase accuracy, in turn leading to better decisions and results.

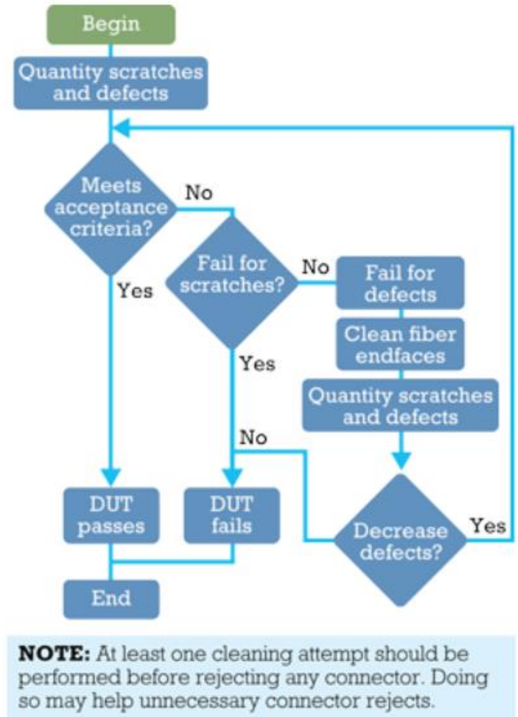

FIGURE 2. Inspection procedure for IEC Standard 61300-3-35

A requirement of intelligent mapper/OTDR testing is completion and submission of a table. This table/report may vary in form and content depending on the customer and end user and can be generated via dedicated reporting tools or general tools such as Microsoft Excel.

Although often dismissed as a long and useless step, reporting is actually quite simple, extremely useful, and highly valuable. For instance, if a third party oversees the construction of the fiber network, the operator will need a documented test report to be confident that the work meets requirements. Proper documentation also greatly reduces maintenance and service calls (yes, the famous opex and truck-roll conundrum). The more information you have about the network, including its original location and condition at the time of initial testing, the easier it is to compare and address issues. Documentation is often required to fine-tune analysis, merge several test measurements together, gather business intelligence, or perform other related tasks. Documentation is also a high-ROI activity that's quick and easy to perform using today's efficient reporting tools.

Fiber up the tower, verticals in a DAS environment, and mobile fronthaul and backhaul are all different application spaces for fiber optics and therefore subject to the same test requirements described earlier. Best practices may vary slightly from application to application due to the different access points and parties involved. But as a general rule, the best practices outlined in the next section apply to all the fiber applications that are part of the HetNet soup.

Best testing practices/procedures

Connectors are key elements that interconnect the different components of a network, and failing to inspect and clean them as needed can lead to network failure. For this reason, the first best testing practice relates to connector maintenance. The flow chart in Figure 2 details the inspection procedure recommended by IEC Standard 61300-3-35.

Ideally, both ends of every fiber should be tested, in addition to every single connection. However, that's not always possible in the case of fiber to the antenna. Although the baseband connection is inspected, more often than not the connector at the RRU is pre-connectorized in the factory. In such cases, this connector does not need to be tested. But if the connector at the RRU has not been pre-connectorized, a technician will need to climb to the tower top to validate that connector. Once the connector of the fiber under test has been inspected, the next step is to characterize loss and attenuation to ensure that the system complies with supplier or design specifications.

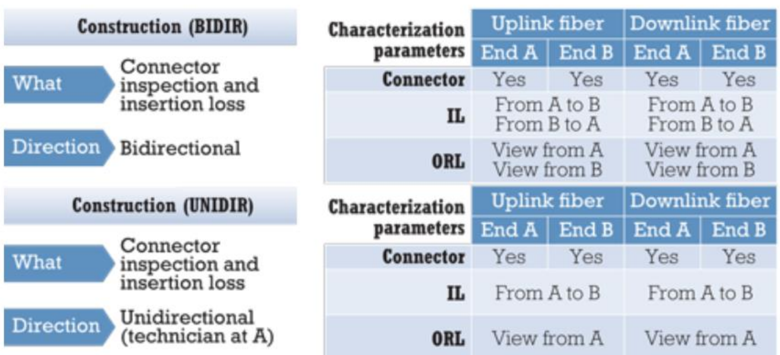

FIGURE 3. Different DAS test scenarios

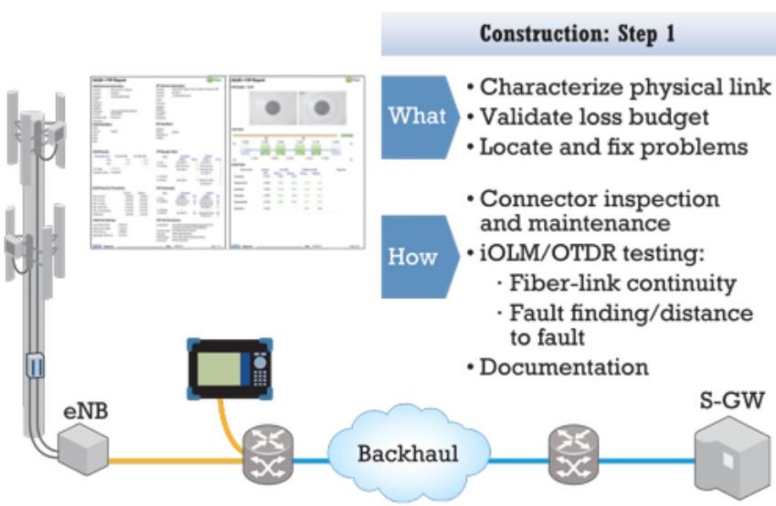

FIGURE 4. Backhaul testing scenario

That step is followed by testing end-to-end loss and connector and splice quality using an OTDR or intelligent mapper for increased efficiency. Testing of these characteristics during construction is mandatory, regardless of the fiber's application (RRH, DAS, fronthaul, or backhaul). In troubleshooting situations, testing the fiber helps pinpoint whether the fiber or the transmission equipment is the source of the issue. Figure 3 details different test scenarios for a DAS. These scenarios can be handled by one technician equipped with the following items:

- Intelligent mapper/OTDR module.
- 4 different standalone pulse suppressor boxes (SPSBs) with the appropriate connector interfaces.
- Connector inspection probe.

The next example examines a backhaul scenario (see Figure 4). Because of the way an intelligent mapper or OTDR measures loss within a link, characterization of the first and last connectors isn't possible without the use of a launch test cable – an SPSB. A critical aspect of fiber commissioning involves obtaining an accurate, complete picture of the system's loss, and to do so, an SPSB must be used at all times at both ends of the fiber link. In terms of singlemode versus multimode fiber, the tolerances and labeling change indicated earlier apply in addition to the current procedure.

Practice makes perfect

The HetNet represents the point at which wireline meets wireless and merges technologies such as DAS, RRH, RRU, and small cells with the macro cellular network to augment wireless broadband coverage and capacity. Because so much bandwidth (and investment dollars) is at stake, it's essential to increase fiber connectivity and penetration to ensure that adequate bandwidth is fed to the entire wireless infrastructure.

To this end, fiber-optic infrastructure best testing practices help ensure proper installation of the optical physical layer and are essential to maximizing the capabilities of antennas. Sufficient testing during construction is key to an easy-to-maintain system and high ROI.

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