Frame Level Testing: Going Beyond Cable Certification to Assure Data Integrity

White Paper

Frame Level Testing: Going Beyond Cable Certification to Assure Data Integrity

Ensuring a network's physical cable plant supports the necessary bandwidth in accordance with specifications and without errors is paramount

INTRODUCTION

As organizations grapple with ever-increasing amounts of data and evolving network speeds, ensuring that a network's physical cable plant can support the necessary bandwidth in accordance with specifications and without errors is paramount.

Cable certification has long been viewed as verification that a premise network cabling infrastructure meets the parametric requirements of the ANSI/TIA-568 cabling bandwidth and categories standard. Cabling systems that meet the requirements of the standard (those that are "certified") should therefore carry IEEE 802.3 Ethernet protocol frames, such as IEEE NBASE-T or 10GBASE-T, error free.

However, cable certification tools require complex, expensive circuitry and algorithms to test parameters like Near End Cross Talk (NEXT), Far End Cross Talk (FEXT) and Alien Crosstalk as required by the standard. This puts the cost of certification testers beyond the available budgets of many installer and enterprise organizations. While there are warranty requirements for ANSI/TIA certification at the time of installation, the reality is that after "day zero" installation, these testers have little to offer in the way of active network troubleshooting capabilities.

Wi-Fi Technology Driving New Bandwidth Demands

Due to the increased bandwidth available in the latest Wi-Fi technologies such as Wi-Fi 6 (802.11ax) and number of connected clients per AP, network owners must ensure that their wired network infrastructure has the capacity to serve new access points. However, with the vast majority of installed cable systems rated Category 5e, the expense and feasibility of upgrading cabling for support greater than 1Gbps speeds may be prohibitive.

It was for this purpose that the NBASE-T standard was developed (also known as IEEE 802.3bz, Multi-Gig, and 2.5GBASE-T or 5GBASE-T.) For cabling installations that comply with the relevant standards (ISO/IEC 11801-1, EN 50173-1 or ANSI/TIA 568.1-E), 2.5GBASE-T is typically expected to operate on Category 5e or better, 5GBASE-T on Category 6 or better and 10GBASE-T on Category 6A or better. However, when cabling is of sufficiently high quality and with proper installation, performance may exceed those parameters. The reality is that in most cases, cabling systems will carry much more than the rated categories would indicate. This raises the question of how best to determine when to upgrade a network to ensure multigigabit deployment success.

	1000BASE-T	2.5GBASE-T	5GBASE-T	10GBASE-T
Cat 5e	Yes	Yes	Testing Required	Testing Required
Cat 6	Yes	Yes	Yes	Testing Required
Cat 6A	Yes	Yes	Yes	Yes

Premise cabling certification level vs. transmission speed

Beyond Certification: The True Value of Frames

While certification testing does reliably measure the parametric values as by the ANSI/TIA-568 standard it does not actually transmit any data over the wire. An analogy here is that this type of testing is equivalent to a plumber measuring the diameter of a pipe to determine potential flow as opposed to measuring the actual flow and quality through the pipe over time.

Whether for understanding the maximum bandwidth possible in an existing cabling plant or validating the installation of new links and adds/moves/changes, there are technologies offering viable (and in many ways, superior – and less expensive) methods over traditional certification tools. A practical alternative is to saturate the media with actual network traffic for a designated time to ensure that all frames are transported error free.

Frequently referred to as Bit Error Rate Testing (or BERT), the process involves transmitting IEEE 802.3 data frames on the media and measuring how many frames are successfully received error free. The transmission of actual traffic over a cable plant can be adversely affected by multiple factors such as cabling quality, cable length, bundle sizes, external noise/interference, and installation practices.

There are many benefits to media qualification using high volumes of actual data frames rather than parametric substitutes. For example, when upgrading to newer access points that require 2.5G or 5G links, it can be determined if the existing installed cabling is already capable supporting NBASE-T traffic, saving an expensive cabling upgrade. Additionally, testers with this capability tend to be less expensive than single-purpose cable certification tools.

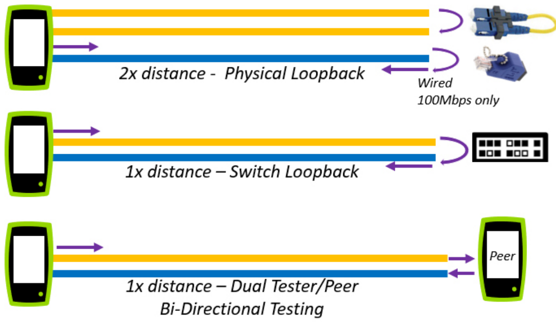
Information and communications technology (ICT) professionals, whether contractors, field service/MSP teams, or end-users at enterprise organizations, need to understand the quality of their media infrastructure as measured by the quality of data frame transmission from one end of the media to the other. As previously mentioned, cable certification is a bit "theoretical" – as it posits that if a particular cable run meets the parametric requirements of the ANS/TIA-568 standard then it will carry certain IEEE communications protocol frames, such as IEEE 10GBASE-T, error free. However, the application of actual Ethernet traffic on the media is far more predictive than parametric measurements. Put another way, millions, billions, and trillions of error free frames simply cannot be wrong.

Of course, not all transmission testers are born equal. In the case of multigigabit deployment, it is important that the tester be capable of determining whether installed cabling can support multigigabit rates, as well as be able to qualify the entire network infrastructure – not just one length of copper or fiber media – and troubleshoot a multitude of additional problems. Unlike many single purpose BERT or media testers, line rate performance testing with appropriate Layer 2 and Layer 3 controls (VLAN and QoS configurations) and multiple packet streams of varying configurations are imperative. After all, what good is simply testing a length of cabling if you cannot also test through the active network switches and routers? (See "The Importance of End-to-End Performance Testing" further in this document.)

Endpoints: Single Versus Dual Testers

When testing media on copper for 100Mb Ethernet, ICT professionals may choose to use a single tester as the generator. In this scenario, a physical loopback terminator can be used, taking advantage of the fact that there are enough extra pairs in the Ethernet cable to create the loopback. This technology only works for 100MB Ethernet, as speeds at 1Gbps and above utilize all four pairs for transmission.

A similar loopback approach can be employed with fiber, which works for 1Gbps and 10Gbps Ethernet speeds since one strand is use for transmission (Tx) the other for reception (Rx). The limitation of a physical loopback is that you cannot exceed 100 meters for copper cabling, and depending on the fiber type and wavelength, up to 80 kilometers. A single tester on fiber can be highly effective when optimal distance parameters are not exceeded.



Test endpoint alternatives

Another technology for achieving loopback is to use a special configuration available in some Ethernet switches to have the switch port itself loopback received traffic to the tester. This can function up to the rated link speed of the port, but performance may vary depending on the manufacturer and model.

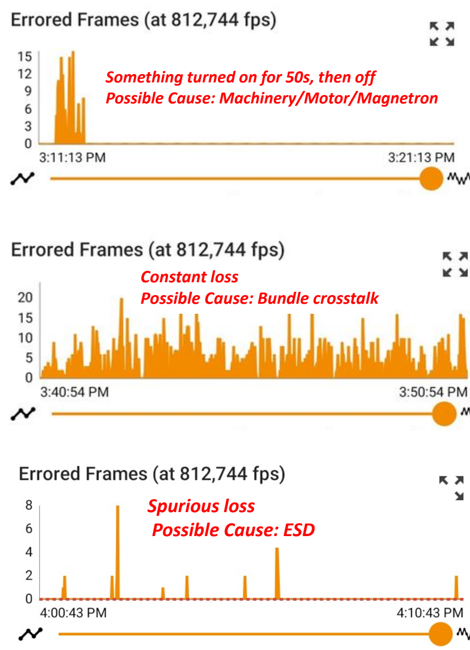
Employing a far end (dual) tester approach offers some important advantages. The far end tester utilizes its PHY (the circuitry that encodes Ethernet frames on the wire) to retransmit the signal, making it possible to reliably send the packets bi-directionally across the full length of the media, and identify asymmetric (upstream vs downstream) issues by utilizing independent upstream and downstream flows. It also becomes possible to display statistics/errors on the remote unit, providing greater flexibility in monitoring results. Additionally, having a second full-function instrument (rather than a "dumb" peer) means you have an additional tester for other tasks, equipping more people on your staff.

Applications for Fiber Deployments & Soak Testing

The clear value in Ethernet BER testing is that it may reveal the fact that existing cabling is sufficient to support the desired multigigabit speed. Testing may show that the category of cabling will not be an impediment to the performance of the network. In addition to cable testing, BERT testing can be used on fiber links when troubleshooting or adding capacity.

A good example is when ICT professionals are deploying additional strands of fiber in an existing bundle between buildings in a campus/metro, between floors within a building, or upgrading the existing links to a higher speed. BERT testing can be used to qualify fiber media for error free operation at the desired speeds. Unlike optical fiber certification testing, the actual SFPs that will be deployed in the switches can be used in the tester to ensure the entire link ecosystem is operating properly. Likewise, Direct Access Cables (DAC) or Active Optical Cables (AOC) can be qualified prior to data center usage.

Conducting "soak testing" can be an effective means for finding and drilling in on errors. In a single hour, over 53 billion frames (at 10Gbps) are sent and received from both ends (full duplex.) This allows an advanced qualification testing application to detect when even a single bit is corrupted. An additional advantage is that unlike cable certification that focuses on minimum test time (many offering sub-10 second tests), an advanced solution can be used to test the media over many hours. A 24-hour test (over 1.28 trillion frames at 10G) may reveal that a conveyor belt static buildup corrupts the media every couple of hours or when the humidity is low, for example.

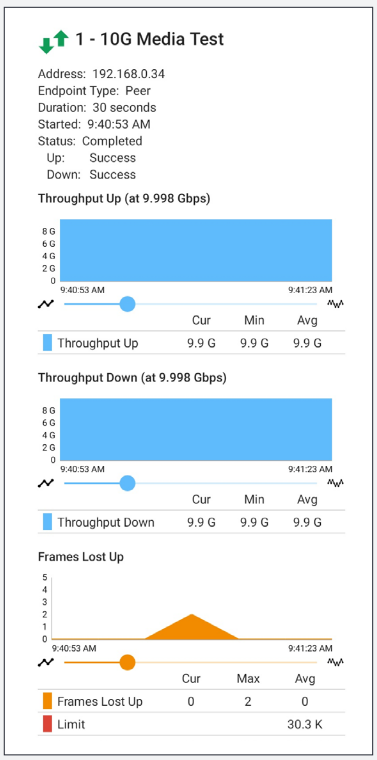


NetAlly LANBERT app indicating errors over 24-hour testing, with 1-second drill-down capability

In operation, external events such as ESD discharges, EMF pulses from motors, bundle noise, even physical movement of the media can not only cause bit errors but may prevent certain technologies from linking at the designated speed causing a downshift to the next lower rate. In addition to monitoring for bit errors, signal to noise ratio (SNR) and delay skew should be simultaneously monitored to further understand the available SNR margin on the cable at the current link speed.

Having these errors displayed graphically, and trended in time, with the ability to zoom in on any error with 1-second granularity, can be invaluable for understanding the time of day, frequency, duration, and root cause of the corruption.

It should be reemphasized that while BER testing of a media plant is a good way to validate the foundation of the infrastructure, it is not sufficient to ensure proper live network operation. The qualification of key network services from PoE to link speed/duplex, VLAN configuration, switching and routing, DHCP/DNS services – and even the actual end-user response time of pulling a web page – is essential to confirming the operational aspects of a network.



NetAlly Network Performance Test enables true end-to-end (Layer 2, Layer 3) performance measurements, essential for understanding overall network capacity and quality, including active infrastructure components

The Importance of End-to-End Network Performance Testing

Standard Layer-2 Ethernet BERT testing sends frames over the media but lacks the ability to pass test traffic across enterprise switches and routers. Because it does not use the IP (Internet Protocol) layer, this methodology cannot pass through Layer 3 devices and therefore has no ability to validate enterprise performance, service provider SLAs or WAN throughput/jitter/latency/loss.

In addition to layer 1 media testing, an advanced qualification application allows testing through switches and routers, bidirectional/asymmetrical testing, and Layer 2/Layer 3 quality of service (QoS) testing on different streams. Higher layer testing offers a measure of flexibility and visibility greatly valued by ICT professionals. Without this capability, technicians can spend hours trying to isolate transmission errors.

Conclusion

Bit Error Rate Testing (BERT) is invaluable for determining the quality of cabling links as a foundation for network communications. However, it is not sufficient for characterizing the overall quality of packet transmission across an enterprise network (either during turn-up or when fully operational), through a switched (layer 2) and routed (layer 3) infrastructure or with QoS provisioned. Critically, this test methodology offers little for troubleshooting an active production network. Diagnosing issues with network services (DHCP, DNS), routing and provisioning, IP-level connectivity, discovering devices and connection paths, and ultimately, the ability to capture traffic for in-depth analysis – all are necessary capabilities for network professionals to ensure end-user satisfaction and productivity

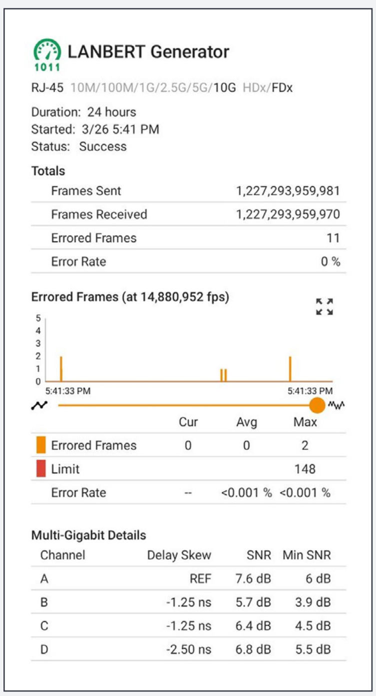
NetAlly Advantages

BERT capabilities are useful for certification purposes, but have little bearing on day-to-day network operations, such as upgrading Wi-Fi and validating links to access points. There is where having a tester that is more versatile is far more efficient and cost-effective over the long run.

NetAlly has upgraded the EtherScope® nXG Portable Network Expert analyzer and LinkRunner® 10G Advanced Ethernet Tester software to include the LANBERT™ Media Qualification App. This app provides a flexible, easy way to validate the quality of "dark media" and media components, such as SFPs, wall and patch panels, and patch cables. With 24-hour testing and the ability to drill down to 1-second granularity on errors, NetAlly offers a superior solution with in-depth visibility that other solutions do not provide.

Every NetAlly wired Ethernet tester provides basic cable "verification" – which establishes whether a specific cable or link is wired properly, ensuring there are no mis-wires, opens, shorts, split pairs or other physical impairments as determined through TDR (time-domain reflectometry) testing. Additionally, the testers can conduct pin-to-pin continuity testing ("wire mapping"), and office/jack location identification by way of a cable terminator. Most are also capable of injecting a digital or analog tone for cable tracing. These tools include the EtherScope nXG, the LinkRunner family of products, AirCheck G2, and LinkSprinter.

LANBERT sends Ethernet frames between NetAlly testers (EtherScope nXG or LinkRunner 10G) for full bi-directional testing, devices capable of layer 1 loopback, or a media physical loopback (fiber or 100M Ethernet). With this capability, these testers offer a complete L1 - L7 integrated unit capable of discovery, services tests, and in some models, Wi-Fi analysis and AirMapper™ site surveys. These testers are also capable of remote operations, which is handy for far end device deployments. These instruments can be used for more than just BERT endpoints, acting as a fully functional second testing device.



24-hour LANBERT test showing issues at 4 different times