White Paper

Copper and Glass: Securing the Foundation of your 10 Gigabit Data Center

How much time and money would you save if you could assure the performance of your data center's 10 Gigabit Ethernet network, before you turned up service? How much confidence would you gain by knowing the 10 Gigabit cabling was installed according to standards? This paper describes changes 10 Gigabit Ethernet brings to the network infrastructure and the specific steps you can take to make your new data center network rock-solid.

FLUKE networks

Copper and Glass: Securing the Foundation of your 10 Gigabit Data Center

Introduction

Today's data center manager oversees a long list of issues – including the physical plant. The emergence of 10 Gigabit Ethernet adds another topic to this worry list as 10 Gigabit technology has tight tolerances for transport over fiber or copper, thus renewing the importance of the physical layer of data center networks.

Compared to "vertical" and "horizontal" cabling for network access, data center cabling typically has shorter runs, is more densely-packed, involves patch cords and is subject to planned and unplanned changes. Adopting 10 Gigabit Ethernet in the data center is a bigger task than shifting a decimal point "one place to the right" from 1 Gigabit Ethernet. This whitepaper describes how to make the Layer 1 foundation for a 10 Gigabit Ethernet data center network stable and problem-free throughout its operational life.

Cabling for 10 Gigabit Ethernet

When you decide to upgrade your data center network to 10 Gigabit Ethernet, you may begin by investigating switch and router technology. Savvy IT managers are also looking below the surface and consider the cabling that supports the 10 Gigabit network. The questions posed include:

- Should I use fiber or copper?
- Is my existing copper up to the stress of 10 Gigabit?
- If I install new copper, can I be certain it will be up-to-spec?
- If I use fiber, do I have to hire a specialist to certify it for 10 Gigabit?

The physical layer is every network's foundation. Malfunctions in copper or fiber will disrupt every service on a network link, and the disruption is often catastrophic. High-throughput networks have more services exposed to disruption.

The rise of 10 Gbps

The need for network throughput in the data center is almost insatiable. Server consolidation, link aggregation, storage networks, blade-based servers and multimedia applications are just a few of the reasons multi-Gigabit networks will be the norm.

In 2002, the IEEE approved the first 10 Gigabit Ethernet standard, 802.3ae. The 802.3ae standard cracked opened the gate to use 10 Gigabit Ethernet, and a series of other standards followed. A table of the major 10 Gigabit Ethernet connectivity standards is below.

Standard	Media Type	Type	Maximum Distance
10GBASE-SR	Fiber	850 nm MMF	300 m
10GBASE-LX4	Fiber	1310 nm MMF	10 Km
10GBASE-LRM	Fiber	850/1310 nm MMF	220 m
10GBASE-LR/ER	Fiber	1310 nm SMF	10-25 Km
10GBASE-T	Copper	Cat 6/6a	55 m/100 m

A popular 10 Gig fiber option uses short wavelength Vertical Cavity Surface Emitting Lasers (VCSEL). Most legacy 62.5 um multimode fiber is only capable of supporting 10 Gigabits for 26 meters. In order to achieve distances needed for most fiber backbones, most new data center installations are being deployed with 50 um laser optimized fiber. By mid 2007, laser optimized 50 um fiber shipments will exceed shipments of 62.5 um.

While it has higher bandwidth, 50 um laser optimized fiber is the most sensitive to microbending. Microbending is a tiny but sharp curve that causes transmission loss on all wavelengths. It can be the result of improper manufacturing or installation. Microbending is localized and hard to detect. It is important to design cable pathways with proper bend radius and cable management to avoid this problem.

The majority of links in data centers are less than 55 meters in length. This made the 2006 approval of 10GBASE-T, also known as IEEE 802.3an, a watershed event for 10 Gigabit Ethernet. 10GBASE-T defined the parameters for 10 Gigabit transmissions over twisted-pair copper, the most common media for data center applications.

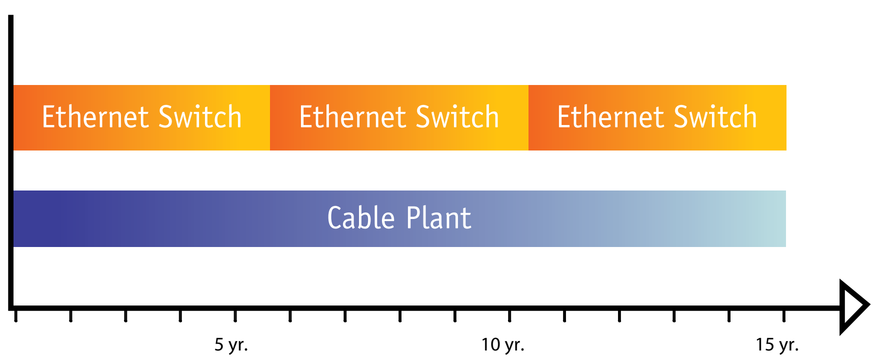
The Dell'Oro Group estimates that more than 100,000 10 Gigabit Ethernet ports were shipped in 2006, growing the installed population more than one-half million. 10GBASE-T will drive down cost further and catalyze growth of 10 Gigabit Ethernet. As costs decline and the demand for bandwidth grows, 10 Gigabit Ethernet will become the norm in data centers.

The physical foundation

Designing a 10 Gigabit Ethernet network may begin by evaluating the active components of the network, such as Ethernet switches. Because of the cost of active components, time applied to their evaluation is time well spent. However, a truly thorough design for a 10 Gigabit Ethernet network goes beyond active components to include the cabling system.

Unequal lifespans make analysis of the cabling system essential. Ethernet switches are typically replaced every 5 years or less because of rapid technology progression. Cabling systems remain installed for 10 years or more because replacement is highly disruptive.

Comparative Lifespans:
Switches and Cable Plant



If you install new cabling for 10 Gigabit Ethernet today, it will likely be with you through two or three generations of switch hardware. Choose wisely.

One decision in 10 Gigabit Ethernet cabling will be selecting fiber versus copper. Each has advantages and a healthy debate may precede your choice. Your debate should consider:

- Cost
- Ease of installation
- Ease of termination
- Reliability
- Distance
- Existing investment

Regardless which media you choose, it will be the foundation for the network. Like the foundation of any building, it has a long life, it must be durable and it must remain stable to support the structures above it.

Replace or re-use

You may have the option to re-use existing cabling for your 10 Gigabit network. Re-use usually saves money in the near-term. If your present cabling plant uses fiber or Cat6/6a copper, certification testing can determine if it is suitable for 10 Gigabit Ethernet.

If you install new cabling, you can take comfort in having fresh technology. New technology does not guarantee best performance, however. This is because good copper or fiber cable is easily undermined by poor installation workmanship. For this reason, certification tests are also wise in new cabling installations.

With proper certification testing you will know with certainty that your network's foundation is installed per industry standards and will perform as expected. Heed the saying, "In-spect what you ex-pect."

Certification testing = problem prevention

Would it save you time, money and aggravation if you could be certain your 10 Gigabit infrastructure operates as required, before you deploy services? Of course it would. This is the underlying principle of certification testing.

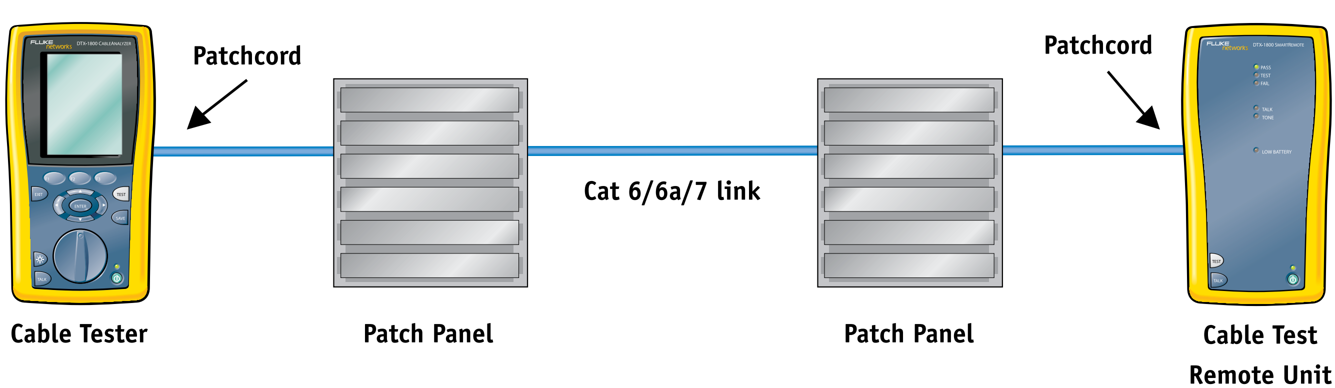
Certifying copper and fiber network links ensures compliance with requirements established by the Telecommunication Industry Association (TIA) and International Standards Organization (ISO) bodies. These requirements define the performance standards for 10 Gigabit Ethernet.

Certification testing is often performed by cabling installers, but IT departments with a strong self-support attitude may do it themselves. Certification testing on new and existing networks assures performance, reliability and installation workmanship. An IT manager must insist on testing to all the applicable standards and complete documentation in a hardcopy or softcopy report.

Certifying copper

Certifying 10GBASE-T copper cabling has two phases. In the first phase, parameters defined in the TIA/EIA-568-B or ISO 11801 standards must meet defined minimums. These parameters are Insertion Loss, Return Loss, Pair-to-Pair Near-end Crosstalk, Power Sum Near-end Crosstalk, Pair-to-Pair Equal Level Far-end Crosstalk, Power Sum Equal Level Far-end Crosstalk, Propagation Delay, Length, Delay Skew and Wiremap. Tests are conducted over a frequency range from 1 MHz through 500 MHz.

In the second phase, Alien Crosstalk is tested. Alien Crosstalk tests measure signal coupling from a wire pair in one cable to a wire pair in another cable routed in the same bundle of twisted-pair links. Signal coupling is detrimental because it creates a disturbance in the wire pair, similar to a noisy transmission line. While crosstalk is a critical performance parameter in all data communications, the higher bandwidth and higher dynamic range of 10 Gigabit Ethernet mandates specific Alien Crosstalk testing on copper links to ensure performance and reliability.



The certification process for twisted-pair copper cabling requires a test tool that supports the capabilities outlined in the applicable industry standards such as TIA-568-B or ISO std11801:2002. The test standards define different categories (TIA) or classes (ISO). The standards for each category or class define:

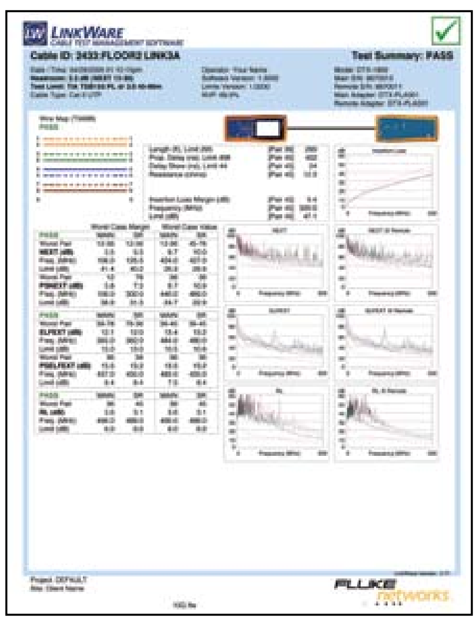
1. The test parameters to be measured
2. The frequency range over which these parameters must be measured and the maximum frequency step size between consecutive measurements
3. The Pass/Fail value (test limit value) for each parameter at each frequency throughout the applicable range.

The test tool also needs to store test results and upload them to a PC for reporting and analysis. Results management software should sort, archive and retrieve test results, displaying them for any cabling link. This is the best way to audit certification data.

While the certification tests are complex, a good test tool will automate the process. The only critical decision in using the tester should be the selection of the relevant test standard. The tester will apply the standard-dependent configuration as described above.

Proper certification demands testing transmission performance parameters from both ends of the link. Therefore, certification test tools consist of two units: a main with operator control and display, and a “smart” remote unit. They connect on either end of each of the links to be tested. A technician will press an “Autotest” button on the main unit to certify the link and store the test results. A complete certification test for a Cat 6/Class E link should take approximately 9 seconds. Using an “auto save” feature, the test results are stored in a fraction of a second. The technicians move from link to link to perform the “in-channel” certification.

This report shows the results of certification test results from a Category 6 copper link.



Certifying fiber

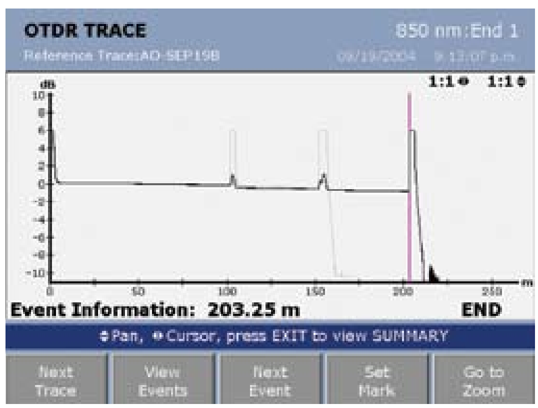
Data centers use fiber for backbone cabling due to its bandwidth and capability to transport data over long distances. As data rates increase, however, the distance supported and the loss budgets decline. In other words, a fiber link that had little trouble running slower applications may not run 10 Gigabit due to distance or loss budget. This accentuates the need to fully certify fiber for 10 Gigabit Ethernet in the data center.

The first step of fiber certification is conducted with an Optical Loss Test Set (OLTS). This first tier of fiber testing conforms to TIA-526-14A and TIA-526-7 and measures the total loss of a fiber channel. An OLTS consists of an optical source and a power meter. Some OLTS units initially verify polarity and continuity. Then, a reference is taken to determine the power of the source. Finally, a power meter is connected at one end of the fiber link and the optical source at the other. The OLTS measures the total loss on the link and compares it to the loss budget allowed by the appropriate standard.

Application	Data Rate	Designation	Supported Distance (m)*	Cable Plant Loss Budget (db)
Fiber Channel	1 Gbps	100-M5-SN-I	0.5 – 860*	4.62
Fiber Channel	2 Gbps	200-M5-SN-I	0.5 – 500*	3.31
Fiber Channel	4 Gbps	400-M5-SN-I	0.5 – 270*	2.48
Fiber Channel	10 Gbps	1200-M5-SN-I	0.5 – 300*	2.6

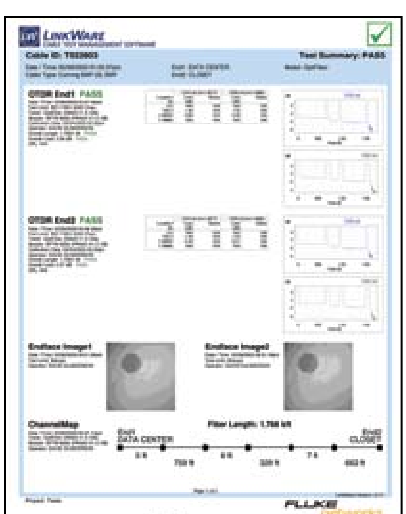
If the link does not meet the loss budget, it is necessary to use an Optical Time Domain Reflectometer (OTDR) to troubleshoot the fiber. An OTDR pinpoints the sources of loss and reflectance. Once located, they can be fixed and the link certified to meet the needs of the application. An OTDR is most useful in a data center if it is designed to "see" any short patch cords in a cross connect.

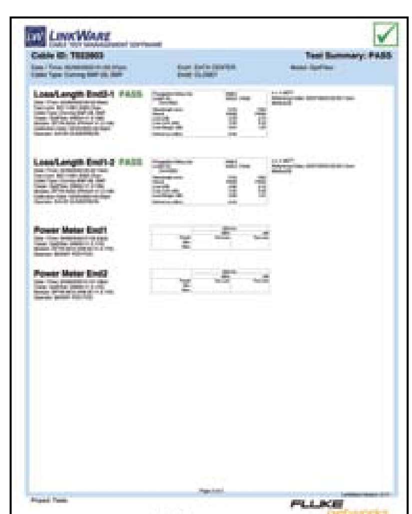
To perform the troubleshooting, an OTDR is plugged into a fiber link and it sends pulses of light down the fiber. The OTDR has a sensitive photodetector that measures how much light is reflected back. This information determines segment lengths, connector locations and losses, and any losses that are not at connection points. Shown below is the result of an OTDR trace, indicating the location of a fault in a fiber link.



A network's fiber links are often installed and certified by outside contractors. In order to ensure success in 10 Gigabit applications, it is important that the entire channel is certified. Many network owners have an OTDR with loss length certification capability permanently on-site so that they can certify and troubleshoot as fiber channels are assembled and turned up. Rapid, in-house troubleshooting with an OTDR is invaluable when a failure occurs with fiber optic cabling.

An OTDR will produce detailed reports on the results of its tests. Below are examples of such reports, which show the results of loss-length tests, OTDR traces and actual images of the fiber endfaces.





It's important all test reports always and only show the actual, as-recorded results from the test device. While it is unlikely that an individual would "fudge" a report to embellish the results, clear reporting specifications eliminate any ambiguity.

FUD: fear, uncertainty and downtime

Is there a cost to certifying your cable plant with proper testing? Yes. Is there a cost to not certifying your cable plant with proper testing? Also yes.

The purpose of certifying your network is to avoid the network downtime that inflates operating expense. Gartner Dataquest assessed the impact of network downtime on productivity and revenue in several industries. Their findings included:

Industry	Average Cost Per Hour of Downtime
Brokerage	$6.5 million (USD)
Credit card authorization	$2.6 million (USD)
Airline	$90 thousand (USD)
Retail catalog sales	$90 thousand (USD)
Shipping	$28 thousand (USD)

These estimates may not be directly applicable to your organization, but as representative samples, they confirm something you knew: downtime incidents are painfully expensive. Since a downtime incident may last more than one hour and occur more than once, conservative arithmetic points out the gravity of the exposure.

Greater throughput on a network link does not necessarily translate to more criticality and higher cost of downtime, but in some applications, it plainly does. Examples:

- Link aggregation
- Storage area networks
- Video-on-demand
- Server consolidation

In applications like these, the downtime avoidance provided by cable certification is exceptionally valuable.

What is the cost of certifying the new 10 Gigabit Ethernet network in your datacenter? It varies, but representative model is as follows:

Type of network	Copper
Number of lines	500
Certification test time per line, (make connection, test and store data)	0.75 minutes per line
Failure rate on tested lines	5%
Repair time per failed line	20 minutes
Technician cost per hour, including overhead	$50 (USD)
Cost to certify, repair and re-certify (two technicians)	$1,490 (USD)
Lines tested for Alien Crosstalk	5
Alien Crosstalk test time per line (24 cable bundles, make connection test and store data)	30 minutes
Technician cost per hour, including overhead	$50 (USD)
Cost to test for Alien Crosstalk	$250 (USD)
Total cost for certification, repair and Alien Crosstalk testing	$1,740 (USD)

For less than $4 per line, the physical layer has been certified as the most robust element of this 10 Gigabit Ethernet network.

Looking ahead

Faster networking technology is already being planned. 40 Gigabit and 100 Gigabit networking standards are being defined and should reach the market within the next five years. Higher speeds will drive changes at the physical layer, as well.

For example, shielded twisted-pair copper cabling (also called Category 7 or Class F) may move from fringe use into the mainstream of 10 Gigabit+ speeds. This cable is thicker, heavier and harder to bend. More important, the metallic shielding in Cat 7 must be properly grounded to achieve the desired performance.

As new kinds of products appear in the mainstream market, data center managers that implement thorough certification will be assured of increased reliability, performance and flexibility.

Benefits too valuable to ignore

Networking technology is advancing at a staggering pace, but no such advance will ensure guaranteed, or even best effort, delivery without a dependable physical layer of the network.

Using 10 Gigabit Ethernet in your data center elevates cable certification from "good practice" to "mandatory requirement." Tight tolerances combined with high-value services necessitate steps to avoid problems and downtime. Cable certification does exactly this. There is no reason not to begin certification today.

NETWORK SUPERVISION

Fluke Networks
P.O. Box 777, Everett, WA USA 98206-0777

Fluke Networks operates in more than 50 countries worldwide. To find your local office contact details, go to **www.flukenetworks.com/contact**.

Printed in U.S.A. 3/2007 3004145 D-ENG-N Rev A