

Need for Speed: 40GBASE-T in Data Center Networks

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Data center network infrastructure is witnessing a transformation, driven by growing bandwidth and network performance demand. 10 Gigabit Ethernet is de-facto standard in today's data center with growing adoption of 40G. While 40G Ethernet standards already exist for SM fiber and MPO based MM fiber cables, standards bodies have developed 40GBASE-T Ethernet over twisted pair copper cabling systems. Such high networking speed imposes strict performance requirements for cable components and cabling systems. This article examines challenges in ensuring adequate performance of installed cabling, with specific attention to certification testing in field.

40G Ethernet Physical Layer Alternatives Singlemode Fiber

Due to its long reach and superior transmission performance, singlemode fiber is specified for carrying 40Gbps data up to a distance as long as 10km (40GBASE-LR4). The physical layer electronics and optics consist of four channels, each carrying 10Gbps data with different wavelengths. Singlemode fiber is the preferred option where budget is not a constraint, or when the link distances are long.

Multimode Fiber

Multimode fiber with parallel optics MPO interface is the most popular medium for 40G Ethernet today (40GBASE-SR4). The networking hardware is cheaper compared to singlemode, and it supports all typical link lengths (up to 100m for OM3 cable and 125m for OM4) in a data center network.

Copper Twinax

For short reach channels up to a length of 7m (40GBASE-CR4) standard specifies use of twinax copper cable assemblies. Typical use is interconnecting networked devices which are physically located adjacent to each other.

Copper Twisted Pair

Recent developments suggest that copper structured cabling systems are here to stay and will be an important alternative to fiber links for 40G Ethernet. Twisted pair copper cabling is likely to retain its cost advantage over fiber for the next several years. Copper cables are perceived to be easier to install





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and maintain. Importantly, BASE-T networking standards over twisted pair cable are backwards compatible with auto-negotiation capability. This enables organizations to upgrade to higher speeds incrementally, with better control over capital expenses.

IEEE initiated a formal project for defining 40GBASE-T standard using twisted pair cabling in 2012. Cabling standardization bodies are also updating their specifications. TIA has developed specifications for "Category 8" cabling systems suitable for 40GBASE-T.

ISO/IEC has a similar project that aims to define two variants of cabling systems that will support 40GBASE-T. These new cabling systems are being called Class I (using CAT6A like components with higher capacity), and Class II (using CAT7A like components with higher capacity). Additionally, ISO/IEC is defining recommendations about using existing cabling systems such as Class FA for 40GBASE-T application.





One of the key tasks in defining Ethernet standards is to determine appropriate RF bandwidth for communication. For example, 10GBASE-T uses 400MHz bandwidth, which roughly means that every Hz of RF spectrum carries 25 bits of binary data, in other words, channel capacity utilization is 25bits/Hz. Higher order and more complex modulation schemes can increase capacity utilization. There is a maximum limit to channel capacity, known as Shannon Capacity.

This limit is due to the electromagnetic noise experienced by the channel. Noise comes from external and internal sources. Examples of internal noise sources are cross-talk and return-loss. Ethernet physical layer devices use sophisticated signal processing techniques to predict and cancel the effects of internal noise sources, thereby increasing capacity of the channel. However, the trade-off is higher power consumption and the resulting heat generation.

Learning from the 10GBASE-T Experience

High power consumption was the single largest reason why 10GBASE-T adoption lagged all predictions made when the standard was released in 2006. This problem has been largely overcome today through innovative designs and semiconductor technology advancements.

With this 10GBASE-T experience fresh in mind, the experts developing 40GBASE-T standard are reluctant to increase the target for capacity utilization significantly.

But 40G is four times as much data as 10G. One way of squeezing more data, without significantly changing modulation density (capacity utilization), is to increase the bandwidth. In this case, it would mean a four-fold increase from 400MHz to 1,600MHz. This is what the 40GBASE-T standard seems to be driving towards.

There is one issue with increase of bandwidth. On twisted pair cables, signal attenuates rapidly with increasing frequency. This means, received signal at 2,000MHz is significantly smaller than received signal at 100MHz. This phenomenon imposes restrictions on the length of cable.

With a 100m cable, received signal at high frequencies would be buried in the noise. A compromise therefore has to be made on the maximum supportable link distance.



Selecting Transmission Bandwidth for Twisted Pair Cabling for 40GBASE-T





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The Net Effect of all these Considerations is:

- 40GBASE-T uses bandwidth spectrum from 1MHz- 2,000MHz
- The maximum length of the cable is limited to 30m
- The cabling channel is specified for two connectors

The good news is, a large percentage of data center link lengths are well within this 30m constraint. Studies have indicated that more than 80% of data center links are 30m or shorter, and therefore eligible to benefit from 40GBASE-T.

Field Testing of 40G Copper Cabling

While cabling technologies and semiconductor technologies can support 40Gbps Ethernet over twisted pair copper cables, wide spread market adoption calls for additional considerations. One of the key elements is availability of field test instruments to characterize and certify installed cabling for suitability for 40GbE.

Conclusion

Despite the growth in wireless and fiber infrastructure, copper cabling will still be the dominant media for enterprise networks in a foreseeable future. When designing infrastructure for use over next 15 to 20 years, one must consider the fact that there is a high likelihood that 40GBASE-T systems will be defined, and become common place in 5-10 years. There are technical challenges in supporting such high data rates, one of the main challenges being complexity of physical layer devices. In order to create a complete eco system for adoption of technologies like 40GBASE-T, the industry will need cabling systems, networking devices, standardization, and also field test instruments suitable for that technology.

Field testing over wider bandwidth has been constrained in the past due to several factors, but now at least one commercially available field tester features the capability of certifying cabling to bandwidths higher than 2,000MHz, which is expected to meet field testing needs for future 40GBASE-T systems.

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History

Founded in 2003 as Psiber Data, and as a sister company of Psiber Data Systems Inc. USA, Psiber was acquired by Softing AG in January 2014.

Softing AG is a publicly traded Germany company, specializing in software developed for industrial and automation, automotive electronics and manufacturing, as well as hardware/ software solutions for IT Network solutions. The company was founded in 1979 and its headquarters are in Haar, near Munich. In fiscal 2015, Softing employed 429 employees and had a turnover of 82 million euros.

The competencies of Softing IT Networks are complemented by the Softing Industrial division's expertise in networking industrial worlds and Softing Automotive's expertise in evaluating the functionality of electronic vehicle components.

Competences & Specializations.

Softing IT Networks specializes in measurement equipment for testing, qualifying, certifying and documenting the performance of copper and fiber-optic IT cabling based on global technological standards.

Whether it is used for telecommunications, databases, mainframes or plant engineering in the field of industrial automation, the professional measurement equipment from Softing IT Networks will help you optimize the performance of your data communication through faster, more secure connections over the entire lifecycle of your network.

With the rapidly growing and all-encompassing networking of people, things and services (Internet of Everything/loE), powerful and reliable IT networks have already become the backbone of our modern world.

The failure of such networking infrastructure can lead to data loss and is almost always very costly. This is why it is so important to prevent unplanned network outages. To make this possible and ensure a rapid response in the event of network faults, installers, system integrators and network operators, need access to powerful and professional measurement equipment.

Our measurement equipment makes it possible to ensure the physical efficiency and high quality of communication between network components.

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