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EDITORIAL GUIDE

Evolving Standards for Cabling, Networking and Power Delivery

Standards continue to emerge and evolve, specifying cabling infrastructure performance, data transmission across networks, and delivering power via network cable. Understanding the interrelationship among these standards can enable cabling system designers, installers and users to ensure the systems they specify will support current and future applications. This editorial guide includes reporting from Cabling Installation & Maintenance, along with an original work from Siemon. It provides detail on current standards activities, the practicalities of cabling performance levels, and steps that can be taken to build an infrastructure that is up to the task of supporting critical applications.

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Originally published October 2015

Category 8 Questions Answered

Compiled by **PATRICK McLAUGHLIN**

AS THE TELECOMMUNICATIONS Industry Association (TIA) TR-42.7 Subcommittee works diligently toward finalizing the specifications for Category 8 twisted-pair cabling systems, we asked several members of the subcommittee to answer some questions about Category 8.

Q: *Can you provide a summary of how a Category 8 cabling system's capabilities compare to those of previous-generation twisted-pair cabling systems, such as Category 6, 6A, 7, 7A, etc.? Please address bandwidth, channel configuration, and channel distance, as well as other performance characteristics you deem appropriate. Please describe how, if at all, the TIA is approaching backward compatibility between Category 8 and previous-generation twisted-pair systems.*

Answer provided by Mark Dearing, senior product manager with Leviton Network Solutions: Since Category 5e was introduced in 1999, one of the constants in structured cabling has been the 100-meter, 4-connector channel. As data rates have increased, one of the primary differences between category systems is the frequency at which the signal is transmitted over the cable.

Category 7/7A offers a 100-meter 4-connector channel using shielded cabling, and has been designed to transmit signals at a frequency of 1000 MHz. Even though Category 7/7A operates at the higher frequency, there is no corresponding improvement in data rate over Category 6A because 10GBase-T is still the fastest twisted-pair-based data rate recognized by IEEE 802.3. Therefore, even if a Category 7/7A cabling system is installed, any available active equipment would be limited to 10-Gbit/sec performance. Category 7/7A is not a recognized category by TIA.

Category 8 is a significant departure from previous systems in that it uses a frequency of 2000 MHz, and is limited to a 30-meter 2-connector channel. Unlike

Category 5e through Category 6A, which could use either unshielded twisted-pair (UTP) or shielded cable construction, Category 8 will require shielded cabling. The most likely cable construction for Category 8 will be 22-AWG S/FTP cabling.

Category 8 is also unique in that the ISO standard will recognize two different classes of product. (This topic is covered in greater detail later in this article.) Class I is based on the traditional RJ45 connector, while Class II will accept non-RJ45 connectors similar to Category 7/7A. While both solutions will offer backward compatibility in terms of transmitting the lower category data rates (1G or 10G), the Class I solution offers a migration path using the RJ45 connector platform. For example, a customer might install a Category 8 jack-to-jack link now, but continue to use Category 6A patch cords until the active equipment is upgraded. While the ISO standard includes both classes, the TIA Category 8 standard will only recognize a Class I solution.

Q: *Given Category 8's capabilities, where and how is it most likely to be deployed (e.g. in a data center vs. a corporate LAN, top-of-rack vs. end-of-row architectures)?*

Answer provided by Masood Shariff, engineering senior principal with CommScope: Category 8 cabling is designed to support emerging IEEE 25GBase-T and 40GBase-T needed as server-to-access-switch interconnect applications. This need has been identified and available, or under development, over optical fiber links for longer reach (up to 500 meters), or twinax links for short reach (up to 7 meters).

The opportunity for balanced twisted-pair as a cost-effective viable media option for the intermediate distance needs between 5 and 30 meters, sufficient to serve 20 cabinets or racks in a data center, led to the initiation and development of both the IEEE 802.3 application standards and the associated TIA as well as ISO/IEC Category 8 cabling standards.

Q: *What communication or collaboration is taking place between the TIA and the IEEE-particularly the 802.3bq Task Force-to ensure the TIA's Category 8 specifications are in concert with the IEEE's 40GBase-T and 25GBase-T specifications?*

Answer provided by Masood Shariff: The IEEE 802.3bq Task Force is collaborating with TIA TR-42.7 and ISO/IEC/JTC 1/SC 25/WG3 to ensure consistency and compatibility of the cabling specifications within the "link segment" specifications in IEEE 802.3bq applications. Liaison letters to clarify requirements or provide additional information are generated at most meetings and latest drafts of the TIA and ISO Category 8 specifications are sent to the IEEE 802.3bq committee, where they are posted in a "private," password-protected area for members to review and comment. The relationship between IEEE 802.3bq and its companion cabling standards organizations has been very positive and constructive, with several common members attending the meetings.

Q: *Can you explain the relationship between the TIA and ISO/IEC groups working to define Category 8 cabling specifications? Specifically, how are the two groups' efforts similar and how do they differ from each other? Observers of the standards-creation processes see terms like "Class II," "Category 8.1," and "Category 8.2." The meanings of these terms are not necessarily self-evident.*

Answer provided by Valerie Maguire, director of standards and technology with Siemon: The Telecommunications Industry Association (TIA) TR-42 Telecommunications Cabling Systems Engineering Committee and the joint technical committee of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC 1) share similar missions of developing, maintaining, and promoting standards related to information and communications technology. However, while TIA standards represent the consensus positions of their North American corporate constituents, ISO/IEC JTC1 standards represent the consensus positions of their member countries. As a result, voting within these organizations is also different, with TIA recognizing one vote per member company and ISO/IEC recognizing one vote per member country (i.e. North America only has one vote). A voting practice that accommodates regional preferences is the key reason why there are additional shielded options, such as Category 7A/Class FA specified in ISO/IEC standards compared to TIA standards.

While specifications for same-bandwidth balanced twisted-pair copper cabling systems are well harmonized between TIA and ISO/IEC, there are a few differences that stand out-most notably the naming convention for these cabling systems. In ISO/IEC standards, structured cabling components (e.g. cables, connecting hardware, and patch cords) are characterized by a performance "category" and are mated to form a permanent link or channel that is described by a performance "class." In TIA standards, components and cabling are both characterized by a performance "category." ISO/IEC and TIA equivalent grades of cabling, arranged in order of increasingly more stringent transmission performance, are shown in the table.

Note that, although ISO/IEC Class I and TIA Category 8 cabling systems are specified to 2000 MHz, they will not be electrical supersets (i.e. exhibit superior performance) of ISO/IEC Class FA cabling up to 1000 MHz.

Both the ISO/IEC JTC1 and TIA TR-42 are developing requirements for the balanced twisted-pair media that will support the 25GBase-T and 40GBase-T applications that are currently under development by IEEE 802.3. ISO/IEC is developing requirements for Class I cabling constructed from Category 8.1 components, and Class II cabling constructed from Category 8.2 components. TIA is developing requirements for Category 8 cabling constructed from Category 8 components and is also undertaking an initiative to develop Class II cabling requirements that will harmonize with ISO/IEC. Class I and Category 8 cabling specifications support modular RJ45-style connectors. The performance associated with Class II cabling can only be realized when Category 8.2 cables are used in conjunction with non-RJ45 interfaces such as the Siemon TERA connector. Draft ISO/IEC Class I and II, and TIA Category 8 cabling specifications, are mature and currently circulating for industry comment and review.

Note that Class I, Class II, and Category 8 cabling is characterized to 2 GHz and intended to support 30-meter cabling channels that contain no more than two connectors. These channels and the emerging 25/40GBase-T applications that they support are specifically targeted for deployment at the data center "edge," where server-to-switch connections are made. Data center designers who can arrange their rack and cabinet layouts to support maximum 30-meter channel connections at these locations today will be well-positioned to migrate to 25/40GBase-T when the technology becomes available.

Q: *What steps can a customer take today to design their facilities in such a way that they are "future-ready" to install Category 8 when product becomes available?*

Answer provided by Frank Straka, product development manager with Panduit: Category 8 is a 30-meter channel, comprising a 24-meter permanent link and up to 6 meters of patch cable. Therefore, when planning data centers with end-of-row or middle-of-row topologies, ensure that your jack-to-jack links are no more than 24 meters in length and that you do not need more than 6 meters of patch cords in total. What this means for patching is you could have two, 3-meter patch cords, a 1-meter and a 5-meter patch cord, or any combination that adds up to 6 meters or less.

For top-of-rack topologies, the 3-meter reach should be more than sufficient to cover any direct switch-to-server links, especially if the data center had been using technologies like SFP+ that have a reach limit of about 5 meters.

Q: *How similar can we expect Category 8 products to be compared to jacks and plugs existing in the market today? Will products be field-terminable? And with Category 8 being a shielded technology, are there any anticipated concerns for installers?*

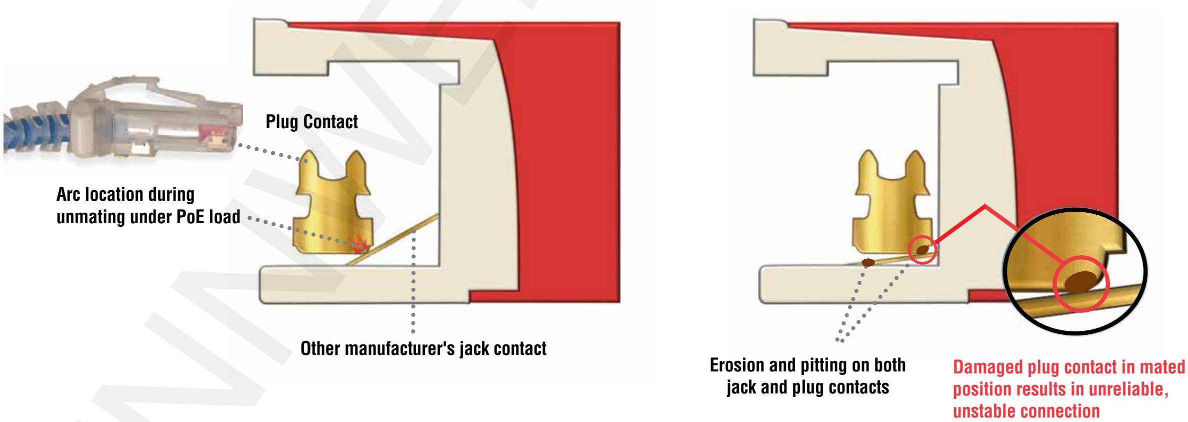
Answer provided by Frank Straka: Category 8 products are anticipated to be significant upgrades over existing Category 6A products due to the 4-times increase in bandwidth. However, these upgrades will primarily occur internally to the jack and plug in order to meet that bandwidth. Externally, they will be about the same form and fit as prior category jacks. This makes sense, as they need to work with the same patch panels, switches, and other equipment with which users are familiar today.

Category 8 will be field-terminable. Now given that Category 8 is shielded, field-terminable, and with a very high bandwidth, expect there to be at least some improvements made to how jacks are terminated in the field to both meet this new bandwidth and to ensure a good bond with the shield. For many contractors, the biggest change will be going into a shielded system and ensuring that the cable is properly grounded. If we connector companies do our job right, grounding the Category 8 cables and connectors will be a seamless process for the installer.

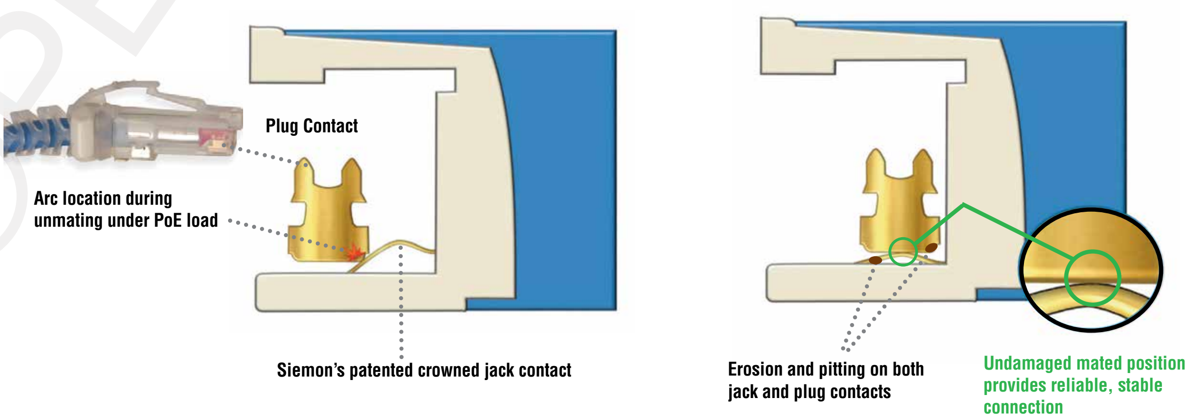
Siemon Jacks Crowned King of PoE

Unmating a jack-plug connection under a PoE load produces an arc that erodes the gold plated jack-plug contact surfaces at the arcing location. When this erosion occurs in the area of the fully mated position, the result is an unreliable connection. Siemon's patented curved or "crowned" jack contact geometry for its Z-MAX® and MAX® jacks places arcing damage to both the plug and jack contacts away from the final mated position—allowing you to connect and disconnect to the latest PoE applications with zero risk.

Other Jacks... Damaged Fully Mated Position



Siemon... Undamaged Fully Mated Position



As the IoT continues to place more PoE-enabled devices on the network and PoE standards advance to deliver higher power over all four pairs, it's time to pull the plug on inferior connections and choose Siemon's patented crowned contact geometry— it's what makes our jacks King of PoE.

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PoE and other technologies are pushing powered-device wattages ever-higher

Two new flavors of IEEE-specified Power over Ethernet are in the works, and non-IEEE technologies are already common. What does it mean for cabling?

By **PATRICK MCLAUGHLIN,** Chief Editor

IT HAS BEEN said many times, in live and online seminars, that typically industry standards are at least a step or two behind the latest technological developments-catching up the best they can but almost always trailing, not leading, the capabilities being made available to a market. That refrain holds true today for the technologies that enable the powering of network devices using twisted-pair copper cabling as the medium that carries appropriate wattage to those powered devices. Collectively, the technologies that enable this type of device powering commonly are referred to as Power over Ethernet (PoE). As we published in an article last year, the use of that term has drawbacks as well as benefits ("Why the industry needs a PoE Logo Program," October 2014). Nonetheless, the term PoE is widely used as an inclusive term, and we will use it in this article as well.

To date, the Institute of Electrical and Electronics Engineers (IEEE; www.ieee.org) has published two sets of specifications defining these capabilities. IEEE 802.3af (commonly called simply "PoE") specifies the generation of up to 15.4 watts of power, with 12.9 watts delivered to the powered device (PD). And IEEE 802.3at (commonly called "PoE Plus,") specifies the generation of up to 34.2 watts of power, with 25.5 watts delivered to the PD.

Ty Estes, director of marketing at Omnitron Systems Technology Inc. (www.omnitron-systems.com), explained, “The IEEE standard for 60W, also known as PoE++, is currently in development with the IEEE 802.3bt Type 3 Work Group, and is projected to be ratified in early 2017. In lieu of a 60W PoE standard, equipment manufacturers have doubled the 802.3at PoE+ capability on four pairs, and powered all eight pairs to achieve 60 watts.”

Going beyond IEEE

To Estes’s point, in 2010-the year after IEEE 802.3at was published-Microsemi’s (www.microsemi.com) director of product management and product marketing, Sani Ronen, explained, “Four-pair powering is supported in the latest PoE standard, and uses all four pairs of Ethernet cable to enable up to 60 W of DC [direct current] power to be delivered over a single cable using current levels of 600 mA … To enable these powering levels, the IEEE specifications changed the definition of a PD so that it considers the PD the power interface, as opposed to the whole device being powered. This means that there can now be two power interfaces, each taking 25.5W, in the same box. Nothing precludes these from being connected, one over two pairs using lines 1, 2, 3, and 6 and the other two over the two pairs using lines 4, 5, 7, and 8. This is what makes it possible to double the standard 802.3at-2009 maximum of 25 W and go up to 51 W while fully complying with the standard.”

In 2011, Cisco (www.cisco.com) debuted its Universal Power over Ethernet (UPOE) system, which delivers 60 W to PDs. At the time of that announcement, Cisco’s Catalyst 4500E switch was the infrastructure that housed the 60-watt UPOE capability. The company said target applications for UPOE included IP phones, personal telepresence systems, compact switches and wireless access points. Others also have pointed out that some IP cameras can benefit from more power than that afforded by IEEE 802.3at. Specifically, cameras that reside outside and require temperature-control in the form of blowers and heaters are power-hungry, and are often referenced as the types of network devices pushing the need for higher power delivered via cabling.

Omnitron provides an array of media converters, including models that provide PoE. In that vein, Estes noted, “In addition to the increasing power required by PoE devices, the 100-meter distance limitation of UTP cabling is a challenge in large facilities like airports, arenas, building complexes, and government facilities. High-power media converters can power the latest generation of 60-watt devices that have emerged onto the market, and extend distances with fiber cabling."

In 2011, the same year Cisco introduced UPOE, the HDBase-T Alliance (www.hdbaset.org) released the Power over HDBase-T (PoH) specification, which defines the delivery of up to 100 watts of power over a single cable, up to 100 meters. At that time Daniel Feldman, vice president with Microsemi, explained, "Core PoE technology has been enhanced for the PoH specification to include a higher current of almost 1 Amp for every two pairs, with an appropriate three-event classification that identifies PoH power sourcing equipment [PSEs]. This enables PoH technology to transfer up to 100 w of continuous DC power, per port, from one side of the HDBase-T link to the other. Unlike in PoE, where the PD must assume a worst-case cabling infrastructure at all times, PoH enables the PD to identify the cable length/resistance and draw more power, as long as the overall power consumption does not exceed 100 W."

Feldman's comment broaches the topic of cabling performance level and support of PoE/PoH. That topic has been, and remains, the subject of significant study as the IEEE moves forward with its latest PoE specifications. As Estes mentioned, IEEE 802.3bt is under development. Within IEEE nomenclature, the 802.3af

Type	Standards	Max Current	Energized Pairs	Power at Device	Standard Ratified
PoE	IEEE 802.3af (802.3at Type 1)	350 mA	2	12.95W	2003
PoE+	IEEE 803.3at Type 2	600 mA	2	25.5W	2009
PoE++	Proposed IEEE 802.3bt Type 3	600 mA	4	49W	Expected 2016-2017
PoE++	Proposed IEEE 802.3bt Type 4	1000 mA	4	96W	Expected 2016-2017
Non-PoE standard-based	Cisco UPOE	600 mA	4	60W	No official ratification
Non-PoE standard-based	HDBase-T	1000 mA	4	96W	No official ratification

specification is known at "Type 1" PoE, and 802.3at is known as "Type 2." The current effort, 802.3bt, is likely to include a "Type 3" and "Type 4" PoE. Type 3 will specify a current level up to 600 milliAmps (mA) and 49 watts at the powered device, while Type 4 will specify a 1,000-milliAmp (1 Amp) current level and 96 watts at the powered device.

Cabling implications

In April at the Ethernet Technology Summit (www.ethernetsummit.com), Frank Straka, product development manager with Panduit (www.panduit.com), addressed the issue in a presentation titled "100W PoE++'s Impact on Infrastructure." Just as 802.3af has become known as "PoE" and 802.3at as "PoE Plus," 802.3bt is being dubbed "PoE Plus Plus" in some circles. (Note: This author did not attend the Ethernet Technology Summit, but did obtain the visuals of the presentation that Straka delivered. The summary that follows is derived from those visuals. The table within this article also is reproduced from Straka's presentation.)

Among other topics, Straka addressed the extent to which heat rise within cable bundles could have deleterious effects on cabling system performance when those cables are carrying 100-watt PoE. Straka's presentation noted, "Cable temperature matters because some temperature rise will increase cable insertion loss and may create bit errors; extreme temperature increase above the cable operating range can damage the cable." Cable manufacturers, he noted, will provide users with information about the maximum bundle size that can meet the 15-degree temperature rise limit recommended in the TIA TSB-184 document, "Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling." Straka stated that the equation that should be used when planning for higher-power PoE is: cable temperature rating is less than or equal to the ambient temperature plus 15.

He pointed out that of PoE and PoE Plus, Category 5e, 6, and 6A cables all complied with TSB-184's 15-degree maximum temperature rise when tested in bundles of 100 cables. However, during testing of 802.3bt pre-standard technology, only Category 6A cables stayed within the 15-degree recommendation. A couple recommendations to take away from these test findings are that Category 5e and 6 runs should be assembled in bundles of fewer than 100 cables. And, as one line in Straka's presentation stated, "If thinking of running PoE++, Category 6A cabling is recommended."

Much remains to be determined concerning the type of cabling that will adequately support IEEE 802.3bt, and the physical placement and layout of that cabling. The TIA also is in the process of revising TSB-184 to address 802.3bt support.

Examining options

In a recently published technical paper titled "Power Over Ethernet: A Consumer-centric Development Perspective," General Cable (www.generalcable.com) communications-products engineer Roy Kusuma also addressed temperature-rise considerations in cable bundles. In the paper Kusuma points out, "In many cases a large cable bundle may be present under the floors, behind walls or enclosed in an insulated space. In the last circumstance, the heat rise figures are significantly worse, with numbers as high as 50 degrees Celsius above ambient temperatures for the typical worst-case Category 5e construction.

"Currently, in applications where higher power usage is expected in excess of 50 watts, yet higher data transmission rates are not required, there are few, if any, options," he continues. "To appropriately address the increased temperature rise, one could be confined to using Category 6A [UTP] or Category 6A F/UTP. The limiting factor of many devices, especially IP cameras, nurse call systems, building management controls and point-of-sale is power consumption, not data. This places a difficulty on premises designers to justify the use of higher category cabling or the need to pull a power source onto a location."

Portions of the technical paper discuss and support the use of Category 6 cable designed specifically for supporting higher-power PoE applications. "There are real benefits to using specially designed PoE cabling with properties such as larger, lower-gauge conductors and higher temperature cable ratings for the majority of PoE applications," Kusuma says. "Aside from having the confidence that the cable will withstand higher temperature operations and generate lower temperatures, energy savings and efficiency are also considerations when deploying a large-scale PoE infrastructure."

Straka's presentation at the Ethernet Technology Summit also addressed the phenomenon of arcing, or sparking, that can occur on twisted-pair cabling contacts when a plug is removed from a jack. "Arcing damage may prevent data transmission through the plug and jack," the presentation stated plainly. Additionally, it said, "Connectors should meet IEC 60512-9-3 and IEC 60512-99-001 to ensure that when (not if) arcing occurs, it will not damage the critical plug-and-jack mating point where the plug is fully engaged."

In a post to Leviton's blog (blog.leviton.com) in January 2015, the company's senior product manager for copper systems, Grayling Love, discussed several of the cabling issues addressed in this article. Concerning connection reliability, Love noted, "When a patch cord is unplugged while the connection is charged, an electrical arc will occur between the connector and the plug. While there is no immediate damage (and the arc is not dangerous to users), the integrity of the connection can become weakened over numerous disconnections. To add extra protection and longevity to the life of the connection, Leviton recommends using connectors with 50-µm gold-plated tines (as specified by TIA standards), as well as designs that distance the connection point between the connector tines and plug from the arcing damage." Love also referenced the IEC 60512-99-001 standard covering connectors for electronic equipment. "High-quality connectivity is essential for attaining the performance, reliability, and flexibility needed in today's network operations," he added.

In the case of powering network devices with upwards of 100 watts of DC, industry standards may indeed be a step or even two steps behind the technologies being brought to market. But the testing and investigation going into the standardization process-within the IEEE as well as the TIA-are for the purpose of ensuring, to the extent possible, that an installed standard-compliant system can be relied upon as an enabling infrastructure for data and power delivery. The standards currently under development are no exception. When ultimately published, these standards will guide the installation of powered devices, power sourcing equipment, and cabling systems around the world.

PATRICK McLAUGHLIN is our chief editor.

Copper vs. Fiber

The War is Over and Everybody Won. Where Do We Go From Here?

By **Valerie Maguire** and **Betsy Conroy**

For years, no discussion about future-proofing was ever complete without pondering the question of when copper cabling would become obsolete. Today, it is virtually impossible to debate the overall superiority of optical fiber versus copper cabling since both have unique and distinct advantages when networks are looked at as a whole—from the device to the data center.

Two decades ago, many optical fiber proponents declared that category 6 balanced twisted-pair would be the limit for copper cabling. However, the advancements that have since brought us category 6A and category 7_A, and will soon bring us category 8, have done more than simply prove that mind-set wrong. Instead, they have paved the way for copper cabling to remain the de-facto media to the desktop or building device for decades to come. And advancements happening now with copper cabling technology and within standards bodies will uphold a long-term position for balanced twisted-pair copper cabling at the data center edge where switch-to-server connections are supported.

Nonetheless, optical fiber cabling remains, and will remain, the standard for bandwidth-hungry applications such as backbone cabling, data center core networking and outside plant communication. New optical fiber technologies and standards are making it easier, more cost-effective and less complex than ever to deploy high speed links in these areas where there is a need to quickly and efficiently move large amounts of data over longer distances. Optical fiber is also finding a new home in some premise environments where passive optical networks make sense.

The Ethernet Alliance predicts that Ethernet could have as many as six new speeds in the next five years, twelve new speeds by the year 2020 and greater than Terabit per second (Tb/s) speeds beyond 2020. With such a dramatic copper and optical fiber technological revolution taking place (see Figure 1), there is a need to understand the benefits that each media type can offer in data center, campus and premise (i.e., all in-building cabling excluding the data center) environments. To that end, let's take a look at performance differentiators between media, some key considerations for selecting the type of copper and optical fiber cable and connectivity, and some of the developing standards that will further impact media selection.

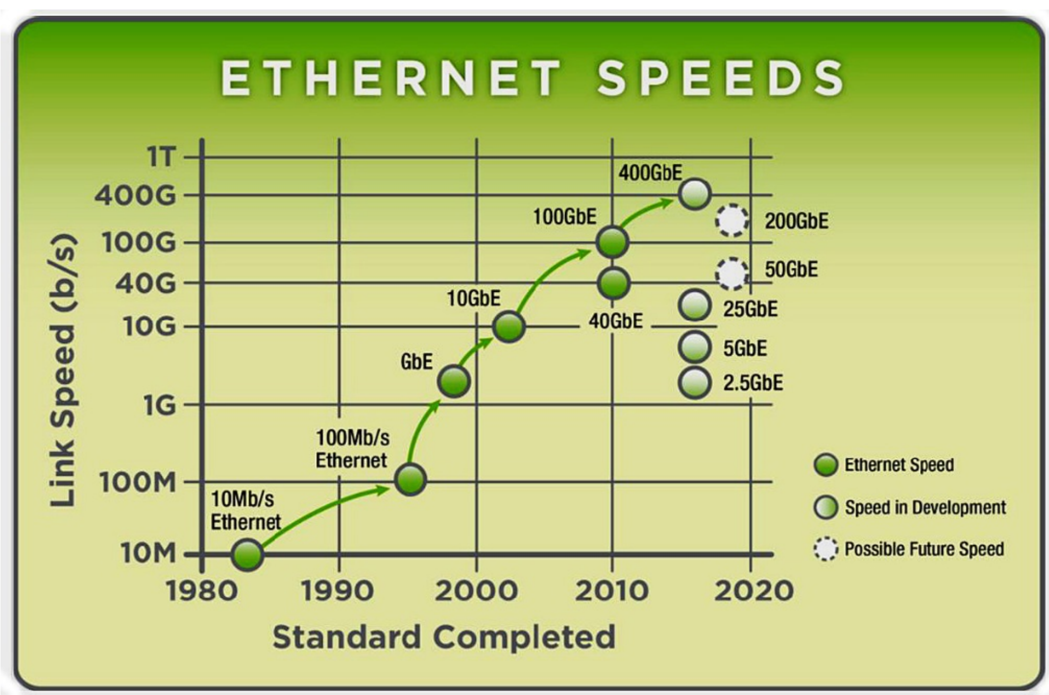


Figure 1: Composite of past, present and future balanced twisted-pair, multimode and singlemode optical fiber, and twinaxial direct attach Ethernet speeds. Source: Ethernet Alliance 2015 Ethernet Roadmap (http://www.ethernetalliance.org/roadmap/)

Copper is the Premise Power Play

In premise applications, optical fiber cabling is commonly deployed for the backbone infrastructure where longer distances than what copper cabling can support are often required. As work area and building device speeds and data throughput increase, an optical fiber backbone also offers the incremental bandwidth capability required for aggregation, future proofing and transmitting increasing amounts of data at a faster rate.

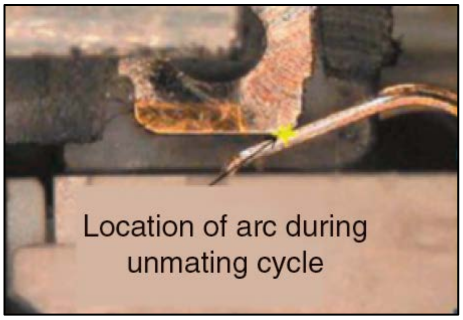
From the telecommunications room (TR) to the device (i.e., horizontal premise cabling), balanced twisted-pair copper remains the primary cabling media due to its low cost, availability of equipment, easy installation and flexibility, as well the ubiquitous RJ45 network interface. Required speeds for horizontal premise cabling have also remained within copper's capabilities with limited need for speeds greater than 10 gigabit per second (Gb/s) to the desktop or building device. However, there is another reason why copper cabling is preferred in this environment—power.

In less than a decade, remote powering technology has revolutionized the look and feel of the ICT world. Unlike optical fiber, balanced twisted-pair copper cabling has the capability to deliver dc power to IP-enabled devices such as surveillance cameras, wireless access points (WAPs), LED lighting fixtures, radio-frequency identification (RFID) readers, digital displays, IP phones and an ever growing list of new devices. The popularity of this technology is staggering—more than 100 million power over Ethernet (PoE) enabled ports are shipping annually. In addition to Ethernet, the presence of HDBaseT supported by copper cabling deployed in the global professional audiovisual (AV) market is growing dramatically and predicted to exceed 21 million ports next year. Furthermore, published Power over HDBaseT (POH) technology can power any Energy Star™ 6.1 compliant television (typically up to and including 60 inches) that consumes less than 100 watts (W), throwing open the doors to advanced AV opportunities supported by premise networks.

Remote powering applications are also continuing to advance. The IEEE P802.3bt DTE Power via MDI over 4-Pair Task Force is currently developing standards for using all four pairs in a twisted-pair copper cable to deliver even higher levels of remote power than has previously been available in existing Type 1 and Type 2 PoE technologies that use just two balanced twisted pairs. These four-pair PoE projects will augment the capabilities of existing power sourcing equipment (PSE) and powered device (PD) specifications with Type 3 (≤ 60W at the PSE) and Type 4 (≤ 90W at the PSE) requirements.

While copper typically wins out over optical fiber in horizontal premise cabling applications due to its remote powering capabilities, there are some considerations. Unmating a jack-plug connection while transmitting PoE power produces an arc that erodes the connector contact surfaces at the arcing location. When erosion occurs in the area of the fully mated position of the connector, the result is an unreliable connection due to the contact surface damage. This can cause degraded network performance and increased bit error rates. Some connecting hardware manufacturers have succeeded in ensuring that arc location on jack contacts during the unmating cycle is separate from the fully mated position, however erosion on either the jack *or* plug contacts results in an unreliable connection. It is better to select connecting hardware that ensures arcing will occur in the initial contact "wipe" area on *both* jack and plug contacts and will not affect mating integrity in the fully mated contact position.

Figure 2 depicts a specially-designed curved jack contact geometry that results in a distinct "make-first, break-last" zone separated by at least 2mm from the fully mated contact zone. Note that any potential damage due to arcing occurs well away from the final contact mating position on both the jack and the plug. Text incorporated into the latest draft of TSB-184-A, *Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling*, recommends choosing connecting hardware that has the required performance for mating and un-mating under the relevant levels of electrical power and identifies IEC 60512-99-001 as an example performance test schedule. Connecting hardware featuring curved contact jack geometry meets fully meets the IEC 60512-99-001 standard.



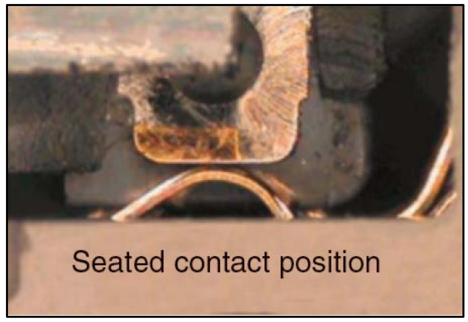


Figure 2: Z-MAX, MAX and TERA jacks feature a curved, or "crowned," contact geometry that ensures arcing will occur in the initial "wipe" area outside of the final seated contact position for both jack and plug contacts, ensuring an undamaged, reliable and stable connection.

In extreme environments, remote power delivery produces temperature rise in cable bundles. Exceeding the operating temperature range for copper cabling, which is specified as -20°C to 60°C (-4°F to 140°F) by TIA and ISO/IEC, can have an irreversible effect on transmission performance. Since deployment of certain remote powering applications can result in a temperature rise of 10°C (50°F) or higher within bundled cables, the typical rule of thumb is to not install cables in environments above 50°C (122°F). This restriction can be problematic in regions such as the American southwest, the Middle East and Northern areas of Australia where temperatures in enclosed ceiling, plenum and riser shaft spaces can easily exceed these temperatures. Using higher-quality shielded category 6_A and 7_A cables that are qualified for mechanical reliability up to 75°C (167°F) can help designers overcome this obstacle.

Awareness of the amount of heat build-up inside the cable bundle due to remote power delivery is important because cable insertion loss (i.e., signal attenuation) is directly proportionate to temperature—insertion loss increases as temperature increases. Accordingly, both TIA and ISO/IEC specify an insertion loss de-rating factor for use in determining the maximum channel length at temperatures above 20°C (68°F). The temperature dependence is different for unshielded and shielded cables—in fact, the de-rating coefficient for unshielded cable is actually three times greater than shielded cable above 40°C (104°F).[1]

As shown in Figure3, at 60°C (140°F), the standards-specified length reduction for category 6A UTP horizontal cables is 18 meters [60 feet (ft)]. In this case, the maximum

[1] Annex G in ANSI/TIA-568-C.2 and Table 21 in ISO/IEC 11801, 2nd edition

permanent link length must be reduced from 90 m (295 ft) to 72 m (236 ft) to offset increased insertion loss due to temperature. For minimally compliant category 6A F/UTP horizontal cables, the length reduction is only 7 m (23 ft) at 60°C (140°F). Simply put, shielded cabling's inherently superior transmission performance at elevated temperatures translates to less need for reduction in overall channel length at temperatures greater than 20°C (68°F).

In addition, cables specifically designed to exhibit superior mechanical reliability and stable insertion loss performance can support channel lengths greater than specified by the standards at elevated temperatures. For example, some fully-shielded category 7_A cables qualified for mechanical reliability up to 75°C (167°F) do not require any length de-rating to support remote powering currents up to 600mA applied to all four pairs in environments up to 70°C (150°F). The flexibility to support longer channel lengths provides designers with the opportunity to reach the greatest number of PoE devices in premise environments. With the higher power of emerging four-pair PoE Type 3 and Type 4 on the horizon, the ability for cabling to reliably support remote powering will become even more critical.

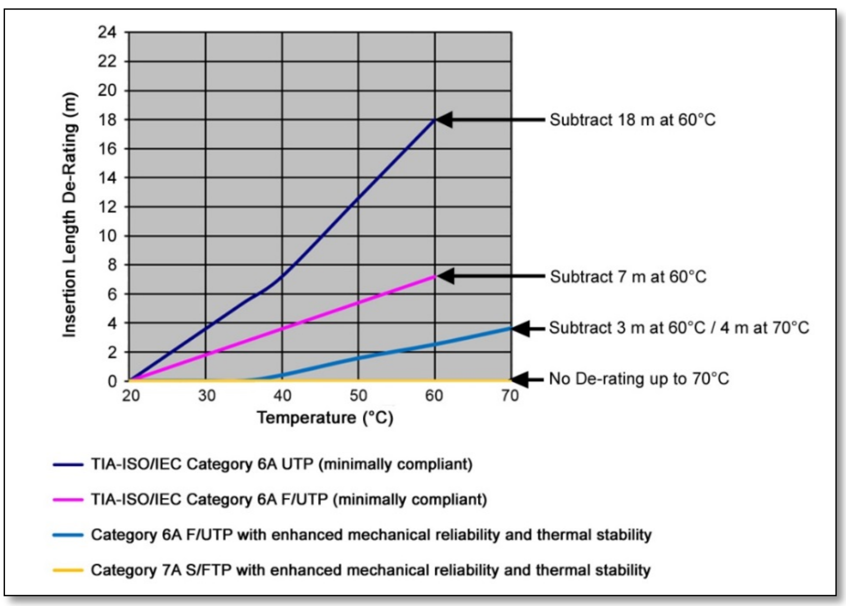


Figure 3: Horizontal cable length de-rating versus temperature for application speeds up to 10GBASE-T show that category 6A and 7_A shielded cables with enhanced mechanical reliability and thermal stability require less length reduction to satisfy insertion loss requirements, providing an optimum solution for supporting emerging four-pair remote power applications.

In addition, multiple low speed, low pair count applications can still be found in many dense premise environments, such as those supporting call-center, automation and industrial applications, where it is cost prohibitive to provide an optical fiber network. While these systems do not require high bandwidth cabling, many of today's category 7_A cable and connector offerings can support multiple 1- and 2-pair low-speed, high-density applications over one 4-pair cable. This standards-approved strategy is referred to as cable sharing and can free-up valuable pathway space, reduce the number of cables and unused pairs, provide cost savings, and may be leveraged along with other practices that reduce material and energy waste for green performance credits.

Fiber Offers Premise Benefits Too

Despite copper cabling's support for PoE and other remote powering applications, there are still some scenarios in horizontal premise networks that call for fiber to the desk (FTTD) applications. In addition to some specialized applications and devices that require optical fiber connectivity, highly secure networks can benefit from optical fiber since its immunity to any electromagnetic interference (EMI) and radio frequency interference (RFI) significantly reduce the risk of hackers accessing data.

Premise optical fiber cabling can also be beneficial in historical facilities, large warehouses, hotels or other facilities where locating TRs to maintain the 100 m (328 ft) distance limitation of copper is not always feasible or cost effective. One option that can make sense in these horizontal cabling environments is a passive optical network (PON). Having recently emerged as an alternative to copper switched networks, PONs are capable of distributing voice, video and data to the desktop over one singlemode optical fiber. In a PON, a singlemode optical fiber runs from an optical line terminal (OLT) to a passive optical splitter where it splits into multiple optical fibers. It then connects to optical network terminals (ONTs) at work areas that convert the optical signal for transmission over copper twisted-pair cabling. PONs offer the benefit of transmission distances that are well in excess of 100 m (328 ft), as well as easy deployment and reduced pathway and conduit space requirements due to the smaller size of a singlemode cable.

There are however some considerations when deploying a PON. While these systems often use direct equipment connections or "point-to-point" cabling that is not standards compliant and can limit flexibility, implementing structured cabling cross-connects or interconnects between the OLT and splitter and between the splitter and ONTs can improve manageability. This allows OLT ports to be easily allocated to any splitter, and splitter ports to be easily allocated to any ONT. In addition, deploying two singlemode optical fibers to each ONT provides an upgrade path supporting Ethernet equipment.

For a PON to support PoE, an upgraded ONT must be deployed at the work area. To date, PON ONTs only support power over Ethernet (PoE) Type 1 (i.e., maximum output of 15.4 W from the power source) power injection. This can limit the ability to support emerging IEEE 802.11ac Wi-Fi and other technologies, which require Type 2 (i.e., maximum output of 30 W from the power source) PoE. One way to enhance PONs and ensure support for emerging PoE applications is to include the addition of a copper outlet at the work area. This also provides the second permanent link at the work area required as the minimum topology by commercial building standards.

Data Center Teammates

In the data center environment, copper and optical fiber cabling co-exist in a similar fashion to the premise network—copper in the horizontal (or edge) supporting switch-to-server connections and optical fiber in the higher speed backbone (or core) supporting switch-to-switch connections.

The ability of balanced twisted-pair copper cabling to support speeds of 10 Gb/s makes it the preferred choice for today's data center switch-to-server connections. With cabling channel lengths supported up to 100 m (328 ft) and transceiver costs still well below that of optical fiber, category 6A and higher copper cabling is currently well suited to support a variety of architectures for switch-to-server connections, including top of rack, middle of row (MoR) and end of row (EoR) scenarios.

However, with switch-to-server connection speeds pushing beyond 10 Gb/s, TIA and ISO/IEC cabling-standards development groups have already initiated work on category 8 cabling to support 40 gigabit Ethernet (i.e., 40GBASE-T) over balanced twisted-pair copper cabling. In July of 2015, the IEEE 802.3 Ethernet Working Group also formally approved merging the initiative to develop 25GBASE-T application requirements with the IEEE P802.3bq project to develop 40GBASE-T. The opportunity for 25GBASE-T lies in the 30 m (98 ft) reach zone as a cost-optimized step on the speed migration path to 40GBASE-T. Like 40GBASE-T, 25GBASE-T will have the reach to support a much broader range of architectures than direct attach twinaxial connections to easily facilitate all types of cabinet to cabinet, MoR and EoR switch-to-server connections.

Intended for operation over the same two-connector ISO/IEC class I/class II and TIA category 8 channels planned for 40GBASE-T, 25GBASE-T is technically feasible, building on the existing and well-established 10GBASE-T technology that is evolving to support 40GBASE-T over copper. Because it shares open and common specifications, ensures interoperability and backwards compatibility, and offers the reach to support a broad range of switch-to-server architectures, 25GBASE-T will positively fit within the successful copper Ethernet ecosystem. The development of these two new applications will preserve copper's place in the data center for several years to come.

While copper cabling's position is stable in horizontal premise networks and at the data center edge, core backbone switch-to-switch data center deployments for networking and storage area networks (SANs) require optical fiber. The distances in these environments can extend beyond the range supported by copper and transmission speeds here have evolved to 40 and 100 Gb/s for Ethernet-based networks and 16 and 32 Gb/s for Fibre Channel-based SANs. While optical fiber is really the only choice in these environments, again there are considerations.

Staying within optical insertion loss budgets is essential for ensuring proper transmission of data signals between switches. The length and number of connections within a channel all contribute to link loss, and higher speeds have more stringent loss requirements. Today's flattened architectures with fewer switch tiers also result in longer lengths between switches and the need for distribution points or cross connects to maintain flexibility, facilitate upgrades and limit access to critical switches. This adds more connections and link loss within the channel.

The use of specially qualified low loss MTP connectors deployed for switch-to-switch connections in the data center is therefore becoming essential. These interfaces better support multiple mated connections for flexibility over a wide range of distances and configurations while remaining within the loss budget. As shown in Figure 4, standard loss MTP connectors with a typical insertion loss value of 0.4 dB can only support two mated connections in a 40/100 Gb/s OM4 multimode optical fiber Ethernet channel. Alternatively, low loss MTP connectors that offer a loss of 0.2 dB can support five mated connections.

Application	Distance (m)	Max Channel Loss /Connector Loss	Fiber Attenuation (3.0 dB/kM)	# of MTP Connection Points	
				Standard Loss (0.4 dB)	Low Loss (0.2 dB)
40/100 GbE OM3 @ 850 nm	100	1.9 dB/1.5 dB	0.3 dB	2	8
40/100 GbE OM4 @ 850 nm	150	1.5 dB/1.0 dB	0.4 dB	2	5

Figure 4: Low loss 0.2dB MTP connectors can support significantly more mated connections than standard loss 0.4dB MTP connectors in 40/100 Gb/s OM3 and OM4 multimode optical fiber Ethernet channels, enabling the use of distribution points or cross connects to maintain flexibility, facilitate upgrades and limit access to critical switches.

Another consideration in switch-to-switch data center backbone applications is the ability to easily migrate to higher transmission speeds. Modular components that can be swapped to upgrade from LC interfaces used for 10 gig applications to MTP interfaces used for 40 and 100 Gb/s applications make it easier to migrate.

Maximizing optical fiber utilization for high-speed applications should also be considered. 40 Gb/s transmission is based on 8 optical fibers—4 transmitting and 4 receiving at 10 Gb/s each. Published as IEEE Std 802.3bm™ earlier this year, the latest 100GBASE-SR4 standard for 100 Gb/s also uses 8 optical fibers—4 transmitting and 4 receiving at 25 Gb/s each. With MTPs being a 12-fiber connector but only requiring 8 for transmission, 33 percent of the optical fiber goes unused. An ideal way for data center managers to ensure 100 percent utilization of optical fiber in both 40 and 100 Gb/s applications is to use conversion cords or modules that transition two 12-fiber

MTPs from backbone cabling to three 8-fiber MTPs for connecting to 40 and 100 Gb/s equipment (see Figure 5).

Figure 5: 40/100G equipment conversion cords that transition two low-loss 12-fiber MTP connectors from the backbone to three low-loss 8-fiber MTP connectors for equipment offer 100 percent optical fiber utilization in 40 and 100 Gb/s applications.

More to Come

While copper and optical fiber's positions are stable in the premise and data center environments, there are emerging technology advancements and developing standards that continue to have an impact on cabling media choice.

In the premise environment, next generation Wi-Fi applications have many designers carefully considering the type of copper cabling to choose for new deployments and upgrades. Various implementations of the latest IEEE Std 802.11ac™-2013 based enterprise WAPs can operate at 1.3 Gb/s, 2.6 Gb/s, 3.5 Gb/s and even higher theoretical maximum throughput speeds. As a result, there is an opportunity for optimized Ethernet speeds between 1 Gb/s and 10 Gb/s to support balanced twisted-pair uplink connections to these devices. In response, the IEEE 802.3bz Standard for Ethernet Amendment: *Media Access Control Parameters, Physical Layers and Management*

Parameters for 2.5 Gb/s and 5 Gb/s Operation is currently under development and anticipated to publish in August 2017.

While 2.5GBASE-T is targeted to operate over existing category 5e cabling and 5GBASE-T is targeted to operate over category 5e cabling and category 6 cabling, it is likely that some of the installed base of cabling systems will not support 2.5 Gb/s and 5 Gb/s speeds. Efforts are therefore underway by TIA and ISO/IEC to address the qualification of installed category 5e and 6 cabling, which will include testing to extended frequencies, to ensure support of 2.5GBASE-T and 5GBASE-T. For new deployments, two category 6A or higher channels are recommended for support of each new 802.11ac WAP uplink connection, even if it is anticipated that 2.5GBASE-T or 5GBASE-T equipment will be deployed. Furthermore, it is well understood that Type 2 PoE is needed to support the latest generation of 802.11ac WAPs and higher power four-pair PoE may be required for next generation 802.11ac WAPs. This brings us back to the higher temperature rise issue within cable bundles and the fact that advanced shielded copper cabling is better able to support remote powering with less length de-rating.

In the data center, the aforementioned 25GBASE-T and 40GBASE-T standards in development will drive the adoption of the future category 8 cabling in switch-to-server data center connections. When it comes to optical fiber, the IEEE P802.3bs 400 Gb/s Ethernet Task Force is also already hard at work on determining physical layer specifications for 400 Gb/s fiber applications—objectives were approved earlier this year and the standard is anticipated to publish in early 2017. While still early in the development process, 400GBASE-DR4 is expected to use 8 singlemode optical fibers (4 transmitting and 4 receiving at 100 Gb/s) to support 400 Gb/s over 500 m (1,640 ft) and 400GBASE-SR16 is anticipated to use 32 multimode optical fibers (16 transmitting and 16 receiving at 25 Gb/s) to support 400 Gb/s over 100 m (328 ft). 400 Gb/s Ethernet applications supported by singlemode optical fiber for operation over 2 km (1.2 mi) and 10 km (6.2 mi) for outside plant and campus environments are also under development.

In addition, there is current work within standards bodies to specify wideband multimode fiber (WBMMF) which uses wavelength division multiplexing (WDM) technology. The technical work on the optical fiber standard is not expected to be completed until sometime in 2016, and it will likely result in a new multimode optical fiber type (potentially OM5 or OM4WB) that expands capacity over a wider range of wavelengths to support WDM technology. While not set in stone, the wavelengths being discussed within standards groups are 850, 880, 910 and 940nm. As a standards-based, interoperable technology, WBMMF is expected to be backwards compatible with existing OM4 optical fiber applications. It is slated to support unidirectional duplex 40 Gb/s optical fiber links using 10 Gb/s channels on four different wavelengths and 100 Gb/s optical fiber links using 25 Gb/s channels on four different wavelengths. WBMMF is also positioned to support future 400 Gb/s applications using 25 Gb/s channels on four different wavelengths over eight optical fibers using the current standards-based MTP interface. Depending on the outcomes, the WBMMF standards will have a significant future impact on the amount and type of optical fiber selected for data center switch-to-switch backbone connections.

Call it a Truce

Unlike optical fiber, copper has the ability to support remote power requirements in horizontal premise networks. And with the upcoming category 8 twisted-pair cabling positioned to support cost-effective 25GBASE-T and 40GBASE-T applications in data center switch-to-server edge connections, copper is here to stay. At the same time, optical fiber is the only cable media able to handle longer distance 40 and 100 Gb/s channels in the data center, as well as future 400 Gb/s and TB/s applications.

While there are many considerations when it comes to selecting media—from the ability to adequately handle emerging four-pair PoE and support longer-distant secure links in premise networks, to ensuring low loss, flexible and scalable optical fiber connections in the data center—it is obvious that balanced twisted-pair copper and optical fiber both have their place in these environments and will co-exist for many years to come. In other words, it time to stop asking when copper cabling will become obsolete.

About the Authors:

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About Siemon:

Established in 1903, Siemon is an industry leader in the manufacturing and innovation of high-quality, high performance low voltage infrastructure solutions for Data Centers, LANs and Intelligent Buildings. Headquartered in Connecticut, USA, Siemon offers one of the most comprehensive suites of fiber and copper cabling systems, cabinets, racks, cable management, power solutions and next generation automated infrastructure management. The combination of Siemon's high-performance products, value-add solutions and long-standing commitment to its customers and the industry have earned the company an impressive customer list that spans multiple markets, including over one-third of Global 500 companies. With global sales, technical and logistics expertise spanning 100 countries, Siemon has a well-earned reputation for industry leadership, innovation, world-class quality, expert service and support, and environmental stewardship, including leading participation in industry standards and dedication to understanding and supporting the unique needs of the market and a significant investment in R&D with more than 400 patents specific to structured cabling.

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LINKS:

- Find out what makes Siemon Z-MAX, MAX and TERA jacks King of PoE
- Learn how you can support IP-based devices within an intelligent building's plenum space
- Get the latest on Category 8, 25GBASE-T and more with Siemon's Standards Informant blog
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