DECIPHERING CATEGORY CABLING SYSTEMS ›
INDUSTRY STANDARDS & BEST PRACTICES

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WHITE PAPER

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Whether you are a consultant designing a new cabling infrastructure for a new costumer or an IT manager who is tasked with designing a new datacenter, choosing the best cabling system for a premise LAN or a datacenter can be a daunting task. Fortunately, there are industry standards and best practices to help select and deploy the right cabling system. This article will assist you in making an informed decision to select the right copper cabling system for your next premise LAN or datacenter project.

"Sorting out the truths from the non-truths can be an overwhelming task."

The array of copper cabling systems and marketing fluff out there can make selecting the right cabling system a mind-boggling task for IT managers new to structured cabling. Sorting out the truths from the non-truths can be an overwhelming task. The good news is that category cabling over copper twisted pair has a foundation within industry standards. The main standards bodies responsible for developing structured cabling standards are the TIA (Telecommunication Industry Association) and the ISO (International Organization for Standardization). These standards bodies specify requirements for cable and connecting hardware manufacturers who design and build cabling products. For example, these standards specify requirements such as cable's transmission performance, conductor insulation color, the maximum allowable length for installed horizontal cable (90m), copper wire size (22 AWG to 24 AWG), and many other requirements.

The TIA and ISO cabling standard bodies are supported by the IEEE (Institute of Electrical and Electronics Engineers). The IEEE 802.3 work groups specify cable transmission requirements for various Ethernet protocols. The IEEE 802.3 Ethernet standards specify the cabling's transmission performance, backward compatibility, and wide variety of specification for switches, servers, and routers to operate seamlessly at the required level of operation. IEEE standards are recognized worldwide and ensure interoperability between manufacturers' active equipment from all over the world. These standards cover requirements for copper and optical fiber cabling components, such as cables, connectors and cable assemblies, installation and field testing, as well as administration, spaces and pathways to support the cabling.

The TIA and ISO standards group cables and connecting hardware into different categories. The standards specify bandwidth and data rate capability for each category. These specifications include a number of electrical performance parameters and are tested within a specific electrical frequency range or bandwidth. The table below highlights bandwidth limits for the various categories of twisted pair copper cable and applicable Ethernet protocols.

Cabling

Category	Bandwidth (MHz)	Data Rate (Mbps)	Ethernet Protocol	Industry Standard
3	16	10	10Base-T	TIA & ISO
5e	100	1000	1000Base-T	TIA & ISO
6	250	1000	1000Base-T	TIA & ISO
6A	500	10,000	10GBase-T	TIA & ISO
7	600	10,000	10GBase-T	ISO Only
7A	1000	10,000	10GBase-T	ISO Only
8*	2000	25,000/40,000	25/40GBase-T	TIA & ISO

Table. Structured Cabling Categories with associated Ethernet Protocols

**Note: Cat 8 standard had not been ratified when this article was published*

"There's a perception that Cat 6 cabling provides better performance over Cat 5e cabling for GbE transmission."

The first category of cabling is Cat 3, this category of cabling was originally developed for use in telephone wiring but it can also be used to transmit 10 megabits of data per second. Then follows Cat 5e, this cabling was specifically designed to support GbE (Gigabit Ethernet). This means that each of the four pairs in the cable must support bandwidth of 25MHz (100MHz total) to transmit 1000 megabits of data per second. Cat 6 cabling was introduced in 1998 and was originally developed to support the 1000BASE-TX protocol. This Ethernet protocol would have enabled GbE over two pairs instead of four. This meant that each of the two pairs would need to support 100MHz (200MHz). They also added a little headroom of 50MHz. However, the IEEE never moved forward with the 1000BASE-TX Ethernet protocol over Cat 6 cable because active equipment manufacturers decided not to redesign their equipment to allow GbE transmission over two pairs and the per-port cost of GbE significantly dropped.

Choosing between Cat 5e and Cat 6 for GbE has caused a lot of confusion because there's a perception that Cat 6 cabling provides better performance over Cat 5e cabling for GbE transmission. Many years ago cable manufacturers used the "high headroom" strategy to sell Cat 6 cabling since 1000BASE-TX never evolved in to an Ethernet protocol. The Gigabit Ethernet, 1000BASE-T application was designed to run over Cat 5e cabling. However, some cable manufacturers convinced end-users to install Cat 6 to "future-proof" their network and because it provided superior performance over that specified by the IEEE GbE 1000BASE-T standard.

“Today’s savvy IT managers are watching their budgets...”

Today’s savvy IT managers are watching their budgets and are not concerned with claims of high headroom or bandwidth beyond what’s specified by industry standards. These IT managers are now reconsidering Cat 5e to run GbE Consultants and installers often chose Cat 6 cables over Cat 5e because there was a perception that 250MHz is required for GbE. The truth is that Cat 6 cabling solutions are more costly than Cat 5e cabling solutions and are often overkill for GbE application. The IEEE 802.3ab specifies that bandwidth of 100MHz provides more than sufficient bandwidth for the transmission of GbE. Furthermore Cat 5e cabling was specially designed to support 1000BASE-T protocol. In spite of this, Cat 6 cabling solutions have been marketed as being a much better solution than Cat 5e cabling solutions, but that is not necessarily the case. Most enterprise networks still run at GbE or less, and as mentioned earlier, Cat 5e cabling systems were specifically designed to transmit GbE. One of the biggest misconceptions is that Enhanced Cat 6 (Cat 6E) cabling rated up to 550MHz provides better performance than standards compliant Cat 6 cabling system. Higher bandwidth isn’t a good way to measure a cable’s ability to transmit a signal. Bandwidth beyond 250MHz or headroom for Cat 6 is meaningless because the TIA and ISO cabling standards set bandwidth limit for Cat 6 at 250MHz. They also set minimum performance limits on key electrical parameters to ensure reliable performance. To make matters worse, industry standards do not recognize Cat 6E. Therefore, there isn’t a good way to measure headroom performance or bandwidth beyond 250MHz in the field beyond limits specified standards. Another misconception is that Cat 6 will carry a signal further than other cables. This is not true; Cat 6 cables cannot carry a signal further than the Cat 5e although the signal itself may be stronger.

After Cat 6 cabling follows Cat 6A cabling which is the latest copper cabling category from the TIA. Cat 6A is defined at frequencies up to 500MHz. Cat 6A doubles the capability of Cat 6 by performing at up to 500MHz, which enables 10Gbit, IEEE 10GBASE-T protocol, to run over distances of up to 100 meters. Both Cat6 and Cat6A are backward-compatible with Cat 3 and Cat 5e. Cat 6A performs at improved specifications, in particular in the area of alien crosstalk as compared to Cat 6 UTP (unshielded twisted pair), which exhibits high alien noise cross talk between cables at high frequencies. As mentioned previously, most LANs operate at GbE because most users don’t require faster data transmission than this. However, the increased use of smartphones, tablets, and laptops plus the need for file sharing, networking and instant access will significantly increase the need for data storage and speed. Therefore, Cat 6A for data transmission of 10GbE is a good choice for datacenters or for IT managers looking to future proof their LAN.

After Cat 6A cabling follows Cat 7 and Cat 7A cabling. Cat 7 has bandwidth range of 600MHz and Cat 7A has bandwidth rage of 1000MHz. Specifications for these cable categories are outlined in the ISO standard but they are not defined in the TIA standard. Therefore they are not recognized in the United States. There has been a lot of debate on why Cat 7 cables were not sanctioned by the TIA for use in the US. One reason Cat 7 cabling was not adopted by the TIA is because this category has a 600 MHz bandwidth and Cat 6A already has a 500MHz bandwidth. This did not justify generating a new category of cabling since Cat 6A is more than suitable for the transmission of 10Gbit. It appears the TIA is now only developing cabling standards that align with IEEE 802.3 Ethernet protocols.

"Choosing Cat 6 for GbE or Cat 7/7A cabling for 10GbE is like driving a Ferrari on a road with a 35 mph speed limit."

Cat 7 and Cat 7A cabling standards were sanctioned by ISO in 1999 (shortly after Cat 6 cabling was released in 1998) but these cabling systems don't really possess advantages over Cat 6A cabling systems. Cat 7 cable manufacturers will argue that Cat 7 cabling can handle various multimedia applications, but applications such as CATV are disappearing because Cat 5e cabling can handle a voice, video, and data. As for Cat 7A cabling, as mentioned earlier Cat 5e was designed specifically for GbE and Cat 6A was designed for 10GbE but Cat 7A was designed to achieve a certain frequency; therefore, it provides no advantage over Cat 6A. The main issue with Cat 7 and Cat 7A cabling systems is that they don't have an Ethernet application other than 10GbE (10Gbase-T). These cabling systems may perform at a higher level than Cat 6A, but it's hard to justify the higher price tag of Cat 7/7A systems since they provide no advantage over Cat 6A. Choosing a Cat 7 or Cat 7A cabling solution would be like taking an Airbus A380 from the US to Europe. The A380 is the largest passenger plane in the world but it won't get you to your destination any faster than an Airbus A330. Another analogy would be choosing Cat 6 for GbE or Cat 7/7A cabling for 10GbE is like driving a Ferrari on a road with a 35 mph speed limit.

It's also worth noting that existing Cat 7A has a usable bandwidth of 1000MHz and there was hope that this category of cabling would support transmission performance beyond 10GbE. However, this is not the case because the IEEE 802.3bq 25/40GBASE-T work group has specified that 2000MHz bandwidth will be required to transmit 40GbE speeds. Also, Cat 7 and Cat 7A cabling systems use proprietary connectors that are incompatible with the RJ45 connector interface which violates the IEEE 802.3 requirement for the RJ45 connector interface. These systems require special hybrid patch cable assemblies to be compliant with IEEE 802.3 Ethernet BASE-T standards.

Some will also also argue that Cat 7 and Cat 7A shielded cabling systems offer the best EMI (electromagnetic interface) protection for industrial applications. This may be true because Cat 7 SF/FTP

(screened mesh over individually shielded twisted pairs) cables contain an additional layer of braided metallic mesh over the individually foiled pairs that provide an extra level of protection. Cat 6A shielded cables are typically available as U/UTP (unshielded over metalized unshielded twisted pairs), F/UTP (overall foil over unshielded twisted pairs) or as U/FTP (unshielded over individually shielded twisted pairs) construction. U/UTP cabling solutions are not good choice for industrial applications because they are susceptible to EMI (electromagnetic interference) frequency. Therefore, Cat 7 cables may be a better choice for where EMI is a concern because of the extra braided metallic mesh. However, the twisted pairs within Cat 7 cables have very long twists because they rely only on the shield to block the noise. That means that the added EMI protection they offer is at the cost of a very high sensitivity to noise from the ground and the shield efficiency is never tested on site. Also, most industrial cabling applications require ruggedized connectors with an IP (ingress protection) of IP67. However, most Cat 7A solutions currently available in the market are not offered with ruggedized connectors. These connectors are best suited for office environments.

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The last category of copper cabling currently being developed by the TIA and ISO is Category 8 – IEEE 25/40GBASE-T protocol. This category of cabling is specifically being developed for use in datacenters and will have maximum length limit of 30 meters opposed to the traditional 100 meters for conventional premise applications. Cat 8 cabling's physical characteristic will be similar to Cat 6A U/FTP cable construction. This cabling system utilize the RJ45 connectors interface as desired by the IEEE 802.3bq work group. The TIA and ISO Cat 8 standards are expected to be released late 2015 or early 2016. The development of Cat 8 is being developed in tandem with the IEEE's 25/40BASE-T Ethernet protocol. This differs from the development of the Cat 6 standard because the IEEE, active equipment manufacturers, and TIA and ISO standards bodies are all in alignment with each other.

In today's economy, IT managers are more concerned with project budgets, material costs, and installation time than ever before. It's more critical than ever to choose the right type of structured cabling system for every project. Structured cabling solutions should be chosen based on the required Ethernet protocol. Don't be fooled by claims of high headroom or claims of performance beyond what is specified by the TIA or ISO cabling standards. The TIA, ISO, and IEEE standards bodies specifically designed in sufficient headroom and bandwidth to provide reliable transmission performance for the required Ethernet protocol. Consider going with C5e if you're under tight budget and don't have a need beyond GbE. Go with Cat 6 if you are not under budget constraints, but want Cat 6's added headroom to compensate for potential poor installation practice. However, please keep in mind that proper installation should not be an issue if

you are buying an end-to-end cabling system that's being installed by a certified installer and is being backed by an extended warranty. Choose Cat 6A if you are looking for a cost-effective alternate to fiber in the datacenter or you want to future proof your cabling infrastructure. Finally don't contemplate Cat 8 until the TIA and ISO standards for this cabling system are ratified. Even then, it's likely that Cat 8 will only be suitable for the datacenter or for users who require ultra-high data transmission. Please do your homework, plan for the long run, and look at the big picture—these tired but true clichés will ensure long-term performance of your Ethernet copper cabling system.

"Do your homework, plan for the long run, and look at the big picture."