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Determining the Right Media

Twisted pair, optical fiber or wireless—first examine the pros and cons of each. **BY JOHN SCHMIDT**

The problem with having choices is that in the end, you must make one. This is clearly apparent with structured cabling where the primary protocol, Ethernet, is supported by a variety of media types, including singlemode and multimode fiber, different categories of shielded and unshielded twisted pair copper, and wireless. Regardless of what you may hear in the marketplace, each media has an inherent set of strengths and weaknesses. The choice you make as a network designer should be made based upon what is right for the unique requirements of the network.

This article explores the advantages and disadvantages of the common media types that are used today to transmit Ethernet with a focus in on higher speeds such as gigabit Ethernet and 10 gigabit Ethernet because these are, for the most part, new to many network designs.

Optical Fiber Systems

Optical fiber is a valid media for transmitting gigabit and 10 gigabit signals per IEEE 802.3z and 802.3ae, respectively. The primary advantage of using optical fiber is the capability of laser optimized optical fiber to increase distances that 10 gigabit signals can run before being regenerated. The IEEE 802.3ae standard defines distance limitations of grades of fiber per the chart below.

The distance advantage makes optical fiber the best choice for the areas in the network that require longer

distances such as:

- » Campus backbone cabling
- » Building backbone cabling
- » Horizontal or centralized cabling for distances greater than 100 meters, such as a factory environment or large data center

The disadvantage of optical fiber is the cost of active electronics such as switch ports and network interface cards (NIC). It is estimated that the cost of 10GBASE-T copper electronics will be roughly half the cost of 10 gigabit optical fiber equivalents initially and will continue to drop as volume and technology progress.

Optical Fiber Advantages

- » Distance
- » Size of media, relative to copper solutions
- » Security – impervious to EMI, extremely difficult to tap or monitor without detection
- » Bandwidth – future protocols beyond 10 gigabit will be supported by fiber

Optical Fiber Disadvantages

- » Electronics cost
- » Inability to carry substantial power on the cable
- » Installation – optical fiber today is more difficult to field terminate than UTP copper

IEEE Standard	Designation	Bandwidth	Distance Limitation	Common Applications	Solutions
802.3z	1000Base-SX	1000 Mb/s	220 to 550 meters	Enterprise backbone	» Laser Optimized Multimode Fiber
802.3z	1000Base-LX	1000 Mb/s	5 kilometers	WAN, MAN	» Singlemode Fiber
802.3ae	10GBase-SR/SW	10 Gb/s	300 meters	Data Center and Enterprise Backbone Cabling	» Laser Optimized Multimode Fiber
802.3ae	10GBase-LR/LW	10 Gb/s	10 kilometers	WAN, MAN	» Singlemode Fiber
802.3ae	10GBase-ER/EW	10 Gb/s	40 kilometers	WAN	» Singlemode Fiber
802.3ae	10GBase-LX-4	10 Gb/s	300 meters	Data Center and Enterprise Backbone Cabling	» Standard Grade Multimode Fiber
802.3ae	10GBase-LX-4	10 Gb/s	10 kilometers	WAN, MAN	» Singlemode Fiber

- » Compatibility – requires singlemode or multimode specific electronics

Work is underway to enable power over fiber (PoF) and it appears at this writing that enough power to operate a transceiver is possible. However, it also appears questionable today if PoF can deliver enough power for devices such as IP phones.

Shielded Twisted Pair Systems

There are different types of shielded systems:

- » S/FTP – shielded overall cable with individual foiled twisted pairs, also known as ISO Class F or category 7.
- » F/UTP – foil over unshielded twisted pairs, also known as foiled twisted pair (FTP) or screened twisted pair (ScTP). This design does not meet ISO Class F or category 7 requirements and can be used to meet augmented category 6 requirements.

Shielded twisted pair systems are popular in Germany, France, Switzerland and parts of eastern Europe. Shielded systems are not pervasive in the U.S. or other regions of the world, especially in the U.S. where unshielded twisted pair (UTP) has been the dominant choice for copper media. According to the Building Services Research International Association (BSRIA), over six billion feet of UTP cable was installed in the U.S. in 2006, compared to 90 million feet of F/UTP and three million feet of S/FTP. In 2006, shielded systems accounted for about 1.6 percent of all installations in the U.S.

A properly installed and grounded shielded system effectively suppresses alien crosstalk, which is noise between cables in a bundle, for 10GBASE-T applications. However, as with any copper system, an improperly grounded shielded system will perform poorly because the shields may become antennas when there is no ground for radiating signals to flow to. It is critical to use a certified and properly trained contractor that is experienced with shielded systems when doing this type of installation.

When considering a shielded system it is also critical to consider all of the electrical parameters, and not just alien crosstalk. For a given conductor size, UTP cables will have superior attenuation characteristics as compared to S/FTP and F/UTP systems because shields absorb some of the radiated energy from the signaling conductors. Also, if patch cords used in a shielded system are 26 AWG, versus 24 AWG in UTP systems, this smaller gauge of copper can further compromise the attenuation of the system.

STP Advantages

- » Distance – supports 10GBASE-T for 100 meters
- » Internal noise suppression (S/FTP)
- » External noise suppression (S/FTP and F/UTP)
- » Backwards compatibility – supports 10/100/1000BASE-T

STP Disadvantages

- » Market share within North America
- » Installation, relative to UTP
- » Attenuation, relative to UTP where smaller conductors are used
- » Size and cost of media, relative to UTP

Of course, installation practices can vary. Yet today, termination time for STP systems can be two to three times longer than for UTP systems. More problematic is finding a contractor in North America trained and experienced with installing and grounding STP.

Category 6 UTP

Category 6 supports gigabit Ethernet and is recognized by standards bodies as supporting 10GBASE-T, however there are limitations that must be considered. The IEEE 802.3an standard cites a 55 meter distance limitation for standard category 6, which is not universally agreed upon within the TIA and ISO standards. TIA TSB 155 recently released a Technical Service Bulletin covering additional parameters for running 10GBASE-T on standard category 6. In this document a 37 meter distance limitation is referenced for 10GBASE-T on standards-compliant category 6 systems. Between 37 meters and the IEEE referenced 55 meters, standard category 6 may support 10GBASE-T, but it is possible that the installer may have to use alien crosstalk mitigation techniques such as unbundling cables or replacing patch cords to improve the electrical parameters to allow 10GBASE-T to work properly. Above 55 meters, it is unlikely that category 6 UTP would work properly without a large amount of mitigation to reduce alien crosstalk.

A key takeaway is that using category 6 UTP for 10GBASE-T should be focused on existing installations, not new installations. The choice for new installations designed to support 10GBASE-T should be augmented category 6 UTP, STP or optical fiber systems.

Category 6 Advantages

- » Cost and size of media, relative to augmented category 6 and STP
- » Installed base – currently the dominant UTP cabling standard
- » Installation – widely accepted

Category 6 Disadvantages

- » Limited distance for 10GBASE-T
- » External noise suppression at 100 m, relative to shielded systems or augmented category 6

There is no standard released or in draft state for “category 6E,” and there is no alien crosstalk performance advantage with category 6E. Category 6E was a marketing effort to show additional headroom on the internal

electrical parameters for category 6 UTP. From an application standpoint, the IEEE does not recognize category 6E as having any advantage over category 6 for 10GBASE-T, so the same 37 and 55 meter distance limits would apply to so-called category 6E systems. It is important not to confuse category 6E or “enhanced” category 6 with augmented category 6 or category 6A, which are standards based. Category 6E or enhanced category 6 has no standard associated with it.

Augmented Category 6 UTP

The newest media for the transmission of 10 gigabit Ethernet is augmented category 6 UTP, also referred to as category 6A. Augmented category 6 was specifically designed to support the IEEE 802.3an 10GBASE-T standard. It differs from standard category 6 in that it is tested to 500 MHz (versus 250 MHz) and has additional parameters for mitigation of alien crosstalk. Improvement of these electrical parameters is what allows augmented category 6 to run 10GBASE-T for a full 100 meters.

The primary concern with augmented category 6 UTP is the size of the cable, which could be as large as 0.354 inches in diameter. Most vendors offering an augmented category 6 solution have sized cable in the 0.310 inch diameter range while, currently, the smallest augmented category 6 cable measures 0.275 inches in diameter. Cable with smaller outside diameter helps alleviate issues and concerns surrounding diminished conduit and tray fill rates.

Augmented Category 6 Advantages

- » Distance, relative to category 6 – supports 10GBASE-T for 100 meters
- » Installation – comparable to category 6, for smaller diameter cable
- » External and internal noise suppression, relative to category 6
- » Enhanced performance for PoE Plus – larger conductor and cable size

Augmented Category 6 Disadvantages

- » Size of media, relative to category 6 or optical fiber
- » External noise suppression, relative to S/FTP and F/UTP
- » Standardization – TIA and ISO standards are still in draft state, although draft standards are available

PoE Plus is proposed to push over 30 Watts of power down two pairs of cable. Heat dissipation is a concern per IEEE studies. Yet it is known from IEEE testing that a larger conductor has less resistance and less heat generation due to resistance. The larger augmented category 6 cables are also able to dissipate heat better because the conductors are spaced apart from each other to suppress alien crosstalk.

Wireless (IEEE 802.11x)

Wireless technology continues to progress and be a convenient way to give users more freedom and accessibility to the network. Largely, these wireless networks are an overlay to the existing wired network. Although security was once a concern on these networks, encryption and authentication has progressed to a point where casual intrusion is really not an issue. The advantages of a wireless network are obvious as users are free to move about without restriction, making wireless an attractive solution for common areas and conference rooms. The primary concern with wireless becomes an issue of both capacity and coverage. Too many users on a given access point will limit the available bandwidth to each user, which even at maximum capacity is limited to 54 Mb/s (IEEE 802.11g). Additionally, the larger the coverage area, the more access points that are required, which can cause co-channel interference that further limits bandwidth. Future standards may address this by increasing the amount of bandwidth available.

Wireless Advantages

- » Mobility
- » Ease of deployment
- » Standardization

Wireless Disadvantages

- » Coverage—limited to type and number of access points
- » Capacity

Conclusion

There are distinct advantages and disadvantages for each media type. It is critical that each of these is factored into network design. In many cases several of the above media will be deployed into a single network—for example, deployment of category 6 to each desktop with a wireless overlay or augmented category 6 in the data center with and a fiber infrastructure to support the building and data center backbone and storage area network. Each network has specific needs and requirements, so it is important to make your decisions based on the strengths and weaknesses of available media for the project. ■



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