Trends in Network Technology

Ethernet and its Cables

Over the last few decades, there have been numerous advances made in the area of network technology. One of the most significant was the development of Ethernet. Ethernet, with its inception in the late 1970's, was a technology originally designed to allow computers within a work area to share printers. In the early 1980's, Ethernet was released as a standard for networking computers. The Institute of Electrical and Electronics Engineers (IEEE), the organization that is tasked with developing the next network protocol, established Ethernet as IEEE 802.3. As acceptance of Ethernet grew, so did the applications for its use. Spawned by an era of rapid growth in software development and increasingly faster computer processing speeds, as well as the rise of the Internet, Ethernet became the technology of choice for computer networks worldwide.

To keep pace with the ever-growing needs of users, enhanced versions of Ethernet found their way to the global market. These new versions provided greater data throughput, which allowed users to do more in less time. Today, there are nearly 30 different Ethernet protocols in use. In fact, the vast majority of Internet data is transported via Ethernet. To support all this technology, the physical layer or the network, the actual cable and connecting hardware also had to adapt. This paper will look at the advancements in network electronics and how they impact the choice of twisted-pair copper cable chosen for a local area network.

Over the years, as the performance of Ethernet grew, so did its demand on the cable infrastructure. Cable manufacturers, in unison with the Telecommunication Industry Association and the Electronics Industries Association (TIA/EIA) developed categories of cables to be used with the appropriate network application. And like the more powerful versions of Ethernet that offered increased throughput versus their predecessors, the later categories of cable out-performed the earlier ones.

In 1990, 10BASE-T Ethernet (IEEE 802.3i) which provides 10 Megabits-per-second throughput, was released and designed to operate over Category 3 4-pair cable. Category 3 cable is tested to 16MHz. In 1995, as 100BASE-T Ethernet (IEEE 802.3u) was being released, Category 5 Cable (tested to 100MHz) was being designed to accommodate it. Category 5 cables also included 4 pairs of conductors, but the twist rate of the pairs was significantly higher than Category 3 since the cable had to be able to handle the higher frequencies to which Category 5 cable was tested. The higher cable performance was necessary to accommodate the 100 Mbps of 100BASE-T.

By 1999, when 1,000 Mbps 1000BASE-T Ethernet (IEEE 802.3ab) was introduced, Category 5 was being phased out by Category 5e and in 2001, the TIA/EIA standard for Category 5e was released and Category 5 was no longer a recognized standard. Category 5e differed from Category 5 in that it included additional test parameters that were necessary to ensure a higher level of performance.

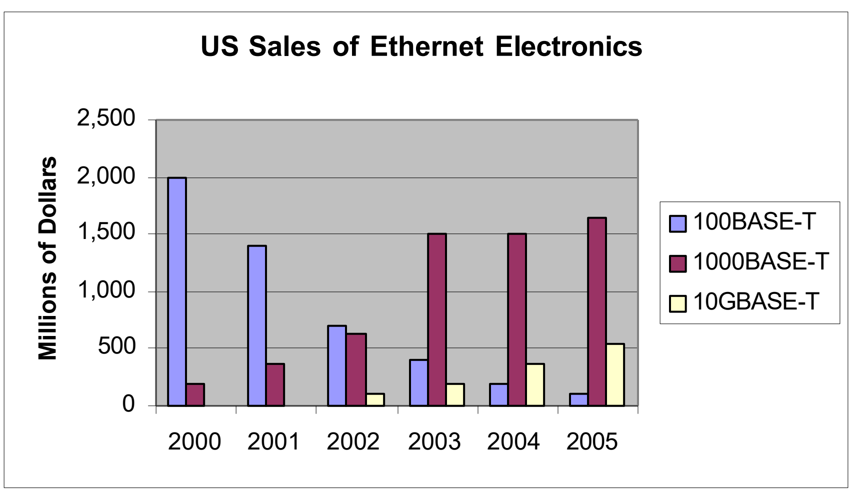
In 2002, the Category 6 cable standard was released to accommodate 1000BASE-T Ethernet as well as current and future applications, such as Voice over Internet Protocol (VoIP). Category 6, tested to 250MHz, provides more than double the bandwidth of Category 5e and has significantly higher signal-to-noise ratios compared to Category 5e.

The latest iteration of Ethernet is 10GBASE-T, (IEEE 802.3an). It's more commonly referred to as 10 Gigabit Ethernet. 10GBASE-T, tested to 500MHz, was released by IEEE in 2006. 10GBASE-T, designed to provide 10 gigabit-per-second throughput requires a new level of cable performance due to the increased frequency. Factors such as alien crosstalk, or the transferring of signals from one cable to an adjacent cable, were not concerns with earlier Ethernet protocols and, therefore, were not a factor when designing the appropriate cable. The TIA/EIA began development on Category 6 Augmented cable shortly after the release of the IEEE standard and have recently wrapped up work on the new Category 6A standard. To accommodate the future needs of customers, some cable manufacturers have been building cables to the various drafts of the standard over the past few years. However, only a few including PCA, have their Category 6A cables UL verified to the last draft of the standard. The standard is expected to be ratified in Q2 of 2008.

As demands and dependence on our computers and our networks have grown, the market has responded with ever-faster processors and network electronics. In 1993, Intel introduced the Pentium processor for personal computers. It operated at 60MHz. Today's Pentium processors operate near 3 Gigahertz. As we've seen, over a relatively short period of time, computing power has dramatically increased and this has helped perpetuate an increase in performance requirements for virtually anything computer or network related.

Chart 1, below, shows the very rapid migration to faster network electronics as they become available both from a cost and accessibility perspective. The trends are a clear indication that as new technologies arrive on the market, end users are picking them up and putting them to work.

Chart 1



Proterial Cable Manchester, 900 Holt Avenue, Manchester, NH
03109 603-669-4347 www.usa.proterial.com

As a result of the trend identified in Chart 1, the category of cable chosen for the network infrastructure has also been changing. Chart 2, below, identifies the relationship between the sales of networks electronics and the sales of Category 3, 5e and 6 cables. For example, you can see that as sales of 1000BASE-T electronics increased, so did the sales of Category 6 cables. The sales of higher performance Ethernet protocols has also reduced the viability of Category 3 cable, thus making it virtually obsolete in the network. Category 3 in high-pair configurations is often used as backbone cabling for voice applications and will continue to be so as long as PBX phone switches remain on the market.

Chart 2

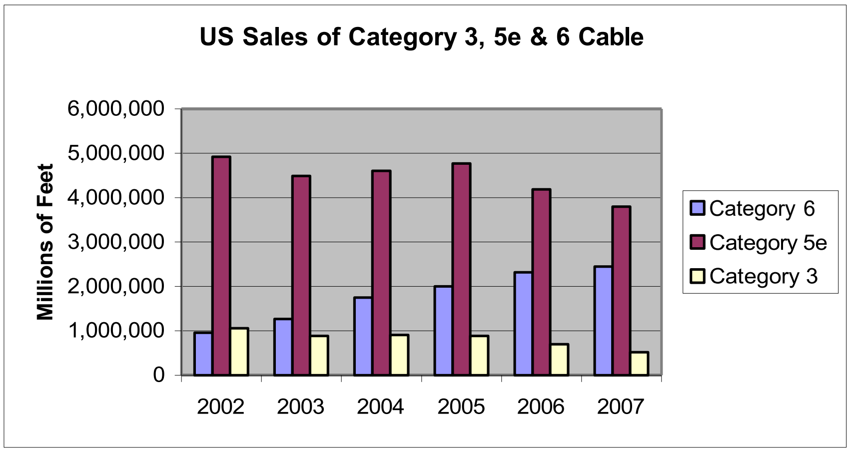


Chart 1 shows that 10GBASE-T sales are also increasing on an annual basis. Though, at this time, most of those sales are likely for backbone electronics, trends in the industry have shown that what is currently being used in the backbone will migrate to the desktop within approximately 5 years. Chart 3 shows, however, that many end users are beginning to install Category 6A cable in their facilities with the intent of running 10GBASE-T to the desktop in the near future. Since the cost associated with replacing the network infrastructure can be significant, installing a cable based on future needs is a sound practice. The costs associated with upgrading network electronics tends to consist primarily of the expense of those electronics. The installations can happen off hours and the impact to the work environment can be limited. Replacing the cable infrastructure, however, typically involves significant costs for the cable, the termination hardware and labor. The installation can take weeks or longer and the potential for interruptions to the existing network during construction are good.

Obviously, cabling for the future is the wisest approach when designing a local area network. But, there are numerous factors that can also impact those decisions. How long will the company be in a facility? Do they rent it or own it? How likely is the company to require and adopt the new performance levels of electronics that will undoubtedly become available? Do they have the budget to install the network with the longest possible lifespan? Will they be in a better position a few years down the road?

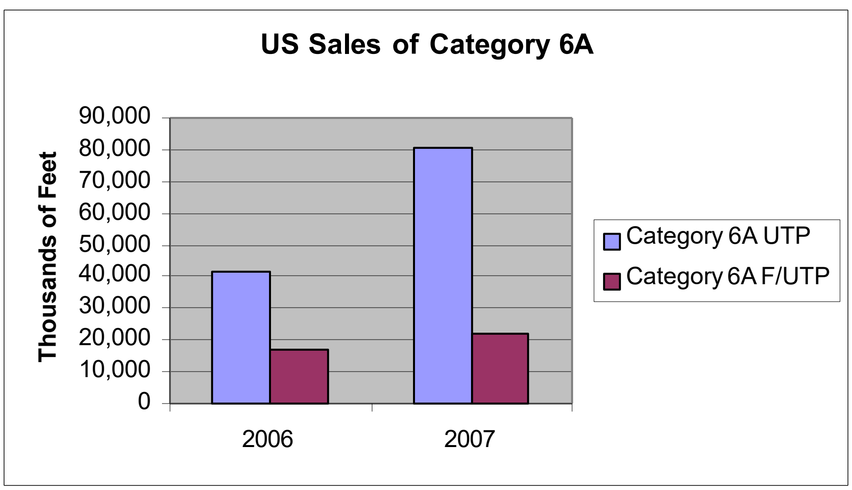
As Chart 3 indicates, end users are beginning to install Category 6A copper cables with the intent of upgrading their network electronics at some point.

Since all category cables are backwards compatible with lower performance categories, network electronics that operate over Category 5e cables, will operate over Category 6 and Category 6A.

In regards to Category 6A cables, the UTP (unshielded) version was the first to gain recognition in the market. It is easier to install and has an overall lower cost than the F/UTP (shielded) version since it does not require shielded connectivity nor does it require the level of bonding and grounding that the F/UTP version does. However, when installed properly, a shielded system provides immunity to RFI (Radio Frequency Interference) and EMI (electromagnetic interference), and issues such as alien crosstalk are not a factor in the performance of the network. Also, different constructions of Category 6A F/UTP exist. PCA's version utilizes a single foil wrapped around a core of 4 twisted pairs. Some manufacturers wrap each pair in foil. This construction style is likely to add to the termination costs of the cable and will require more expensive connectivity.

Again, installing the most advanced cable possible, such as Category 6A cable, will ensure the longest useful life of the cable infrastructure. Unless outside factors, such as a slow economy, impact the purchase and installation of high-performance networks, the market should see increased sales of Category 6A cable and connectivity into the foreseeable future. Category 6 sales will also increase and within 5 years, will most likely surpass Category 5e sales.

Chart 3



There is another cable on the horizon that may, at some point, pick up where Category 6A leaves off. ISO/IEC 11801 Class F cable, sometimes referred to Category 7, is another cable option. Class F cable is constructed of 4 pairs, each wrapped in foil with a braid around all 4 pairs. Tested to 600 MHz, Class F cable will provide exceptional crosstalk performance. At this time, Class F is not recognized by TIA/EIA and there is no Ethernet application designed specifically to operate over it. Costs associated with the cable, connectivity and installation will be greater than that of Category 6A with, at this time, no appreciable gain in performance. Future applications not yet on the industries collective radar may, at some point, create a need for this cable. PCA, however, with its eye always on the future, has developed a Class F cable and it is available for those who may seek it.

Trends in Network Cabling

A deeper look into the evolution of network cabling

Less than ten years ago, when local area networks were being designed, each work area outlet typically consisted of one Category 3 circuit for voice and one Category 5e circuit for data. The design allowed for voice on one circuit and data on the other. As network equipment data rates increased and more network devices were finding their way onto the network, this design quickly became obsolete. Companies wisely began installing all Category 5e circuits with often three or more circuits per work area outlet. Often, all circuits, including voice, were fed off of patch panels. This design allowed information technology managers to use any circuit as either a voice or a data circuit. Overbuilding the system upfront, though it added costs to the original project, ultimately saved money since future cable additions or cable upgrades would cost significantly more after construction than during original construction phase. By installing all Category 5e cables, they knew their infrastructure would accommodate all their network needs for a number of years and that they would be ready for the next generation of network technology coming down the road.

Though a Category 5e cable infrastructure would safely accommodate the widely used 10BASE-T and 100BASE-T, it may not perform as well with the next Ethernet protocol, 1000Base-T Ethernet. Factors such as the quality of the cable and the installation will influence performance. Thus, those IT managers looking to increase their network's speed and obtain maximum performance from their network electronics might be limited by the cable that was installed in their facility. Though testing of the Category 5e infrastructure could determine its efficacy, the quality of both the cable and its installation could play a role in whether or not 1000Base-T Ethernet will operate properly over the cable. Category 6 Cable was developed to ensure 1000Base-T performance as well as accommodate other protocols.

10BASE-T and 100BASE-T operated over only two of the four pairs in the cable. One pair is dedicated to sending data while the other is dedicated to receiving data. Two pairs go unused. 1000BASE-T, however, operates over all four pairs. There are two gigabit Ethernet protocols currently in use, 1000BASE-T and 1000BASE-TX. 1000BASE-T transmits and receives data at 250 Mbits/sec on each of the four pairs, for a total transfer rate of 1000 Mbps. The transfer of data is bi-directional on each of the four pairs. 1000BASE-TX transmits data at 500 Mbps on two pairs and receives data on the remaining two pairs at the same data rate. Well, Category 5e cable has four pairs. Why won't it work? Well, it may and it may not.

As the transfer speeds increase, so do the performance requirements of the cable being used. Delay skew, which is the difference between the slowest and fastest pairs within a cable, becomes increasingly important as data rates increase. In the past, shortages of some materials, including those used in making plenum rated cables, forced manufacturers to find alternative compounds and alternative construction methods that would allow them to continue manufacturing and to comply with the appropriate UL burn tests required for plenum rated cables. These compounds have a direct impact on the speed at which a signal will travel down the conductor. The nominal velocity of propagation, NVP, is the speed of a signal down a conductor measured as a percentage of the speed of light. Though not an issue with protocols that utilize only two pairs, such as 10BASE-T and 100BASE-T, a cable that has different NVP values for two of its four pairs would have a negative impact on protocols that utilize all four pairs, such as gigabit Ethernet. 1000BASE-T and 1000BASE-TX may not work properly over these cables. For end users with these cables installed, new cabling will have to be installed if protocols requiring all four pairs are desired.

Though they may be capable of supporting gigabit Ethernet, Category 5e cables also limit the future uses of the infrastructure. Streaming media applications such as video and multi-media have created an ever-growing demand for bandwidth that shows no sign of slowing down. Today's data requirements have made Category 3 virtually obsolete. With the speed at which electronics have advanced, it is quite likely that the bandwidth provided by Category 5e will be exceeded in the near future, making it for all intents and purposes, obsolete as well. Bandwidth is the frequency range in which a cable will perform. As frequency injected onto a conductor increases, so does the likelihood of noise on adjacent conductor. Once noise overcomes the signal, the cable will no longer function properly. This is important to keep in mind since the cabling infrastructure should be designed to last at least 10 years and accommodate three to four generations of electronics.

While Category 5e is tested to 100 MHz, Category 6 cabling is tested to 250 MHz. Test parameters such as near end crosstalk (NEXT), return loss, and attenuation are elevated for Category 6 and as result, ensure better performance over Category 5e cables. Category 6 cabling is also physically different from Category 5e. A center filler or star filler is typically used to separate the pairs from each other and the insulation on the individual conductors is thicker than that of Category 5e cable. These features allow it to accommodate higher frequencies as well as provide better immunity from external noise. As frequencies increase, the likelihood of experiencing alien crosstalk (crosstalk from adjacent cables) increase. Category 6 is more immune from alien crosstalk than Category 5e, but not as immune as Category 6A cable.

Category 6 cable can also be used for 10GBASE-T in limited applications. IEEE's TSB-155 permits the use of existing Category 6 cable for 10GBASE-T up to a distance of 55 meters. The distance limit is due to the high frequencies at which 10G Base-T will operate. Just like 1000BASE-T pushes the performance levels of Category 5e cabling, 10GBASE-T will push the limits of standard Category 6 cabling. Tested to 500MHz, twice that required by the Category 6 standard, Category 6 cables used for 10G Base-T must be capable of exceptional performance in regards to both individual cable performance and cable performance in a bundle. The higher frequencies of 10G Base-T will induce alien crosstalk in adjacent cables and challenge the performance of a standard Category 6 cable. Thus, the maximum distance of 55 meters was incorporated into the TSB.

Verified Category 6A cables permit the proper operation of 10GBASE-T to a full 100 meters. For that reason, Category 6A cable is the appropriate choice for end users who wish to eventually run 10GBASE-T to the desktop and for those seeking to install the highest performing category cable available.