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IT Infrastructure Solutions

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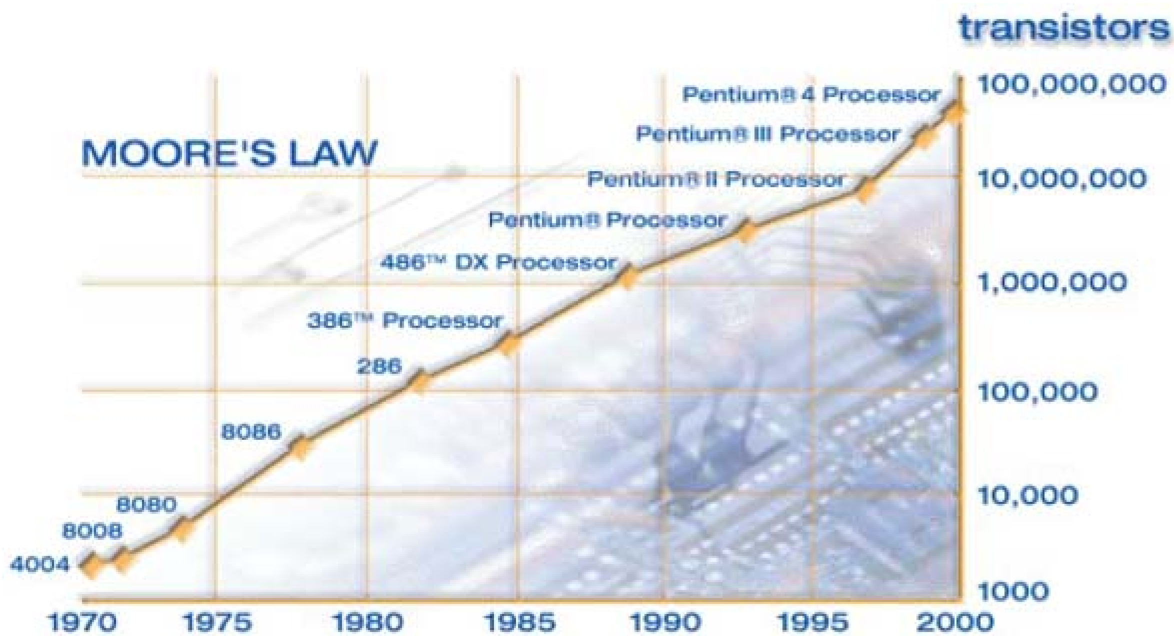
Cabling Life Cycles and the Laws of Networking Communications

In recent years, advances in network electronics have turned what used to be a 10-15 year cabling system investment into a 5-7 year investment. Customers that choose to install older technology such as Category 5 or 5e will lose the extended life cycle of their investments. So do you pay slightly more today for a Cat 6 or higher system, maximizing your investment, or pay less today and face the cost of reinstallation tomorrow?

A standards-based structured cabling system should be capable of supporting network applications for 10-15 years or 2-5 generations of electronics. In recent years, IT budgets have been slashed resulting in pressure to skimp on infrastructure, forcing IT managers into a pay now or pay later scenario. The consequences of adopting a pay later approach include shortened cabling life cycles and increased costs of ownership due to re-cabling of problem channels, increased troubleshooting, administration and the need for higher cost electronics to help make up for the lower performing cabling.

Several theorems exist that chart the growth of computing and networking technology. The first is Moore's Law, which states that the computing power or the number of transistors within the same silicon processor doubles every 18 months, or in short, computing speed doubles every 18 months. Gordon Moore, the founder of Intel®, made his famous observation in 1965, just four years after the first planar integrated circuit was discovered. The following diagram (Figure 1) courtesy of Intel shows the progression of speed. This is necessary, in part due to Gates' law (Bill Gates, one of the founders of Microsoft®), which states the speed of applications halves every 18 months. So in order to have the same speed, the processor must keep pace with applications advancements that enable increased functionality and interoperability while preserving the same relative speed of prior releases.



	Year	Transistors
4004	1971	2,250
8008	1972	2,500
8080	1974	5,000
8086	1978	29,000
286	1982	120,000
386™ processor	1985	275,000
486™ DX processor	1989	1,180,000
Pentium® processor	1993	3,100,000
Pentium II processor	1997	7,500,000
Pentium III processor	1999	24,000,000
Pentium 4 processor	2000	42,000,000

Figure 1: Progression in the Processor through 2000

This law holds true not only for computer processors, but also for other integrated circuits such as those used for networking that add to the processing capabilities of the PC and increase the throughput of switches and other network electronics. The semiconductor industry capitalizes on the fact that the shorter the path, the greater the potential speed. The more that can be integrated within a single chip, the greater its potential. Ethernet cards that once required up to 10 chips now contain one fully integrated circuit

Robert Metcalf, founder of 3Com and one of the founders of Ethernet, also authored a widely accepted theorem. Robert Metcalf's law states that the "value" or "power" of a network increases in proportion to the square of the number of nodes on the network. In other words, if you have four nodes, or computers, on a network, its "value" would be 16. If you added an additional node, or PC, then the value increases to 25. To put this in perspective, if we look at the number of Internet users according to the bureau of labor statistics, in 1993, there were roughly 2.5 million host computers on the Internet. By 1997 that number grew to 25 million. In 2002, it is estimated that there were 605.6 million users worldwide. Every new node, every new server, every new user expands the possibilities for everyone else who's already there. Conversely, should a server fail, its impact on the people and business it serves is far greater than its purchase price. The same goes for the cabling

Bandwidth Progression

Another relevant theory is Parkinson's Law of Data. Cyril Northcote Parkinson, PhD, stated that data will grow to fill available storage. Applying Moore's Law, we also know that storage space and storage processing capability doubles every 18 months. Industry experts predict that by the end of the 21st century there will be one Terabyte of data stored for every person on earth. Another notable observation by Parkinson is Parkinson's Law of Bandwidth Absorption: "Network traffic expands to fill the available bandwidth."

Network bandwidth needs are increasing as the number of connections rise and networking applications become more demanding. Your infrastructure's ability to support greater capacity and higher speeds becomes paramount to ensure the quality of service. Networks can no longer be thought of in terms of file and print services. The IP protocol now delivers voice, telephony, storage hardware commands, video, building automation controls, router and switch failover commands, and a plethora of other services either in native form or encapsulated within the packet structure.

The bandwidth that used to be consumed by user requests has now been divided to allow for additional services, leaving the end-user with less bandwidth than needed. Actual throughput for most network connections is generally one-third to one-half of the rating of the port connection speed depending on the number of users. For instance, a 100Mb/s port may only deliver 30-50 Mb/s of actual data transmission. If the cabling channel is faulty or hardware problems exist causing frequent retransmissions, this number will decrease significantly.

In Figure 2 below, one can see the progression of data rates over the last several years. With available bandwidth increasing, newer technologies such as full motion video, convergence of voice, data, security and building automation systems, data center and backbone needs are already approaching the threshold of what gigabit has to offer.

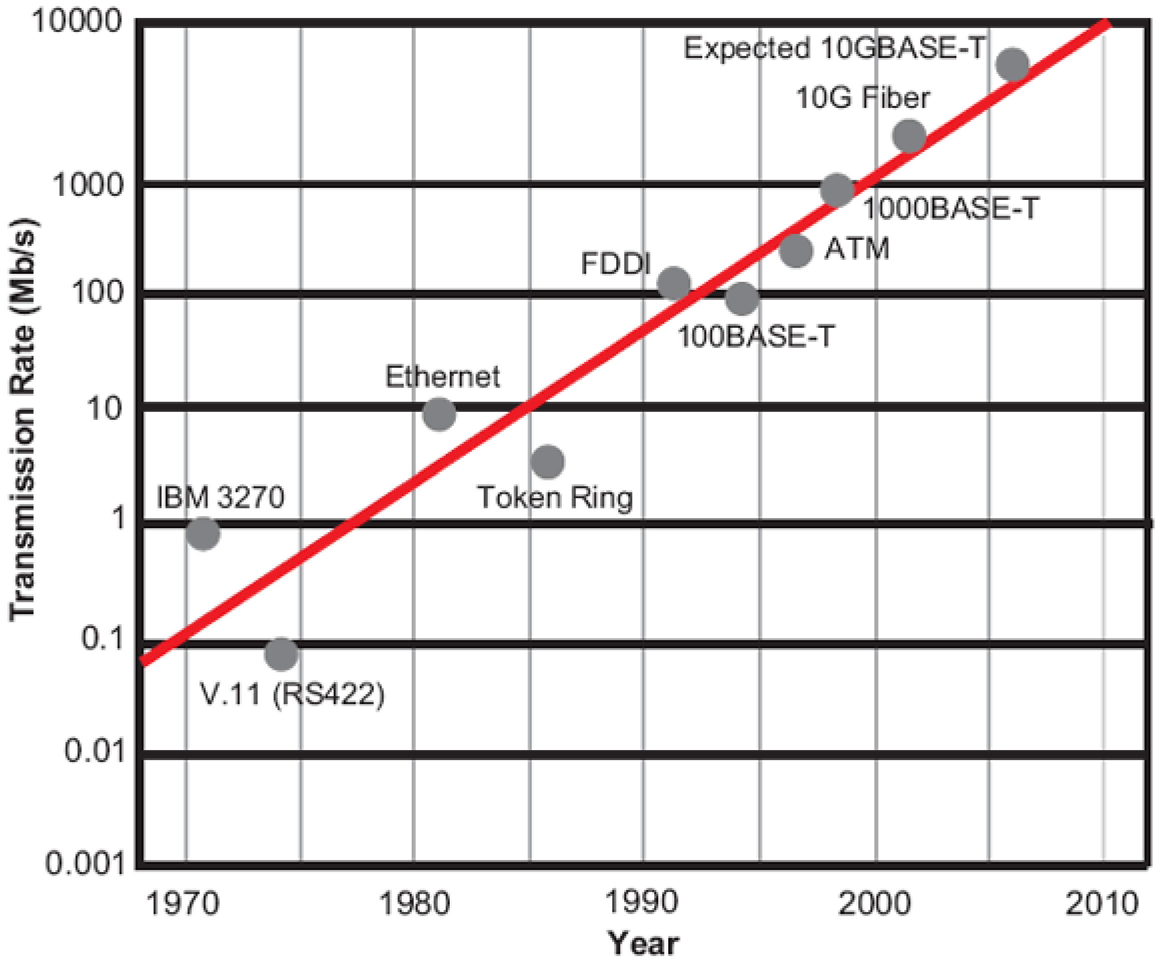


Figure 2: Growth of Application Transmission Rates

In June 2002, a 10 Gb/s fiber standard 802.3ae was finalized and 40 Gb/s is underway. IEEE has authorized a project to standardize 10GBASE-T over a 100 meter, 4 connector twisted-pair copper channel with the first draft of the standard expected in June 2004 and a final standard (802.3an) is expected by June 2006. One 10 Gb/s copper standard already exists to address the needs of the data center - the 10GBASE-CX4 standard 802.3ak specifies 10 Gb/s transmission over twinax (shielded) channel lengths up to 15 meters. One interesting note is that this distance has been nearly doubled with a TERA™ channel using existing chip technology for a significant cost savings over the pricier twinax transmission media. Two Category 7/Class F Siemon TERA connectors fit within XPAK and X2 multisource agreement (MSA) packages which allow for simple upgrades of 10G Ethernet hot plugable modules. MSAs define performance, interfaces, physical dimensions, and environmental conditions for the modules to enable low cost 10G solutions for extended distances. While the CX4 data center standard specifies shorter distances, Category 7/class F cabling is capable of supporting 10G Ethernet over a full 100 meter 4 connector channel.

The Physics of Transmission

Network downtime, lost productivity and system life cycles all are directly affected by the transmission capability of the cabling system. Getting the most out of your active equipment also depends on the transmission characteristics of the cabling system. In fact, several hardware manufacturers will state the minimum cabling required and recommend a higher performing cabling system much like software vendors specify minimum vs.

recommended system requirements. The reasons behind these enhanced recommendations lie within the physics of transmission

As processing speeds increase, the need for bandwidth also increases, which means that signal transmission requires a wider range of frequencies. Claude E. Shannon, author of "The Mathematical Theory of Communication" defined Shannon capacity, also known as Shannon's Law, which demonstrates the limits of the capacity of a link in relation to the signal-to-noise ratio of the transmission channel, expressed in bits per second. In other words, the amount of information that a transmission line can support decreases as the amount of noise in the channel increases and as the signal strength decreases. There are many types of noise ranging from those self-generated within the transmission channel to those generated by external sources.

Category 6/Class E systems offer 2 times the bandwidth in terms of Power Sum to Attenuation Crosstalk Ratio (PSACR), an indication of the channel's immunity to internally generated crosstalk noise. The signal to noise ratio of a transmission channel can be improved further with a screened cabling system that is capable of "shielding" the signal carriers from sources of external noise. The expression "external noise" usually evokes images of high-noise environments such as factory floors or radiology equipment. But as transmission rates climb and the signals extend into higher frequencies, other noise sources come into play. Until now, many of these types of noise that are common to "commercial cabling" environments have been considered to be insignificant or benign. One such external noise source, alien crosstalk (ANEXT) is caused by signal coupling between cabling channels adjacent to one another. Although the magnitude of alien crosstalk is usually less than crosstalk (NEXT) within the cable, its effect on channel capacity is greater because it is more difficult to suppress ANEXT through digital signal processing techniques commonly used in active equipment today.

Category 6 F/UTP (foiled twisted-pair) cabling systems include an overall foil shield, which not only improves the system's immunity to external noise sources including alien crosstalk, but also reduces the extent to which the signals within the cable will interfere with other signals.

Category 7/Class F systems offer yet a higher level of performance. ISO/IEC has approved edition 2 of 11801 complimented with IEC 61076-3-104 and IEC 60603-7-7 making Category 7/Class F systems, including Siemon's TERA™, interface fully specified and complete. Category 7/Class F utilizes PiMF (Pairs in Metal Foil) cables, sometimes referred to as S/FTP, where each individual pair is wrapped with a foil shield along with an overall shield braid around all four pairs. The individually shielded pairs virtually eliminate crosstalk between pairs within the same cable and, in combination with the shield braid provides noise immunity that is typically better than F/UTP cabling discussed previously.

The pending 10GBASE-T standard is expected to use augmented Category 6/Class E (6A or AC6) for channels with an objective to support channel lengths of 55 to 100 meters. Increased data transmission capacity is directly related to the ability of the cabling channel and electronics to cancel in channel noise such as crosstalk and return loss. Since Alien Crosstalk cannot be cancelled using the same digital signal processing technology, channel length will be dependent on the system's ability to mitigate alien crosstalk. Because alien crosstalk is not a factor with screened/foiled and fully shielded twisted-pair systems, Category 6A/Class E F/UTP and Category 7/Class F systems are available today that can offer robust support of 10Gb/s transmission rates over a full 100 meter 4 connector channel model.

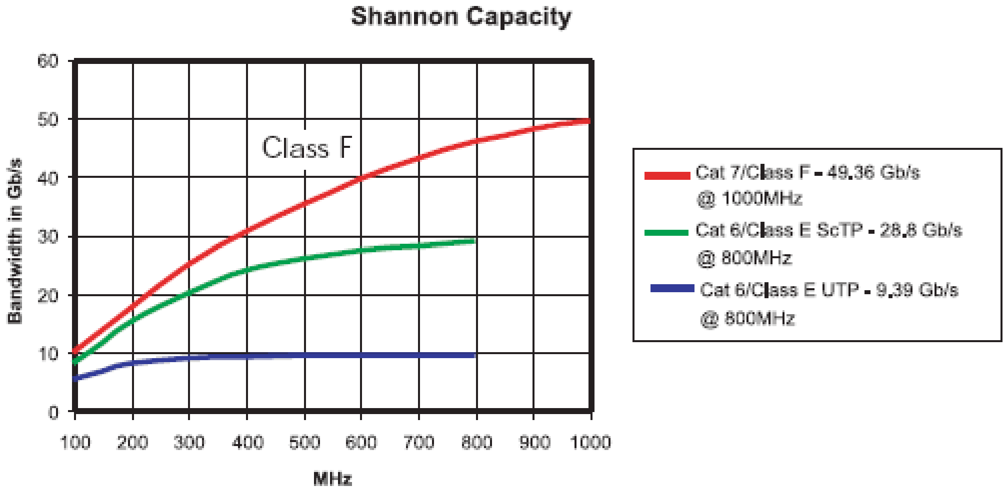


Figure 3: Theoretical Channel Capacity for Class E UTP, Class E ScTP and Class F

As you can see from Figure 3, the greater the noise cancellation, the greater the data transmission.

Unlike their copper counterparts, fiber channels do not suffer from the types of noise that pose challenges for copper cabling, primarily because the problems associated with transmitting photons are unique. As such, fiber channels have other properties that can enhance or limit performance. As insertion loss and noise are the primary concerns for copper transmissions, loss of light or the ability to convey all transmission modes such that they arrive as a coherent signal at the receiver are the types of issues that keep fiber engineers thinking about new solutions. Fiber is ideal for transmitting at high bit rates over long distances, but this capability comes at a price due to the high cost of optical transmitters and receivers. Glass properties and connectivity continue to be the primary factors in a fiber system's ability to support future generations of networking communications operating at higher bit rates

Going Beyond the Standards

Industry Standards are not written overnight. Many companies participate and technical issues are addressed to assure that allowed implementations of cabling systems will deliver performance that meets or exceeds the specified minimum requirements. There are liaisons between the different standards bodies to assure interoperability and functionality. The IEEE uses cabling ad-hoc groups, reports from cable manufacturers and liaison services with TIA and ISO in their standards development. Siemon participates in these standards bodies and allocates a significant portion of our R&D, engineering and lab resources to support standards development. This commitment to global standards development provides our end-users with assurance that our systems not only meet, but also exceed minimum standards requirements in a way that anticipates the needs of applications that are over the horizon

Customers can sort through marketing claims and minimize risk in their cabling system selection process by following a few simple steps. Look for systems that comfortably exceed the requirements of the latest standards. Not only will these systems provide additional performance benefits, but also, when and if the standards change, augmented systems are likely to meet the new parameters. Those offered with an extended warranty that includes support of existing as well as future applications enable a higher level of confidence that the incremental cost of these systems will pay off over the long run.

As mentioned previously, IEEE has identified the need for enhanced performance parameters for Category 6A/Class E systems to allow for 10 Gb/s operation. The extended performance parameters will require a system that is capable of delivering 500 MHz of usable bandwidth. Siemon's 10G ip™ solution is the first in the industry to offer 500 MHz performance guarantees and 10Gb/s applications assurance over both copper and fiber. Siemon offers the world's highest performing and most complete 10G solution set consisting of unshielded, screened/foiled, fully shielded twisted-pair, multimode and singlemode fiber options.

First To Market

To Shield or Not to Shield?

In early networks, most connections were shielded. As the telecommunications carriers entered the cabling and network markets, networks were adapted with baluns (Balanced to Unbalanced adapters) to allow the balanced signal to run over unshielded (unbalanced) systems. Electronics were then developed that would utilize unshielded cabling systems eliminating the need for baluns. Shielding is gaining popularity in high bandwidth and in noisy environments. For example, shielded systems are favored in industrial networks due to extreme noise sources such as AC motors and servos, transformers and other high power equipment. Shielded systems also provide a more robust solution for 10GBASE-T because the shielding significantly reduces interference due to noise from external sources, including alien crosstalk which become more of a factor at higher data rates and frequencies.

Shielded systems have changed significantly from the earlier "iTERA®ions". The cable is much smaller, easier to handle, and connectors provide the ability to self terminate the shield. With these new advancements, installation time comparable to UTP systems when performed by a trained certified installer.

For more information on terminating shielded systems, visit the installation instruction section.

Siemon was first to market with a complete line of Category 6 connecting hardware in November of 1998. Through our active industry standards participation, we knew the draft performance limits being proposed for Cat 6, and we knew that our products already exceeded these limits. While Siemon competitors were lobbying to lower the standard, Siemon offered a warranty that its system would conform to the final standard once ratified. Today, we are in a similar position with 10GBASE-T.

Siemon also developed the first commercially available ISO approved non-RJ interface for Category 7 in 1999. The Siemon TERA™ connector is a 4 quadrant, fully shielded connector that fits in the same footprint as an RJ45. The TERA connector can deliver 1.2 GHz of bandwidth per pair - double that of the Cat 7 standard. This innovative connector allows one 4-pair cable to be split into multiple configurations and applications via 1-, 2- or 4-pair patch cords for enhanced configuration and cost savings. For instance, one cable could run a 10/100 workstation, one telephone, and still have a pair left over for video. In the case of VoIP, one cable could run a 10/100 workstation with the other pairs providing power and data services to the phone. With channel capacity of five times a minimally compliant Category 6/class D system, the TERA is the most versatile and robust copper system on the market today.

By some estimates, delivering a future 10GBASE-T system will require a Shannon capacity of approximately 18 Gb/s. This theoretical capacity is partially based on the assumptions of proven mature technologies, as implemented by applications such as 1000BASE-T. The major challenge in UTP systems is suppression of alien crosstalk noise. According to the IEEE 802.3an™ 10GBASE-T task force this technical challenge has limited the overall channel distance for standards-based Category 6/Class E UTP systems to about 55 and then only with some form of alien crosstalk mitigation. The ability to suppress alien crosstalk noise impairments to low levels has allowed Siemon's shielded 10G 6A™ and TERA solutions to easily deliver this capacity over 100 meter 4connector channels.

Recent developments in the 10GBASE-T task force have demonstrated that it is feasible to achieve 10GBASE-T data rates with a Shannon capacity less than 18Gb/s. The ability to push the technical envelope through a combination of more complex channel codes (such as low density parity check, 'LDPC') and higher performance UTP cabling components will enable 10Gb/s applications to operate over a 100m channel. By anticipating these requirements, Siemon 10G 6A UTP and 10G 6A F/UTP offers unsurpassed channel capacity that takes full advantage of future advancements in 10Gb/s chip technology while supporting standards based lengths and topologies. Further channel capacity is available over TERA.

Conclusion

According to Moore, Metcalf and Parkinson, computing power, storage and bandwidth will all continue to grow at exponential rates. In summary, today's servers will become tomorrow's desktops. One may not think that 10Gigabit

Ethernet will be seen at the desktop any time soon, but just 5 years ago, the same was thought to be true about 1Gigabit Ethernet

Networking technology will continue to advance. The cabling system is typically less than 5% of your overall network investment, yet your cabling system supports your entire network investment. Install the best cabling system today to protect your investment and maximize your system's life cycle. Siemon's 10G ip™ provides the best performance and offers a full array of 10G ready cabling systems - UTP & F/UTP 10G 6A™, Category 7 TERA™ and XGLO® fiber. Siemon has been doing business under the Siemon name for over 100 years and specializes in the manufacturing and innovation of high quality, high performance cabling systems. What other company would you want to stand behind your cabling system the foundation for your business success?

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