ANIXTER

Technology White Paper

STRUCTURED CABLING

Foundation for the Future

Table of Contents

Introduction

As today's communication networks become more complex—as more users share peripherals, as more mission-critical tasks are accomplished over networks and as the need for faster access to information increases—a good foundation for these networks becomes increasingly important. The first step toward the adaptability, flexibility and longevity required of today's networks begins with structured cabling—the foundation of any information system.

It is vital that communications cabling be able to support a variety of applications and last for the life of a network. If that cabling is part of a well-designed structured cabling system, it can allow for easy administration of moves, adds and changes and smooth migration to new network topologies. On the other hand, "worry-about-it-when-you-need-to" systems will make moves, adds and changes a hassle and make new network topologies too difficult to implement. Network problems occur more often, and are more difficult and time-consuming to troubleshoot. When communication systems fail, employees and assets sit idle, causing a loss of revenues and profits. Even worse, the perceptions of customers and suppliers can be adversely affected.

The purpose of this white paper is to present the advantages of using a standards-based structured cabling system for a business enterprise. The paper will cover a brief historical perspective of structured cabling, a review of the current standards, media types and performance criteria, system design and installation recommendations. Particular attention will be given to the ANSI/TIA/EIA-568-A standard and the horizontal cabling subsystem in that standard.

The Evolution of Structured Cabling

In the early 1980s, when computers were first linked together in order to exchange information, many different cabling designs were used. Some companies built their systems to run over coaxial cables. Others thought that twinaxial or other cables would work best. With these cables, certain parameters had to be followed in order to make the system work. Certain connectors had to be used, maximum cable distances had to be established and particular topologies were necessary. See Figure 1.

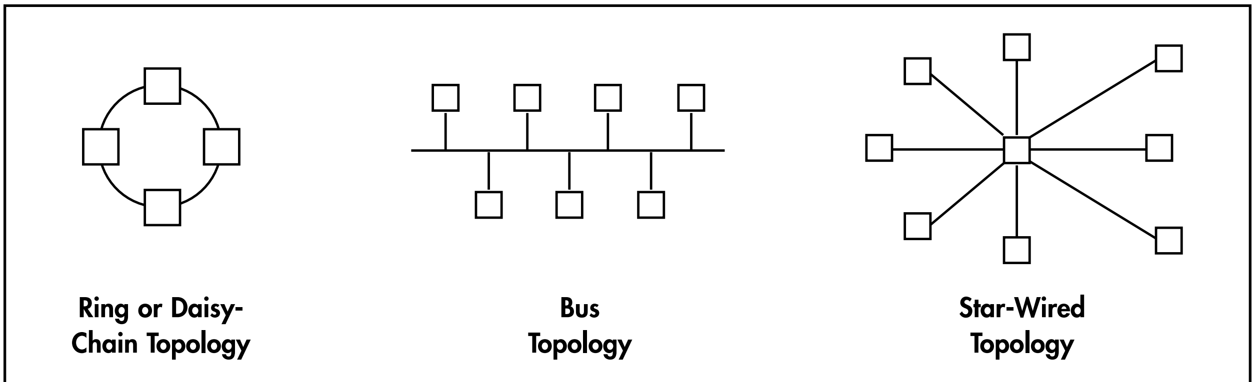

Figure 1. Network Topologies

By defining every aspect of their system, manufacturers "locked" customers into a proprietary system. One manufacturer's system would not work with another, or run over any other type of cabling. If a customer decided to change systems, not only would new electronics and software need to be purchased, but new cabling would need to be installed as well.

Troubleshooting proprietary systems was very difficult and time-consuming compared to today's structured systems. A problem at one workstation could bring the entire proprietary system down, leaving no indication to the network manager where the problem may have occurred. In the case of a daisy-chain topology, troubleshooting consisted of starting at one machine and physically tracing the cables to each of the other machines on the network. Eventually, the cause of the problem, such as a broken connection, was found. Once repairs were completed, the system would be back on line. This troubleshooting process could last hours—or days—leaving users sitting idle.

Moves, adds or changes were also difficult with a proprietary system. Each time a new machine was added to the network, new cable had to be installed and inserted into the ring or attached to the bus. Furthermore, the whole system might have had to come down to add the new user.

These factors contributed to a growing frustration among network managers and administrators who constantly searched for easier ways to maintain their networks, reduce downtime and lower costs. In fact, studies have shown that up to 70 percent of network downtime can be attributed to the cabling in a non-structured or proprietary system (LAN Times, 1991).

Compounding the problem of proprietary systems was the telephone cabling system. As part of its 1984 divestiture agreement, AT&T was no longer responsible for the cabling inside a customer's building. From then on the service provider maintained the system only up to the demarcation point where the telephone service entered the building. Beyond that point, maintenance and upgrade of the telephone system was the customer's responsibility.

As a result, network managers had (and many still do have) two distinct systems demanding their full and undivided attention. The desire for one system that could run any application without the accompanying hassles and headaches of past systems was magnified exponentially. Enter structured cabling.

Standards for Structured Cabling

Structured cabling is designed to run anything, anywhere, at any time. Structured cabling eliminates the need to follow one vendor's rules concerning cable types, connectors, distances or topology. It allows for the installation of cabling in a facility once and the adapting of that cabling for any application—from telephone to an Ethernet or Token Ring local area network (LAN) or an emerging technology like ATM (Asynchronous Transfer Mode).

A flexible cabling plant is made possible with standards adopted by both the cable plant manufacturers and by the electronic manufacturers. If an end-user also follows these same standards, then any application, cable, connector or electronic device built for compliance will work in the same system.

The central standard that specifies a generic telecommunications cabling system to support a multiproduct, multivendor environment is the ANSI/TIA/EIA-568-A, "Commercial Building Telecommunications Cabling Standard." This standard was developed and approved by committees of the American National Standards Institute (ANSI), the Telecommunications Industry Association (TIA) and the Electronics Industry Association (EIA). These committees are composed of representatives from various manufacturers, distributors and customers in the networking industry. The ANSI/TIA/EIA-568-A standard establishes performance and technical criteria for various system configurations and components.

There are a number of related standards that should also be closely followed to ensure the greatest possible benefits from a structured cabling system. These related standards include ANSI/EIA/TIA-569, "Commercial Building Standard for Telecommunications Pathways and Spaceways." This standard provides guidelines for rooms, areas and pathways through which telecommunications equipment and media are installed. It also details some of the considerations to be addressed when designing and constructing a building that will include a telecommunications system.

Another related standard is ANSI/TIA/EIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings." This provides standards for color-coding, labeling and documenting an installed cabling system. Following this standard allows for better administration of a network by creating a method to track moves, adds and changes. It also eases troubleshooting by detailing each cable run for such specifics as type, performance, application, user and layout.

ANSI/TIA/EIA-607, "Commercial Building Grounding and Bonding Requirements for Telecommunications," prescribes practices for installing grounding systems to ensure a reliable ground reference level for all telecommunications equipment subsequently installed.

Each of these standards works in conjunction with 568-A. Additional standards like the National Electric Code (NEC) or local provisions and laws also must be reviewed when designing or installing any telecommunications system. This paper concentrates on 568-A and describes some of the basic elements of a generic cabling system, cable types and some of their advantages and disadvantages, and installation requirements and practices.

The ANSI/TIA/EIA-568-A Standard

Subsystems

The ANSI/TIA/EIA-568-A standard specifies minimum requirements for telecommunications cabling within a commercial building, up to and including the telecommunications outlet/connector, and between buildings in a campus environment. According to the standard, a structured cabling system consists of six functional subsystems:

1. The entrance facility is the point where outside plant cables and associated hardware are brought into the building. The entrance facilities may be used for public network services, private network customer services or both. The demarcation point between carrier and customer, and overvoltage protection devices are located here.

2. The equipment room is a centralized space for telecommunications equipment (e.g., PBX, computing equipment, video switch, etc.) that serves users in the building.

3. The backbone cabling provides interconnections between telecommunications closets, equipment rooms and entrance facilities. It consists of the backbone cables, main and intermediate cross-connects, mechanical terminations, and patch cords or jumpers used for cross-connection. Backbones may connect closets within a building or between buildings.

4. The telecommunications closet is where the horizontal distribution cables are terminated. All recognized types of horizontal cabling are terminated on compatible connecting hardware. Similarly, recognized backbone cables are also terminated in the closet. Cross-connection is done with jumpers or patch cords to provide flexible connectivity for extending various services to users at the telecommunications outlets.

5. The horizontal cabling consists of the physical media used to connect each outlet to a closet. Various types of cable can be used for horizontal distribution. Each type has its own performance limitations, size, cost and ease-of-use. (More on this later.)

6. The work-area components extend the telecommunications outlet/connector end of the horizontal cabling system to the station equipment. All adapters, filters or baluns used to adapt various electronic equipment to the structured cabling system must be external to the telecommunications outlet and are outside the scope of 568-A.

Figure 2 illustrates the relationship between the six subsystems of a structured cabling system.

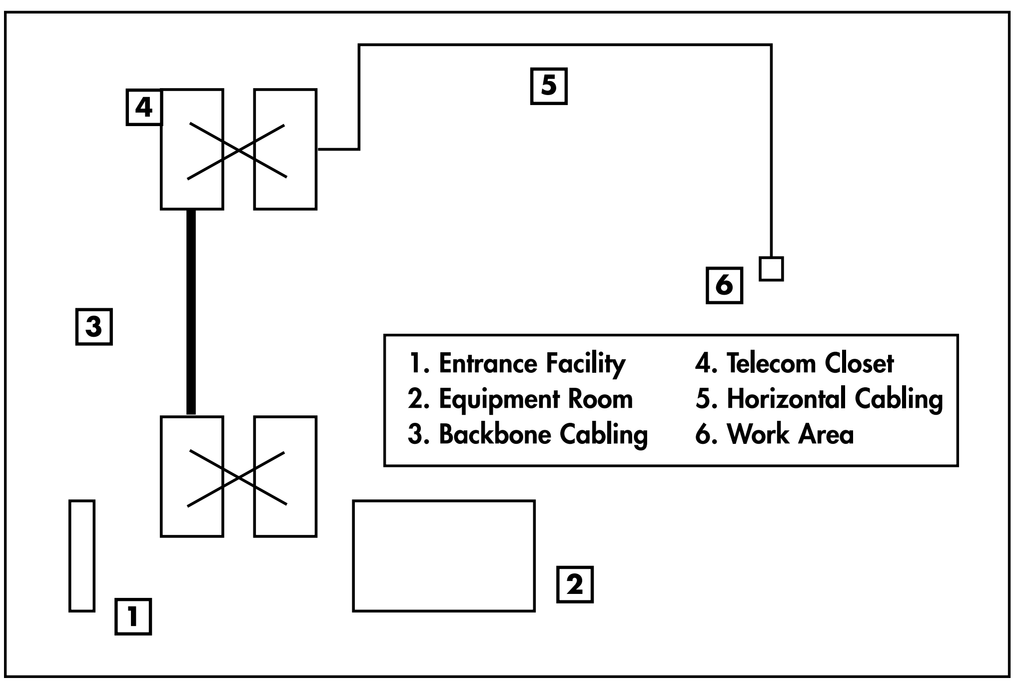

Figure 2. Structured Cabling Subsystems

MHz

Star-wired Topology

The 568-A standard specifies that a structured cabling system use a star topology (refer to Figure 1). Each work-area telecommunications outlet must be connected to a cross-connect in a telecommunications closet. All cables from a floor or area in a building therefore run back to one central point for administration. Each telecommunications closet must be star-wired back to the equipment room for the building. In a campus environment each building is star-wired back to one main administration area.

Using a star-wired topology eliminates many of the pitfalls encountered with proprietary systems. First, a physical star will still work as though connected to a ring or bus topology so that in the event of a station failure, the networking electronics can bypass that particular station. This keeps station or lobe problems local, avoiding a global system crash. Star-wiring allows for changes in network applications—such as going from a ring or chain-based application to a bus-oriented one—without pulling new cable, thus saving time, effort and money.

With good planning, changing a telephone outlet to a workstation location is easily accomplished by changing patch cords in the closet and equipment at the outlet. No additional cable needs to be pulled or terminated.

Media Types

One of the first choices faced when planning or developing a structured cabling system is the type of media to be used. 568-A recognizes three different media:

- Unshielded Twisted Pair (UTP) — 4-pair, 24-gauge, 100 Ohm copper cable
- Shielded Twisted Pair (STP) — 2-pair, 22-gauge, 150 Ohm copper cable
- Single-mode and multimode optical fiber cables

Coaxial cables were recognized by the original 568 standard mainly because their installed base was used for Ethernet (10BASE2 and 10BASE5) applications. In the 568-A document, coax is grandfathered, but not recognized. In other words, if a system has already been installed using coax, it may be maintained, added to or changed. However, it should not be used for new system installations.

UTP

Unshielded twisted pair cables closely resemble telephone cables but are enhanced for data communications to allow higher frequency transmissions. Today, UTP data cables and components can be classified into three different performance categories. Category 3 is rated for transmission frequencies up to 16 Megahertz (MHz). Category 3 systems are most commonly used for low-speed data applications like asynchronous transmissions, telephone systems and medium-speed data applications such as 4 Megabit per second (Mbps) Token Ring or 10 Mbps Ethernet. Category 4 cables and components are designed for frequencies ranging up to 20 MHz and can handle any Category 3 application as well as 16 Mbps Token Ring. The highest rated UTP system, Category 5 cables and connection hardware are rated up to 100 MHz. Category 5 systems are designed to handle any current copper-based application for voice, video or data.

Today, Category 5 is the most popular standards-recognized media for high-speed data applications due to ease of installation, lower installation costs and lower space consumption. Compared to STP, UTP cables are smaller, more flexible and less expensive. The electronic components used with UTP are also the least expensive of the three recognized media. And since these make up a large portion of the overall network investment, this expense is factored heavily in the decision to use UTP.

A word of caution: As with any chain, a structured cabling system is only as strong as its weakest link. Therefore, to obtain Category 5 performance from a link, the entire link must be composed of components that comply to Category 5 standards. Using Category 5 distribution cable, connecting hardware and outlets along with Category 3 patch cords will result in only Category 3 performance.

The purchase of Category 5 cables and components, however, does not guarantee Category 5 performance from an installed system. The installation of Category 5 structured cabling systems has a tremendous effect on the final performance level. In fact, without proper installation, the high performance of a Category 5 system can be reduced to that of a simple phone system.

STP

Shielded Twisted Pair systems were originally developed by IBM for use with their Token Ring systems and were rated up to 20 MHz. To this day, STP cables are commonly referred to as IBM Type 1. When the system was first developed for 16 Mbps Token Ring, 20 MHz was plenty of bandwidth. However, STP systems have much higher performance limitations than originally published. The 568-A standard now recognizes STP-A, which extends that system's rating through 300 MHz. In fact, a properly installed STP-A structured cabling system can run a 16 Mbps Token Ring signal *and* a 550 MHz broadband video signal at the same time.

The high performance of STP systems is a result of shielding. In an STP cable, each twisted pair is foil-wrapped and a metallic braid is placed just underneath the cable sheath. These components reduce emissions from the cable and protect the pairs from outside interference when the shielding is properly grounded.

Electrical Performance of Twisted-Pair Cabling

Copper-based structured cabling systems use electrical signals for transmitting information. Attenuation and Near-End Crosstalk (NEXT) are the two most crucial electrical parameters that distinguish performance characteristics. Their combined effect can either allow for successful data transmission or bring down a system.

Decibels

Attenuation and NEXT are both reported in decibels (dB) as negative numbers. Since the minus (-) sign is assumed for these two parameters, a statement of "... 40 dB of NEXT..." actually means -40 dB. Attenuation and NEXT dBs are relative measures of changes in voltage. Further, an increase of 10 dB means a 10-fold increase in the measured parameter. Figure 3 shows the logarithmic progression of decibels. Note that the minus signs have been assumed.

3 dB = 2X
10 dB = 10X
20 dB = 100X
30 dB = 1000X
40 dB = 10,000X
50 dB = 100,000X
60 dB = 1,000,000 X

Figure 3. Logarithmic Progression of Decibels

Attenuation
Attenuation refers to the power loss an electrical signal experiences as it travels through a cable. For a communication system to work, the receiving electronics must be able to detect a signal. In a Category 5 system, 568-A limits attenuation to 24 dB for a 100 MHz signal. A look at Figure 3 demonstrates that attenuation of just 20 dB means only about 1/100th of the original signal power is received, illustrating just how weak transmissions can become. Since attenuation results represent signal lost, numbers closer to zero indicate less attenuation and stronger signals. Therefore, 5 dB represents less attenuation than 10 dB. Longer distances, higher frequencies and higher temperatures all increase attenuation.

Near-End Crosstalk
Crosstalk occurs along a circuit when a portion of the energy from one signal is jumping or crossing from one pair to another. In data communications, the main concern is with crosstalk that occurs at the "near end" or close to the transmitters. UTP and STP cables are designed for bidirectional conversations. That is, at each end of the cable length, one pair is used for transmitting and another for receiving. The transmit pair at one end becomes the receive pair at the other.

The close proximity of the transmit and receive pairs increases the probability of excessive NEXT. Since transmissions attenuate so rapidly, a relatively powerful signal must be transmitted for something recognizable to arrive at the other end. Simultaneously, relatively weak signals are being received on an adjacent pair. Even small imbalances in the transmitted signal can cause NEXT. The first 50–60 feet of a cable run are especially vulnerable to NEXT because the greatest disparity exists there between the strengths of the transmit and receive signals. Further down the run, the transmitted signal has attenuated to the point where little, if any, of the effects of NEXT are present. However, connection points are also susceptible to crosstalk. Quality products and proper installation will ensure that NEXT does not overpower received signals.

To measure NEXT, a known signal level is generated onto a transmit pair. Any portion of that signal "heard" on the receive pair is crosstalk. Less of this signal on the receive pair and bigger numbers are ideal. Therefore, NEXT of 40 dB is better than 30 dB performance. Both environmental and installation-related factors can cause increases in noise and NEXT. Some of these factors include untwisting of pairs, cable jacket removal, bend radius, fluorescent lights and motors.

Attenuation-to-Crosstalk Margin
The effect of attenuation on data transmissions requires the reduction of all noise forms in cabling, including crosstalk. Too much noise will prevent the receiver from distinguishing the transmitted signals from unwanted noise. The result can be garbled, incoherent data, retransmissions and slow network response time.

According to the 568-A standard, the limitations for attenuation and crosstalk at 100 MHz for Category 5 are 24 dB and 27.1 dB, respectively. Figure 3 shows that this margin of 3.1 dB indicates that the attenuated signal received is roughly twice as strong as any noise encountered on the line. The relationship between attenuation and NEXT is graphically represented in Figure 4. As frequency increases, both attenuation and NEXT increase. An increase in NEXT pushes the lower shaded area farther up the graph. As attenuation increases, the upper shaded area moves farther down the graph. Anytime the margin between the two shaded areas falls below 3 dB, transmitted data becomes corrupted.

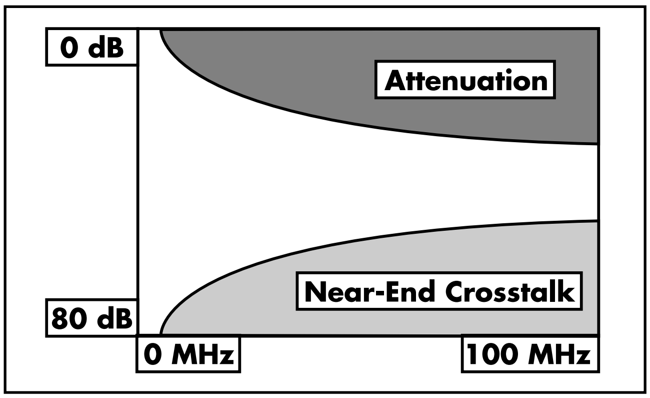

Figure 4. Attenuation-to-Crosstalk Margin

High-quality products and proper installation techniques will attain the greatest possible margin between NEXT and attenuation—optimizing the performance and reliability of a network. For example, if products are used that meet, but do not exceed, the minimum Category 5 requirements, the installed system may not perform at Category 5 levels. Each time a cable is pulled, bent, untwisted and terminated, a small amount of attenuation and/or NEXT is added to the link. Necessary installation tasks can cause the attenuation-to-crosstalk ratio of marginal Category 5 products to fall below the 3 dB minimum. Choosing products that exceed the standards—ones that provide "head room"—prevents this situation. The greater the head room of a product, the more use and abuse that product will withstand before it no longer meets Category 5 requirements.

Figure 5 compares the three data grade categories of 4-pair UTP cables. The results compare the performance of these categories at 16 MHz, the peak frequency for Category 3. A look back to Figure 3 shows that the 21 dB differential between Category 3 and Category 5 represents a 100-fold increase in NEXT performance.

	Cat 3	Cat 4	Cat 5
Attenuation* per 100 meters	13.1 dB	8.9 dB	8.2 dB
NEXT*	23 dB	38 dB	44 dB
Peak frequency	16 MHz	20 MHz	100 MHz

*All measurement values correspond to performance at 16 MHz.

Figure 5. UTP Cable Performance

Optical Fiber Systems

The highest performing structured cabling systems use fiber optics. As the cost of the electronic devices used with fiber systems decreases, many more fiber-based systems are being installed. These systems offer many advantages over copper-based systems. Since fiber optics use light pulses instead of electrical signals for transmitting information, there is no concern for EMI (electromagnetic interference) or RFI (radio frequency interference). Transmission distances are greater because light pulses attenuate or lose energy much more slowly than electrical signals. Fiber also offers a much greater bandwidth than copper cables, allowing more information to be carried on each fiber. In fact, a single pair of fibers can handle the same amount of voice traffic as 1,400 pairs of copper. In the race to improve efficiency and data rates, there is no better media than fiber.

Fiber optic cables consist of a glass core and cladding surrounded by a protective coating. The core and cladding are part of the same glass rod but have different optical properties. Light pulses are injected into the core. As light pulses travel down the cable, the cladding, acting as a mirror, reflects the pulse back to the center of the core. A plastic protective coating, called a buffer, surrounds the core and cladding. Figure 6 shows the construction of a fiber optic cable.

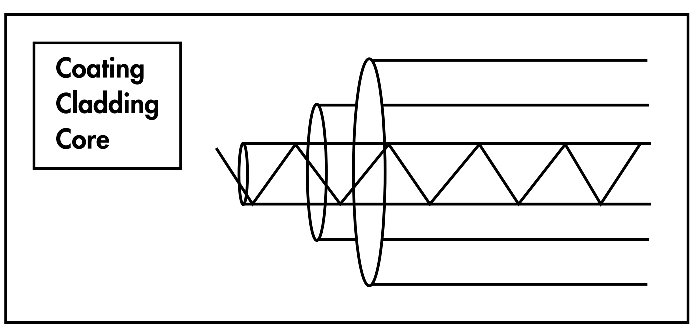

Figure 6. Fiber Optic Cable Construction

The two basic types of fiber optic cables are multimode and single-mode. Multimode fibers provide a number of paths for light pulses to take as they traverse a cable; single-mode has only one path. The number of modes is determined by the wavelength of the light source and size of the core. Multimode fiber has a core width of 62.5 microns (um); single-mode fiber has an 8.3 um core. By comparison, the average human hair is 80 um thick.

Single-mode and multimode fibers also have different optical light sources. Lasers transmit optical signals into a single-mode fiber because they emit a focused, high-powered light beam. The lasers' wavelengths in single-mode applications are 1,310 and 1,550 nanometers (nm). Since the core size of multimode fibers is much larger than that of single-mode, lower-powered LEDs (light emitting diodes) in the 850 and 1,300 nm range are typically used as their optical source.

Fiber optic cable construction differs depending on the purpose and application of the cable. A tight buffer construction is used for indoor applications. This buffer brings the total fiber size to 900 um, providing extra protection to allow for direct connectorization of a fiber. Outdoor cables use a loose tube design in which 250 um coated fibers float in a moisture-resistant gel. The gel combats the harmful effects of temperature, humidity and mechanical loads. In addition to the buffer tubes, fiber optic cables may include Kevlar yarn, armor sheaths, steel messengers or other components.

System Design

Since the 568-A standard recognizes the need for both data and voice communications, it requires a minimum of two ports per workstation. The first port must be supported by a 4-pair, 100 Ohm, UTP cable, Category 3 or higher. The second port must be supported by one of the following media: a UTP cable (Category 5 recommended), STP or a multimode 62.5 um optical fiber cable (two strand minimum).

For horizontal cable runs from a telecommunications closet to a work-area outlet, the maximum transmission distance allowed for any media type is 295 feet (90 meters). An additional 33 feet (10 meters) provides for patch cords both in the closet and the work area. Figure 7 shows the TIA horizontal link model with corresponding distance limitations for cables and cordage.

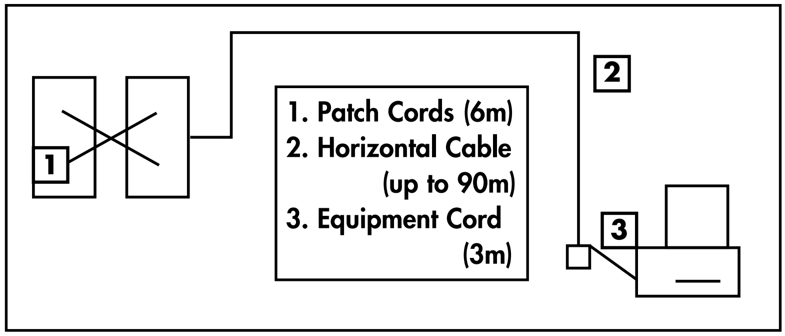

Figure 7. Horizontal Link Model

When considering backbone cabling, distance requirements depend on the application and media. For instance, the maximum distance for UTP is 800 meters when the spectral bandwidth of the application is less than 5 MHz. For any application greater than 5 MHz (i.e., Asnyc, IBM 3270, AS 400, and voice), the maximum distance returns to 90 meters. When using Token Ring and STP-A cables in the backbone, the maximum distance depends on the number of Multistation Access Units (MAU), Controlled Access Units (CAU), Lobe Attachment Modules (LAM), etc. When using optical fiber in the backbone, the distance limitations are two kilometers for multimode and three kilometers for single-mode. The most widely used media in the backbone are UTP Category 3 for voice applications and multimode optical fiber for data applications.

Installation Practices

It is vital to use proper installation practices to ensure that the performance of the entire system is not diminished simply through improper installation. Using a Category 5 system as an example, any one of the following practices may not, by itself, reduce a system below Category 5 compliance. Since many of these items such as pulling cables and untwisting pairs are unavoidable, care must be taken not to allow their combined effect to lower the performance of the system.

One of the first installation tasks is pulling cables from the telecommunications closet to each outlet location. The maximum pulling tension for Category 5, according to 568-A, is 25 lbf. Higher tension on the cable may stretch the twists, or in effect, untwist the pairs. Extreme tension will also increase attenuation. Visual inspection of an installed link cannot identify that tension limitations have been exceeded. Using proper pull techniques, pull cords and cable lubricants will prevent this type of damage.

Extending a cable from closet to outlet may involve going through walls, ceilings, floors, conduits, ducts, raceway, corners or bends. It is crucial not to exceed the minimum bend radius of the cable being installed. Four-pair Category 5 cables must keep the bend radius for each turn in excess of one inch. Multipair Category 5 cables (more than 4-pair) have a minimum bend radius of 10 times the outside diameter of the cable. Tight bends will force the pairs in a jacket to lay flat, or untwist, which may increase NEXT at that point.

The next step in the installation process is to prepare the cable for termination. This involves stripping away some of the jacketing material and untwisting the conductors. The jacketing material should not be removed any more than necessary to complete a termination.

As stated in 568-A, the pairs in a Category 5 cable should never be untwisted more than 1/2 inch from the point of termination. Any further untwisting of the pairs will increase crosstalk and susceptibility to EMI/RFI.

After all of the conductors in a cable have been terminated, the cable must be dressed or managed. Cable management keeps termination fields neat and orderly, and provides strain relief for the cable. Strain relief transfers the weight of the cable from the cable itself to some sort of supporting hardware. Without strain relief, the weight of the cable will cause it to sag and eventually pull away from its termination.

Cable ties are the most popular method of attaching cables to support hardware. These thin plastic strips are looped around a bundle of cables and cinched tight enough to support the cables. Cable ties also make large bundles of cables more manageable and give the installation a neat appearance. But over-cinching of cable ties has the same effect as tight bends. The conductors of the outermost cables in the bundle tend to become flattened. A proper cinch of a cable tie will allow the cables to slide easily back and forth within its loop. Staples are not recommended for Category 5 installations.

Conclusion

Many companies are investing huge amounts of money in the latest technology to increase the speed and capacity of their communications systems in order to gain the greatest competitive advantages. New applications like ATM, 100BASE-T, TP-PMD (Twisted Pair-Physical Media Dependent) and FDDI (Fiber-Distributed Data Interface) will allow people to share vast amounts of information in the form of voice, data and video faster than ever. However, investing in the latest electronics to support these applications will be an exercise in futility if the installed cabling plant cannot handle the frequencies involved.

Structured cabling allows businesses to build an infrastructure for their communication needs to last well beyond the turn of the century. However, the ability to run any application, to any work area, at any time comes only with the proper planning and installation of a high-performance structured cabling system.

Proper planning includes examining all applications, network technologies and telecommunication outlet locations that are currently used or might be used in the future. Accounting for all foreseeable scenarios allows the physical infrastructure to be installed once, yet serve business requirements not yet on the horizon. Moves, adds and changes no longer require pulling new cables—except when your physical space expands.

Choosing the proper media for a new cable installation depends on the applications and services that the network is expected to provide. Category 3 UTP cables are sufficient if a network is designed strictly for telephony or low- to medium-speed data applications like Ethernet. Electrically noisy areas such as X-ray labs, HVAC equipment rooms or near motors may lend themselves more to a shielded or optical fiber cable. Complete fiber solutions are ideal for enterprises that want to cable once regardless of the application being used today or tomorrow—or for groups or users that demand large quantities of information.

Budgetary concerns should impact the decisions made to this point. However, keep in mind that standards-based systems are designed to last a minimum of 10 years from time of installation. Further, many of today's products are warranted for longer periods such as 15 or 25 years. Therefore, cutting corners on the foundation of the network will have ramifications for many years to come.

A properly planned and installed system will allow companies to spend their time, attention and scarce capital resources in other areas for years. The ultimate goal is to run anything, anywhere, at any time. The other option is to face each network problem and issue as it arises. The choice is yours.

Appendix

If you would like a copy of the complete 568-A standard, or any of the others mentioned in this white paper, contact Global Engineering at (800) 854-7179. The materials produced by the EIA, TIA and other standards bodies are protected by copyrights.

ANSI/TIA/EIA-568-A, Commercial Building Telecommunications Cabling Standard (CSA T529)*

ANSI/EIA/TIA-569, Commercial Building Standard for Telecommunications Pathways and Spaces (CSA T530)*

ANSI/EIA/TIA-570, Residential and Light Commercial Telecommunications Wiring Standard (CSA T525)*

ANSI/TIA/EIA-606, Administration Standard for the Telecommunications Infrastructure of Commercial Buildings (CSA T528)*

ANSI/TIA/EIA-607, Commercial Building Grounding/Bonding Requirements (CSA T527)*

TSB-67, Transmission Performance Specifications for Field Testing of UTP Cabling Systems

TSB-72, Centralized Optical Fiber Cabling Guidelines

* Equivalent Canadian Standards Document

1-800-ANIXTER

Worldwide Headquarters: Anixter Inc., 4711 Golf Road, Skokie, IL 60076-1278 • 847/677-2600 • http://www.anixter.com

#175058 5K 02/96