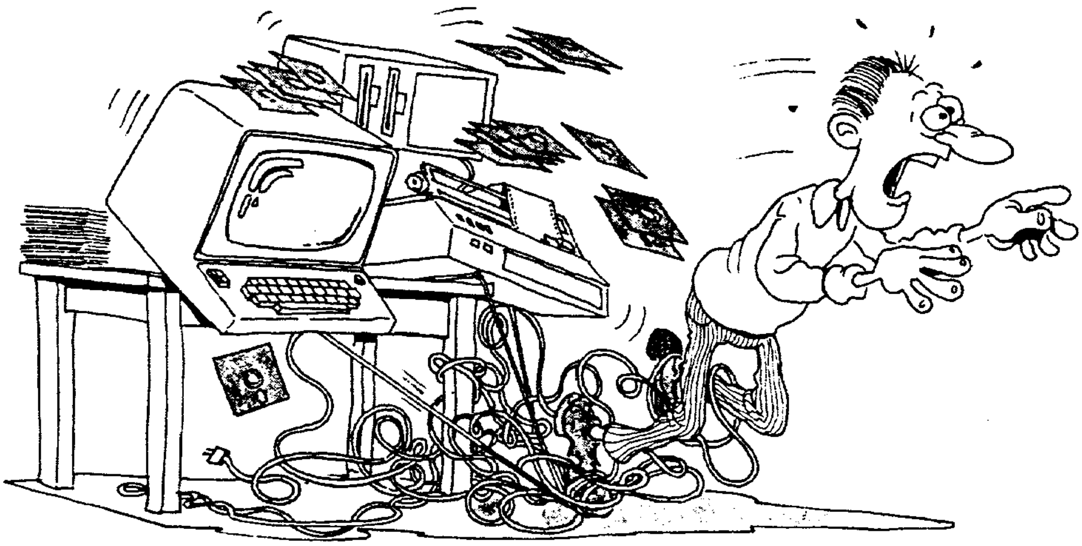
INTRODUCTION TO STRUCTURED CABLING



Compiled by
Sonam Dukda

Division of Information Technology
Ministry of Communication
September 2000

TABLE OF CONTENTS

1 INTRODUCTION

DIT recommends the adoption of Structured Cabling standards in the establishment of Network in the country. This paper is intended to serve as a guideline and introduction to the concepts involved in the issue of structured cabling.

Many network administrators keep hearing that the network is down because of some or the other reason. Various researches indicate that in many cases, the network is down on account of inferior cabling systems. And installing standards-complaint structured cabling systems can eliminate much of this downtime. Another important factor that needs to be taken into account is that the structured cabling system, though it outlives most other networking components, represents just five percent of the total network investment.

The structured cable is the only one that needs to be installed to contend with the needs of telephone and data communications now and in the future. It is a system that provides a very "structured" approach to the entire cabling system—a single-mixed media network that handles all information traffic like voice, data, video, and even big complex building management systems. In brief, it could be described as a system that comprises a set of transmission products, applied with engineering design rules that allow the user to apply voice, data, and signals in a manner that maximizes data rates.

Structured cabling divides the entire infrastructure into manageable blocks and then attempts to integrate these blocks to produce the high-performance networks that we have now come to rely on. To the user, this means investment protection.

In addition to investment protection, structured cabling also provides administrative and management capabilities. All cables originating from the different work locations are terminated on a passive centralized cross-connect in the network room. Simple labeling and colouring mechanisms provide for easy and quick identification of work outlets. Hence, it provides for a single point for all administrative and management requirements. Another underlying factor is management of change. It must be realized that system architectures keep changing as the system evolves. And the cabling architecture should be able to change with minimal inconvenience. The provision of a central administrative panel provides the flexibility to make additions, moves, and changes. The changes can be facilitated with simple switch over of patch cords. Apart from this, structured cabling is also technology independent.

The advantages of Structured cabling are:

- **Consistency** – A structured cabling systems means the same cabling systems for Data, voice and video.

- **Support for multi-vendor equipment** – A standard-based cable system will support applications and hardware even with mix & match vendors.

- **Simplify moves/adds/changes –** Structured cabling systems can support any changes within the systems.

- **Simplify troubleshooting –** With structured cabling systems, problems are less likely to down the entire network, easier to isolate and easier to fix.

- **Support for future applications** – Structured cabling system supports future applications like multimedia, video conferencing etc with little or no upgrade pain.

Another primary advantage of structured cabling is fault isolation. By dividing the entire infrastructure into simple manageable blocks, it is easy to test and isolate the specific points of fault and correct them with minimal disturbance to the network. A structured approach in cabling helps reduce maintenance costs too.

Structured cabling system is fast becoming the norm for small, medium and large networks

2 NETWORKING

2.1 Objectives

The first step is to establish the aims of network implementation.

These might include:-

- Implementation of administrative and financial database
- Staff access to company records
- Automation of letter, report or specification writing
- E-mail for staff
- Staff scheduling
- General information automation (including library, plans, graphics and images)
- Learning or training aids (interactive software)
- Computer skills training rooms (word processing, publishing, CADD, spreadsheets, databases)
- Printer sharing
- File transfer
- Internet access (graphical, text, news)
- Access to centralized information sources (e.g. CD-ROM stacks)
- Automate software updates
- Centralize application software

2.2 Choice of Software and Hardware

Before considering network requirements, the machines and software, which are to be networked now or in the future, must be identified. The purpose of this step is to:

- Identify which software applications the network operating system and hardware must support
- Exclude software or machines that will be discarded for other reasons from further networking considerations.

After answering the following questions, it should be possible to identify which PC's will initially be networked, and what existing "legacy" networks should be supported and grafted to the new network.

a) Which software packages are proposed to implement the target applications?

b) What hardware platform (type, size and speed of PC) will be required to run the software?

c) Can existing computers be used, or will they require replacement?

d) Can existing computers be upgraded (higher speed CPU, add DOS card to Mac, etc)?

e) If existing computers require replacement, should they be redeployed to less demanding tasks?

f) To what extent will expenditure on replacement PC's and software reduce the available budget for networking?

3 NETWORKING TRENDS

Local Area Network (LAN) technology has been available for over fifteen years. The first decade of LAN technology development was a period in which corporate computing users were gradually adapting to the new technology and steadily rolling it out within organizations on a department basis. The technology options for implementing corporate LANs during this period consisted primarily of “Ethernet” and “Token Ring” products which would deliver on the average approximately 200 Kbps to 500 Kbps per user and no more than 10 Mbps to 16 Mbps for an entire network. This first phase of LAN market growth was characterized by an increasing penetration of LAN technology into corporate computing environments.

Within the last five years, the corporate computing marketplace has been almost completely converted to the LAN-based model, with over 80% of all PCs now attached to corporate LANs. As the use of corporate LANs for supporting critical business functions has been increased, so has the importance of speeding the rate at which these LANs process this critical corporate information. This trend has recently fueled the development of multiple new higher speed LAN technologies such as LAN switching, multiple 100 Mbps Ethernet replacements and ATM-the ultimate high speed LAN/WAN technology.

4 STANDARDS

4.1 International Standards

The TIA is not the only standards body considering extended performance cabling. The International Standards Organization (ISO) has initiated work on the definition of Category 6 and 7 cabling. Category 6 cabling will specify transmission parameters upto 200 MHZ while Category 7 cable will extend to 600 MHZ. Category 6 and 7 specifications will be included in the second edition of the ISO/IEC 11801 standard. However, the definition of Category 6 and 7 is at an early stage with no input from U.S. at this time. Final ratification is not expected until the year 2000 at the earliest. Reference guide to EIA/TIA Standards are given in **Annex I**

4.2 Industry Standards.

The advantage of sticking to the industry standards is the knowledge that your cabling will be compatible with standards applications. The disadvantage is that standards organizations seem to take their good old time ratifying the standards. The final standard may also be different than the proposed standard, but the differences are usually minimal. You will often see cable listed as meeting proposed standards. For example, the proposed standard for Category 6 is 250 MHZ, and the proposed standard for Category 7 is 600 MHZ.
The important thing to remember is this: **the proposed standards are improvements over Category 5 and Category 5e cable, and should serve you well in terms of speed and headroom for future applications.**

4.3 Structured Cabling standards

Network managers face a difficult challenge when fitting up a new corporate facility. They must ensure that every possible employee location is accessible to the corporate LAN, but they must also ensure that each of these locations can successfully work with a potentially broad range of new high speed LAN technologies, since these technologies are rapidly gaining in importance and becoming cost effective.

The solution to these challenges lies in implementing a structured cabling system within a new facility. Such a system must extend to every employee work area and must be able to support all of the existing LAN technologies and all of the new and emerging high speed LAN technologies, since it is impossible to predict where within a facility the highest capacity users will be at any time in the future.

The group, which sets standards for structured data wiring in the United States, is the Telecommunications Industry Association, or TIA. The TIA 568A standard defines multiple categories or grading of structured wiring system performance, with the category 5 designation as the highest currently standardized. The TIA 568A category 5 specifications are the basis to which many of the new high-speed LAN technologies are targeted.

4.4 Highlights of the EIA/TIA-568A standards

Purpose

- To specify a generic voice and data telecommunications cabling systems that will support a multi-product, multi-vendor environment.
- To provide direction for the design of telecommunications equipment and cabling products intended to serve commercial enterprises
- To enable the planning and installation of a structured cabling system for commercial buildings that is capable of supporting the diverse telecommunications needs of building occupants
- To establish performance and technical criteria for various types of cable and connecting hardware and for cabling system design and installation

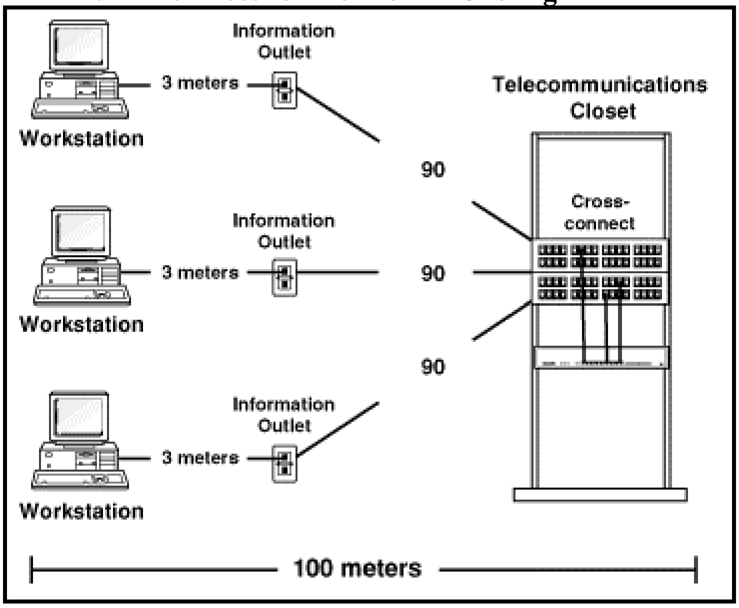
Scope

- Specification are intended for telecommunications installation that are " Office oriented"
- Requirements are for a structured cabling system with a usable life in excess of 10 years
- Specification addressed:
  (a) Recognized Media – cable and connecting hardware
  (b) Performance
  (c) Topology
  (d) Cabling distances
  (e) Installation Practice
  (f) User interface
  (g) Channel Performance

  Cabling Elements

- Horizontal cabling:
  a) Horizontal Cross-connect (HC)
  b) Horizontal Cable
  c) Transition point (optional)
  d) Consolidation Point (optional)
  e) Telecommunications-Outlet (Connector(TO)

Maximum Distances for Horizontal Cabling



In addition to the 90 meters of horizontal cable, a total of 10 meters is allowed for work area and telecommunications closet patch and jumper cables.

- Backbone Cabling:
  a) Main Cross-connect (MC)
  b) Interbuilding Backbone Cable
  c) Intermediate Cross-connect (IC)
  d) Intrabuilding Backbone Cable
- Work Area (WA)
- Telecommunications Closet (TS)
- Equipment Room (ER)
- Entrance Facility (EF)
- Administration**

** *Although administration is addressed to a limited extent, the governing specification on telecommunications administration is ANSI/EIA/TIA-606.*

5 STRUCTURED CABLING

5.1 Structured Cabling System Design Considerations

The six subsystem of a Structured Cabling System are as follows:

A. Building Entrance

Building entrance facilities provide the point at which outside cabling interfaces with the intrabuilding backbone cabling. The physical requirements of the network interface are defined in the EIA/TIA-569 standard.

B. Equipment Room

The design aspects of the equipment room are specified in the EIA/TIA-569 standard. Equipment rooms usually house equipment of higher complexity than telecommunication closets. An equipment room may provide any or all of the functions of a telecommunications closet.

C. Backbone Cabling

The backbone cabling provides interconnection between telecommunications closets, equipment rooms and entrance facilities. It consists of the backbone cables, intermediate and main cross-connects, mechanical terminations and patch cords or jumpers used for backbone-to-backbone cross-connection. This includes:

- Vertical connection between floors (risers)
- Cables between an equipment room and building cable entrance facilities
- Cables between buildings (inter-building)

Cabling Types Recognized and Maximum Backbone Distances

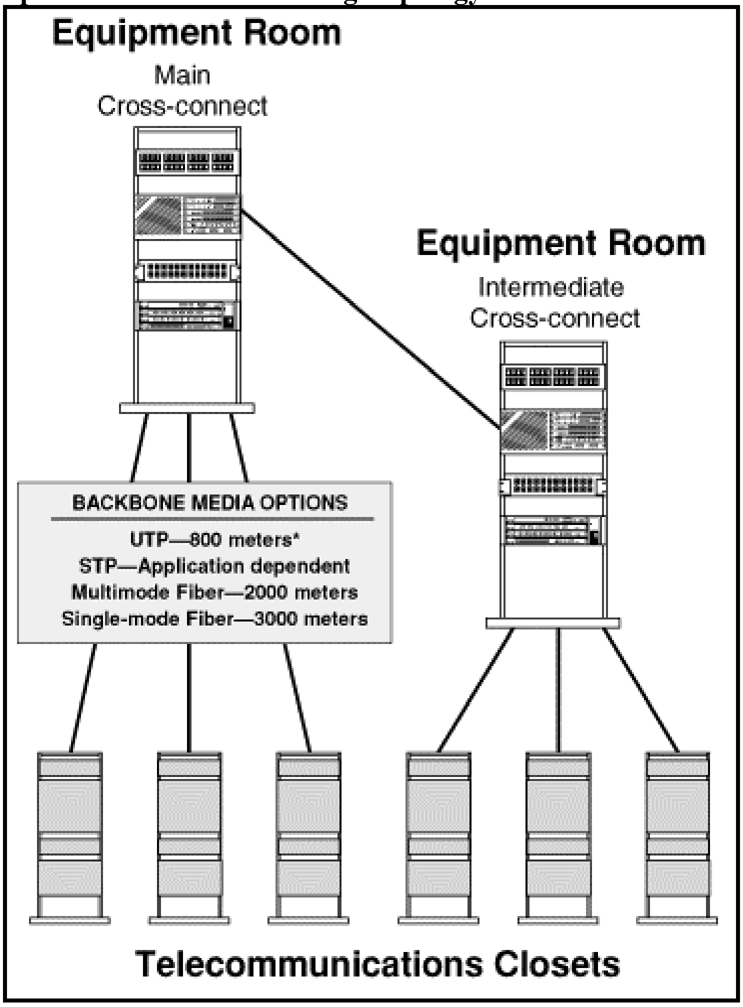
100 ohm UTP (24 or 22 AWG)	800 meters (2625 ft) Voice*
150 ohm STP	90 meters (295 ft) Data*
Multimode 62.5/125 µm optical fiber	2,000 meters (6560 ft)
Single-mode 8.3/125 µm optical fiber	3,000 meters (9840 ft)

***Note**: Backbone distances are application dependent. The maximum distances specified above are based on voice transmission for UTP and data transmission for STP and fiber. The 90 meter distance for STP applies to applications with a spectral bandwidth of 20 MHz to 300 MHz. A 90 meter distance also applies to UTP at spectral bandwidths of 5 MHz - 16 MHz for CAT 3, 10 MHz20 MHz for CAT 4 and 20 MHz100 MHz for CAT 5.

Other Design Requirements

- Star topology
- Bridge and taps are not allowed
- Main and intermediate cross-connect jumper or patch cord lengths should not exceed 20 meters (66 feet)
- Grounding should meet the requirements defined in EIA/TIA 607
- Equipment connections to backbone cabling lengths of 30m (98ft) or less.
- The backbone cabling shall be configured in a star topology. Each horizontal cross-connect is connected directly to a main cross-connect or to an intermediate cross-connect, then to a main cross-connect.
- The backbone is limited to no more than two hierarchical levels of cross-connects (main and intermediate). No more than one cross-connect may exist between a main and a horizontal cross-connect and no more than three cross-connects may exist between any two horizontal cross-connects.
- A total maximum backbone distance of 90m(295ft) is specified for high band-width capability over copper. This distance is for uninterrupted backbone runs. (No intermediate cross-connect)
- The distance between the terminations in the entrance facility and the main cross-connect shall be documented and should be made available to the service provider.
- Recognized media may be used individually or in combination, as required by the installation. Quantity of repairs and fibers needed in individual backbone runs depends on the area served.
- Avoid installing where sources of high levels of EMI/RFI may exist

Specified Backbone Cabling Topology: Star

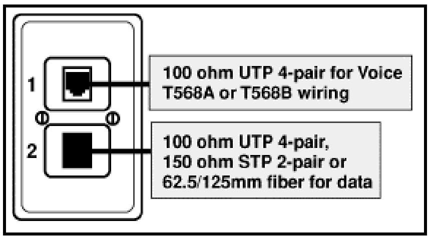


TIA Backbone Cable Distance (MC to HC)

- Singlemode Fiber………………………..3000m(9840ft)
- 62.5/125um Multimode Fiber……………2000m(6560ft)
- UTP Copper Applications<5Mhz………..800m(2625ft)

D. Telecommunications Closet

A telecommunications closet is the area within a building that houses the telecommunications cabling system equipment. This includes the mechanical terminations and/or cross-connect for the horizontal and backbone cabling system.



E. Horizontal Cabling

The horizontal cabling system extends from the telecommunications outlet in the work area to the horizontal cross-connect in the telecommunications closet. It includes the telecommunications outlet, an optional consolidation point or transition point connector, horizontal cable, and the mechanical terminations and patch cords (or jumpers) that comprises the horizontal cross-connect.

- Customer Premises Equipment
- HC Equipment Cord
- Patch-cords/cross-connect jumpers used in the HC, including equipment cables/cords, should not exceed 6m (20ft)
- Horizontal cable 90m (295ft) max. total
- TP or CP (optional)
- Telecommunications outlet/connector(TO)
- WA Equipment cord
  Note: An allowance is made for WA equipment cords of 3m (9.8ft)
  Note:
  An allowance of 10m (33ft) has been provided for the combined length of patch cords/cross-connect jumpers and equipment cables/cords in the HC, including the WA equipment cords.

Some points specified for the horizontal cabling subsystem include:

- Application specific components shall not be installed as the part of the horizontal cabling. When needed, they must be placed external to the telecommunications outlet or horizontal cross-connect(eg. Splitters, baluns)

- The proximity of horizontal cabling to sources of EMI shall be taken into account.

- Recognized Horizontal Cables:
  a) One transition point (TP) is allowed between difference forms of the same cable type (i.e where undercarpet cable connects to round cable)
  b) 50 ohm coax cabling is recognized by 568-A but is not recommended for new cabling installations.
  c) Additional outlets may be provided. These outlets are in addition to and may not replace the minimum requirements of the standard.
  d) Bridged taps and splices are not allowed for copper-based horizontal cabling (splices are allowed for fiber)

The horizontal cabling shall be configured in a star topology; each work area outlet is connected to a horizontal cross-connect(HC) in a telecommunications closet(TC)

F. Work Area

The telecommunications outlet serves as the work area interface to the cabling system. Some specifications related to work area cabling include:

- Equipment cords are assumed to have the same performance as patch cords of the same type and category
- When used, adapters are assumed to be compatible with the transmission capabilities of the equipment to which they connect.

  Horizontal cable lengths are specified with the assumption that a maximum cable length of 3m (10ft)

Work Area Components

- **Station Equipment** computers, data terminals, telephones, etc.
- **Patch Cables** modular cords, PC adapter cables, fiber jumpers, etc.
- **Adapters** baluns, etc. **must be external to telecommunications outlet**

  is used for equipment cords in the work area.

Note: For establishing maximum horizontal link distances, a combined maximum length of 10m (33ft) is allowed for patch cables (or jumpers) and (or equipment cables in the work area and the telecommunications.

6 NETWORK CABLES

Cable is the medium through which information usually moves from one network device to another. There are several types of cable, which are commonly used with LANs. In some cases, a network will utilize only one type of cable; other networks will use a variety of cable types. The type of cable chosen for a network is related to the network's topology, protocol, and size. Understanding the characteristics of different types of cable and how they relate to other aspects of a network is necessary for the development of a successful network.

6.1 Unshielded Twisted Pair

UTP may vary from telephone-grade wire to extremely high-speed cable. This cable has four pairs inside the jacket. Each pair is twisted with a different number of twists per inch to help eliminate interference from adjacent pairs and other electrical devices.

UTP can support telephone, 4 & 16 Mb/s Token Ring, Ethernet, 100 Mb/s Ethernet, Copper FDDI (CDDI), 155 Mb/s ATM. UTP cable is rated by the EIA/TIA standards into categories. Among these the best value on pricing is Category 3 and Category 5. However, Category 3 is rated to 10 MHz, suitable for Ethernet (10 Mb/s), and Category 5 is rated to 100 MHz, suitable for Fast Ethernet (100 Mb/s) and ATM (155 Mb/s).

There is also Category 5e (Enhanced Category 5). It is the recently ratified standard designed to make the world safe for full-duplex Fast Ethernet. The main difference between Category 5 and Category 5e can be found on the specifications and the performance has been raised slightly. UTP cable is generally wired in the star topology due to the troubleshooting advantages associated with stars.

6.2 Shielded Twisted Pair

A disadvantage of the UTP is that it is susceptible to radio and electrical frequency interference. Shielded Twisted Pair is suitable for environments with electrical interference. It has a foil shielding which can block out the electrical interference, but this makes the cable bulky and often difficult to work with and it uses a Universal Data Connector. However, a new version of STP cable introduced and promoted by companies like ITT Datacomm uses RJ-45 connector. It is not bulky, and it is easy to work with. It has a much better signal carrying capability than the UTP.

6.3 Fiber-Optic Cable

Fiber Optic cabling consists of a center glass core surrounded by several layers of protective materials. Fiber optic cable offers up the possibility of very high bandwidth and perfect immunity to noise. It transmits light rather than electronic signals, eliminating the problem of electrical interference. This makes it ideal for environments with large amount electrical interference and it has also been made a standard for connecting networks between buildings, due to its immunity to the effects of moisture and lightning.

Fiber optic cable has the ability to transmit signals over much longer distances than coaxial and twisted pair. It also has the capability to carry information at vastly greater speeds. This capacity broadens communication possibilities to include services such as video conferencing and interactive services. However, it costs significantly more to purchase fiber optic cable, connectors, patch panels, jumper cables, tools and network interface cards. It is also difficult to install and modify.

There are two types of fiber optic cabling- multimode (MMF) and singlemode (SMF). Light propagates through the core (central portion) of optical fiber. Multimode fiber, with a typical core diameter of 62.5 microns or 50 microns, is designed for coupling light from low cost LED-based transmitters. Singlemode fiber has a core diameter of 10 microns and is only suitable for laser-based transmission. Much of the installed base of optical fiber supporting LAN backbones is multi-mode because most of the current-generation 10 or 100 Mb/s LAN equipment is LED-based.

Gigabit Ethernet operating at 1.25 Gbps is too fast for LEDs and requires the use of lasers. Traditionally, laser –based data transmission has been used with singlemode fiber. The 1000Base-X standard has introduced laser-based transmission over multimode fiber and this new type of transmission has introduced new types of physical layer issues.

6.4 Evolution of UTP Categories

With the publication of TIA/EIA-568 standard in 1991 the term “Category” made it’s way into the jargon of cable installers and LAN managers to describe the performance characteristics of UTP cabling systems. Initially, category 3 cable was the biggest seller for use in structured cabling systems capable of running voice traffic and 10Base-T LAN traffic. Category 4 was introduced soon after to provide a higher grade of cable capable of running 16 Mb/s Token Ring networks. With advent of 1ooBase-TX,Category 4 soon gave way to Category 5 cabling, which now constitutes the vast majority of installed data cabling runs.
Recently, it has become clear that Gigabit Ethernet (1000Base-T) will also force some changes in UTP cabling standards and installation practices. Specifically, 1000Base-T will require a more thorough specification of cabling performance than has been used in the past for Category 5 UTP. In addition, due to noise margin concerns, a new cabling category (5E) has been defined to better support new 1000Base-T installations.

Cable Category	**Network Application Primarily Designed to Support**	**Year of Cabling Standard**
Category **3**	Voice, 10Base-T	1991
Category **4**	Token Ring 16 Mb/s	1993
Category **5**	100Base-TX (Fast Ethernet)	1994
Category **5E**	1000Base-T (Gigabit Ethernet) New Installation	1998
Category **6,7**	None proposed at this time	No schedule defined: unlikely before 2000

Gigabit Ethernet-The stimulus for new cabling requirements.

The prospect of Gigabit Ethernet has generated much excitement and discussion in the networking industry. The draft IEEE 802.3 standards that define Gigabit Ethernet have been under development for two years. The 802.3z specification for Gigabit Ethernet over fiber optic and twinax cabling (1000Base-SX,LX and CX) was ratified in June 1998.

The IEEE 802.3z (1000Base-SX & 1000Base-LX) standard defines the requirements for Gigabit Ethernet operation over multimode and singlemode fiber optic cabling. This standard was ratified in June of 1998. Initially, most end users will deploy Gigabit Ethernet in their network backbones, where fiber typically is the medium of choice. The IEEE 802.3ab (1000base-T) standard will be ratified in 1999, paving the way for the eventual deployment of Gigabit Ethernet to the desktop over the installed base of Category 5 or Enhanced Category 5 twisted pair cabling.

For Video Conferencing and Tele-medicine the Gigabit Ethernet is the appropriate technology and for other critical applications. The hardware required to be installed for gigabit Ethernet are gigabit hub/switch, UTP cat E5 and above.

The IEE 802.3 working group was formed in July 1996 and standards work has been in full progress ever since. The initial goal was to ratify and publish the IEEE 802.3z standard by January 1998. The actual date was pushed out to June 1998. The reason for the delay has been the complexity of running Gigabit speeds over multimode fiber. The original goal was to support multimode fiber drive distances upto 500 meters to support campus backbone architectures. While that distance is still achievable for some types of multimode fiber, maximum distance limits have been revised downwards for other types of multimode fiber.

Gigabit Ethernet Standard	**Media Types Supported**	**Anticipated Release Date**
1000Base-SX (802.3z)	Multimode Fiber	June 1998
1000Base-LX (802.3z)	Multimode or Singlemode Fiber	June 1998
1000Base-CX (802.3z)	Twinax jumper for interconnecting Equipment	June 1998
1000Base-T (802.3ab)	.Category **5** UTP (if re-tested for ELFEXT, return loss and skew) .Category **5E** UTP (recommended for new cable installations)	Q2 1999

6.5 Category 5E

A new cabling Category 5E (E=Enhance) is being specified explicitly to handle the challenges of gigabit traffic. The specifications for Category 5E cabling and testing procedures are covered under TIA documents SP4194 and SP4195.Rquirements for Return Loss and ELFEXT will be added in SP4195 which is expected to be published as addendum 4 to the TIA/EIA-568-A. SP4194 is expected to be published as a Technical Systems Bulletin (TSB-95) which will modestly tighten the limits for installed category 5 cabling parameters like NEXT,FEXT, and Return Loss in order to provide improved noise margins for 1000Base-T equipment. TIA is presently working on completing SP4194 and SP4195, in an effort to define the new cabling parameters (ELFEXT, return loss, and skew)before the 1000Base-T standard is published.

6.6 Category 6 & 7

Recently, there has been much speculation about possible future Category 6 & 7 cabling standards. So how real are Category 6 & 7 standards at this point? No LAN applications have yet emerged which require cabling performance beyond Category 5E. Initial conceptual discussions of Category 6 & 7 have occurred at TIA, but specific characteristics have only been defined in very early draft form. At this time, the frequency limit and the cabling specifications are still under discussion. Final ratification of any potential Category 6 & 7 standard is probably at least 1-2 years away. Since no definitions for Category 6 & 7 have been published, it is not possible to currently field test for a “Category 6 & 7” cabling system.

6.7 Comparison of Cable Media.

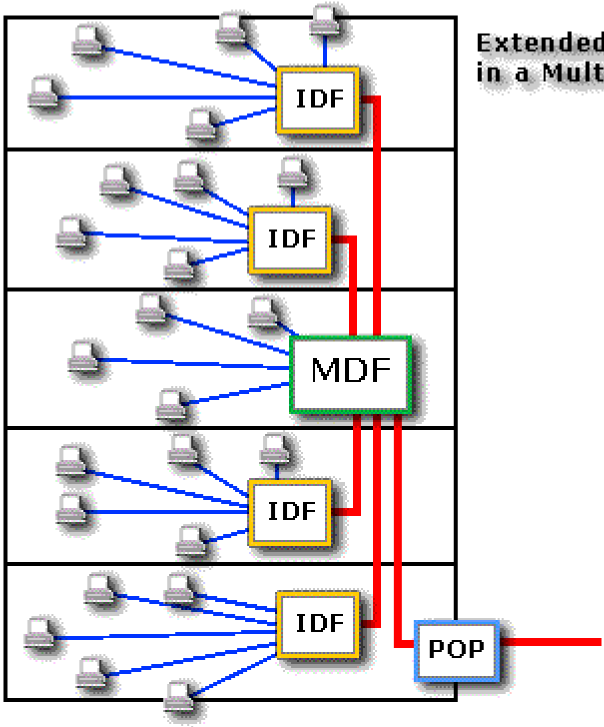
Cable Type	Cost	Installation	Capacity	Range	EMI
Coaxial Thinnet	Less than STP	Inexpensive/easy	10Mbps typical	185 m	Less sensitive than UTP
Coxial Thicknet	Greater than STP, less than fiber	Easy	10Mbps typical	500 m	Less sensitive than UTP
Shielded twisted pair (STP)	Greater than UTP, less than thicknet	Fairly easy	16Mbps typical to 500Mps	100 m typical	Less sensitive than UTP
Unshielded twisted pair (UTP)	Lowest	Inexpensive/easy	10Mbps typical up to 100Mbps	100 m typical	Most Sensitive
Fiber Optic	Highest	Expensive/Difficult	100Mbps typical to as high as 200,000 Mbps	10s of kilometres	Insensitive

When comparing cabling types, remember that the characteristics you observe are highly dependent on the implementations, such as the network cards, hubs, and other devices used. Engineers once thought that UTP cable would never reliably support data rates above 4Mbps, but 100Mbps data rates are now common. Some comparisons between cable types are fairly involved. For example, although fiber-optic cable is costly on a per-foot basis, it may be the most cost-effective alternative when you need to run a cable for many kilometers. To build a copper cable many kilometers in length, you need to install repeaters at several points along the cable to amplify the signal. These repeaters could easily exceed the cost of a fiber-optic cable run.

6.8 Category Specifications

EIA/TIA category specifications provide for the following cable transmission speeds with specifications:

- Category 1 = No performance criteria
- Category 2 = Rated to 1 Mhz (used for telephone wiring)
- Category 3 = Rated to 16 Mhz (used for Ethernet 10 Base-T)
- Category 4 = Rated to 20 Mhz (used for Token ring, 10 Base-T)
- Category 5 = Rated to 100 Mhz (used for 100 Base-T, 10 Base-T)



Extended Star Topology
in a Multi-Story Building

7 NETWORK SET UP

7.1 Node locations

Having selected which PC's, printers and dumb terminals are to be connected to the network initially or in the future, all such network "nodes" must be located on a plan of the building, which is approximately to scale.

7.2 Locating Hubs

It is desirable to have hubs/switches in rooms or closets, which are secure from unauthorized access. It is also desirable to have such hubs/switches at least 1 m away from any switchboards.

Looking at the site node map, make an initial selection of potential hub/switch locations, such as offices, store rooms, preferably close to larger concentrations of computers. In a multi-storey building, the hub will generally be near the building core. *(fig)*

Draw circles of a 50 m radius from each of the hub locations and ensure all nodes fall within one such circle (the hub "catchment" area). Scattered outlets may be outside this radius, but not too far (say no more than 15 m).

Consider eliminating hub locations whose catchment areas substantially overlap. Hubs may serve more than one floor, providing a vertical cable path exists between them.

Select one hub as the campus hub. This should be located at a point within easy reach of the person likely to be responsible for network administration, but it should also be readily accessible for adding future backbone cables, and preferably towards the centre of the campus. On large sites it is generally the computer room.

Hubs may serve more than one building, providing a viable cable path can be found between buildings and both buildings share the same electrical earth and distribution. Possibilities include:-

- Install underground in existing or new conduits. New conduit usually required, and most easily installed if route is grass or garden. Special underground cat 5 cable must be used to guard against moisture damage.
- Run in conduit or clip on cover rectangular duct under covered walkways
- Overhead catenaries between buildings (probably the only practical approach with transportable buildings).

7.3 Selecting Backbone Routes

Having located hubs, a means of connecting all the workgroup hubs back to the campus hub must be found. In the past, this was achieved by running a Thin or Thick Ethernet coaxial cable in a daisy chain manner between all hubs. However, this approach has the limitation that all the network traffic is carried on one wire, and a break anywhere in that wire can potentially bring the whole network down. The coaxial sheath can also cause the power supply in buildings to be linked in an unintended manner, which causes surge voltages on the LAN if a any electrical fault occurs or a fuse blows in one of the buildings.

The structured cabling system approach is to provide separate fibre optic cable pairs (one for transmit and one for receive) radiating out from the campus hub to each workgroup hub. Where voice traffic (telephone, ISDN, etc) is also reticulated through the scheme, multi-pair cable is also provided for this purpose from a PABX frame/patch panel or MDF to a patch panel or "pair management frame" at each hub location. Usually one or more spare fibre pairs would be provided to each hub location in case segmentation of the network occurs in the future, or to make direct connections to remote file servers.

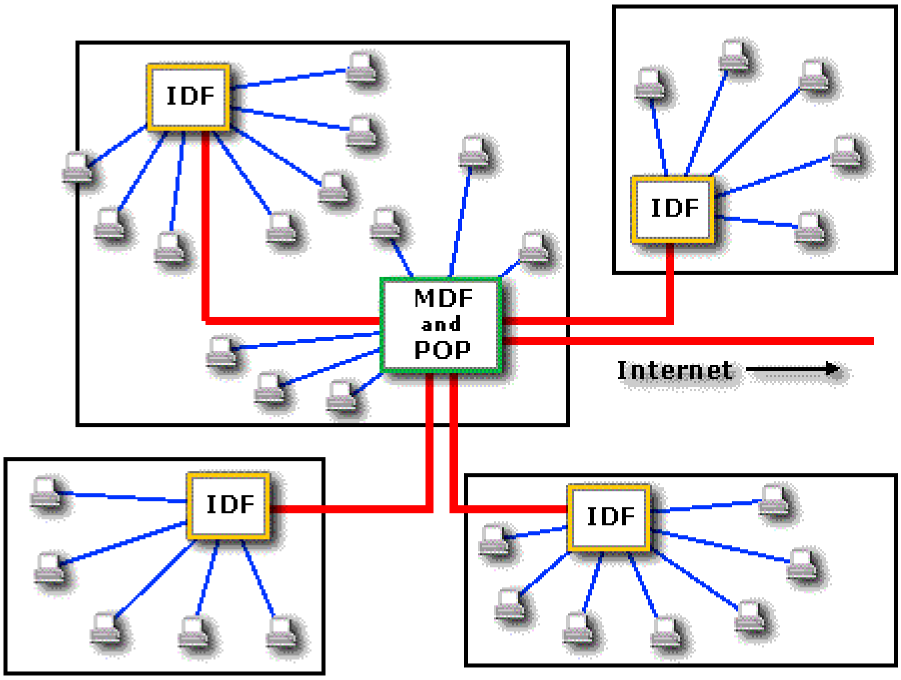
If hubs are in the same building, it might be possible to link them using Cat 5 cable providing equipment at either end is suited to it and there are no lightning protection, surge, or earthing issues which could cause problems (generally more applicable to multi-storey buildings).

The way the fibre optic cable is laid depends on the topology of the campus, and the staging of network implementation. Possibilities include:-

- Cluster style campus, individual cables radiating out from campus hub like spokes on a wheel.
- Ring style campus:- Cables radiate around the ring, possibly all being laid in the same conduit or duct until they exit to a workgroup. A multi-fibre cable may be laid along part of the route to a workgroup patch panel, which is then patched to smaller individual cables continuing on to other hubs.
- Straight line type campus:- As for ring, except cables are laid in a straight line along the campus.

7.4 Linking Workgroups at the campus Hub

Although literature gives the impression that fiber will handle very high data speeds, in reality, the speed of data on a fiber is governed by the available data interface to it. The standard interfaces are 10



Extended Star Topography in a Multi-Building Campus

Mbit/sec just like twisted pair or coax. Higher speeds can only be achieved by purchasing Fast Ethernet (100baseFx, 100Mbit/s), Fibre Distributed Data Interface (100 Mbit/sec) or ATM (155 Mbit/sec) network equipment, which are generally only economic if the network has hundreds of workstations.

All network traffic between workgroup hubs passes through the campus hub. A means of connecting all the fibre radiating out to the hubs is required. The connection can be made in a number of ways:-

- Multi-port fibre optic repeater:- Broadcasts data from any connected workgroup/fibre to all others. Unless bridges are located elsewhere, all parts of the network will carry the entire campus traffic.
- Multi-port switch or bridge:- Only allows traffic from workgroup connected to any particular port intended for other workgroups to pass between ports (stops local workgroup traffic from slowing down the campus network). Some switches/bridges can filter traffic to prevent nodes from accessing selected other nodes or have VLAN capability (distinct virtual LANs). At a switch or bridge, traffic is regenerated, so in terms of network rules, the bridge is the start of a new network. The market is predominantly for switching these days. **Switches are most effective when used with centralized file servers connected directly to switch ports** (eg all file servers in one room or area) and on **large networks** (over 50 PC's).
- Multi-port Router:- Decodes source and destination node addresses of data packets incoming, and forwards them to intended work-group and node. Can have very complex restrictions on the type of traffic which can pass through, and who can talk to who. As for switch, traffic is regenerated, but with some time delay. Can also change network data speed for connection to lower speed outside links. Usage as for switch/bridge.

The minimal installation for any site with more than two hubs is a multiport repeater. Two hubs can be linked by cascading one hub off a single repeater port on the other hub.

7.5 Checking Proposed Approach

After creating a draft plan of action, it will be desirable to verify that the proposed network architecture is practical, and to confirm that important issues haven't been overlooked.

Options for checking proposals include:-

- Engage independent consulting engineer to do a review
- Engage software consultant to review software approach.
- Discuss with potential equipment suppliers and cabling contractors
- Discuss with software vendors
- Discuss with IT Branch of organization
- Discuss with comparable businesses at a more advanced stage of implementation

Engaging consultants will involve expenditure, but may speed the deployment process up by allowing key issues to be quickly identified, and questions to be directly and independently answered.

7.6 Linking Buildings

If links between buildings are required as part of the project, a number of decisions need to be taken to select and specify the appropriate cabling. These include:-

- Will link be run overhead? If so, will it be enclosed in conduit, or will it be out door rated cable?
- Will link be run underground? If so, it will need to be jelly filled moisture barrier cable, usually loose tube construction.
- Is an existing underground route available? If not, planning should allow for other compatible services over the same route, such as security, voice, control.
- Will the route be subject to vermin attack? If so, armoured cable or enclosure in conduit will be required.
- Will the cable be required to carry broadband TV in the future? If so, it should contain some single mode fibre pairs.

Some contractors will offer warranties from 5 to 20 years on any work done, which can provide added confidence, although any work carried out in accordance with the standards and correctly engineered, supervised and tested will meet this requirement.

Keep an eye during installation to ensure that facilities are being provided in the expected manner, and that all outlet lines are tested to Cat 5 specs before completion is claimed.

7.7 Selecting Equipment

Whilst cabling is being installed, hub equipment can be purchased. This equipment will interface to all the cabling provided, and transfer data traffic between workstations, file servers, and internet links.

Draw a schematic diagram of the network proposed showing work-groups, file servers, printers, hubs and backbone routes, in a way, which illustrates the functional and physical relationships of the workgroups.

Create a list of what applications the network is to run, what the preferred NOS selected will be (eg Windows NT4/2000), and what the connectivity objectives of the network are.

Vendors can then be approached to provide suitable equipment to utilize the cabling infrastructure provided, and meet the stated objectives. Include installation and commissioning if necessary.

Hub equipment required will be as follows:-

- **Hub back planes or chassis**:- required at each hub location where plug-in style hubs are to be used. Provides common power supply and interconnection medium.
- **Workgroup Concentrators**:- Alternative to hub chassis. Generally used with stackable hub systems, and comprises repeater, fibre optic backbone interface, power supply, and network management interface in one box.
- **UTP (10BaseT) repeaters**:- Usually come with 8, 12, 16, 24 or 32 ports. One port required for each connected workstation, file server or printer. Must have stacking connection to work with stackable hubs.
- **Miniature (8-port or 16 port) local repeaters**:- Used to connect a cluster of PC's in a room to a single hub closet repeater port, or where 15 or fewer PC's are likely to be connected at a hub location. Use outboard fibre optic to 10BaseT or AUI converter to connect to fibre backbone if necessary.
- **Fibre Optic Media Interfaces**:- Required to connect hub to fibre. Basically a single port repeater or plug in circuit adaptor for a hub.
- **Fibre Optic Multi-Port Repeater or switch**:- Used at campus hub to interconnect fibres.
- **Switch**:- Used to isolate backbone workgroups and servers to allow concurrent sessions within and between segments

The number of different equipment types used should also be minimized, so that equipment is easily interchangeable around the campus, and equipment replaced in one area can be used to boost capacity elsewhere. If spares are to be held on site, equipment rationalization will minimize the inventory.

8 SYSTEM ADMINISTRATION

8.1 Justification

It is vital that documentation be kept for a variety of reasons. Good documentation will:

- Enable a completely unfamiliar person to quickly grasp the network topology. This is most important in an environment where frequent staff changes can be expected.
- Help the network to grow in a planned and well structured manner, allowing the best use of available budget.
- Assist others involved with your network such as cable installers, network trouble-shooters and consultants. By enabling them to see exactly what is in place, they will save time and understand exactly what is required, which will result in cost savings.
- Provide a valuable tool for locating faults when things go wrong.
- Assist recovery of insurance in the event of fire or theft.

8.2 Details to Record

The documentation need not be time-consuming or overly formal, but at a minimum the following details should be kept together, preferably in a loose leaf binder.

- Drawings showing the location of cable runs, (preferably with individual cable lengths marked for any legacy thin Ethernet runs).
- Size and occupancy of any existing cable ducts or conduits, which are available for use when expanding the network.

- Details of the capacity and type of cabling and connectors used.
- Details of type of connectors or sockets at either end of each cable (blanket statements adequate).
- Records of the designation and location of outlets.
- Any certification carried out on the cabling (e.g. Cat5 test results).
- Diagrams showing the relationships of various workstations, file servers, printers and other devices on the network to one another.
- **Diagrams showing how any hubs, bridges, switches or routers are used to connect the network (may be shown on a network management system).**
- Records of software licenses and versions of software installed.
- Configurations of NICs in workstations.

Purchase of a copy of the standard is suggested for the System Administrator.

8.3 Patching and Jumpering Records

Patching records should be retained at each patch panel or cross- connect. These should identify relationship between hub and switch ports, patch panel ports, and end user devices. Spreadsheets can be used to automate this process. Databases and cable management systems may be used to provide added sophistication, but can be cumbersome to enter data and maintain it.

8.4 System Administration

In most occasion networking is not simply a matter of connecting a group of computers together at a hub. The network requires special software called a Network Operating System to allow communication between the various devices. The NOS software does not simply run itself either. It requires a person called the System Administrator to perform administrative functions using the NOS software to do such things as make backups of files, keep the traffic flowing smoothly, and ensure various users have authorization and access to communicate with printers, the Internet, and other computers. When the computer system crashes the System Administrator will bring it back to working condition. When new users or equipment are admitted to the network the System Administrator must update records in the NOS to allow the new users or equipment to be used.

The amount of time and skill required of the System Administrator depends on the size of the network. For a network of 10 computers perhaps only an hour per week would be required on average. For a network of 100 computers, more like 10 hours per week would be required on average. More complex networks involving bridges, routers or Internet servers require more time and skill than simple networks.

8.5 Maintenance and Repair

Inevitably some equipment will fail or need upgrading. A large network of more than 100 computers may require a technician for 20 hours per week. For a small network of 10 computers it may be more cost effective to have a competent member of staff perform the necessary upgrades, or take the equipment to a repair agent. It is worthwhile considering how these issues will be addressed, and perhaps whether a service contract is required with a computer supplier or agent.

9 SOME GUIDELINES

9.1 Unshielded Twisted Pair cable (UTP) separation guidelines from Electro-magnetic Interference (EMI) sources.

Condition	< 2KVA	2-5KVA	>5KVA
Unshielded power lines or electrical equipment in			

the proximity to open or non-metal pathways	5 inches or 12.7 cm	12 inches or 30.5 cm	24 inches or 61 cm
Unshielded power lines or electrical equipment in the proximity to grounded metal conduit pathway	2.5 inches or 6.4 cm	6 inches or 15.2 cm	12 inches or 30.5 cm
Power lines enclosed in a grounded metal conduit (equivalent shielding) in the proximity to grounded metal conduit pathway	-	6 inches or 15.2 cm	12 inches or 30.5 cm
Fluorescent lighting	12 inches or 30.5 cm		
Transformers & electric motors	40 inches or 1.02 meter		

9.2 Minimum bending radius for a cable

According to EIA/TIA SP-2840A the minimum-bending radius for UTP is 4 x cable outside diameter, about 1 inch. For multi-pair cable the minimum bending radius is 10 x outside diameter.

For fiber optic cables not in tension, the minimum bend radius is 10 x diameter; cables loaded in tension may not be bent at less than 20 x diameter. SP-2840A states that no fiber optic will be bent on a radius less than 3.0 cm (1.18 inches).

Minimum for pulling during installation is 8 x cable diameter, minimum installed radius is 6 x cable diameter for riser cable, 4 x cable diameter for horizontal cable.

9.3 Recommended Cabling Practices.

Do's	Don'ts
• Use connecting hardware that is compatible with the installed cable	♦ Do not use connecting hardware that is of a lower category than the cable being used
• Terminate each horizontal cable on a dedicated telecommunications outlet	♦ Do not tap a new line from the middle of another cable (called bridge taps), as it picks up more noise. Do not leave cables un-terminated.
• Locate the main cross-connect near the center of the building to limit cable distances	♦ Do not locate cross-connects where cable distance will exceed the maximum allowed distance.
• Maintain the twist of horizontal and backbone cable pairs upto the point of terminations	♦ Do not leave any wire pairs untwisted (Keep the twist until the closest possible places to the terminations).
• Tie and dress horizontal cables neatly and with a minimum bend radius of 4 times the cable diameter	♦ Do not over-tighten cables ties. Never use staples or make sharp bends with cables
• Place cabling at a sufficient distance from equipment	♦ Do not place cable near equipment that may generate high levels of EMI (i.e.; electricity wire (power line) and fluorescent light).

When running cable, it is best to follow a few rule of thumb:

- **Always use more cable than you need. Leave plenty of slack.**
- **Test every part of a network as you install it. Even if it is brand new, it may have problems that will be difficult to isolate later.**
- **Stay at least 3 feet away from fluorescent light boxes and other sources of electrical interference.**

- **If it is necessary to run cable across the floor, cover the cable with cable protectors.**
- **Label both ends of each cable.**
- **Use cable ties (not tape) to keep cables in the same location together.**
- **The conduit or casing should not be filled completely with the cables. There should be room for future expansion.**

9.4 UTP cabling installation practices

- To avoid stretching, pulling tension should not exceed 110N or (25 lb *f*) for 4-pair cables.
- Installed bend radii shall not exceed: - 4 times the cable diameter for horizontal UTP cables. – 10 times the cable diameter for multi-pair backbone UTP cables.
- Avoid cable stress, as caused by:- cable twist during pulling or installation – tension in suspended cable runs – tightly clinched cable ties or staples – tight bend radii.

- Horizontal cables should be used with connecting hardware and patch cords (or jumpers) of the same performance category or higher.
- Important Note: Installed UTP cabling shall be classified by the least performing component in the link.

9.5 Installation of Optical Fiber Connecting Hardware

The specifications on optical fiber cabling consist of one recognized cable type for horizontal subsystems and two cable types for backbone subsystems:

a) Horizontal – 62.5/125 um multimode (two fibers per outlet)
b) Backbone – 62.5/125 um multimode or singlemode

The following are some of the guidelines to be followed during installation of Optical fiber connecting hardware:

- Connectors shall be protected from physical damage and moisture
- Capacity for 12 or more fibers per rack space [44.5mm(1.75inches)] should be provided
- Optical fiber connecting hardware shall be installed:
    - To provide well organized installation with cable management
    - In accordance with manufacturers' guidelines

9.6 Optical Fiber Cabling Installation

- A minimum of 1m (3.28ft) of two-fiber cable (or two buffered fibers) shall be accessible for termination purposes
- Testing is recommended to assure correct polarity and acceptable link performance. Informative annex H of 568-A is provided for recommended optical fiber link performance testing criteria.

10 ANNEX I

Evaluation Parameters

Most vendors will have the basic structured cabling components. However, there are few other factors to consider when evaluating these players:

- Speed and bandwidth availability
- Return on investment
- Vendor reputation, local support etc.
- Warranty commitments
- Aesthetics
- Price to performance factor

11 ANNEX - II

Structured cabling standards.

The group, which sets standards, for structured cabling system is the Electronic Industry Association/Telecommunication Industry Association, or EIA/TIA. The EIA/TIA 568A standard defines multiple categories or upgrading of structure cabling system performance, with the category 5 designations as the highest currently standardized. The EIA/TIA 568A category 5 specification is the basis to which many of the new high-speed LAN technologies are targeted.

In October of 1995, EIA/TIA published a baseline standard for field-testing installed category 5 structured cabling. This document, EIA/TIA TSB-67, defines the test functions, test procedures and the minimum instrument requirements to accurately determine if installed cabling meets the category 5 performance level.

The following are the published standards:

- **EIA/TIA-568-A:** Commercial Building Telecommunications Cabling/wiring Standards.
- **EIA/TIA-569-A:** Telecommunications Pathways & Spaces.
- **EIA/TIA TSB-36:** Additional UTP Specifications.
- **EIA/TIA TSB-40A:** Additional UTP Connecting Hardware Specifications.
- **EIA/TIA TSB-53:** Additional STP Connecting Hardware Specifications.
- **EIA/TIA TSB-67:** Field Testing Bulletin for TIA 568-A.
- **EIA/TIA TSB-95:** Field Testing Bulletin for TIA 568-A.
- **EIA/TIA-606:** Building Infrastructure Administration Standard.
- **EIA/TIA-607:** Grounding and Bonding Requirements.
- **EIA/TIA TSB-72:** Centralized Optical Fiber Cabling Guidelines.
- **EIA/TIA 526-14(OFSTP-14):** Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant.
- **EIA/TIA 526-7(OFSTP-7):** Measurement of Optical Power Loss of Installed Single-Mode fiber Cable Plant.

Standards Under Development:

- **TSB-95:** ELFEXT, Return Loss, Level II-E Test Equipment
- **TIA 568-A-5:** Category 5E Enhanced Cable.
- **TIA 568-B:** Commercial Building Telecommunications Cabling Standard
- **Category 6:** Transmission Performance Specification for 4-Pair Category 6 Cabling.

11.1 DETAILS – EIA/TIA Cabling Standards

11.1.1 EIA/TIA-568A

Standard: EIA/TIA-568A
Description: Commercial Building Telecommunications Wiring Standard
Scope: This standard specifies; minimum requirements for telecommunications cabling, recommended topology and distances, media and connecting hardware performance specifications, connector and pin assignments. This document superseded the original standard document EIA/TIA-568. The standard also incorporates and revises the content of EIA/TIA-TSB36, EIA/TIA-TSB40, EIA/TIA-TSB40A and EIA/TIA-TSB53.
Date Ratified: October 1995, EIA/TIA-568 originally published in 1991.

11.1.2 EIA/TIA-569A

Standard: EIA/TIA-569A
Description: Commercial Building Standards for Telecommunications Pathways and Spaces.
Scope: This standard specifies; design and construction practices within and between buildings that are in support of telecommunications media and equipment. Specific standards are given for rooms or areas and pathways into and through which telecommunications equipment and media are installed.
Date Ratified: Originally published in October, 1990

11.1.3 EIA/TIA TSB-36

Standard: TSB-36
Description: Additional Cables Specifications for UTP cables.
Scope: This technical systems bulletin provides requirements for the transmission characteristics of bulk high performance UTP cables not specified in the original EIA/TIA-568 standard. The bulletin has been incorporated into EIA/TIA-568A. This bulletin is intended primarily for manufacturers of UTP cabling.
Date Ratified: August, 1991

11.1.4 EIA/TIA TSB-40A

Standard: TSB-40A
Description: Additional Transmission Specifications for UTP pair Connecting Hardware
Scope: This technical systems bulletin specifies transmission performance requirements for UTP connecting hardware, consistent with the three categories(3-5) of UTP cable specified in EIA/TIA-TSB36. UTP hardware includes but is not limited to; telecommunications outlets, patch panels, transition connectors and cross connect blocks. The document also specifies additional requirements for cross-connect jumpers and for UTP patch cords. This bulletin has been incorporated into EIA/TIA-568A. This bulletin is primarily intended for manufacturers of UTP connecting hardware.
Date Ratified: January, 1994.

11.1.5 EIA/TIA TSB-53

Standard: TSB-53
Description: Additional Specifications for STP Connecting Hardware
Scope: This technical systems bulletin provides requirements for the transmission characteristics of STP connecting hardware. The bulletin has been incorporated into EIA/TIA-568A.
Date Ratified: Published 1992, part of 568A as of October, 1995

11.1.6 EIA/TIA TSB-67

Standard: TSB-67
Description: Transmission Performance Specifications for Field Testing of UTP Cabling Systems.
Scope: This bulletin specifies test methods, parameters and minimum requirements for the testing of installed Category 3,4&5 cabling with a hand held test instrument. Defines performance requirements for UTP cabling links consistent with the three categories of UTP cables and connecting hardware as defined by EIA/TIA-568A. This bulletin also specifies the electrical characteristics and required accuracy of field testers, the difference between channel and basic link test configurations, and the required tests necessary to determine Pass/Fail of installed cabling.
Date Ratified: October, 1995

11.1.7 EIA/TIA-606

Standard: EIA/TIA-606
Description: Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
Scope: Specifies uniform methods for labeling installed telecommunications infrastructure, including telecommunications pathways, spaces and media independent of applications. Includes specifications for labelling, color coding and recording data for the administration of telecommunications pathways/bonding. This bulletin has been incorporated into EIA/TIA-568A.
Date Ratified: February, 1993

11.1.8 EIA/TIA-607

Standard: EIA/TIA-607
Description: Commercial Building Grounding and Bonding Requirements for Telecommunications.
Scope: This document facilitates the planning , design and installation of telecommunications building grounding systems which will support multi-vendor and multi-product environments. Includes specifications for Telecommunications main grounding busbar(TMGB), telecommunications grounding busbar(TGB), bonding conductor for telecommunications, telecommunications bonding backbone(TBB) sizing and bonding.
Date Ratified: August, 1994

11.1.9 EIA/TIA TSB-72

Standard: TSB-72
Description: Centralized Optical Fiber Cabling Guidelines

Scope:	This document specifies guidelines and connecting hardware requirements for fiber optic cabling systems supporting centralized equipment located within a telecommunications closet or equipment room serving work areas. Specifications include centralized fiber optic cable, optical cross-connects, splicing, interconnecting hardware. This bulletin has been incorporated into EIA/TIA –568A
Date Ratified:	Published 1992, part of 568A as of October, 1995

11.1.10 EIA/TIA 526-14 (OFSTP-14)

Standard:	EIA/TIA 526-14 (OFSTP-14)
Description:	Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
Scope:	This document specifies guidelines and procedures used to measure the optical loss between any two passively-connected points, including end terminations of a multimode optical fiber cable plant. The standard specifies information on the light sources, test jumpers, calibration, accuracy, interpretation of results and documentation.
Date ratified:	Currently under ballot

11.1.11 EIA/TIA 526-7 (OFSTP-7)

Standard:	EIA/TIA 526-7 (OfSTP-7)
Description:	Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
Scope:	This document specifies guidelines and procedures used to measure the optical loss between any two passively-connected points, including end terminations of a single-mode optical fiber cable plant. Two methods for measuring loss are described; Method A using optical power measurement equipment and Method B using an Optical Time Domain Reflectometer (OTDR). The standard also specifies guidelines on calibration, test cords, interpretation of results and documentation.
Date ratified:	Currently under ballot.

11.2 Standards Under Development

11.2.1 TSB-95

Document:	TSB-95
Description:	Level II-E Test equipment, Field Certification of installed Category 5 channels for use with 1000Base-T
Scope:	Will specify additional field testing requirements for Category 5 and 5E UTP to support Gigabit Ethernet. The new parameters will include ELFEXT (equal level far-end cross talk), Return Loss, Propagation Dealy and Delay Skew. Will also specify more stringent requirements for a new level of field test equipment (Level II-E). This Addendum was recently changed to a Technical Systems Bulletin (TSB) indicating that this document is not an official standard. The TSB number is yet to be determined.
Timeframe:	Q4 1998 (estimated)

11.2.2 TIA 568-A-5

Document:	TIA 568-A-5
Description:	Defines performance of Category 5E channels
Scope:	Category 5E (Enhanced Category 5) is the next higher grade of UTP beyond Category 5. The category 5E specification has been developed to provide more robust support for 1000Base-T. Category 5E will specify tighter limits than Cat 5 for NEXT, ELFEXT and Return Loss.
Timeframe:	Q4 1998 (Estimated)

11.3 Preliminary Standards Work

11.3.1 Category 6 Cabling

Document: Category 6 Cabling
Description: Transmission Performance Specifications for 4-pair 100 ohm Category 6 Cabling
Scope: Defines components (cable, connecting hardware) and cabling(basic link and channel) for category 6 channels as well as level III field tester requirements.
Timeframe: Draft 2a published April, 1998, final standard not expected until late 1999 or 2000 at the earliest.

11.3.2 Category 7 Cabling

Document: Category 7 Cabling
Description: To be determined
Scope: To be determined
Timeframe: Initial work has only just begun. Approved standard not due until after year 2000.

12 REFERENCES

a) www.siemon.com
b) www.landfield.com
c) www.wirescope.com
d) www.precise.com
e) www.lucent.com
f) www.amp.com
g) www.cisco.com
h) www.commscope.com