Cabling and Building Infrastructure for Technology

by:

Ernest J. Schirmer, Director
Information Technology Infrastructure Design
CUH2A Architecture Engineering Planning
211 Carnegie Center
Princeton, NJ 08540
609-452-1212 ext.
609-419-8124 Email FAX
www.cuh2a.com
eschirmer@cuh2a.com

Introduction

Over the last ten years it has become increasingly common to see buildings wired to support voice, data, multimedia and Internet services. Although the subject can get complex and sometimes confusing, there are specialized industry standards that can help guide the design process. So whether it=s cabling a small home office (SOHO) or the world=s tallest building, the same basic design considerations apply. Sure, the scope of the project and the formality of the design process will varying greatly between these two extremes, but the same fundamentals still apply.

Jargon, Buzzwords, Hardware and Tools

Like any specialized field, the telecommunications industry is loaded with trade slang. Although this presentation will minimize the use of these terms, there may come a time when you will need to talk-the-talk even if it=s only to order the parts to network the computers in your home office or install the termination hardware for a cable. Some of the best sources of this information are the catalogs of the major cable and hardware manufacturers. Most are filled with technical specifications and illustrations of installation techniques.

Why Has Cabling Gotten So Complicated?
In the Aold days≅ cabling a building was relatively straight-forward by today=s standards. There were, in most cases, only telephone wires to be installed and those were pretty forgiving in that they could be installed in almost any location or environment and still work.

Beginning with the installation of mainframe computers in the second-half of the twentieth century, many new cable type were created; in fact, each computer manufacturer had a proprietary cabling system. As a result, if a user wanted to switch from one computer system to another there where two obvious costs, and one major hidden cost, involved in the conversion. The two obvious costs were the new mainframe hardware and the man-hours to convert programs to run on the new operating systems. The third cost was literally hidden within the walls of the building: the cabling for the computer system. Since the cost of re-cabling a large building can run into the high six figures, it was a cost that could not be ignored.

Unfortunately, because many architects, engineers and designers still think of telecommunications cabling as Aonly telephone wire≅ it is not unusual to see telecommunications building and cabling-related issues ignored until almost the end or the project.

Attempts To Simplify Cabling
Over time, the issue of cabling complexity was attacked from two different directions.

First, equipment manufacturers searched for lower cost methods to interconnect and network computer equipment. Since telephone cable was already installed in almost every nook-and-cranny of the building, it was an obvious choice. So much so that by the mid-1980s many telephone switch (PBX) manufacturers tried, with limited success, to market the PBX as a centralized means of switching, interconnecting and networking computer equipment. At the same time, computer facilities managers were putting pressure on cable and computer equipment manufacturers to develop a standardize, universal cabling system capable of supporting multiple technologies and applications.

Structured Cabling Systems
The result of these efforts is today=s *Structured Cabling System* design guidelines and standards. These standards cover the size and design of physical spaces and pathways, cable types, backbone cabling, horizontal cabling (these terms will be explained later), and cable plant management.

Who Designs Infrastructure?
Many different types of firms offer infrastructure design services:
! Individual consultants
! Telecommunications infrastructure design/consulting firms

! Telecommunications cabling contractors
! Electrical contractors
! Mechanical/Electrical/Plumbing design firms (known by the initials MEP)
! Distributors
! Manufacturers

How Do I Know Which Type of Firm to Use?
In most cases, the size and complexity of the project is a good starting point for determining which type of firm to use. For example, to wire a small office or to add more telephone and data jacks in an existing facility, an experienced telecommunications cabling contractor might be appropriate. On the other hand, for a major renovation project or the construction of a new building, it would probably be best to engage the services of a consultant. Even if your firm or organization has someone responsible for cabling infrastructure, the magnitude of the workload associated with a major project can often be overwhelming. But even beyond the workload issue, there is the need to understand and coordinate a wide range of construction issues that will probably be outside the experience of the in-house staff.

What Qualifications Do I Look For?
In general, there are no restrictions regarding who may design telecommunications cabling. However, the Building Industry Consulting Services International (BICSI) organization has taken the leadership role in creating an industry recognized program for individuals who want to earn the designation of Registered Cable Distribution Designer (RCDD); currently only about 20% of the individuals taking the RCDD examination pass it on their first attempt. Although the RCDD exam is difficult and comprehensive, it can not guarantee that the individual posses all the skill, knowledge and experience required for a given project.

What Standards Are Used?
Standards come in two main flavors:

! De factor standards = just because Aeverybody≅ does it that way

These standards come about if a Acritical mass≅ of usage develops related to a specification. Probably the most famous de facto standard was RS-232 (RS = Recommended Standard) used for serial data transmission. It looked like a standard, was used like a standard, was marketed as a standard, but in reality was only a de facto standard (until recently when it became a formal standard).

! De jure = formal standards issued by a recognized authority

Designs based on de jure standards help to ensure technical compliance, functionality and inter-operability. In the case of telecommunications cabling, these standards are issued jointly by the

Telecommunications Industry Association (TIA) and the Electronics Industry Association (EIA) and are known as EIA/TIA standards.

Let=s Get Started

1. What Are the Design Stages of a Building?

The formal building design process has a number of stages:

- ! Conceptual/Site Selection
- ! Schematic Design (SD phase - lines on paper)
- ! Design Detail (DD phase - how do all the pieces fit together)
- ! Construction Documents (CD phase - drawings issued to the contractor)
- ! Contract Administration (CA - making sure the work is done right)

2. When Should I Get Involved?

If at all possible, get involved during the Conceptual/Site Selection stage of the project. Where do the telephone company cables enter the property? Are there enough conduits coming in from the street? Are diversity-routed, redundant services available? Although these considerations might not be the ultimate deciding factors in determining if a particular building or property is selected, it is still good to understand them as soon as possible.

What Spaces Are Required to Support Telecommunications Services?

3. The Telecommunications Service Entrance Room (TSER)

Office Buildings:

EIA/TIA Standard 569 covers the size of the room required to ensure adequate space for the termination and splicing of cables entering the building based on the gross square footage of the building. For example, a building of 70,000 sq. ft. requires a 12' X 7' room while a 1,000,000 sq. ft. building requires a 12' X 28' room. For buildings smaller than 70,000 sq. ft. a single room usually serves as a combined service entrance room, equipment room and telecommunications closet.

Small Office/Home Office

Although there are many engineering initiatives underway that may ultimately see fiber optic cable replace copper cable between the street and the house, it is likely that copper cable will serve the needs of most small offices and home offices for many years to come. Therefore, only a minimal amount of wall space is needed for the proper termination of cables into a small or home office,

4. The Equipment Room

EIA/TIA Standard 569 recommends that the equipment room be sized for the maximum potential number of workstations in a building based on 0.75 sq. ft. of equipment room per workstation; a workstation is assumed to be 100 sq. ft. in area. For example, for 100 workstations or less a 150 sq. ft. room is recommended while a room of 1,200 sq. ft. is recommended for a building with 1,200 workstations.

It should be noted that the term Aequipment room≅ as defined in EIA/TIA 569 allows great freedom as to its function. In a single-tenant building, there might be one equipment room for the building as a whole containing its computer equipment, telephone equipment and telecommunications electronics.

On the other hand, in a multi-tenant office building the equipment room would typically be used only by the service providers to house their electronics. In addition, each tenant would also have an equipment room within their rental space.

For the small office/home office it should only be necessary to set aside about 4 sq. ft. of wall space to mount equipment.

5. The Telecommunications (TC) Closet

TC closets are rooms that function as the interconnection point between the main voice and data network cables (called backbone cables) and the cables (called horizontal cables) that run to the workstations. It also houses the network electronics (e.g. Ethernet switches) that interfaces the backbone and horizontal cables.

If the exact intent of EIA/TIA Standard 569 were followed there would be one 10' X 12' TC closet per 10,000 sq. ft. of floor space on every floor. However, since floor space is always a valuable commodity, it is more typical to find one TC closet serving 20,000 or even 30,000 sq. ft. Sometimes that is stretched even further by having one TC closet serve the floor above and the floor below.

6. What kind of cable should be installed?

EIA/TIA Standard 568 cover the types, quantities and distance limitations of cables to be installed.

Backbone cables are used to connect networking hardware such as routers, hubs and switches while *horizontal cables* are used to connect workstations to the electronics in the TC closets.

Horizontal Cabling

! Two cables per workstation, minimum.
! The first cable must be a Cat. 3, UTP cable, or better.

! The maximum total cable length from the TC closet to the workstation can not exceed 90 meters or 295 feet.
! The physical cable distribution pathways must be capable of supporting a minium of three cables to the workstation.

OK, I said I would keep trade slang to a minimum, but this is one area where we have to use it.

Cat. 3, UTP stands for Category 3, Unshielded Twisted-Pair cable. This type of cable consists of 4 pairs of #24 gauge wire under a common outer sheath; each pair of wires has a different number of twists-per-foot.

Without going into technical issues, there are currently five UTP cables types in common usage:
! Cat. 1, UTP is telephone cable (typically large (e.g. (100-pair) telephone cables).

! Cat. 3, UTP cable supports telephone and low-speed (10 Mbps) data applications.

! Cat. 5, UTP cable, until recently, was the default cable for new installations. It supports telephone and 100 Mbps data applications. Although not well known, this type of cable can also be used, via inexpensive transformers called baluns, for baseband and broadband video signal distribution up to 100 MHZ.

! Cat. 5e, UTP is the latest cable type to have an official industry standard; the Ae≅ stands for enhanced performance and represents significant technical advancement over Cat. 5 cable. It supports Gigabit Ethernet by using all 4 cable pairs to simultaneously transmit and receive 250 Mbps bi-directionally on each pair. Like Cat. 5 cable, its bandwidth is 100 MHz.

! Cat. 6 UTP is under development. It will support Gigabit Ethernet buy sending 500 Mbps on each pair of wires uni-directionally; it has a bandwidth of 250 MHZ.

One major cable manufacturer has objected to the current proposed standard for Cat. 6, UTP cable noting that it is required to meet performance specifications at only one temperature, 20^{o} C. The manufacturer feels that this is not a realistic specification (based on the fact that cabling is often installed in overhead spaces) and instead has proposed having a Cat. 6a cable with a maximum temperature limitation of 20^{o} C. and a Cat. 6b cable with a maximum temperature of 40^{o} C. It is not clear at this time when the standard for Cat. 6, UTP cable will be finished, but it will be at least a year or two before it is ready.

Fiber to the workstation. Not yet, in most cases.

Backbone Cabling

Backbone cables connect network hardware. As such they usually, but not always, operate at bit rates much higher than those found on the horizontal cabling.

Depending on the distance and bit rate, either copper or fiber optic cable can be used in the backbone, but, in general, fiber optic is the preferred medium.

There are two main types of fiber optic cable:
! multimode, and
! single-mode.

Multimode fiber optic cable is available in two core sizes: 62.5 micron and 50 micron. Although the current EIA/TIA Standard 568 only recognizes 62.5 micron fiber, certain problems with running Gigabit Ethernet over 62.5 micron cable for distances of over 220 meters has caused designers to specify 50 micron multimode fiber. It is cheaper, has higher performance, uses the same connectors as 62.5 micron fiber and supports Gigabit Ethernet over a full 500 meters. Inexpensive LED light sources can be used with multimode fiber.

Single-mode fiber optic cable represents the ultimate in cabling bandwidth. As used by telecommunications companies (e.g. AT&T, Sprint, MCI, Quest, etc.) it supports bit rates far in excess to 40 Gbps. It=s main drawback is the cost of the laser light sources that are required to be used with single-mode fiber.

Fiber Optic Connectors

EIA/TIA Standard 568 specifies SC connectors in new construction with ST connectors to be used to match existing equipment.

For the last few years the industry has been trying to define a standard for a new type of fiber optic connector known as the Small Form Factor (SFF) connector. The objective is to define a smaller connector that snaps in and out of a faceplate much like the 8-pin connector used on UTP cables. Unfortunately, the standards committee has, so far, been unable to reach a consensus and there are currently 5 SFF connectors on the market.

Plug and Jack Wiring Standards

There are four pairs of wires in a UTP cable and 8 pins in a data jack. As a result, there are a number of ways in which the cable pairs and the pins in the jack can be wired.

The T568A pinout is recommended in EIA/TIA Standard 568 for new construction.

The T568B pinout is recommended when the need exists to match existing jacks wired to the T568B pinout.

The difference between T568A and T568B represents the compromises that are sometimes required in a standards committee. The T568B pinout represents the reality that 90% of the world was already wired using this Bell System (i.e. AT&T 258A) pinout for many years before there was a EIA/TIA Standard 568. So even though the standards committee decided that there was enough merit to the T568A pinout to have it as the default standard, it is rarely specified. Instead, most of the world continues to use the old Bell System pinout as defined in T568B. Both the T568A and the T568B pinouts support the most common telephone and data networking hardware.

In addition to the two pinouts just mentioned, there is an entirely separate set of jack types and pinouts used in the telephone industry known as USOC (Universal Service Order Code) codes, This is the pinout used on telephone jacks. Therefore, if a jack will be used exclusively for telephone service, an option would be to wire it with the USOC pinout to ensure that it will 100% compatible with any telephone equipment that might be installed.

Conclusion

This presentation has summarized the highlights of telecommunications cabling infrastructure. For more information, please feel free to contact Ernie Schirmer at eschirmer@cuh2a.com.