



Cabling: The Complete Guide to Network Wiring, Third Edition

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10 9 8 7 6 5 4 3 2 1

For Jordan and Cameron
—D.B.

*For my wife, my daughter, my family,
and my friends.*
—D.G.

*This book is dedicated to my family (Mom, Dad,
sisters, cousins, and aunts). Over a distance of
thousands of miles and many years, you still
influence my actions every day. We are all
products of our environment; mine was great!*
—J.M.

Acknowledgments

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—*David Barnett*

This book has been a long time in the making. First and foremost, I would like to acknowledge my co-author, Jim McBee, for his excellent work on this project. He should be proud of his efforts, and it shows in the quality of this book. Also, we would like to acknowledge the other behind-the-scenes people that helped to make this book, starting with Dan Whiting of Border States Electric Supply in Fargo, ND, for all the reference material and pictures he and his company provided.

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—*David Groth*

At the Spring 1999 Network+InterOp, David Groth, Maureen Adams from Sybex, and I talked about the need for a book about network cabling that was targeted toward IT professionals and people just starting out with cabling. The first edition was a resounding success, and now you hold a brand-new third edition in your hands!

Special thanks also goes to Janice Boothe, RCDD (and her awesome www.wiring.com Web site) and Mike Holt for their knowledge of codes. Paul Lucas, RCDD, of Paul's Cabling tolerated my nonstop questions and provided many great stories and experiences. Kudos to Matt Bridges for his assistance with components. Jeff Deckman gave his vital insight and input to the Request for Proposal (RFP) chapter; his cooperative approach to working with vendors will help many people successfully deploy telecommunications infrastructures. Charles Perkins drew from his years of field experience to help with the case studies. Others who reviewed portions of the book and provided feedback include Maureen McFerrin, Randy Williams, RD Clyde, John Poehler, and David Trachsel. Jeff Bloom and the folks at Computer Training Academy (where I teach Windows NT, TCP/IP, and Exchange courses) are always outstandingly patient when I take on a project like this. Finally, the consummate professionals at Sybex always leave me in awe of their skills, patience, and insight.

—*Jim McBee*

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Introduction

Welcome to the incredibly complex world of premises data-communications cabling. This introduction will tell you a little about how this book came about and how you can use it to your best advantage.

Not only does cabling carry the data across your network, it can also carry voice, serial communications, alarm signals, video, and audio transmissions. In the past, people took their cabling systems for granted. However, over the last decade, the information technology world began to understand the importance of a reliable and well-designed structured cabling system. This period also resulted in an explosion in the number of registered structured-cabling installers. The number of people who need to know the basics of cabling has increased dramatically.

We had a great time writing this book. In the year-long process of researching, writing, and editing it, we met many consummate professionals in the cabling business. Many distributors, manufacturers, and cabling contractors provided us with feedback, tips, and in-the-field experiences.

During the research phase of the book, we continually reviewed newsgroups, cabling FAQs, and other Internet resources, besides polling information technology managers, help-desk staff, network designers, cable installers, and system managers to find out what people want to know about their cabling system. The answers we received helped us write this book.

About This Book

This book's topics run the gamut of cabling; they include the following:

- An introduction to data cabling
- Information on cabling standards and how to choose the correct ones
- Cable system and infrastructure constraints
- Cabling-System Components
- Tools of the trade
- Copper, fiber-optic, and unbounded media
- Wall plates and cable connectors
- Cabling-system design and installation
- Cable-connector installation

- Cabling-system testing and troubleshooting
- Creating Request for Proposals (RFPs)
- Cabling case studies

A cabling dictionary is included at the end of the book so you can look up unfamiliar terms. Five other appendixes include resources for cabling information, tips on how to get your Registered Communications and Distribution Designer (RCDD) certification, information for the home cabler, a discussion of USB/1394 cabling, and information about ETA's line of cabling certifications. Finally, a multipage color insert shows you what various cabling products look like in their "natural environment."

Who Is This Book For?

If you are standing in your neighborhood bookstore browsing through this book, you may be asking yourself if you should buy it. The procedures in this book are illustrated and written in English rather than "technospeak." That's because we, the authors, designed this book specifically to help unlock the mysteries of the wiring closet, cable in the ceiling, wall jacks, and other components of a cabling system. Cabling can be a confusing topic; it has its own language, acronyms, and standards. We designed this book with the following types of people in mind:

- Information technology (IT) professionals who can use this book to gain a better understanding and appreciation of a structured cabling system
- IT managers who are preparing to install a new computer system
- Do-it-yourselfers who need to install a few new cabling runs in their facility and want to get it right the first time
- New cable installers who want to learn more than just what it takes to pull a cable through the ceiling and terminate it to the patch panel

How to Use This Book

To understand the way this book is put together, you must learn about a few of the special conventions we used. Following are some of the items you will commonly see.

Italicized words indicate new terms. After each italicized term, you will find a definition.

TIP

Tips will be formatted like this. A tip is a special bit of information that can make your work easier or make an installation go more smoothly.

NOTE

Notes are formatted like this. When you see a note, it usually indicates some special circumstance to make note of. Notes often include out-of-the-ordinary information about working with a telecommunications infrastructure.

WARNING

Warnings are found within the text whenever a technical situation arises that may cause damage to a component or cause a system failure of some kind. Additionally, warnings are placed in the text to call particular attention to a potentially dangerous situation.

KEY TERM

Key terms are used to introduce a new word or term that you should be aware of. Just as in the worlds of networking, software, and programming, the world of cabling and telecommunications has its own language.

Sidebars

This special formatting indicates a sidebar. *Sidebars* are entire paragraphs of information that, although related to the topic being discussed, fit better into a standalone discussion. They are just what their name suggests: a sidebar discussion.

Cabling @ Work Sidebars

These special sidebars are used to give real-life examples of situations that actually occurred in the cabling world.

Enjoy!

Have fun reading this book—we've had fun writing it. We hope that it will be a valuable resource to you and will answer at least some of your questions on LAN cabling. As always, we love to hear from our readers; you can reach David Groth at dgroth@cableone.net. Jim McBee can be reached at JMcBee@cta.net. David Barnett can be contacted at barnettdh@comcast.net.



PART I

TECHNOLOGY AND COMPONENTS

Chapter 1: Introduction to Data Cabling

Chapter 2: Cabling Specifications and Standards

Chapter 3: Choosing the Correct Cabling

Chapter 4: Cable System and Infrastructure Constraints

Chapter 5: Cabling System Components

Chapter 6: Tools of the Trade



CHAPTER I

Introduction to Data Cabling

- The Golden Rules of Data Cabling
- The Importance of Reliable Cabling
- The Legacy of Proprietary Cabling Systems
- Cabling and the Need for Speed
- Cable Design
- Data Communications 101
- Speed Bumps: What Slows Down Your Data
- The Future of Cabling Performance

“Data cabling! It’s just wire. What is there to plan?” the newly promoted programmer-turned-MIS-director commented to Jim. The MIS director had been contracted to help the company move its 750-node network to a new location. During the initial conversation, the director had a couple of other “insights”:

- He said that the walls were not even up in the new location, so it was too early to be talking about data cabling.
- To save money, he wanted to pull the old Category 3 cabling and move it to the new location. (“We can run 100Base-TX on the old cable.”)
- He said not to worry about the voice cabling and the cabling for the photocopier tracking system; someone else would coordinate that.

Jim shouldn’t have been too surprised by the ridiculous nature of these comments. Too few people understand the importance of a reliable, standards-based, flexible cabling system. Fewer still understand the challenges of building a high-speed network. Some of the technical problems associated with building a cabling system to support a high-speed network are comprehended only by electrical engineers. And many believe that a separate type of cable should be in the wall for each application (PCs, printers, terminals, copiers, etc.).

Data cabling has come a long way in the past 20 years. This chapter discusses some of the basics of data cabling, including topics such as:

- The golden rules of data cabling
- The importance of reliable cabling
- The legacy of proprietary cabling systems
- The increasing demands on data cabling to support higher speeds
- Cable design and materials used to make cables
- Types of communications media
- Limitations that cabling imposes on higher-speed communications
- The future of cabling performance

You are probably thinking right now that all you really want to know is how to install cable to support a few 10Base-T workstations. Words and phrases such as *attenuation*, *crosstalk*, *twisted pair*, *modular connectors*, and *multimode optical-fiber cable* may be completely foreign to you. Just as the world of PC LANs and WANs has its own industry buzzwords, so does the cabling business. In fact, you may hear such an endless stream of buzzwords and foreign terminology that you’ll wish you had majored in electrical engineering in college. But it’s not really that mysterious and, armed with the background and information we’ll provide, you’ll soon be using cablespeak like a cabling professional.

The Golden Rules of Data Cabling

Listing our own golden rules of data cabling is a great way to start this chapter and the book. If your cabling is not designed and installed properly, you will have problems that you can't even imagine. From our experience, we've become cabling evangelists, spreading the good news of proper cabling. What follows is our list of rules to consider when planning structured-cabling systems:

- Networks never get smaller or less complicated.
- Build one cabling system that will accommodate voice and data.
- Always install more cabling than you currently require. Those extra outlets will come in handy someday.
- Use structured-cabling standards when building a new cabling system. Avoid anything proprietary!
- Quality counts! Use high-quality cabling and cabling components. Cabling is the foundation of your network; if the cabling fails, nothing else will matter. For a given grade or category of cabling, you'll see a range of pricing, but the highest prices don't necessarily mean the highest quality. Buy based on the manufacturer's reputation and proven performance, not the price.
- Don't scrimp on installation costs. Even quality components and cable must be installed correctly; poor workmanship has trashed more than one cabling installation.
- Plan for higher speed technologies than are commonly available today. Just because 1000Base-T Ethernet seems unnecessary today does not mean it won't be a requirement in five years.
- Documentation, although dull, is a necessary evil that should be taken care of while you're setting up the cabling system. If you wait, more pressing concerns may cause you to ignore it.

The Importance of Reliable Cabling

We cannot stress enough the importance of reliable cabling. Two recent studies vindicated our evangelical approach to data cabling. The studies showed:

- Data cabling typically accounts for less than 10 percent of the total cost of the network infrastructure.
- The life span of the typical cabling system is upwards of 16 years. Cabling is likely the second most long-lived asset you have (the first being the shell of the building).
- Nearly 70 percent of all network-related problems are due to poor cabling techniques and cable-component problems.

TIP

If you have installed the proper Category or grade of cable, the majority of cabling problems will usually be related to patch cables, connectors, and termination techniques. The permanent portion of the cable (the part in the wall) will not likely be a problem unless it was damaged during installation.

Of course, these were facts that we already knew from our own experiences. We have spent countless hours troubleshooting cabling systems that were nonstandard, badly designed, poorly documented, and shoddily installed. We have seen many dollars wasted on the installation of additional cabling and cabling infrastructure support that should have been part of the original installation.

Regardless of how you look at it, cabling is the foundation of your network. It must be reliable!

The Cost of Poor Cabling

The costs that result from poorly planned and poorly implemented cabling systems can be staggering. One company that had recently moved into a new office space used the existing cabling, which was supposed to be Category 5 cable. Almost immediately, 100Mbps Ethernet network users reported intermittent problems.

These problems included exceptionally slow access times when reading e-mail, saving documents, and using the sales database. Other users reported that applications running under Windows 98 and Windows NT were locking up, which often caused them to have to reboot their PC.

After many months of network annoyances, the company finally had the cable runs tested. Many cables did not even meet the minimum requirements of a Category 5 installation, and other cabling runs were installed and terminated poorly.

WARNING

Often, network managers mistakenly assume that data cabling either works or it does not, with no in-between. Cabling *can* cause intermittent problems.

Is the Cabling to Blame?

Can faulty cabling cause the type of intermittent problems that the aforementioned company experienced? Contrary to popular opinion, it certainly can. In addition to being vulnerable to outside interference from electric motors, fluorescent lighting, elevators, cellular phones, copiers, and microwave ovens, faulty cabling can lead to intermittent problems for other reasons.

These reasons usually pertain to substandard components (patch panels, connectors, and cable) and poor installation techniques, and they can subtly cause dropped or incomplete packets. These lost packets cause the network adapters to have to time out and retransmit the data.