[PDF] Cabling Handbook, The (2nd Edition)

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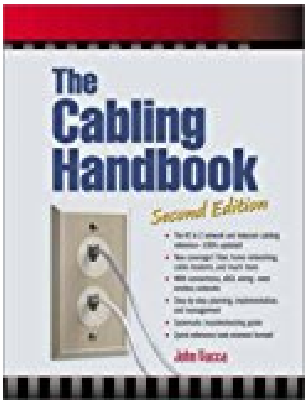

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From the Publisher This is the first edition of The Cabling Handbook, published in 1998. The second edition published in December 2000 as is ISBN 0130883174. --This text refers to an out of print or unavailable edition of this title.

From the Inside Flap Introduction

The cabling industry is becoming a full-service provider as it evolves its infrastructure into an all-digital superhighway. Both the telephone and computer industries are suggesting that their networking models—traditional point-to-point and extended distributed local area network (LAN) and wide area network (WAN) technology—become part of the cable industry solution. Cable is creating the multimedia networking model solution for the next millennium as a full-service provider through its migration to higher speed bandwidths.Migrating to High-Bandwidth Cabling Solutions

Network cabling may not always be the first thing mentioned in the marketing literature for high-speed LAN technologies, but it certainly is the first thing considered by experts contemplating a migration to high-speed bandwidth solutions. That's why, according to recent cable industry research studies and cabling professionals, many large companies are turning to wiring such as category 5e copper cable and multimode fiber. Furthermore, such cabling is becoming more prevalent for desktop connections.

The push to upgrade both backbone and desktop wiring is indicative of the fear IT managers have that older cabling will not be able to handle next-generation technologies such as ATM and fast Ethernet. This migration is calling into question the value of 25 Mbps ATM and fast-Ethernet technology designed to run over the old category 3 cable.

Category 5e is now the most dominant form of cabling for large installations, and multimode fiber is the most popular medium for vertical connections between floors and buildings in those organizations. Experts in the cabling industry say that massive category 5e upgrades are indeed under way to prepare for future technologies. Most cabling experts agree that when faced with a choice between category 3 and category 5e copper, most people find category 5e worth the extra cost, mostly because the cost of the cable itself is trivial in comparison with installation costs, so one might as well go to category 5e. Cable industry experts have also found that many of the companies that are planning cable changes are also putting fiber in at the desktop level. A lot of people are installing category 5e and fiber to prepare for the future.

The primary application driving the desire for greater bandwidth, cable industry analysts found, was desktop video conferencing. Sixty-five percent of the large organizations surveyed said they planned to implement desktop video conferencing. In the long run, video conferencing is much cheaper than travel. Nevertheless, although big companies are bulking up on category 5e, technology vendors continue to tout the potential to run high-speed bandwidth applications over category 5e's older sibling, category 3. Naturally, that's because of the huge installed base of category 3.

Members of the ATM25 Alliance claim that 25 Mbps ATM can run over category 3 cabling, but implementations of such technology are hard to find. Concerns such as these are driving IT managers to update their cable plants. But as long as copper remains the predominant cable source, testing problems will continue to occur. Because of the difficulty in testing category 5e (caused mostly by the connections between cable segments), networks will still experience cable-related problems—although technology is minimizing cable-related problems. In other words, testing category 5e is a real problem and there is virtually no way to certify a cable installation.

Furthermore, despite the number of industry standard tests (TIA Cat 5, 5E, 6, 7; ISO/IEC Class C, D, E, F; etc.), other groups and organizations have needs for test limits that differ from the standards. This includes vendors that tailor test limits to a particular connection system or organizations that require performance that exceeds standards.

Eventually we're all going to go to fiber optic, optical systems, or wireless anyway. So, can widening the fiber highway or optical systems through wave division multiplexing deliver the bandwidth promise?Widening the Optical Systems Highway

Recent advances in wave division multiplexing (WDM) technology have offered the potential for the deployment of cost-effective, highly reliable, high-capacity fiber optic network solutions. This is particularly important since the sustained growth of increasingly bandwidth-hungry applications requires an unprecedented rate of fiber optic network expansion, and places increasing demands on network design and planning. Development of time division multiplexing (TDM) transport systems has reached a plateau and operators can no longer wait for technology, such as managed Synchronous Transfer Mode-64 (STM-64) transmission, to mature. As a result, operators are increasingly pursuing WDM solutions to address evolving capacity issues. Cost-benefit analysis, however, reveals that the deployment of currently available small-scale (four wavelength) stand-alone systems only makes sense in long-distance carrier networks—of the kind found in North America, for example. For European intraoperator networks, efficiencies only begin to be realized with 16 wavelength systems.

As a longer-term strategy, the creation of a high-capacity managed WDM network layer using optical add-drop multiplexers or wavelength routers is gaining acceptance in the formulation of future network architectures. The biggest challenge in implementing an all-optical fiber network will be in the delivery of an optical layer network management platform and the successful integration with existing synchronous digital hierarchy (SDH) network management systems. Most modern fiber optic networks today use time division multiplexing techniques to send data down the Physical layer. But, experts say, most TDM equipment utilizes only about 2 percent of the intrinsic capacity of fiber. Dense wavelength division multiplexing is a technology that allows multiple data streams to be simultaneously transmitted over a single fiber at data rates as high as the fiber plant will allow—typically 3.5 Gbps. The WDM approach multiplies the simple 3.5 Gbps system by up to 16 times. So a 16-channel system (with ITU-recommended channel-spacing) will support 50 Gbps in each direction over a fiber pair. Also under development are 50-channel systems that will support 200 Gbps—the equivalent of over 20 STM-64 transmitters.

Current WDM technology utilizes a composite optical signal carrying 4, 8, or 16 data streams, each transmitted on a distinct optical wavelength. Although WDM has been a known technology for years, its early application was restricted to providing two widely separated wavelengths. Only recently has the technology evolved to the point where parallel wavelengths can be densely packed and integrated into a transmission system with multiple, simultaneous, extremely high frequency signals in the 192 to 200 Terahertz (Thz) range. The 16-channel system in essence provides a virtual 16-fiber cable, with each frequency channel serving as a unique STM-16 carrier. The most common form of WDM uses a fiber pair—one for transmission and one for reception. The availability of precise demultiplexers and erbium-doped fiber amplifiers has allowed WDM with 8 and 16 channel counts to be commercially delivered. Incoming optic streams are split into individual wavelengths using a newly developed technique of embedding a component (known as a fiber Bragg grating) so that the refractive index of the core is permanently modified to allow only a specific wavelength to pass through. A series of such gratings are used to split the carrier into a required composite wave. The fiber gating creates a highly selective, narrow bandwidth filter that functions somewhat like a mirror and provides significantly greater wavelength selectivity than any other optical technology.

So, would wireless technology be any better?Wireless WANs and LANs

As school districts struggle with how to interconnect local area networks that they have in operation at various campuses to form a wide area network, one viable solution that is not well known is the use of wireless technology. Wireless network bridges to transmit data within or between buildings, using spread spectrum radio waves or infrared technologies or microwaves, can be used to connect LANs that are separated by as much as 50 miles. Many of the less powerful bridges, however, may be limited to a range of five to eight miles. These wireless links can provide data transfer rates from less than 1 Mbps to more than 10 Mbps. As one might expect, the greater the link distance capability, and the higher the data transfer rate, the more expensive the equipment. For example, a pair of bridges operating at a radio frequency of 900 MHz may cost over $9,000, provide a link distance of two to three miles, and transfer data at 1 Mbps. A 2.4 Ghz bridge might cost over $8,000, provide a reliable link over a distance of six to nine miles, and transfer data at 2 Mbps. On the other hand, a microwave link at 31 Ghz may provide a connection over 10 to 13 miles at 10 Mbps (full duplex) for an equipment cost of less than $60,000.

One really attractive feature of wireless connections, and their major advantage, is that there is a one-time cost for the equipment and installation. There are no recurring, ongoing monthly costs! Thus, when compared to connection options that have continuing monthly fees associated, the wireless solution quickly pays for itself.

The potential drawbacks to a wireless solution include environmental factors. Terrain may eliminate wireless as an option; intervening hills and tall buildings or trees can block the radio frequency (RF) signals. Terrestrial wireless RF technology (non-satellite-based) is referred to as line-of-sight. This means that the antennas on the wireless bridge units must be able to see each other. There must be no obstacles in the way to block or reflect the transmitted signals. Severe weather, such as torrential rains, can adversely affect signal transmission and temporarily down the link. Similarly, the link might be susceptible to other radio frequency interference. Dense fog could possibly be a problem for microwave links.

On the other hand, wireless broadband networks can solve the terrain problem via fixed satellite orbital patterns. Wireless broadband networks are defined as communication without wires over distance by the use of arbitrary codes. Modern examples include hand-held devices like pagers, smart phones, personal digital assistants (PDAs) and personal communication services (PCS) using wireless modems or satellites to enable wireless data communications.

The bottom line: Wireless connectivity must be seriously considered if the terrain allows its use or satellites are capable of receiving (uplink) and sending (downlink) high-speed data. Some reports indicate that microwave links can be more reliable than leased data lines. Furthermore, there are some major potential benefits to wireless solutions. For example, school district administrators could enter a conference room, turn on their laptop computers, and achieve high-speed connectivity to the district network. Teachers could sit down in the cafeteria with their notebooks and instantly update class schedules, grades, and attendance records in a centralized database. Students can take hand-held devices outside of the classroom, collect scientific data, and share their findings in real time with peers via the Internet.

Finally, as the price of technology drops and demand for next-generation applications rises, home cable networking is moving into a new phase of convenience and functionality. The reasons have everything to do with the phenomenal success of the Internet and the advent of the integrated digital home.

It's an exciting time for home networks. Multicomputer households are definitely on the rise as the power of the Web grows daily and new Internet-based applications and appliances are introduced. High-speed Internet access via DSL, cable, or satellite service is imminent if not already available in your area, unlocking the full capabilities of the Internet for home-based communications, education, commerce, entertainment, and more.

The integrated digital home will merge with what we now think of as separate application dimensions (security, music and video entertainment, telephone and fax, and computing devices) into one seamless environment. The key to that future is the development of the home gateway (a network device that translates between different types of networks or computer systems) with its ability to bridge these different systems so that they can communicate with one another.

Sound like a vision for the middle part of this century? Actually, all of these scenarios are taking place today thanks to recent advances in mobile computing and wireless technology. Already, wireless local area networks (WLANs) have extended, or replaced, traditional LANs in hundreds of educational sites, and many more IT managers are carefully examining the benefits of wireless solutions. Actually, the bottom line to all of this is that although the initial investment for WLAN hardware might be higher, long-term cost savings can be realized because technicians never need to pull wire through walls or ceilings to expand the network.Who This Book Is For

This book can be used by domestic and international system administrators, government computer security officials, network administrators, senior managers, engineers, sales engineers, marketing staff, Web developers, military senior top brass, network designers and technicians, cabling project managers, cable installers, LAN and PBX administrators, and other satellite communications personnel. In short, the book is targeted for all types of people and organizations around the globe who have responsibility for cabling decisions and/or project implementation, network cabling installation, cost justification and investments, and standards. Others who may find it useful are scientists, engineers, educators, top-level executives, information technology and department managers, technical staff, and the more than 800 million Internet, intranet, and extranet users around the world. Some previous experience with cabling installation is required. What's So Special About This Book?

The Cabling Handbook, Second Edition, is unique in its comprehensive coverage of network cabling installation, cost justification and investments, and the latest standards. The book is a thorough, up-to-the-minute professional's guide to every aspect of LAN and telecommunications cabling, from planning through installation and management. From category 5e twisted pair and fiber to the latest wireless LAN solutions, it's all here: standards, product comparisons, topology and architecture design, electrical and safety considerations, and more—including invaluable information for anyone preparing for CompTIA Network+ certification. This brand-new second edition has been updated with extensive new coverage of fiber technologies, home networking, cable modems, and much more. Key features include:

Intermediate- to advanced-level instruction to help you install the latest copper, fiber, and wireless network cabling systems.

Practical tips on cost-justifying your cabling investments.

Tips on how to manage contractor/client relationships.

Extensive coverage of how to certify cabling system requirements performance to 100 Mbit/second and beyond.

Discussion of the latest LAN design issues: optimal use in structured cabling systems; how to drive a project from design to certification; and how to ensure today's cable design supports emerging workgroup technologies.

A thorough discussion of all of the latest national and international cabling standards.

An installation section covering testing techniques, installation, and certification of system performance.

Estimating the cost of cable plant upgrades.

Choosing the right installer and supervising installation.

Selecting the optimal cabling system and products.

Deploying wireless LANs with maximum reliability, coverage, throughput, and security.

Managing cable systems to minimize long-term costs and maximize long-term reliability.

Troubleshooting cable system problems rapidly and effectively.

The book is organized into eight parts and includes appendices as well as an extensive glossary of network cabling terms and acronyms at the back. It provides a step-by-step approach to everything you need to know about network cabling as well as information about many topics relevant to the planning, design, and implementation of high-speed performance network cabling systems. The book gives an indepth overview of the latest structured cabling technology and emerging global standards. It discusses what background work needs to be done, such as developing a cabling technology plan, and shows how to develop network cabling plans for organizations and educational institutions. More importantly, this book shows how to install a network cabling system, along with the techniques used to test the system, as well as the certification of system performance. It covers many of the common pieces of network cabling equipment used in the maintenance of the system, as well as the ongoing maintenance issues. The book concludes with a discussion about future planning, standards development, and the cabling industry.Part I: Overview of Cabling Technology

In this part of the book, the three cabling media (copper, fiber, and wireless) are discussed, followed by a discussion about the six major types of networks: local area network (LAN), wide area network (WAN), virtual area network (VAN), virtual private network (VPN), intranet, extranet, and Internet. Some companies are fortunate to have all six types connecting their systems. Next, we'll examine how all three cabling media can be used with one or all six of the network types to allow your organization to soar beyond the traditional constraints of network cabling. You'll be shown how and when to expand, contract, or redeploy your network type(s) virtually anywhere, anytime, as quickly as today's accelerating pace of change demands. Next, an indepth discussion of the various cabling standards (TIA/EIA568A, ISO/IEC 11801, IEEE 802.x, FDDI, ISDN, LATM, etc.) is presented. Part I reaches its climax with an indepth presentation of the current state of cable modem access versus DSL. It also examines how prevalent cable modem and DSL services are in major U.S. markets. A comparison of the two technologies with regard to speed, cost, and so on, are presented. It also covers the planning implications or considerations for the enterprise network manager (for example, to support telecommuting employees, etc.) and the N+ certification audience. In addition, Part I will take a close look at DSL; cable modems; ADSL; CDSL; G.Lite; HDSL; IDSL; RADSL; SDSL; VDSL; POTS; DSL and cable modem rollouts; high-speed data entry; buying DSL service; installing DSL; security problems, residential users, telecommuters, DSL system components; DSL networks; and DSL hubs. Finally, Part I discusses future directions for cable modems and DSL and concludes by taking a close look at some third-party vendor cabling systems: AT&T (Lucent) Systimax and Powersum, IBM Cabling System, DECconnect, Northern Telecom IBDN, AMP Connect, KRONE, Mod-Tap, BCS, ITT, IBCS, and so on.Part II: Designing Cabling Systems

Part II begins by giving an overview of network design issues and how they can help you design and install a better cabling system. Next, it discusses the various category 5 structured wiring components and how they all fit together. Part II also discusses a more proactive approach to cost justification issues, with regard to how fiber's higher cost is compensated or countered by UTP's more troubled implementations and downtime. It provides an overview of the various aspects of cabling system standards design issues and of cabling system architectural design considerations (structured cabling system, wiring closet design, cabling facilities, and user-to-outlet ratios). Additionally, Part II discusses copper design considerations (layout, components, connectors, and shielding and maintenance). It concludes with a discussion of wireless design considerations (spread spectrum, microwave, infrared, wireless WANs and LANs, etc.).Part III: Fiber-Optic Systems: A Hands-On Approach

Part III opens up by taking a thorough look at fiber optic types and materials, with an emphasis in how fibers guide light; and how single-mode (SMF) and multimode fiber (MMF) are different. Next, it examines how to specify fibers by covering loss and attenuation of fibers; bandwidth, the capacity for information; and physical sizes of fiber. Part III also shows you how to use fiber optic transmitters and receivers by taking a close look at light sources and how to detect light with photodiodes. Next, it shows you how to design cable plants by examining indoor cable, outdoor cable, and how you would benefit from structured cabling options. In addition, Part III also discusses how to verify cable installations and provides you with testing tips and techniques to make verification seem less painful. It also shows you how to conduct acceptance testing and help you troubleshoot your fiber systems. Next, Part III examines optical time domain reflectometer (OTDR), and shows you how to test fiber paths with OTDR and interpret OTDR traces. It also shows you how to select connectors and splices by examining the quality factors, mechanical and fusion splices, and identify different types of connectors. Additionally, it shows you how to build connectors and splices by taking a look at practical fiber termination. Finally, Part III comes to a close with a look at the latest fiber optic cutting-edge technologies. It focuses on advanced fiber optic components such as fiber couplers, optical amplifiers, wavelength division multiplexers (WDM), and the advantages of specialty fibers.Part IV: Planning for High-Speed Cabling Systems

Part IV covers high-speed real-time data compression and how to plan for higher-speed cabling systems. It also describes the development of the high-speed cabling system implementation plan (scheduling, analyzing site surveys, connectivity requirements, equipment, security, and performance).Part V: Installing the Cabling System

This part begins by taking a look at the installation of the cabling system, starting with a presentation on testing techniques as part of preinstallation activities, including the preparation of cable facilities, testing the cable and components, and code compliance and safety considerations. Next, it describes in detail the installation of the cabling system and covers specific areas such as core drilling considerations; conduit installation and fill guidelines; grounding, shielding, and safety; pulling the cable without damage; splicing and patching; blown fiber; labeling schemes; and quality control and installation standards. Part V concludes by taking a close look at the following post-installation activities: cable fault detection with OTDR; cabling system troubleshooting and testing; copper and fiber optic loss testing; documenting the cabling system; cabling system performance certification; and accuracy levels testing as defined in Telecommunications System Bulletin (TSB) 67.Part VI: Maintaining Cabling Systems

Opening up with a discussion on how to maintain your cabling system, this part examines the facilitation of ongoing cabling system maintenance by covering the building of the Cable Plant Management (CPM) database, vendor CPM products, and the EIA/TIA 606 standard. Part VI also examines future standards development (ATM, 300-600 Mhz cable systems Category 6, zone wiring, TIA/EIA-T568-B, EN50174, 100BaseT2, 1000BaseT Gigabit Ethernet, etc.).Part VII: Future Directions

Part VII opens up by taking a look at the future of wireless communications□cable-less connectivity. It also takes a look at home networking and how to connect to your home in the future. Finally, Part VII concludes by making recommendations and taking a peek at the cabling industry as it continues on its way to becoming a full information service provider in the beginning of this millennium via the ever changing cable specification process.

You'll find a glossary of network cabling-related terms at the end of the text.Part VIII: Appendices

Nine appendices provide direction to additional resources available for cabling. Appendix A is a list of fiber channel products, organizations, vendors, and high-energy projects and applications. Appendix B is a list of top cable installation companies. Appendix C is a list of top fiber optic cable companies, and Appendix D is a Cabling Directory—an interactive buyer's guide for cabling products as well as for all cabling-related topics with direct links to each company's website. Appendix E is an EENET Interconnect Directory—a comprehensive listing of interconnect companies in different categories. Appendix F is a list of top cable labeling companies, Appendix G is a list of top SCSI companies, Appendix H is a list of wireless LAN products and sites, and Appendix I is a list of CCITT/ISO standards.Conventions

This book has several conventions to help your way around and to help you find important facts, notes, cautions, and warnings:

Sidebars: We use sidebars to highlight related information, give an example, discuss an item in greater detail, or help you make sense of the swirl of terms, acronyms, and abbreviations so abundant to this subject. The sidebars are meant to supplement each chapter's topic. If you're in a hurry on the a cover-to-cover read, skip the sidebars. If you're quickly flipping through the book looking for juicy information, read only the sidebars.

Notes: A note highlights a special point of interest about the cabling topic.

Caution: A caution tells you to watch your step to avoid any cabling-related problems (safety or security, etc.).

Warning: A warning alerts you to the fact that a cabling-related problem is imminent or will probably occur (safety, security, etc.).

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