

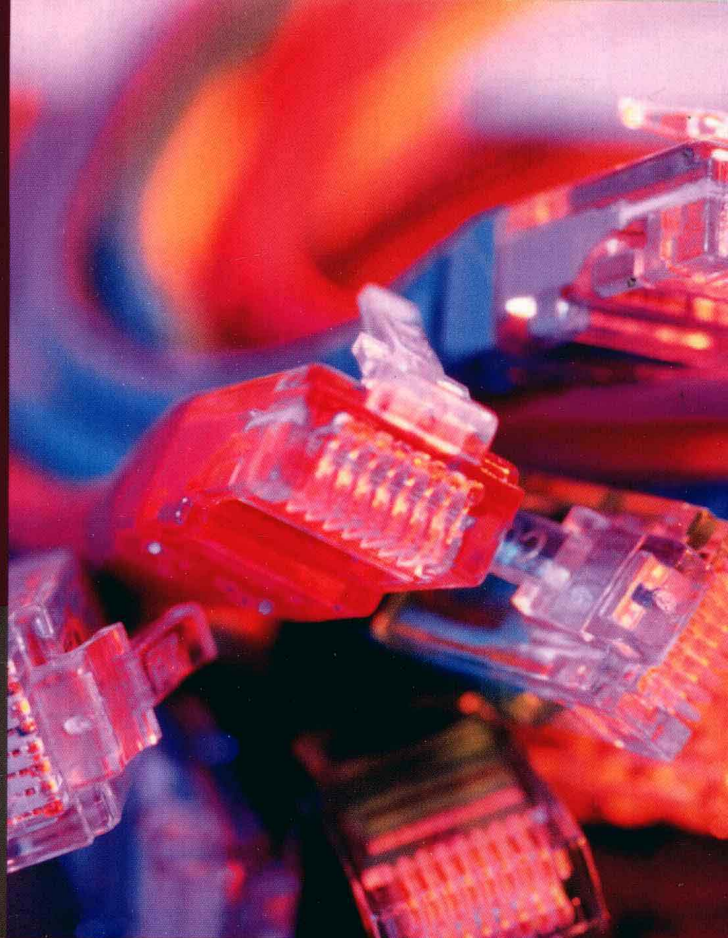
JAMES TRULOVE

LAN

WIRING

□ Third Edition

- Category 7 and Augmented Category 6
- Copper and Fiber Cabling for 10-Gigabit Ethernet Speeds
- TIA/EIA 568-C Standard Updates
- 802.11 WiFi to over 100 Mbps



LAN Wiring

Third Edition

James Trulove

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LAN Wiring

Introduction

LAN wiring, in the form of copper and fiber-optic cabling, continues to play an extremely vital role in digital communication. It is critical to our voice and data communications infrastructure. Yet, this standardized cabling is the Mark Twain of communications: “The reports of [its] death are greatly exaggerated!” For over a decade, the demise first of copper cabling and ultimately of all wired technologies has been trumpeted by pundits and prognosticators. We have heard, “copper cannot support gigabit data rates” and “fiber has limited bandwidth,... limited distance, ... is too expensive.” More recently, it was pronounced, “10 gigabit will never run over copper.” Now, many quarters have declared, “wiring is dead, wireless is the future.”

In spite of all this, physical cabling still rules the seas of communications. Copper not only supports Gigabit Ethernet, but indeed now supports 10 Gigabit Ethernet. Fiber surprised everyone, first by carrying Gigabit Ethernet to 70 km, and then by supporting multiple wavelength multiplexing. This dense wave-division multiplexing has multiplied the effective bandwidth of single-mode fiber by 100 times or more.

Copper cabling has advanced the state-of-the-art for balanced-pair transmission, and has added twist-geometry stability, extended-bandwidth connectors, and now pair shielding to raise the bandwidth into the near-microwave region. Fiber-optic cabling has evolved new connector types, new extended wavelength cores, and optical multiplexing techniques to reduce costs and simplify assembly, to expand bandwidth and distances, and to multiply services per fiber link.

Copper and fiber-optic wiring have overcome every hurdle put before them but one. The final frontier is certainly the threat of wireless. To some, wireless is the answer to everything. To borrow a concept from Stephen W. Hawking, some people think that wireless is “The Theory of Everything.” It solves all problems. It cures all ills. It costs virtually nothing, and it is of infinite capacity. It must be very cool.

Unfortunately, as with older theories of the universe, wireless must bow to the laws of physics, quantum mechanics notwithstanding. There simply is no such thing

as unlimited bandwidth, at least as far as wireless is concerned. First, the frequencies are limited, and many are already in use by other important services, such as radio, television, microwave, police, fire, emergency services, and on and on. Second, it is simply not possible for two signals to occupy the same physical space at the same frequency without destructive interference. Given these facts, wireless cools off.

Most of these “...whatever...is dead” claims are made for self-serving reasons. One cannot totally condemn the proponents (and venture capitalists) of new technologies for shameless self-promotion. One simply does not have to believe them—completely. As with all half-truths, half of what they say is true. Fiber did carry gigabit (and later 10 gigabit), and copper did not—initially. Fiber did have limited bandwidth and distance—initially. Wireless truly is amazing and can do things one cannot do with conventional wiring—but not all things, and not without constraints.

OK, what can copper and fiber cabling do that wireless cannot? Lots of things! For one, unlike structured cabling, wireless has terrible interference problems. And its security problems are legend. Implementation is rather interesting: no property rights on most frequencies, and no way to mitigate interference. The frequency bands of wireless LANs are fraught with troublesome interferers, including microwave ovens, cordless phones, competing technologies, and (yes, as unbelievable as it seems) even radio frequency lighting.

Wireless communications, by its very nature, travels with little regard to walls, ceilings, or property lines. The average urban home can probably detect from 5 to 25 wireless LAN signals, not including their own. Transmission bandwidths limit the channel capacity of the most popular band (2.4 GHz) to only three nonoverlapping channels (two actually overlap a little). Security has been a joke, with any joker able to crack the limited encryption method most often used, if one even bothers to implement it at all. Popular wireless LAN implementations operate in unlicensed bands, so you cannot even depend on long-term use of a channel for a wireless link or coverage area, unless you own the land for a considerable distance. The popular wireless protocol, being quite the gentleman, obliges the use of the channel for any other user, no matter how uncouth.

How then can structured cabling be inferior? LAN wiring has no interference issues, other than a few very minor concerns that are easily eliminated with proper cable routing and placement.

LAN Wiring has no frequency issues: within its rated bandwidth, you get exclusive use of the cable link. And, you can place as many parallel cables as you wish. One cable, one gigabit (or even 10 gigabits). Two cables, two gigabits (or 20). One hundred cables, 100 gigabits. Easy math, easy to do, no particular problems, other than the size of 100 cables, but with fiber, you could multiply that bandwidth many-fold in a fraction of the size.

On security, again LAN wiring is superior. Granted, there are sophisticated techniques that can allow one to sample data from a cable from a very close range. But, physical security of a home, building, campus, or government facility is generally quite good. In contrast, the wireless signal at best can travel miles, and at worst can be easily detected from across the parking lot with a high-gain antenna and low-noise amplifier. You can get the code-breakers for free on the 'net. In contrast, the very latest high-bandwidth Category 6 and 7 cables are low-radiation technologies, so the signal stays close. And fiber is inherently secure, as it essentially does not radiate at all.

Well, let's talk distance. In an ideal world, with no other users and no objects in the way, wireless distance is limited only by the transmit power, the receiver sensitivity, and the distance in between. Today, that environment exists only in the desert and that won't last for long. Depending on the technology you use, cabling can go 100 m, 2000 m, or even 70 km, or more. Not only across that desert, but right through the most dense population areas in the world, crisscrossed as many times as you like.

To be fair, copper and fiber cabling do have infrastructure costs and implementation issues. It takes time, planning, and skill to create a network of structured cabling. The details of planning, installation, and testing do matter. That's what we're here to learn about.

LAN Wiring, 3rd edition, will take you through the steps of designing and building a modern structured cabling system. Along the way, we will show you how to plan your installation, how to lay out wiring rooms, and how to install and terminate the components of a structured system. We will discuss cable types, connectors, patch panels, and outlets. In addition, we will cover best practices and tricks of the trade you will need to know to design, contract, or install structured cabling. And, as an added bonus, we will cover details on LAN topologies, legacy cabling, international standards, and ... oh, yes ... wireless LANs. Finally, we will show you how to performance test and troubleshoot an installed system. You will find loads of drawings, photos, and tables to help you understand the concepts and to use as a permanent reference for all your LAN wiring needs.

This edition has been completely revised to bring you the very latest in structured cabling technology. We have rearranged the material to get you to the core of the subject more quickly, while maintaining our coverage of the entire range of technology used for LAN wiring. We wish you all the success in your cabling adventures.

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