Long and Winding Road

Getting Electricity, Voice, and Data to the Desktop

When things are going right (the network's up, the power's uninterrupted, the connections are stable), office workers don't give their electronic work tools another thought.

Yet for this to happen, vast lengths of cable, complex power grids, and intricate switches must all remain aligned like the sun, moon, and stars in an astrologer's auspicious reading. In these flawless connections, electrons and data packets dance along from Point A to Point B in nanoseconds.

This report examines the last leg of this journey—how power and data make their way from building source to the place where the work gets done (typically the desktop, sometimes the palmtop).

Typically this means wires and cables travel through office furniture on their way to their ultimate destination. And that fact has information technology professionals and real estate and facility managers seeking to integrate their efforts as never before.

Humdrum Power

Of the three parts of the equation—power, voice, and data—the first, while remaining a critical consideration, is the most familiar and predictable. It wasn't always that way.

In the late 80s, nearly everyone suspected that the "harmonic," or pulsing, currents computers generate produced substantial distortion on the electrical system. The belief was that this distortion could cause the neutral conductor to overload, and possibly cause fires.

Manufacturers responded by upsizing the neutral conductor or providing separate neutral conductors for each phase conductor. The industry adopted standards to quantify the overheating capacity of transformers serving non-linear loads.

A National Electric Code (NEC) subcommittee studied the issue and determined there was no indication that either the problem occurred with regularity or that fires could be associated with it. However, the NEC did advise manufacturers in its 1996 code to consider harmonics when designing and sizing branch circuits and distribution systems.

Meanwhile, computers continued to gobble more energy. According to Energy Information Administration, 13 percent of the energy consumed in the United States in 1995 (the last year for which figures are available) went to power personal computers and office equipment. This is nearly the amount of energy used to air-condition commercial buildings.

Between 1995 and 1998, the energy personal computers and office equipment consumed rose 15.8 percent while total electrical energy consumption rose only 5.7 percent.

Statistical analysis of buildings shows that in commercial office buildings there are 797 computers or terminals for every 1000 workers. This figure varies from 743 per 1000 workers in buildings of less than 50,000 square feet to 833 per 1000 workers in buildings over 50,000 square feet.[1]

But even as offices become saturated with power-hungry equipment, the equipment, and its use, becomes more efficient. For example, buildings that meet the standards of the Environmental Protection Agency's Energy Star program must have a means to power down machines that are not in active use.

Flat panel, solid-state displays will also have a significant impact in the near future. These monitors use less energy and generate less heat than conventional cathode-ray monitors, but won't see wide usage until their price drops significantly.

The Digital Revolution

Distributing power within offices will remain important, but handling data and voice communications will overshadow it for the foreseeable future. Packets—such as those that make up the data routed over the Internet—are all the rage.[2] And everyone is concerned about whether their networks have enough bandwidth to handle them.

Most voice and data networks use unshielded twisted pair (UTP) copper wires. Many are legacy environments (they've been around for awhile with applications and data inherited from languages, platforms, and techniques earlier than current technology). They're stretching to cope with more demand and straining to incorporate new technologies.

In a nutshell, typical commercial buildings reflect these characteristics:

- Voice and data networks are separate.
- Three-quarters of premises wiring is UTP copper cabling.
- Backbone cabling (i.e., the cabling routed from the building point of entry to and between telecommunications closets) is usually fiber optic cable; the horizontal cabling (i.e., the link from the telecommunications closet to the outlets in the workstations) is Category 5e or Category 6 cable.
- Voice and data cables are routed directly from the telecommunications closet to each individual workstation in a method known as Home Run distribution.
- A few have wireless voice and data systems. (This is growing modestly but consistently.)
- Some have videoconferencing capabilities, but the focus remains on group systems (one camera in a conference room) versus an individual capability at each desktop.
- Nearly every one provides network access to the Internet and corporate intranets.

Copper is King

In 1998, UTP copper cabling accounted for 73 percent of all commercial office premises wiring, and fiber for the remaining 27 percent. Fiber is expected to grow to 38 percent by 2002, with most of it being used in backbones. Horizontal (to the desktop) cabling is expected to be only 5 percent fiber in 2000 and 10 percent by 2004.[3]

The increased deployment of Local Area Networks (LANs), rising Internet usage, and the need for high-speed access to multimedia applications have resulted in a tug-of-war between copper and fiber optic cable vendors. As the former tries to hold onto its dominance of the horizontal space between the wiring closet and the workstation, the latter is trying to unseat it.

However, basic Category 5 and Category 5e cables cannot fully support the sophisticated multi-pair, bi-directional transmission technique used by Gigabit Ethernet, a LAN transmission standard that provides a data rate of 1 billion bits per second. Cable manufacturers have responded by developing Category 6 gigabit-speed structured cabling systems rated at 200 MHz and higher with better performance in terms of cross-talk, attenuation, and return loss.

While copper cable still dominates the market, experts believe fiber will claim a greater share if the cost of the active components (switches, routers, and hubs) goes down. Using fiber to connect to the desktop would play to its strengths: It doesn't lose signal over distance, it has a 200-pound pull strength (versus copper's 25-pound), it is immune to electrical noise, and it can handle a tighter bend radius without signal disturbance.

Add to these benefits the fact that the cost of fiber is increasingly comparable to a proposed Category 6 copper upgrade option, and fiber's future looks brighter still. Many organizations are likely to choose fiber when it comes time to install new cable.

Still Hitting Home Runs

In most offices in North America, voice and data get to individual workstations by a direct connection between the telecommunications closet and the workstation outlet. The method is known as home run distribution. Each cable (currently Category 5e for data and anything from Category 3 to Category 5 for voice) makes the full trip from telecommunications closet at the building entry point, through the building (in the ceiling or under a raised floor), and into and through the furniture to the individual desktop outlet.

In the realm of data networks, home run distribution offers several advantages. First, everyone, from installers to information technology, is familiar with it. Second, it provides high reliability since there are a minimum number of connections, and connection points are one place where signals can break down. Third, there's so much of it. With a huge installed base of copper wire data networks and significant investment required to change them, most firms opt to continue the home run approach.

Whether home run distribution is accomplished by running cables through ceiling plenum or under a raised floor, it has one distinct disadvantage: it's difficult and costly to move. That wouldn't be a problem if moves, adds, and changes weren't a stark reality of business life. For many firms, the less-than-ideal response is to move people around from office to office and resist changing furniture and cabling even when that would increase productivity.

Recently, a couple of variations on home run distribution have emerged (see illustrations on page 3). One is a cabling practice that employs a consolidation point (CP).

The CP is an interconnection point where cables from the wiring closet terminate in an interconnection device. Additional cables run from the interconnection device to the outlet or connector in the work area.

A second variation is called the Multi-User Telecommunications Outlet Assembly, or MUTOA. In this case, instead of installing an outlet or connector in each work area, a multi-port outlet/connector panel is centrally located in a work area of up to 12 stations. Cable is run from the wiring closet to the MUTOA and patch cables of up to 66 feet in length run from the MUTOA to the equipment in the work area.

Organizations with a high rate of moves, adds, and changes can benefit from these alternative approaches. When they want to alter a workstation, these organizations can typically limit recabling to the patch cables—the section of the home run cable from telecommunications closet to consolidation point can often remain unchanged.

There are limitations, however. The length of the patch cable cannot exceed 66 feet; doing so would exceed EIA/TIA standards designed to prevent signal loss. Second, these organizations haven't overcome the initial costs of running individual cables to each workstation outlet.

As shown in this comparison matrix, information technology, telecommunications, and facility managers report a strong preference for conventional, home run cabling (see matrix on page 4). While they judge raised floors to be the most flexible and simple solution, few take this route because of the significantly higher cost.[4]

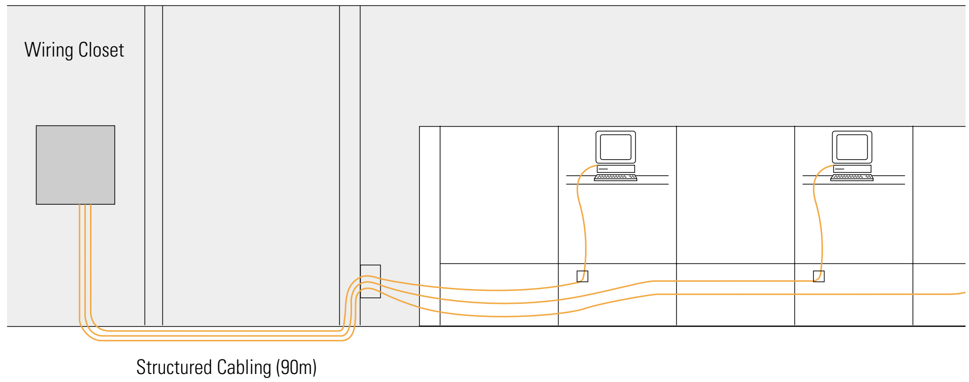
Switches in the Zone

Some organizations are shifting from the home run method to an approach known as zone distribution. These firms view moves, adds, and changes as necessary, ongoing activities that give them the flexibility required to take advantage of business opportunities.

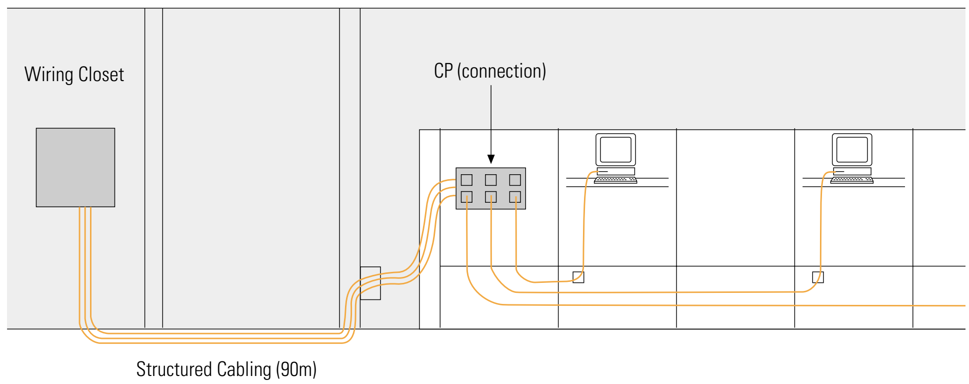
Zone distribution has already gone through several iterations, but the essential components remain the same—a backbone consisting of a high-performance fiber optic cable running from the telecommunications closet to a strategically located distribution point or remote wiring space (see illustrations on page 3).

These distribution points, which house patch panels and active devices (switches, hubs, and routers), fit in the interior of systems furniture walls, separate cabinets, the ceiling plenum, or under a raised floor.

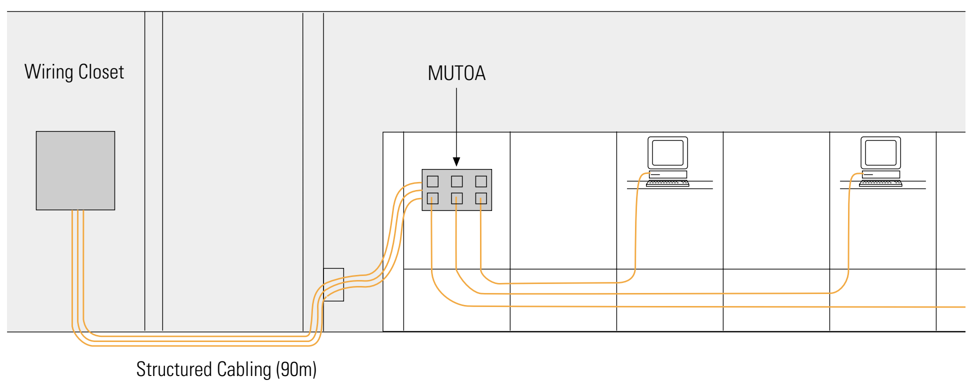
Home Run Installation



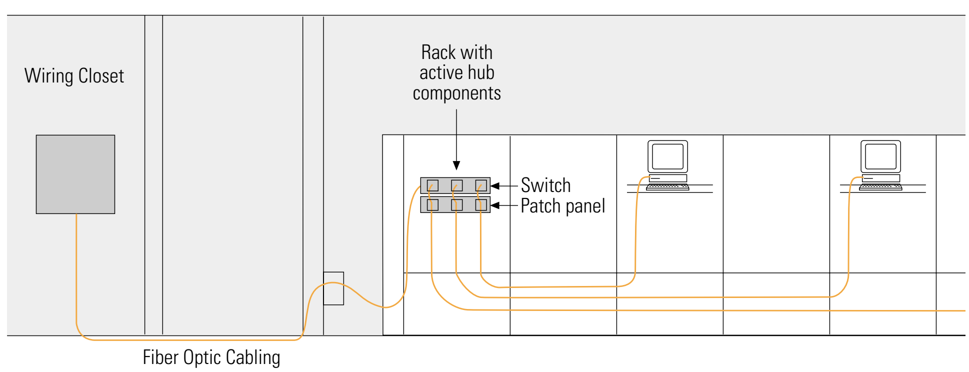
CP Installation



MUTOA Installation



Zone Installation

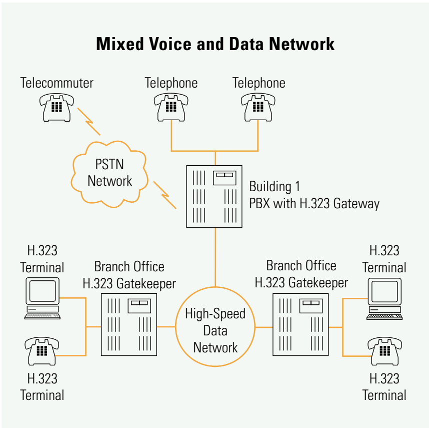


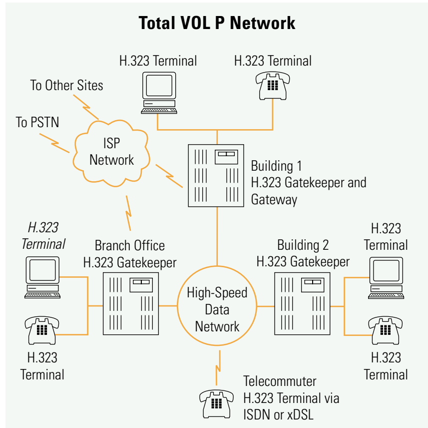
Comparison Matrix

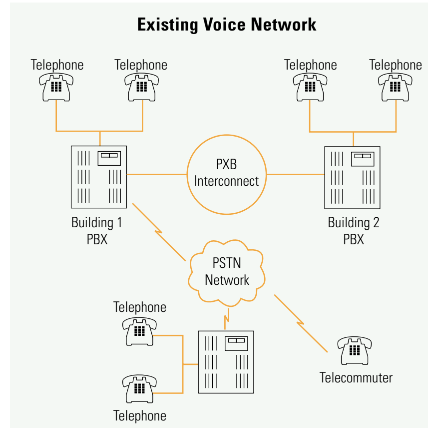
Scenario	Description	Advantages	Disadvantages	Constraints	Usage[1]	Cost Factor[2]
Conventional, homerun (base system)	Ceiling plenum cabling to outlets in walls and columns	Most common system Well understood	Not flexible Costly to change	Few constraints	50% to 90%	100
Ceiling plenum, doghouses	Cabling in ceiling plenum below with poke-throughs to doghouses	Concealed Low cost	Holes in floor Outlets cannot be installed through structural elements Code restrict frequency and placement of outlets Need access to ceiling below for installation and changes Obtrusive outlets	Plenum rated cables generally required Maintenance of fireproofing on structural decking Code limits number of holes per floor area	5% to 25%	109
Raised floor, flush outlets	Cabling in raised floor of 6"+ with flush floor outlets	Best aesthetics Easy access to outlets Nearly unlimited capacity for expansion	High cost Floor transitions Difficult to access cables with furnishings in place.	Few constraints Plenum rated cable may be required.	None to 5%	186
Low profile raised floor, flush outlets	Low profile (3"±) integrated floor and cabling system	Best aesthetics Easy access to outlets	High cost Floor transitions Difficult to access cables with furnishings in place.	Few constraints Plenum rated cable may be required.	None to once or twice	242
Ceiling plenum cabling with poles	Cabling in ceiling plenum with poles through ceiling	Low cost Easy to change Easy to install Nearly unlimited capacity for change and expansion All work is within the space	Worst aesthetics	Plenum rated cables generally required Maintenance of fire-proofing characteristics of ceiling if part of rated assembly Requires accessible ceiling assembly and support system for pole Requires electrician to relocate poles with power	5% to 25%	109
Cellular decking with flush floor boxes	Cabling in structural decking system with flush outlet boxes	Low impact on space	Fills up over time, cables hard to remove Outlet locations restricted to cell runs Limited capacity Difficult to make changes	Few constraints Slab may require thickening to maintain fire rating	None to 5%	151
Floor ducts with dog-houses	Cabling in ducts embedded in floor with doghouse outlets.	Low impact on space Can be used in over-slab in renovated work	Limited capacity Difficult to change Fills up over time, cables hard to remove Limited outlet locations Obtrusive outlets	Few constraints Seldom used in new work	None to once or twice	158

Notes:
Fundamental requirements that must be met by all systems include maintenance of fire and smoke barriers and UL listing.
1. Based on respondents to the survey of designers and installers.
2. Base system is 100, others are in relation to this for the model office environment used in a cost analysis.

Convergence Solutions







From this remote wiring space, short and conveniently accessed lengths of copper cabling deliver one or more data drops to each work-station in a nearby cluster. Since fiber optics transmits at speeds of up to 10 Gbps and experiences virtually no loss of signal over any distance within a building, it is the recommended choice for the backbone.

Zone distribution based on fiber optic cables in the backbone delivers significant costs savings at installation because a single fiber optic cable replaces the need for any Category 5e cables to be strung from closet to workstation clusters. Category 5e cables are only used to make the relatively short connection between the patch panel or switch in the remote wiring space in the furniture and the outlet at the desktop. Many firms prefer to use patch cords for computer connections in the workstation, instead of an additional outlet. This allows them to reuse all cable when moves, adds, or changes occur.

This approach saves on materials and installation labor compared to the home run method. Because of the dramatic reduction in cabling required, many organizations have realized from 15 to 35 percent savings at initial installation.[5] And these savings increase with every additional drop per workstation.

Initial cost savings aside, even larger savings occur when making moves, adds, and changes because the backbone stays intact, so there is no need for installers to re-string cables from closet to reconfigured workstations. The furniture and the short connections they carry change as needed, and if the furniture provides lay-in access to cables, rerouting these short connections is relatively easy.

Zone distribution also makes upgrading network speeds easier. Because high bandwidth is already available in the workstation cluster, changing a switch and patch cord is all that is required to bring fiber to the desk. The result is higher network speeds due to a lower bit error rate.

Organizations with multi-story facilities also save by "collapsing the backbone." They, in effect, turn the zone distribution model on its side. Using a high-speed fiber optics cable, known as a riser, to connect the network between floors, they can significantly reduce the number of cables compared to what would be required with home run distribution.

However, using fiber optic cables in the backbone and copper patch cables presents one challenge that few furniture manufacturers can meet. Fiber optic cables transmit signals using light pulses. In order for the Category 5e cable to link from a patch panel in the furniture to the desktop outlet, an electronic switch to convert light pulses to electrical signals must be used.

This requires that the furniture have the capability to not only house active electronic switches but also safely supply the electrical power they need to operate. Most furniture can only handle passive components—those that merely connect cables but cannot change a signal from the light form to the electrical form.

Worlds Converge

While agile corporations adopt methods such as zone distribution to ensure flexibility, they are at the same time investigating ways to decrease the number of wires and cables in their facilities. Many are watching carefully as the traditionally separate worlds of voice, data, and video come together in a process known as convergence.

Convergence is occurring in several areas:

- At the transport level, convergence means data networks are also carrying voice, video, and images.
- At the user-interface level, PCs are becoming telephones and mobile phones are becoming devices that can browse the Web and send email.
- At the infrastructure level, PBXs and other phone switches will be replaced or augmented by servers.

Voice over IP (VoIP) is an example of a convergence solution. It integrates voice and data over Internet Protocol (IP) networks. With the addition of video, VoIP networks can support multimedia applications.

VoIP allows voice-enabled Web sites, the ability to work more collaboratively among branch offices, and cost savings on long distance services (some sources estimate companies may be able to lower their communications costs by as much as 40 percent by routing voice traffic through "unused space" in data networks).

A VoIP setup eliminates the phone cable. Also known as an H.323 gateway, it uses an electronic board added to a standard PBX to convert voice traffic to a digital form that can be carried by a LAN system. All communications travel over the data network connected to each user's telephone and from it through a patch cord to that user's personal computer. An Internet protocol (IP) address, instead of a number, identifies the phone. Changing a person's phone is as simple as directing the network to send information for a particular IP address to another location.

Even given current problems with voice quality, interoperability, reliability, and limited functions, VoIP seems destined to take hold. And while it will help in many ways, not the least by eliminating the phone cable and reducing to two (power and data) the number of cables furniture must house, it still means that moves, adds, and changes require time and money. But what if there were no wires at all?

The Role of Wireless

The wireless facility ranks right alongside the paperless office in both allure and elusiveness. The appeal is obvious—freedom to rearrange furniture without a thought to the network.

While wireless could well be the optimum solution to connect workers in a flexible office environment, cables will be with us for some time due to the practical problems of implementing wireless. The most significant of these are higher cost, limited signal bandwidth, and the life-to-weight ratio of batteries.[6]

Wireless Local Area Network (WLAN) equipment has improved in the last few years, from old equipment using the 900 MHz band to deliver 1 to 2 Mbps to the current Institute of Electrical and Electronic Engineers (IEEE) 802.11b standard using the 2.4 GHz band delivering 11 Mbps to the recently introduced IEEE 802.11a standard delivering 54 Mbps.[7]

The 802.11a standard uses the 5.4 GHz band, which is less "crowded." and provides 54 Mbps data speeds. If this equipment continues to come down in price, it will gain in usage, although one problem will remain—these higher frequency transmissions have more difficulty penetrating walls, a possible deterrent in office spaces.

WLAN saw initial use in historical buildings, buildings with asbestos or other hazardous materials in the walls, and in temporary spaces like trade shows—places where wholesale rewiring is either impossible or doesn't make economic sense. Use has expanded to public spaces, such as airports, train stations, and coffee shops, where mobile access is key. Some early adopters have experimented with WLAN on college and university campuses and in commercial office buildings. However, it seems likely that WLANs will not replace wired systems, but will be used to extend the wired network.

A case in point is the use of WLAN equipment in office settings where it is an extension of the wired LAN for highly mobile workers. Workers who have laptops and need access to e-mail, the Internet, intranets, and file servers while they're on the move will probably use this technology.

An environment for WLAN that may catch on is the small office. The small office worker may accept the slower WLAN speed in exchange for a single access point, which reduces cost and increases flexibility. The small office owner also avoids cable installation costs and gets a system that can grow with the business.

Another issue is interoperability. For wider adoption to occur, equipment from various manufacturers must be able to work together. That's the object of the interoperability standard developed by the Wireless Ethernet Compatibility Alliance (WECA), an organization of WLAN vendors formed to certify the interoperability of WLAN products. Their "Wi-Fi" seal of approval (short for "Wireless Fidelity") certifies that a vendor's network interface card will communicate with any "Wi-Fi"-approved access point from any other vendor. WECA has also established an interoperability standard for 802.11a products called "Wi-Fi5."

Even with these advances, another concern remains. Will interference from cellular phones, cordless phones using the 2.4 GHz band, even microwave ovens affect WLAN use in offices?

Yet, WLAN vendors are predicting that the emergence of wireless LAN products, running at 10 and 11 Mbps, will launch WLANs into direct competition with wired LAN products. While industry analysts are not forecasting an "explosion" in WLAN use, they do predict "sustained growth."

Decreasing costs for WLAN equipment will help. But when we get to the point where cost is no longer an issue, the issues of lower data speeds, lower security, and lower reliability compared to cabling systems will remain. The question becomes, what will the corporate user tolerate to achieve mobility?

Bluetooth Gets Personal

The best chance for eliminating wires in the office, or at least in the workstation, may result from a technology initiative named after the king credited with uniting Denmark over a thousand years ago. Bluetooth is the codename for a technology specification for small form factor, low-cost, short-range radio links between mobile PCs, mobile phones, and other portable devices.[8]

Bluetooth promises to eliminate the cables to the mouse, keyboard, cellular phone, handheld, printer, etc., and create a Personal Area Network (PAN). The hierarchy descends from Wide Area Network (WAN) to Metropolitan Area Network (MAN) to Local Area Network (LAN) to PAN.

Both Bluetooth radio transceivers and WLAN equipment operate using the 802.11b standard and the 2.4 GHz frequency range. That fact led many to speculate that Bluetooth appliances would interrupt the data transmissions of WLAN equipment using 802.11b. Although testing for this possibility has been limited, experts believe that the two can coexist without interference.

In some cases, chipset manufacturers are contemplating combining both technologies in a single product. This indicates that they're not too concerned about compatibility.

It may be a moot point, however. WLAN equipment manufacturers are moving away from the 802.11b standard to the 802.11a standard, which uses the 5.4 GHz band and which would not interfere with Bluetooth appliances operating on the 2.4 GHz band.

Finding an intended recipient in a room full of Bluetooth products is another issue. If there are lots of Bluetooth-enabled products in the office, the user may get a list of possible devices to connect with and have to select the correct device manually.

Security is another concern at this point. There is a security layer in the Bluetooth specification, but some vendors do not think it will be effective and communications may be intercepted. And, security is difficult to establish between devices.

Yet, even with these caveats, many predict a bright future for Bluetooth-enabled devices. One group forecasts shipments of 955 million units by 2005, up from the current level of $4 to $5 million. Another believes shipments will reach over 1 billion by 2006.

But as is the case with most new technologies, cost per unit will limit sales until it decreases. If Bluetooth-enabled devices reach the targeted $5 to $10 range per unit, they could replace a desktop computer's corded mouse, keyboard, and speakers in the next two to three years.

Power to the People

Outside of the PAN, people in offices will have to deal with wires and cables of some sort to get their power, voice, and data. While the voice cable may go away by implementing VoIP, there are still the data and power cables traveling through the facility, into the furniture, and to an outlet within the workstation.

New technologies, such as WLAN and Bluetooth, may eliminate some wires and cables, but it seems that the last leg of the journey power, voice, and data take to get to workers will be through furniture. The walls or panels of office furniture systems can provide a neat, efficient means for cable entry from walls, floor, and adjacent freestanding furniture and for managing the electrical cords and network cables that run from electronic devices to outlets and ports.

The best systems help to organize and control wires and cables—not just hide them. Panels that allow cables to be laid in—rather than pulled or snaked through channels—in a systematic fashion can greatly simplify maintenance and change.

Glossary of Terms

Analog. A form of transmitting information characterized by continuously variable quantities, as opposed to digital transmission, which is characterized by discrete bits of information in numerical steps.

Backbone. The part of the communications system that carries the heaviest traffic.

Bandwidth. A measure of spectrum (frequency), use or capacity. Can refer to the amount of information that can be sent, processed, etc., in a given amount of time and can therefore be taken as a measure of the speed of a connection.

bps. Bits per second. Measurement units of the speed of data transmission, and thus bandwidth.

Bend radius. The minimum allowable curvature of a cable before it deforms, degrades, or breaks.

Category 5 and 5e. (Cat 5) A level of performance for twisted-pair copper cable as established by electrical and telecommunications industry standards. Category 5 cable characteristics are specified up to 100 MHz. Like Cat 5, Category 5e (Cat 5e) supports transmission at frequencies up to 100 MHz while several aspects of its transmission performance exceeds Cat 5.

Ethernet. A protocol for local area networks running on coaxial or twisted pair wiring, at 1 or 10 Mbps.

Fast Ethernet. Local area network protocol running at 100 Mbps on unshielded twisted pair copper wire.

Fiber optics. Technology using thin filaments of glass or plastic to transmit light waves carrying data.

Gbps. Gigabits per second, or a billion bits per second.

Gigabit Ethernet. Local area network protocol running at 1 Gbps on unshielded twisted pair copper wire.

LAN. Local-area networks are short-distance telecommunications networks used to link computers and peripheral devices under some form of standard control.

Mbps. Megabits per second, or a million bits per second.

Multimode. In fiber optics, an optical fiber designed to carry multiple signals distinguished by frequency or phase at the same time (contrasts with single-mode).

MUTOA (or MUTO). The multi-user telecommunications outlet assembly connects devices in individual workstations to a home-run cable at a central point in a group work area.

Node. A point of connection into a network. May be a desktop PC, peripheral, or other device.

Packet Switching. Data transmission method that divides messages into standard-sized packets for greater efficiency of routing and transport through a network.

Riser. The high-speed fiber optics cable that connects a network between floors of a multi-story building.

Structured wiring system. Wiring system based on defined standards and schemes, and requiring consistency in design, layout, and logic to provide a complete solution to wiring all communications devices within a company.

UTP. Unshielded twisted-pair cables have one or more pairs of twisted copper conductors bound in a single plastic sheath.

WAN. Wide Area Network. Uses common carrier provided lines that cover an extended geographic area. Contrast with LAN.

WLAN. A wireless Wide Area Network.

Zone distribution. A method of cable distribution in which distribution points outside the wiring closet allow connections to office outlets or equipment.

Notes

1 "Personal Computers and Computer Terminals in Commercial Buildings," The Energy Information Administration, at http://www.eia.doe.gov/emeu/consumption/.

2 A packet is the unit of data that is routed between an origin and a destination on the Internet or any other packet-switched network. When any file (e-mail message, HTML file, GIF file, URL request, and so forth) is sent from one place to another on the Internet, the Transmission Control Protocol (TCP) layer of TCP/IP divides the file into "chunks" of an efficient size for routing. Each of these packets is separately numbered and includes the Internet address of the destination. The individual packets for a given file may travel different routes through the Internet. When they have all arrived, they are reassembled into the original file (by the TCP layer at the receiving end).

3 Herman Miller, "TN Advance Project," proprietary research, June 1999, p. 28. A good deal of the content of this summary is based on this extensive proprietary research project.

4 The information in this comparison matrix is based on interviews conducted with a random sampling of architects, engineers, cable system designers and installers, facility managers, and IT/telecom managers conducted by Teltech Research Services in May 1999 on behalf of Herman Miller, Inc.

5 Estimated savings are based on the experiences of engineers at American Access Technologies, Inc., a firm specializing in providing zone distribution components that can house active switches, hubs, and routers in furniture, ceilings, and raised floors. Independent proprietary research conducted by MIS Labs, Inc., for Herman Miller, Inc., in February 1999 confirmed these results.

6 Much of the information in this section is based on internal documents prepared by Herman Miller researchers in March 1999.

7 For more information on IEEE standards, visit http://www.standards.ieee.org/.

8 The consortium of companies that have banded together to promote Bluetooth provide information on this technology at http://www.bluetooth.net/.