"Tuning In" to the Infrared Wireless Network

As network bandwidths widen, it is becoming more crucial for wireless technologies, such as radio frequency (RF) and infrared (IR), to meet the increasing demands of mobile wireless LAN users.

Today, high speed, wired LANs are being implemented across a wide range of industries to support the expanding, interactive use of computer and communications technologies. Data intensive applications, especially those incorporating graphical transfers, are becoming more prevalent. High-speed, low-cost modems are making the transfer of large files and interactive work more effective. Increased usage of client/server environments, multimedia applications, and the Internet are jointly contributing to the need to support increased individual and aggregate data rates through communications backbones and LANs. On the surface, most wireless LAN solutions appear to fall short in their ability to meet the need resulting from these increased demands.

As demands have increased, there is a developing concern that wireless LANs may fall further behind. In fact, many industry experts feel that the IEEE 802.11 standard for wireless LANs will fall far short, or even be obsolete (supporting 1 or 2 Mbps data rates) by the time the standard is issued. However, Spectrix's SpectrixLite diffuse infrared wireless LAN system (see figure 1) has supported aggregate data rates close to 4 Mbps for some time. The system is based on diffuse infrared technology, an emerging force in the wireless arena. It carries with it benefits, such as security (signals retained within buildings), low power consumption, potentially higher bandwidths, and fewer international transmission restrictions, that are not inherent in other wireless technologies.

The company has develop the technical expertise to transmit at 4 Mbps using diffuse infrared. Here's how: a fast switching infrared emitting diode is turned on and off to signal the data. The system encodes the data using return to zero with bit insertion. A 1 bit is inserted to limit the number of consecutive 0’s and thus the amount of time with no light pulse being sent.

Each 1 bit corresponds to a pulse of infrared light.

Broadcasting

In the same way visible light illuminates a room, diffuse IR uses the room's surfaces to bounce data signals between transmitter and receiver (see figure 2). The important advantage of the diffuse IR transmission is that a signal is broadcast in many directions, bouncing off of walls, floors, ceilings, and objects, so that the receiver gets the signal regardless of the orientation of the transmitter. Diffuse IR is attractive because it uses low power light, which is generated by small devices suitable to battery-powered, portable computers. And, since the light does not interfere with other communications, diffuse IR does not require a government license.

The objective for most diffuse infrared systems is to allow the mobile device to communicate regardless of location and orientation. These systems rely on a wide field of view and on reflections off solid objects to disperse the signal throughout the coverage area. However, just as there are shadows even in a well-lighted room, the IR signal will undoubtedly be weak in some portions of the coverage area. The challenge of the designer is to make the tradeoffs that provide the customer with desired functionality while meeting cost, size, and power consumption goals.

The system is designed to achieve the best error rate performance possible over a wide range of conditions. Bit Error Rate (BER) performance in typical indoor environments can range from as low as 10e -7 to as high as 10e -5. Since relatively high error rates are a fact of life in any wireless communications media, provisions must be made in the system design to detect all error conditions and either correct them at the receiver or request the retransmission of messages until they are received without errors. In this manner, overall system error rates appear to the user to be comparable to wired communications systems.

Why is the error rate so variable compared to quoted error rates for cable-based LANs? The conditions in an undamaged cable medium remain stable

and relatively unaffected by the external environment. In contrast, the conditions in wireless media are not controllable, therefore the error rate will vary.

What are the conditions that can vary? Distance between transmitter and receiver is the most obvious variable. Additional variables include aspects of the room, such as reflection coefficients and the strength of other sources of infrared radiation (from within the room). Radio-based wireless systems must deal with the extra complication that many major variables affecting the RF signal are outside of the room or building.

Software Techniques

The company employs advanced, patented wireless software techniques in the transmission of data and management of the wireless environment (see Figure 3). Since the system uses a proprietary wireless protocol, called Centralized Operation Deterministic Interface Access Control (CODIAC), special optimizations are less critical. For instance, CODIAC operates within the wireless media to lessen consumption of handheld workstation battery power. To minimize power consumption, the Ethernet-compatible CODIAC protocol is designed to allow the Comm Link receiver and logic to "sleep" when there is no data activity in either direction. In addition, CODIAC provides a protocol that best fits many important wireless applications, and when required, it can support many multiple users in one subnet. CODIAC also includes provision for time-bounded services (i.e., multimedia elements over Ethernet such as voice and compressed video).

Just as in any other LAN protocol (i.e., Ethernet, Token Ring, etc.), the details of CODIAC operation are not visible to the user; the user interacts with the NetWare server or a TCP/IP node in the usual manner. The deterministic foundation of the CODIAC protocol provides constant aggregate throughput through the use of pre-determined communications slots.

Application Areas

Wireless LANs present new challenges to the network manager. Users move around and even leave the network for short periods in the middle of a session. With the system, which includes the tools to deal with workstation mobility, the network administrator can configure the subnet parameters for four object types: base station, classes (pseudo-objects), Comm Links, and operators. To speed entry of configuration information, for instance, classes of Comm Links can be defined and then assigned to a class. The network administrator can also access statistics for the SLIC (SpectrixLite Interface Card) and an individual workstation Comm Link. The network manager's console displays alarm messages as they are generated. In response to alarm messages or user complaints, the network administrator can take the diagnostic/corrective actions suggested by the system.

The system Network Management Software, running in the Base Station, provides a windowing, mouse-driven console interface which enables network managers and help desk personnel to monitor and control the system (see figure 4).

To maintain its edge as a technology leader in the financial marketplace, the Chicago Board Options Exchange (CBOE) armed its traders with a wireless IR LAN. The result is a new era in options trading technology. More than 225 CBOE traders are handling higher volumes (more trades per session) electronically with improved control over the flow of information. The Epson EHT-30 and EHT-40 handheld DOS computers they use function as front ends to a new client/server trading and reconciliation system. Weighing less than 20-ounces, the terminals are battery-powered and feature touch sensitive, flat-screen displays. The home-grown terminal software is customized for the options trading environment. The trader and exchange computing system are connected via the system. The cell-based infrared configuration of the system provides secure, high-bandwidth communications ideal for this application. When the data is entered into the custom-built DOS application, it is immediately forwarded to Spectrix's Comm Link unit—a three-inch by one-inch transceiver that is connected to the Epson's serial port. The transceiver converts the data to packets that run over CODIAC.

Since the Comm Link is application independent, entered trades are forwarded from the DOS application to the network seamlessly.

A financial trading floor, such as the CBOE's, has a large number of traders moving around freely in a large open space. Typically the trader stays on the floor for the entire six to eight hour session. Wireless systems can transmit orders to traders and transmit trader’s trades to the financial exchange computers almost instantly. When deciding between RF and diffuse IR, typically financial exchanges are concerned with the following: security of data; reliability of system operation (i.e., freedom from interference, coverage over entire floor, etc.); weight and battery life of terminals; the ability to ensure that trading has taken place only on the trading floor; and the ability to handle a large number of users and high aggregate data rate.

Meanwhile, in the health care industry, the advantage of infrared is also being used in a unique and important application. Safety concerns in hospitals make IR technology a medium of choice. While mobility is a factor in this application, the user does not carry or hold a PC. Instead, the PC is mounted on a cart, which is used in the hospital as a mobile pharmacy. As drugs are removed from the cart and given to a patient, a complete log is kept on the PC using a bar code reader. Relying on the wireless connection, the PC can immediately transfer this information to the LAN. In this way, the patient's record is updated; the cart's inventory is tracked; and the patient is billed—all in real time. If, for any reason, a mistake is made during the dissemination process, the network is equipped to warn the nurse of the error, prior to the prescription being filled.

In addition, IR is also being used in most current tracking systems. Small IR receivers are mounted in each room and in the hallways. Each person and each piece of portable equipment wears a one ounce badge. This badge transmits a diffuse IR signal frequently when motion is detected and periodically when at rest. Such a system can pinpoint asset location and be used to analyze workflow—key elements in reducing health care costs.

Diffuse IR vs. Spread Spectrum Radio

The preceding applications elected to use IR, but could spread spectrum radio achieve the same results?

Spread Spectrum radio has become well known as a medium for license-free data communications. Almost all governments in the world have designated a band at 2.4 GHz for such use. Many 2.4 GHz spread spectrum products are now available and many more can be expected to be announced in the next few years. Diffuse IR only competes directly against radio in some niche applications. Although diffuse IR is not as well known, it does have important advantages over spread spectrum radio where the two technologies do compete. IR offers benefits in the following areas:

- Power Consumption. Although current infrared LEDs are not as efficient as radio semiconductors, the total power consumption for IR transmission is usually less. For instance, the average power consumed during transmit for RF is between 400mA (2watts) and 600mA (3watts) while diffuse IR averages between 200mA (1watt) and 300mA (1.5watts). Here's why: the radio transmits a carrier during the entire transmission while IR usually uses on-off keying of some type. Thus, the infrared LEDs are actually on for a small percentage of the transmit time.

- Interference. All transmissions through air are subject to interference from sources that emit energy in the same frequency band. The difference between radio and diffuse infrared is fewer sources of IR interference (and a greater ability to control the IR interference that does exist). Since there are more radio transmitters every day, more cases of mutual interference will occur. In addition, microwave ovens operate in the same 2.4 GHz band as spread spectrum radio. Since normal walls and floors will block any IR interference from outside the desired operating area, the user can usually identify and correct any IR interference.

- Security. Since RF is not contained by normal walls and floors, an unseen transceiver can both intercept data from, and masquerade in, a network. Certain security situations will find that intolerable. Since IR can be contained by normal walls and floors, it would be the wireless medium of choice for these situations.

- Government Regulation. There is no government licensing or regulation of the near infrared frequency band except primarily laser infrared signals. An IR system can be designed that could be used anywhere in the world, which is not the case with radio systems, as regulations vary from country to country, even for the supposedly standard 2.4 GHz band.

- Data Rate. Current spread spectrum products that are small enough to be portable and can operate from batteries have data rates of 1 to 2 Mbps. The current top data rate in portable IR products is 4 Mbps. Unless there are significant changes in government regulations, the potential for portable data rate products is much greater for IR.

- Location Reporting. There are applications where knowing the location of the mobile user or a piece of equipment is important. Since infrared coverage is predictable, this task is easily accomplished by diffuse infrared.

- Health Concerns. There is no proof that the radio frequencies used for portable communications is a health hazard; however, there are still those who want to avoid it. The biological effects of infrared are well understood. At the low levels used in most communications products, the only potential hazard is to the eye; however, most products transmit well below the safety limits for the eye emitting less infrared than a standard light bulb. Those that exceed those limits must be clearly marked, such as the labels on CD players and CD-ROM drives.

Fine Tuning

In preparation for a wireless installation, a careful site survey is an important step in assuring that the network will perform up to its potential. The site survey will help the system designer to specify the correct number of antennas—saving time and money. If the system is running on a Novell LAN, it is critical to the optimum performance of the network to set the drives at the end of the search path on the wireless computer. This assures that all searches will be done in the local drives first, thereby, not wasting precious network bandwidth. If possible, there should be login.exe and logout.exe files (as well as most applications' executable files) on the hard drive of the wireless computer. This reduces traffic through the wireless serial port and speeds processing.

Expansion of capabilities in IR technology provides confidence that wireless systems will meet increasing bandwidth requirements and become a prominent and integrated member of the LAN family. For those responsible for tuning the wireless network, IR, in many cases, may be the best option for enhancing performance and reducing overall costs.

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About the Author

Bruce Campelia is the Executive Vice President of Technology & Product Marketing at Spectrix Corp. Mr. Campelia is responsible for defining the company's strategic direction and technology focus for product research, development, and marketing. Spectrix Corporation is located at 106 Wilmot Rd., Suite 250, Deerfield, IL 60015 (1-800-710-1805). The company designs and manufactures wireless local area networks for mobile users. Its protocol, bandwidth capacity, and network management functions deliver throughput performance comparable to wired LANs.

Photo Captions

Photo 1:

Spectrix has developed a diffuse IR system, called SpectrixLite, which provides LAN connectivity for up to 1000 users without limiting their mobility within up to 40,000 square feet of building space per system.

Photo 2:

When the data is entered into the custom-built DOS application, it is immediately forwarded to Spectrix's Comm Link unit, a 3-inch by 1-inch transceiver that is connected to the Epson's serial port. The transceiver converts the data to packets that run over CODIAC.