

AN INTRODUCTION TO IEEE 802.11 WIRELESS LANs

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ABSTRACT

As the capability of wireless LAN systems improves, interest in these systems is soaring. In this paper, an overview of wireless LANs is presented which will include broad, system level topics relating directly to IEEE 802.11 systems.

INTRODUCTION

Wireless LAN technology is now becoming a viable alternative to traditional wired solutions. There are several advantages to a wireless network. Since wireless networks require no physical connection between the end user and a network server, they are generally less expensive to install. There are no difficult cable installations, no furniture to reposition and no walls to drill through. A wireless solution may even be possible between separate buildings. All this allows for genuine mobility within a network. Users can move about while staying connected to the network. We've probably all seen the workers in our favorite discount or department store using handheld wireless terminals. Prices can be changed instantaneously and inventory can be maintained in real time. Many of these handheld terminals have scanners and printers built right in. These devices, for example, allow the workers at the car rental company to meet you at your car, print your receipt, and get you on your way. Wireless networks allow workers in warehouses to receive, track, pick and ship orders, while at the same time keeping the inventory up to date in the centralized database. Office workers can move around with laptops and still use network resources anywhere in the building [1].

All the applications mentioned above are already installed in the field and working with radios capable of data rates as high as 11 Mbps or even rates as low as 1 Mbps.

However, newer applications might include any combination of video, voice and high-speed data in a wireless LAN. Data rates in excess of 30 Mbps will be required.

In order to enhance the mobility of the user, provide a mechanism for multiple vendors to operate and to lower prices, the industry has moved toward the IEEE standard 802.11 for wireless networks. IEEE 802.11 allows for multiple modulation schemes, high data rates and the ability to provide a wireless system for all parts of the world.

FREQUENCY HOPPING SPREAD SPECTRUM (FHSS).

In a frequency hopping system, each unit is assigned a "hop" pattern in a given channel set. The access point directs each client's hop pattern. Hopping patterns are divided into sets to prevent prolonged collisions between hoppers. Resistance to interference is realized since the radio will always hop to a new frequency where the data can be re-transmitted.

IEEE 802.11 [2] frequency hopping is realized with Gaussian Frequency Shift Keying (GFSK). 1 Mbps is realized with 2-level GFSK and 2 Mbps is realized with 4-level GFSK. There are variations of course, but North America and Europe allow hopping over the range 2402-2480 MHz with a channel spacing of 1 MHz. Japan allows hopping over the range 2402 - 2478 MHz.

The high allowable output power combined with the good radio sensitivity required leads to good range (perhaps a couple hundred feet in an open office) and reasonably large areas of coverage. However, the wireless LAN business seems to be moving away from hoppers due to

their low data rate capability and the high cost of doing 4GFSK for only 2Mbps operation. However, there are certainly applications for which 2 Mbps are more than adequate.

DIRECT SEQUENCE SPREAD SPECTRUM (DSSS).

The use of direct sequence modulation has become increasingly popular due its ease of implementation and its potential for higher data rates than FHSS. In fact, the IEEE 802.11b standard [3] allows for 1, 2, 5.5 and 11 Mbps operation using various modulation schemes. In the US, the eleven channels are supported between 2412-2462 MHz with 5 MHz channel spacing. In Europe, there are 13 channels up to 2472 MHz and in Japan, there is single channel, 2484MHz.

The 1 and 2 Mbps rates use the familiar DBPSK and DQPSK modulation schemes. For 5.5 and 11 Mbps operation, Complementary Code Keying (CCK) is used. The 802.11b Draft Standard 7.0 specifies the formula used for spreading both 5.5 and 11 Mbps.

It is this 11 Mbps operation that has recently captured the interest of the wireless LAN industry. Users whose needs surpass 1 or 2 Mbps now have a genuine alternative to the traditional cabled network. Now wireless LAN data rates rival those of the traditional 10 Mbps Ethernet.

These systems have more strict linearity requirements than do the FHSS systems. In a linear system spectral re-growth is minimized, modulation accuracy is improved, orthogonality is maintained, and clipping in ADC circuits is minimized thus improving receiver performance.

A power amplifier back off of 5-10 dB would be required and the 802.11b spec requires some power control to accommodate different output power levels as well. The FCC allows 1 W, while ETSI

allows only 100 mW maximum output power so there is interest in power amplifier modules that have some bias adjustment for this variable gain functionality. While 1W is allowed, this is difficult, if not impossible, to achieve with just 3 V. Lower output power tends to be the norm, in the 100 mW range.

The receiver must be capable of handling an input of -10 dBm, which is a reasonably strong signal. The receiver sensitivity must be at least -76 dBm at the 11 Mbps rate so these receivers typically have about 90 dB of RX AGC. Again, with the allowable output powers and the good sensitivity requirements, reasonably large coverage areas are possible. A cell that is covered using only 11 Mbps data can have a radius of around 100 feet in an open office. That kind of coverage makes the 11 Mbps radio the hottest current product in the wireless LAN business.

THE IEEE802.11a STANDARD AND HIGH SPEED

Currently being drafted is the IEEE 802.11a standard [4] that would make use of the newly allotted frequency space between 5150-5250 MHz, 5250MHz-5350 MHz and 5725-5825 MHz. In the U.S., these frequency bands are referred to as the U-NII bands (Unlicensed National Information Infrastructure). There are four channels (20 MHz channel spacing) proposed for each of the three bands. In addition to the IEEE802.11 specifications, there are similar proposals in Europe (called Hiperlan) and Japan. The European Hiperlan Standards use 5150-5350 MHz, as well as 5450-5725 MHz. The standards being considered in Japan make use of only the 5150-5350 MHz frequency band.

In the U.S., the lowest frequency band allows the lowest output power, around 40 mW, and is intended for indoor, short-range

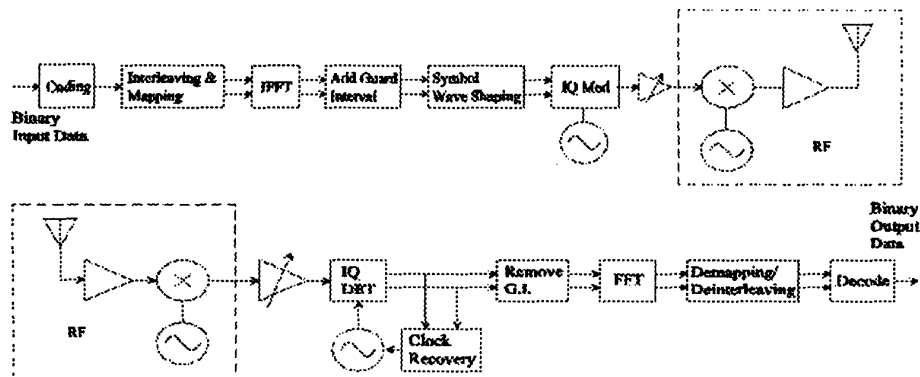


Figure 1. Simplified OFDM Transmitter and Receiver

communications only. Operation in this lowest frequency band will result in small cells, much smaller than traditional wireless LAN coverage areas. An example application might be coverage in a large conference room where access to the network is important.

The middle band, 5250-5350 MHz, allows up to 200 mW and can be used for either indoor or outdoor operation. This band, with its larger cell coverage would most probably be used in a manner similar to current wireless LANs; for example, coverage in the entire office with multiple access points or coverage for the entire home.

The highest band, 5725-5825 MHz, allows an output power of 800 mW and is intended for outdoor use only in applications like wireless bridges or building-to-building communications.

The motivation for working in this frequency space is the bandwidth available and the modulation schemes that would therefore be allowed. The goal is to achieve very high data rates. High data rates can be achieved with a multi-carrier modulation known as Orthogonal Frequency Division Multiplexing (OFDM)[5]. An OFDM signal consists of the sum of a number of sub-carriers that are modulated using some form

of PSK or QAM. Data interleavers “spread” the information throughout the carriers.

The highest data rates are achieved with the highest order QAM modulation. Under 802.11a, BPSK is used for 6 and 9 Mbps, QPSK is used for 12 and 18 Mbps, 16QAM is used for 24 and 36 Mbps, and 64QAM is used for 48 and 54 Mbps operation. Figure 1 shows simplified block diagrams of an OFDM transmitter and receiver. Note the use of the FFT and Inverse FFT in the OFDM scheme for modulation and demodulation of the OFDM signal.

Coding, interleaving and the FFT/IFFT are the most challenging parts of the physical layer (PHY) implementation. The RF implementation has some challenges as well. As in the DSSS implementations with a single carrier, an OFDM system must be highly linear especially to realize the very high data rates. AGC will be required for both the transmit path and the receive path. Amplifier and mixer drive levels well below P1dB will be required, in the range of 6-10dB. Power amplifier implementations with bias adjustment will be desirable for any implementation. LNA implementations with either a bypass switch or some gain control might also be required depending on the radio architecture. The 802.11a specification calls for a maximum input

level of -30 dBm with any of the baseband modulation schemes.

While these requirements are common in the 2.4GHz 802.11 systems, for 5 GHz they take on added significance. Wireless LAN devices are currently on the market in the PCMCIA type II form factor. They are also available in mini-PCI and micro-ISA embedded form factors, all of which rely on 3 V nominal supply voltages.

Currently, power amplifiers and discrete devices on the market are capable of P1dB of only about 20 dBm with a 3 V supply at 5 GHz. With a 6-10 dB back-off, the achievable output power will be far less than the 23 dBm allowable output power. Devices with flanges and heat sinks simply aren't usable in these small wireless LAN devices. High bias currents aren't feasible either. If these low output devices have to be used, cell sizes will suffer.

IEEE 802.11a assumes continuous coverage in the lower two bands to get the most use out of the frequency space allotted. Therefore, the frequency response of all proposed components will have to include 5150-5350 MHz and 5775-5825 MHz if not the entire 5150-5825 MHz range.

To reduce cost, higher levels of integration will have to be made available. While discrete devices have their place, they typically lead to a more expensive solution with more manufacturing difficulties.

The application of wireless LAN technology in the U-NII bands is the current frontier. High data rates will be the result. Users will desire seamless roaming, long battery life, and wide coverage areas in addition to the assumption of very fast data transfer. The framework is already in place with IEEE 802.11a.

SUMMARY

Many wireless LAN devices are integrated into hand-held devices as well as being available as PCMCIA cards for use in

laptops. They are small and require low power consumption. As technology has evolved, these products are capable of increased data rates so that they are now competitive with wired networks.

The main advantages of wireless networks are their ease of installation, the mobility and flexibility they allow and their cost. With the OFDM standard being proposed by IEEE802.11a, wireless LANs will continue to improve on these advantages and find wider application in businesses and in the home as video, voice and data will all be available through wireless products.

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