In-building Wireless LANs

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Abstract

In this paper, we focus on high speed wireless LAN architecture. The goal is to give a general introduction to the next generation of wireless LAN standard. Described here are Physical Layer and Media Access Layer of both IEEE 802.11 and HIPERLAN standards.

See also: Wireless LANs (1997 paper) | The Wireless LANs Page (1995 paper)| Wireless Data Networking (class lecture) | Wireless Local Area Networks: Recent Developments (Talk by Prof. Jain) | Wireless Networking and Mobile IP References | Books on Wireless Networking and Mobile IP

Other Reports on Recent Advances in Networking

Back to Raj Jain's Home Page

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Table of Contents:

1. Introduction

With the success of wired Local Area Network (LAN), the market now is moving toward a more attractive technology: Developing wireless LAN (WLAN) with the speed of current wired LAN. WLAN is a flexible data communication system, which can be used for applications in which mobility is necessary. In home or indoor business environment, although mobility is not an absolute requirement, WLAN can give us more flexibility that we cannot get from wired LAN. Current WLAN speed can reach 1-2 Mbps [Breezecom][Proxim], but now the industry is making a swift move toward high speed Wireless LAN . Companies are quickly developing WLAN systems which can provide data rates 11 Mbps or higher [WaveLAN][Breezecom][RadioLAN][Proxim]. The speed makes WLAN a very promising technology for the future communication market.
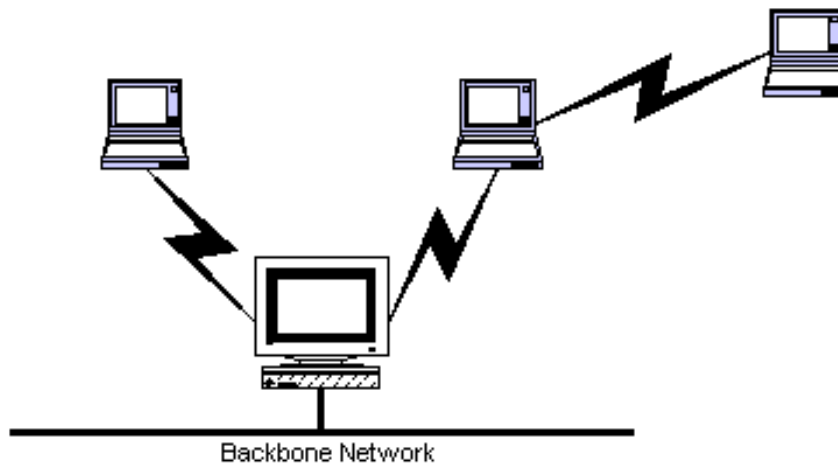

Backbone Network

Figure 1   Wireless LAN

There are several issues associated with Wireless LAN:

- ● Error Rate[Eckhardt96]: For wired LAN, errors are relatively rare. But in the world of radio, error rate is much higher. Noise, multipath, attenuation, spread-spectrum interference, etc. are all common causes for errors in wireless environments.
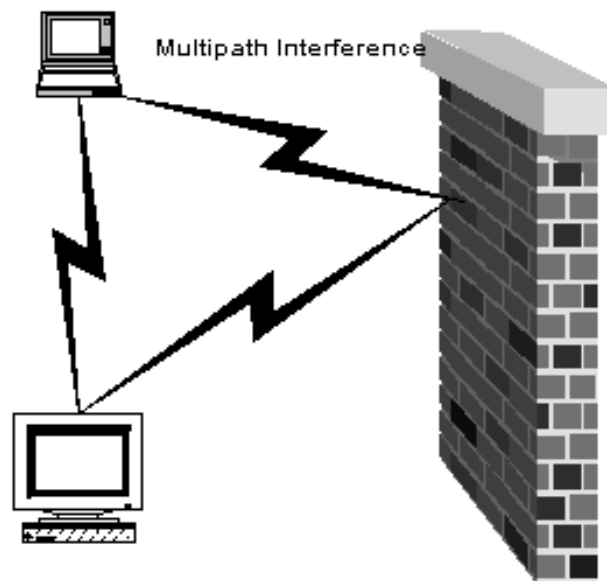
Figure 2   Multipath Interference

- Security: Radio waves are not confined at the boundary of building or campus, there exists the possibility for eavesdropping and intentional interference.

- Interference: In wired LAN, the only machines you hear are the ones connected to the network. In a wireless LAN you may hear other networks, as well as cordless phones, microwave ovens, etc. Any of these can interfere with your transmission of data.

- Power conservation: Wireless LANs are typically related to mobile applications, and in this type of applications battery power is a scare resource.

Wireless LANs are typically designed to operate in Instrumentation, Scientific, and Medical (ISM) radio bands. In the United State, the Federal Communications Commission (FCC) governs radio transmission, but FCC does not require the end-user to purchase license to use the ISM bands. ISM bands includes 902-928 MHz, 2.4-2.483 GHz, 5.15-5.35 GHz, and 5.725-5.875 GHz.

Back to Table of Contents

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2 IEEE 802.11

In June 1997, the IEEE 802.11 Working Group ratified a standard for WLANs operating at a maximum speed of 2 Mbps. This standard was lacking in many areas, resulting in no guarantee of interoperability. This resulted in all of the major WLAN manufacturers working together with the University of New Hampshire Interoperability Lab to ensure that products are interoperable across multiple vendor platforms.

The IEEE 802.11 Working Group is now concentrating its efforts on producing standards for high-speed WLAN. Until recently, The WLAN speed has been confined to a maximum of 2 Mbps. Two task groups, TGa and TGb, have been formed to work on future standards.

TGa is developing a high-speed physical layer (PHY) in the 5 GHz unlicensed ISM band that can be used with the existing 802.11 MAC layer specification and be suitable for the transport of not only data but voice and images [IEEE P802.11a/D5.0]. The 5 GHz ISM band will allow for speeds of 20-25 Mbps. TGa has accepted a combined proposal from NTT and Lucent Technologies as the basis for its work, and the draft standard is now being produced.

TGb is developing a high-speed PHY extension in the 2.4 GHz band [IEEE P802.11b/D5.0]. The current 802.11 MAC provides for multiple data rates within the same area and allows for the computation of higher data rates, even by stations that may not support them. This means that, in theory, stations could support a higher data rate and be backward compatible with existing products. A combined proposal from Harris and Lucent Technologies has been accepted which

will allow a maximum throughput of 11 Mbps [Lucent98].

Table 1 IEEE 802.11 family of Standards

	IEEE 802.11 (DSSS)	IEEE 802.11a	IEEE 802.11b
Application	Wireless Ethernet (LAN)	Wireless ATM	Wireless Ethernet (LAN)
Frequency Range	2.4 GHz	5 GHz	2.4 GHz
Data Rate	1-2Mbps	20-25 Mbps	5.5 Mbps,11 Mbps

Back to Table of Contents

2.1 802.11 Layer Reference Model

As any 802.x protocols, the 802.11 protocol covers the MAC and Physical Layer.
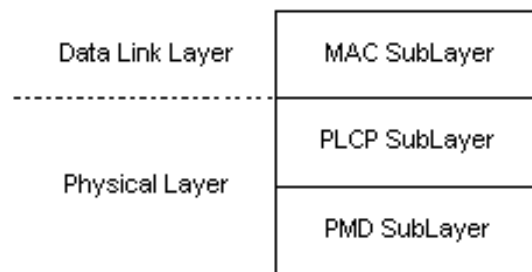

Figure 3 IEEE 802.11 Reference Model

The Physical Layer is further divided into two sublayers: Physical Layer Convergence Procedure (PLCP) Sublayer, Physical Media Dependent (PMD) Sublayer.

PLCP adapts the capabilities of the physical medium dependent system to the Physical Layer service. PLCP defines a method of mapping the 802.11 PHY sublayer Service Data Units (PSDU) into a framing format suitable for sending and receiving user data and management information between two or more stations using the associated physical medium dependent system. This allows 802.11 MAC to operate with minimum dependence on the PMD sublayer.

PMD defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more stations each using the same modulation system.

Back to Table of Contents

2.2 Physical Layer

Up to now, IEEE 802.11 specifies five physical layers:
- Frequency Hopping Spread Spectrum (FHSS)
- Direct Sequence Spread Spectrum (DSSS)
- InfraRed (IR)
- High Rate Direct Sequence Spread Spectrum (HR/DSSS)
- Orthogonal Frequency Division Multiplexing (OFDM)

The last two are used in high speed Wireless LAN. IEEE 802.11a uses OFDM, IEEE 802.11b uses HR/DSSS.

2.2.1 Modulation

Currently, Binary phase-shift keying (BPSK) and quadrature phase-shift keying (QPSK) modulation schemes are used in DSSS WLAN systems. They are sufficient in 1 and 2 Mbps systems, but they do not meet the demands of higher data rate transmission schemes. To achieve the higher speeds, different modulation techniques should be implemented.

The possible techniques considered by the IEEE 802.11 committee are [Andren98]:

- M-ary Orthogonal Keying (MOK)
- Complementary Code Keying (CCK)
- Shift Keying (CCSK)
- Pulse-Position Modulation (PPM)
- Quadrature Amplitude Modulation (DAM)
- Orthogonal Code Division Multiplexing (OCDM)
- Orthogonal Frequency Division Multiplexing (OFDM)

The IEEE 802.11b selects CCK proposed by Lucent Technologies and Harris Semiconductor for high data rate at 2.4 GHz band. CCK supports both 5.5 Mbps and 11 Mbps modulation, and it's backward compatible with the 1-2 Mbps scheme. One of the main benefits of CCK is its resistance to multi-path interference. This allows CCK-based devices to be less susceptible to multi-path interference, which in turn allows these WLAN devices to provide better system performance.

For 5 GHz band, the IEEE 802.11 committee ratifies a specification suggested by 802.11a task group. The new specification is based on OFDM [Speth99] modulation scheme. The RF system operates at 5.15-5.25, 5.25-5.35 and 5.725-5.825 GHz U-NII bands. The OFDM system provides a data rate of 6-54 Mbit/s. Since the similarity of IEEE 802.11a and HIPERLAN/2 Physical Layer, the two specification will feature essentially the same Physical Layer. This will open a world wide development opportunities for WLAN system designers.

2.2.2 General PLCP Frame Format

802.11 PLCP frames are composed of the following components.
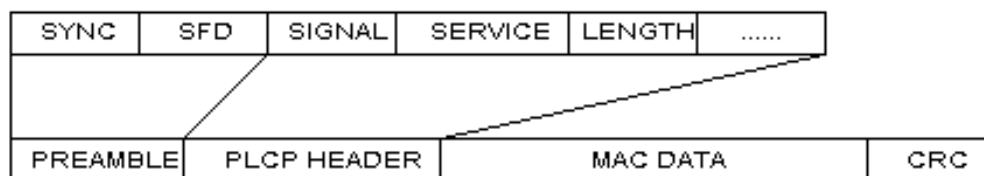
Figure 4   General PLCP Frame Format

Preamble is PHY dependent. It includes two parts: Sychronization (SYNC) and Start Frame Delimiter (SFD). SYNC is a sequence of scrambled zeros and ones, which is used by the PHY circuitry to select the appropriate antenna, and to reach steady-state demodulation and synchronization of bit clock. SFD is used to define frame timing.

The PLCP is transmitted at 1 Mbps and contains logical information used by the PHY layer to decode the frame. PLCP signalling field contains the rate information. The Service field is reserved for future use. The Length field indicates MAC data length or the number of microseconds required to transmit the MAC data.

2.2.3 PLCP for FHSS

Figure 5 PLCP for FHSS

The Preamble SYNC field is an 80-bit field containing an alternating zero-one pattern, transmitted starting with zero and ending with one. The SFD consists of the 16-bit binary pattern 0000 1100 1011 1101 (transmitted leftmost bit first). The first bit of the SFD follows the last bit of the sync pattern.
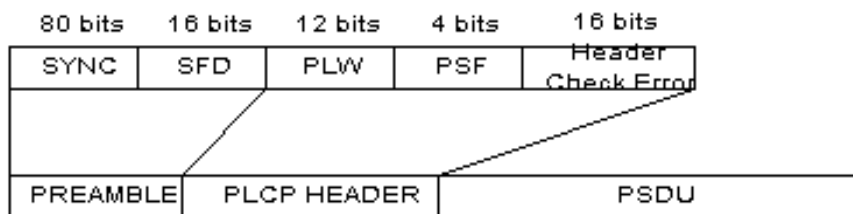
The PLW (PSDU length word) specifies the number of octets contained in the PSDU. The 4-bit PSF (PLCP Signaling field) defines the transmission rate ranging from 1 Mbps to 4.5 Mbps with 0.5 Mbps increments. The first bit of PSF is reserved for future use.

2.2.4 PLCP for DSSS and HR/DSSS
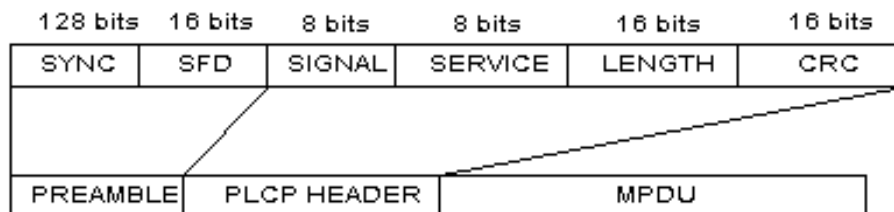
Figure 6   PLCP for DSSS and HR/DSSS

The SYNC field shall consist of 128 bits of scrambled 1 bit. The SFD is a 16-bit '0XF3A0'.

The SIGNAL field indicates the data rate:

   . '0X0A' for 1 Mbps
- b. '0X14' for 2 Mbps
- c. '0X37' for 5.5 Mbps
- d. '0X6E' for 11 Mbps

2.2.5 PLCP for OFDM
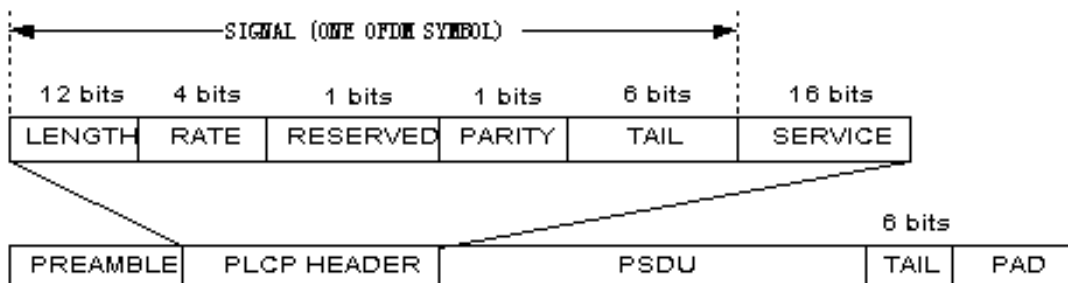
Figure 7   PLCP for OFDM

The PLCP preamble consists of 10 short symbols and 2 long symbols.

The SIGNAL field includes LENGTH, RATE and other fields. The RATE field conveys information about the type of modulation and the coding rate as used in the rest of the packet.

Table 2   Meaning of different RATE

RATE	1011	1111	1010	1110	1001	1101	1000	1100
Data rate	6 Mbps	9 Mbps	12 Mbps	18 Mbps	24 Mbps	36 Mbps	48 Mbps	54 Mbps

2.3 MAC Layer

2.3.1 CSMA/CA

IEEE 802.11 use Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) to access medium. The basic idea is: If a station wants to transmit, it first sense the medium. If the medium is busy, the state defers its transmission to a later time. Otherwise, it is allowed to use the medium. Because of the Hidden Node Problem, collision could occur. In the following graph, If both station A and C try to send data to station B at the same time, collision will occur.
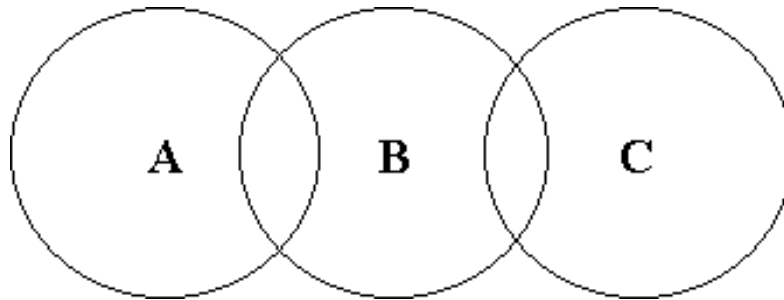
Figure 8 Hidden Node Problem

To avoid collisions, a RTS/CTS mechanism is implemented. When a station gets the chance to send, it sends a short message first. This message is called Ready To Send (RTS). The destination returns a Clear To Send (CTS) message. After that, the source station can begin to send the data. Since collisions may not be detected by source station, the destination will ACK every packet.

2.3.2 Topology

As HIPERLAN, IEEE 802.11 also has two different network topologies: ad-hoc and infrastructure. In the ad-hoc configuration, every station can communicate with any other station. There is no structure to the network. In the infrastructure configuration, there are some fixed points called Access Point (AP). A group of stations using the same radio frequency is called Basic Service Set (BSS). The mobile stations communication through the AP.
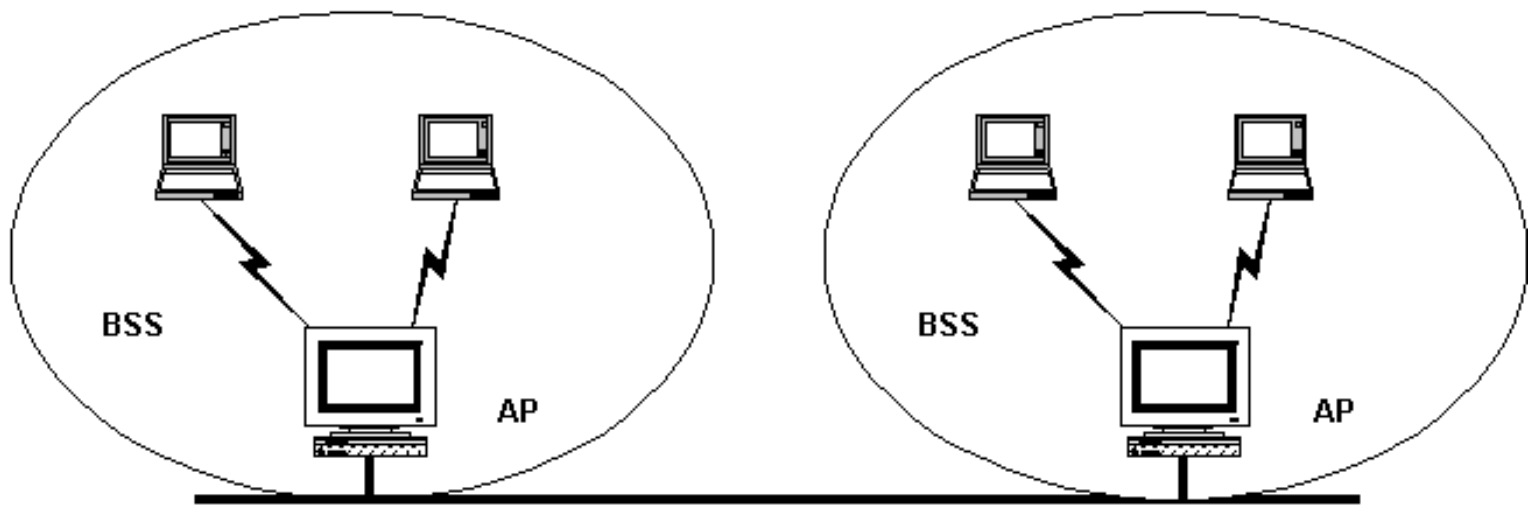
Figure 9 Infrastructure Configuration Example for 802.11

2.3.3 Priority

The standard uses Inter Frame Spaces (IFS) to provide 4 types of priorities:

- SIFS-Short Inter Frame Space
- PIFS-Point Coordination IFS
- DIFS-Distributed IFS
- EIFS-Extended IFS

The IFSs define minimum time a station need to wait after it senses the medium is free. The smaller the IFS, the higher the priority. If collision occurs, an exponential backoff algorithm is used to compete the medium.
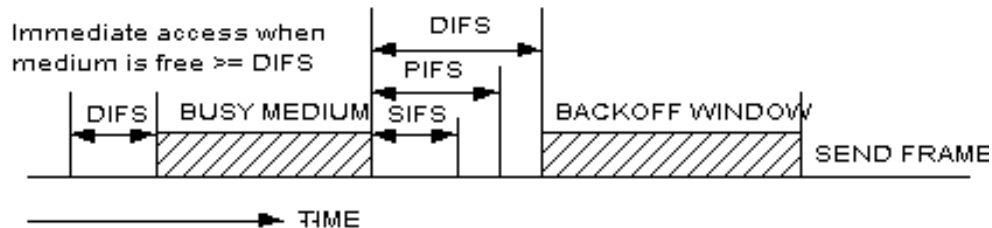
Figure 10   Priority through IFSs

2.3.4 Power Saving

The main idea behind Power Saving mechanism is that the AP will maintain a list of stations currently working in Power Saving mode, and will buffer the packets sent to these stations. When the stations specially require to get the packets by sending a polling request, or they change their operation mode, the AP will send the packets to the stations.

The AP also send periodically information about which Power Saving stations has packets buffered at the AP, so Power Saving stations should wake up to receive Beacon Frames (which bear the former information). If there are packets for them, they will stay awake and send a poll message to the AP to get the packets.

3. HIPERLAN

European Telecommunications Standards Institute (ETSI) is one of the world's recognized Standards bodies. It developed GSM standards for digital cellular telephony, and it also published many other standards dealing with all aspects of telecommunications. HIPERLAN was developed by ETSI during the period 1991 to 1996, whose goal was to achieve higher data rate than IEEE 802.11 data rates - 1 to 2 Mbps.

HIPERLAN includes a family of four standards: HiperLAN type1[EN 300 652][Taylor99], HiperLAN type2 [Johnsson99], HiperAccess (HiperLAN type3), HiperLINK (HiperLAN type4):

Table 3 HIPERLAN Family of Standards

	HiperLAN Type 1	**HiperLAN Type 2**	**HiperAccess**	**HiperLink**
Application	Wireless Ethernet(LAN)	Wireless ATM	Wireless Local Loop	Wireless Point-to-Point
Frequency Range	5 GHz	5 GHz	5 GHz	17 GHz
Data Rate	23.5 Mbps	~20 Mbps	~20 Mbps	~155 Mbps

In the following part, we focus on the discussion of HiperLAN/1.

Back to Table of Contents

3.1 HIPERLAN/1 Reference Model

HIPERLAN/1 defines Data Link Layer and Physical Layer. For Local Area Networks, Data Link Layer is further divided into two sublayers: the Logical Link Control (LLC) and the Medium Access Control (MAC). HIPERLAN only deals with MAC and PHY.
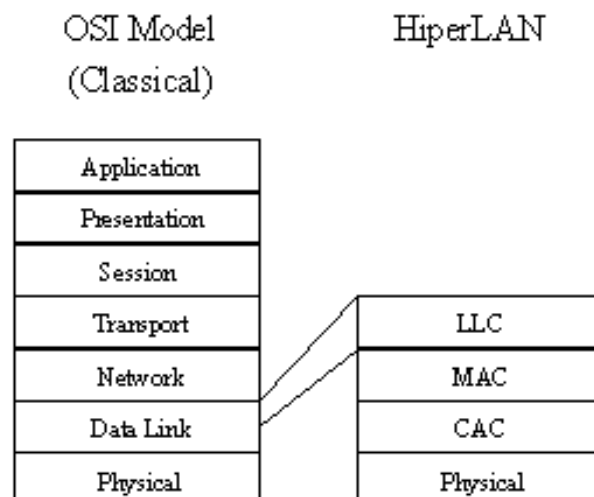

Figure 11 HIPERLAN/1 Reference Model

An intermediate layer, the Channel Access and Control (CAC) sub-layer, is introduced in the HIPERLAN/1 architecture to deal with the channel access signalling and protocol operation required to support packet priority. A pseudo-hierarchically independent access mechanism is achieved via active signalling in a listen-before-talk access protocol. The Elimination-Yield Non-Preemptive Multiple Access (EY-NPMA) mechanism codes priority level selection and contention resolution into a single, variable length radio pulse preceding packet data. EY-NPMA provides good residual collision rate performance for even large numbers of simultaneous channel contenders.

Back to Table of Contents

3.2 Physical Layer

3.2.1 RF carriers

HIPERLAN uses the radio frequency band 5,150 MHz to 5,300 MHz. The following table shows the nominal frequency of each carrier. It's required that all transmissions shall be centered on one of the nominal carrier frequencies, and all HIPERLAN equipments shall operate on all 5 channels.

Table 4 Nominal carrier center frequencies

Carrier number	Center Frequency(MHz)
0	5 176,4680
1	5 199,9974
2	5 223,5268
3	5 247,0562
4	5 270,5856

The carriers numbered 0, 1 and 2 are designated the "default" carriers.

3.2.2 Clear Channel Assessment (CCA)

The HIPERLAN clear channel assessment scheme is based on the measurement of the received signal strength only. A threshold is used for determining whether the channel is busy or idle. Because the signal strength will vary with time, the time-domain variation of the received signal strength is used for threshold adaptation.

The parameters for the measurement of signal strength is expressed as Signal Level Number (SLN) (see the following graph). Because HIPERLAN signals are bursty in nature and any interference will be of relatively constant power level, the channel shall be considered to be idle when the received SLN is less than the defer threshold value. In all other cases the channel shall be considered to be busy. When the channel is busy, the threshold adaptation algorithm seeks to raise the threshold to just above the level of any continuous signal on the channel.

Figure 12 Threshold Adaptation Algorithm (Source [EN 300 652] pg 81)

3.2.3 Modulation

For HIPERLAN, Gaussian Minimum Shift Keying (GMSK)[Turletti96] are used as the high bit rate modulation scheme to modulate a high rate transmission. GMSK is a Constant Envelope modulation scheme, which means that the amplitude of the transmitted signal is constant. This is important, because less stringent linearity can be demanded of the RF amplifier, which in turn means the cost of the radio is lower and, more importantly, the efficiency of the power amplifier (the ratio of actual RF energy transmitted compared to the electrical energy consumed) is quite good.

Frequency Shift Keying (FSK) is used as the low bit rate modulation scheme to modulate a low rate transmission. FSK is specified as follows: (fc is the center frequency.)

Table 5 Nominal frequencies for FSK modulation

Bit value	Nominal frequency
0	f_c - 368 kHz
1	f_c + 368 kHz

Back to Table of Contents

3.3 Channel Access and Control (CAC)

The CAC layer defines how a given channel access attempt will be made depending on whether the channel is busy or idle, and at what priority level the attempt will be made, if contention is necessary. It is the CAC layer which implements the hierarchically independent, Non-pre-emptive Priority Multiple Access (NPMA) mechanism on which most of the HIPERLAN advanced features are built.

A transmission passes through three phases: the priorization phase, the contention phase and the transmission phase. The transmission phase forms the channel access cycles because during the transmission the medium is considered free. The whole three phases forms a synchronized channel access cycle.

CAC works in the following three steps:

1. During priorization phase, the data transmissions with highest channel access priority are selected out. Channel access priority is based on Packet Residual Lifetime and user priority.

2. In contention phase, CAC compete with any other HIPERLAN CAC with same priority. CAC transmits a signal (the length of signal is calculated based on geometric probability distribution). At the end of transmission, the CAC listens to the channel. If another device is still transmitting, it defers its transmission until the next channel access cycle. Otherwise the CAC gains the channel and begins its transmission.
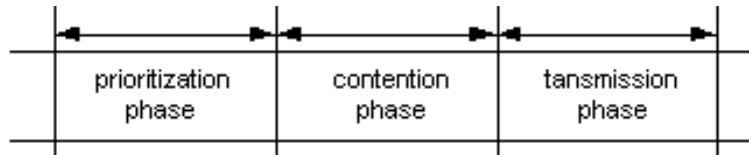
3. Transmit the data in the transmission phase.

Figure 13 Channel Access and Control

Due to the non-pre-emptive requirement, a data transmission can compete the channel only if it's ready at the beginning of a channel access cycle. Otherwise, it should wait until the next channel access cycle.

Back to Table of Contents

3.4 Media Access Control (MAC)

The HIPERLAN MAC layer defines the various protocols which provide the HIPERLAN features of power conservation, security, and multi-hop routing, as well as the data transfer service to the upper layers of protocols.

3.4.1 Topology

HIPERLAN/1 support both infrastucture and ad-hoc topology. In infrastucture topology, each HIPERLAN device will select one and only one neighbor as Forwarder and transmits all traffic to the Forwarder. In ad-hoc topology, there is no such controler, every device can communicate directly with each other.

3.4.2 Priority

In IEEE 802.11, Priority is embedded in Inter-Frame Space, thus the priority is fixed. HIPERLAN assign channel access priorities dynamically to the packets. HIPERLAN uses the following two parameters to calculate the priority:

- Packet Lifetime
- User Priority

Since Packet Lifetime is updated constantly, the priority will increase with time. When it's getting near to the packet expiration, its priority will increase to the highest point.

3.4.3 Multi-Hop Routing

HIPERLAN uese "Hello" message to do Neighborhood Discovery. Each device will periodically send a "Hello" packet to its neighbors. One type of "Hello" packet will carry a list of sender's neighbors.

Forwarder constructs the whole map of the HIPERLAN using this information. Then it can decide which device will be the next hop for a given destination and it can forward packets from on hop to another.
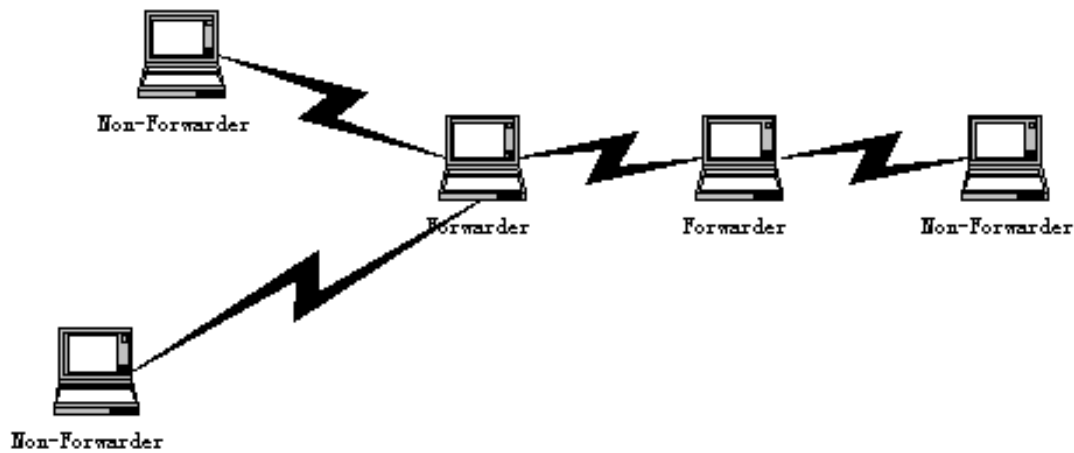
Figure 14 Multi-Hop Routing

3.4.4 Power Saving

In HIPERLAN, mobile devices can agree upon awake patterns (e.g., periodic wake-ups to receive data), some nodes in the networks must be able to buffer data for sleeping devices and to forward them at the right time.

The power conservation functions are performed by two roles: p-supporter and p-saver. P-saver is the power conserving device, and p-supporter are the neighbor of the p-saver who defers transmission of packets to the p-saver. P-saver will broadcast to its neighbors the pattern when it will sleep and when it will wake. Using such information, p-supporter can know when to transmit the buffered packets to p-saver.

In this mechanism, the periodicity and length of the sleep/wake intervals can be selected to match different application needs. So p-saver can decide how to make best use of its power.

Back to Table of Contents

4 Products

WaveLAN IEEE Turbo 11Mb PC Card [WaveLAN]

- Compliant with the IEEE802.11b High Rate (HR) wireless standard
- Operating in the 2.4 GHz band
- Offering 4 speed options (11 Mbps, 5.5 Mbps, 2 Mbps and 1 Mbps)
- Built-in security features
- Interoperable with other manufacturer's high-speed 802.11b compliant systems

Proxim's High Speed RangeLAN5 product family [Proxim]]

- Offering 24 Mbps data rates
- Operating in the 5 GHz band
- Guaranteed Quality of Service (QoS) for Multimedia Applications
- Independent Channels for Increased Aggregate Throughput

RadioLAN provides a set of products for indoor wireless communication [RadioLAN]

- Offering 10Mbps
- Operating in the 5 GHz band
- Peer-to-peer Topology

Aironet Wireless LAN products [Aironet]

- IEEE 802.11 compliant
- 2.4 GHz Direct sequence spread spectrum (DSSS)
- 1, 2, 5.5 and 11 Mbps per channel

BreezeNET DS.11 High Speed Wireless Network [Breezecom]

- IEEE 802.11 TGb Wireless LAN
- 2.4 GHz Direct sequence spread spectrum (DSSS)
- 11 Mbps data rate

Back to Table of Contents

Summary

The IEEE 802.11 committee and ETSI are two recognized organizations who are developing the next generation high speed Wireless LAN standards. The standard IEEE 802.11a, IEEE 802.11b, HIPERLAN/1, HIPERLAN/2 will provide user with more than 11 Mbps wireless communications. For high speed WLANs, the CCK, OFMD, GMSK modulation schemes are used to achieve high speed data rate.

Since ATM network is too expensive to be accepted by enterprise market, IP based network will still dominate the market for a while. So, it's quite possible that in the future market, HIPERLAN/1 and IEEE 802.11b based network, which is linked to wired IP infrastructure, will be a solution for global information infrastructure. Products based on these technologies are imminent, and it is expected that there will be significant take up.

Back to Table of Contents

References

[IEEE P802.11b/D5.0] IEEE, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specification: Higher speed Physical Layer (PHY) extension in the 2.4 GHz band", 65 pages, 1999

[IEEE P802.11a/D5.0] IEEE, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specification: Higher speed Physical Layer (PHY) extension in the 5 GHz band", 60 pages, 1999

[EN 300 652] ETSI, "HIgh PErformance Radio Local Area Network (HIPERLAN) Type 1; Functional specification", 105 pages, http://webapp.etsi.org/pda/home.asp?wki_id=6956

[Johnsson99] M. Johnsson, "HiperLAN/2-The Broadband Radio Transmission Technology Operating in the 5 GHz Frequency Band",21 pages, http://www.hiperlan2.com/site/specific/whitepaper.exe

[Taylor99] L. Taylor, "HIPERLAN Type 1-Technology Overview", 19 pages, http://www.hiperlan.com/hiper_white.pdf

[Andren98] C.Andren, "Modulation Techniques for High Speed WLAN Systems", 6 pages, http://news.wirelessdesignonline.com/content/news/article.asp?DocID={CD206F71-F4FB-11D2-A405-00C04F4F7C39}

[Turletti96] T. Turletti, "GMSK in a nutshell", http://www.tns.lcs.mit.edu/~turletti/gmsk/

[Speth99] M. Speth, "OFDM Receivers for Broadband-Transmission", http://www.ert.rwth-aachen.de/Projekte/Theo/OFDM/www_ofdm.html

[Breezecom] Breezecom, "IEEE 802.11 Technical Tutorial", 18 pages, http://www.breezecom.com/TechSupport/bnpro-ad.htm

[Proxim] Proxim, "What is a Wireless LAN?", http://www.proxim.com/wireless/whiteppr/whatwlan.shtml

[RadioLAN99] RadioLAN, "Wireless Networking at 10Mbps", 17 pages, http://www.radiolan.com/downloads/wp_9707.pdf

[Eckhardt96] D. Eckhardt, P. Steenkiste, "Measurement and Analysis of the Error Characteristics of an In-Building Wireless Network", 12 pages, http://www.cs.cmu.edu/~davide/sigcomm96.ps

[Weinmiller97] J. Weinmiller, M. Schl?er, A. Festag, A. Wolisz , "Performance Study of Access Control in Wireless LANs - IEEE 802.11 DFWMAC and ETSI RES10 HIPERLAN", http://www-tkn.ee.tu-berlin.de/bibl/ours/winlat.ps.gz

[WaveLAN] WaveLAN, http://www.wavelan.com/products/index.html

[Proxim] Proxim, "Proxim's High Speed Products", http://www.proxim.com/products/highspeed/index.shtml

[RadioLAN] RadioLAN, "10Mbps Indoor Wireless Products", http://www.radiolan.com/scripts/indoor.cfm

[Aironet] Aironet, "Aironet Products", http://www.aironet.com/products/index.html

[Breezecom] Breezecom, "BreezeNET DS.11 High Speed Wireless Network", http://www.breezecom.com/Products/DS11_Product_Overview.html

[Lucent98] Lucent, "IEEE selects Lucent/Harris proposal for new high-speed wireless LAN", http://www.lucent.com/press/0798/980713.nsb.html

Back to Table of Contents

List of Acronyms

AP   Access Point
BSS   Basic Service Set
CAC   Channel Access and Control
CCA   Clear Channel Assessment
CCK   Complementary Code Keying
CSMA/CA   Carrier Sense Multiple Access with Collision Avoidance
EY-NPMA   Elimination-Yield Non-Preemptive Multiple Access
FHSS   Frequency Hopping Spread Spectrum
GMSK   Gaussian Minimum Shift Keying
HIPERLAN HIgh PEformance Radio LAN
HR/DSSS   High Rate Direct Sequence Spread Spectrum
ISM   Industrial, Scientific Medical band
OFDM   Orthogonal Frequency Division Multiplexing
PLCP   Physical Layer Convergence Procedure Sublayer
PMD   Physical Media Dependent
SFD   Start Frame Delimiter
SYNC   Synchronization

Back to Table of Contents

Last Modified: November 17,1999.
Note: This paper is available on-line at http://www.cis.ohio-state.edu/~jain/cis788-99/wireless_lans/index.html