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Comprehensive Study of HiperLAN and HiperMAN Family of Wireless Communication Standards

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Abstract

There has been a remarkable growth in the field of wireless communication standards and most of these standards find their roots back in 1996 (IEEE 802.11). These wireless standards are characterized based on their range, maximum signal rate, number of channels, channel bandwidth, data protection, frequency band, Quality of Service (QoS) and applications. The objective of this paper is the comprehensive study of High PErformance Radio Local Area Network (HiperLAN) and High PErformance Radio Metropolitan Area Network (HiperMAN) wireless standards created by the European Telecommunication Standards Institute's (ETSI) project Broadband Radio Access Networks (BRAN). HiperLAN is the European alternative of the IEEE 802.11 WLAN while HiperMAN is the European alternative of the IEEE 802.16 WiMax. HiperLAN was proposed to obtain higher data rates than 802.11 and was launched in 1996 as HiperLAN/1 succeeded by HiperLAN/2 in 2000 to compete with IEEE 802.11a. HiperMAN was aimed to provide access in large area with ease of deployment and was developed on the basis of IEEE 802.16 and 802.16a.

Keywords

Wireless Communication, IEEE 802.11, HiperLAN, HiperMAN, QoS, ETSI, BRAN.

Introduction

Conventional communication network technologies are primarily wired and need of mobility in these networks has led to introduction of radio based wireless broadband networks [8-12]. Although wireless networking comes with mobility support for communication, it does not support high bandwidth data transfer simultaneously to numerous users.

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There are many global standards in wireless LAN family as follows:

- U.S. (IEEE 802.11):
  - ✓ IEEE 802.11 originally developed for 2.4GHz with bit rates up to 20 Mbps published in 1996
  - ✓ Many improvements include IEEE 802.11a/b/g/n etc. with bit rates of up to 54 Mbps

- Europe (ETSI Project BRAN):
  - ✓ Hiperlan (Hiperlan Type 1, Type 2, HiperAccess, HiperLink, similar to 802.11):
  - ✓ HiperLAN/1 in 5 GHz developed by RES10 & being maintained by BRAN, data rate 20 Mbps
  - ✓ HiperLAN/2 in 5 GHz and 17 GHz, data rates up to 54 Mbps/155 Mbps
  - ✓
- Japan (MMAC):
  - ✓ MMAC stands for Multimedia Mobile Access Communication.
  - ✓ High-Speed WirelessAccess and Ultra High-Speed Radio LAN
  - ✓ Three standards in high speed applications in 5 GHz band are:
    - a 802.11a like system
    - a HiperLAN/2 like system
    - a system for wireless home applications.

The ETSI project BRAN specifies Wireless Networking standards as HiperLAN, HiperAccess and HiperMAN. The structure of project BRAN is as follows:

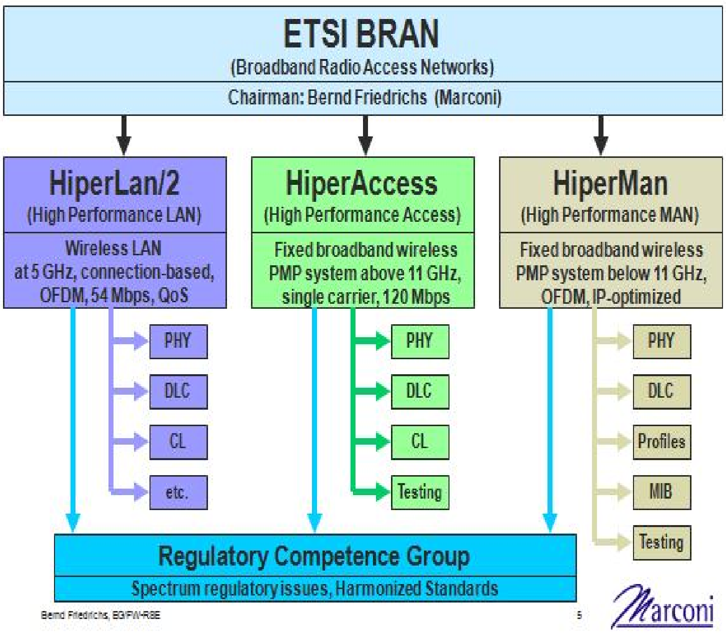

Figure 1: ETSI BRAN structure [1]

As discussed, HiperLAN consists of two types namely HiperLAN/1 and HiperLAN/2. Type 1 was developed in 1996 to support the data rates of up to 20Mbps while Type 2 was developed in 2000 to support the data rates of up to 54 Mbps [2]. HiperLAN/1 provides ranges up to 50m using Omni-directional antennas. Sadly there has not been any commercial success for HiperLAN/1. The HiperLAN/2 was developed to compete with IEEE 802.11a and has more detailed MAC layer than that of 802.11 in terms of QoS and mobility support. Both were developed using 5GHz frequency band but Type 2 provides transmission ranges of 50-100m. Type 2 also features high speed transmission, connection-oriented Data Link and Control layer (DLC) with bandwidth reservation and collision avoidance. It must be noted that HiperLAN did not receive much success as compared to IEEE 802.11 and there have been no further improvements after Type 2. In all HiperLAN was developed as an affordable technology featuring low-cost flexible networking. HiperMAN on the other hand focused more towards covering large networking area hence is a metropolitan area network and was developed in 2003, targeted for residential and small office users [2]. The frequency band for HiperMAN is less than 11 GHz and is developed keeping IEEE 802.16 and IEEE 802.16a as the reference.

The rest of the paper is organized as follows: Section 2 consists of Technical specifications of HiperLAN/2 and HiperMAN standards. Section 3 includes comparison with IEEE 802.11; Section 4 contains the HiperLAN/2 features. At last Section 5 concludes the paper.

Technical Specifications

The technical specifications include – Protocol stack, modes of operation, features, spectrum allocations, logical channels and security in the mentioned European standards.

Network Protocols

The network protocol stack of HiperLAN consists of Physical (PHY) layer, Data Link Control (DLC) layer, Convergence layer (CL) and Higher layers.

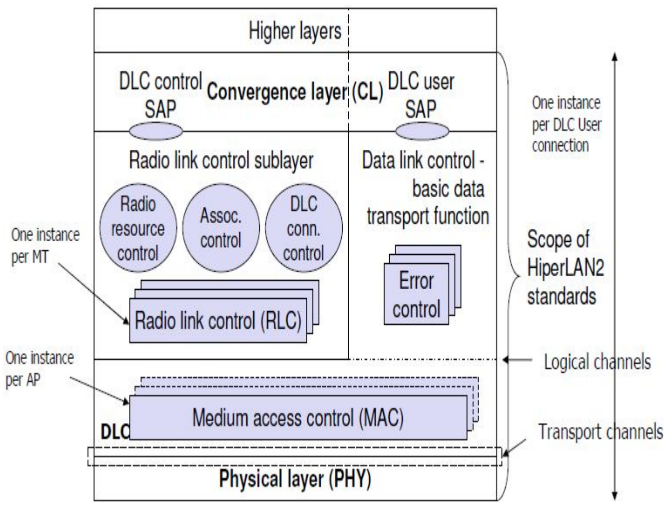

Figure 2: Protocol stack of HiperLAN/2 [3]

Both Type 1 and Type 2 of the HiperLAN family are designed to work at the 5 GHz band. It has a fixed channel bandwidth of 20 MHz. The protocol stack has two planes named as control plane (left half of figure 2) and user plane (right half of figure 2). The PHY layer of HiperLAN uses Orthogonal Frequency Division Multiplexing (OFDM) which has good performance on highly dispersive channels [4]. The PHY layer also provide several modulation and coding schemes in accordance to the current radio link quality and meet the requirements for different physical layer modes as defined by transport channel within DLC [5].

The HiperMAN is designed for broadband speeds and greater ranges than that of HiperLAN/2 and uses 2 and 11 GHz WMAN. It is mainly optimized to work at 3.4-4.2 GHz frequency band. The PHY layer of HiperMAN is also based on OFDM. HiperMAN cell has a variable size of 2 to 15 km.

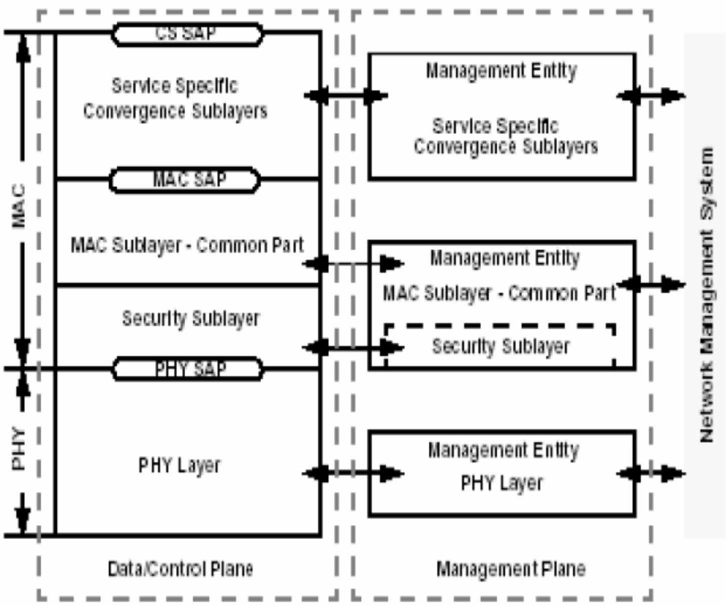

Figure 3: HiperMAN protocol layer

HiperLAN/2 is a cellular system and is controlled by an Access point (AP) similar to a base station. The DLC layer constitutes of logical links between an AP and mobile terminals (MTs). The DLC layer consists of Radio link control (RLC), Error control (EC), Medium Access Control (MAC), Radio resource control (RRC), DLC connection control and association control function (AFC). DLC layer of HiperLAN uses a Time Division Multiple Access (TDMA) scheme. The traffic is controlled by AC/CC (Access point/Central Controller) [5]. As there are two operating modes in HiperLAN; the centralized mode and the direct mode, the centralized mode is similar to the infrastructure mode of IEEE 802.11.

Features of HiperMAN DLC layer are similar to IEEE 802.16. There are three QoS classes in HiperMAN as follows:

1. Expedited Forwarding (EF)
2. Assured Forwarding (AF)
3. Best Effort (BF)

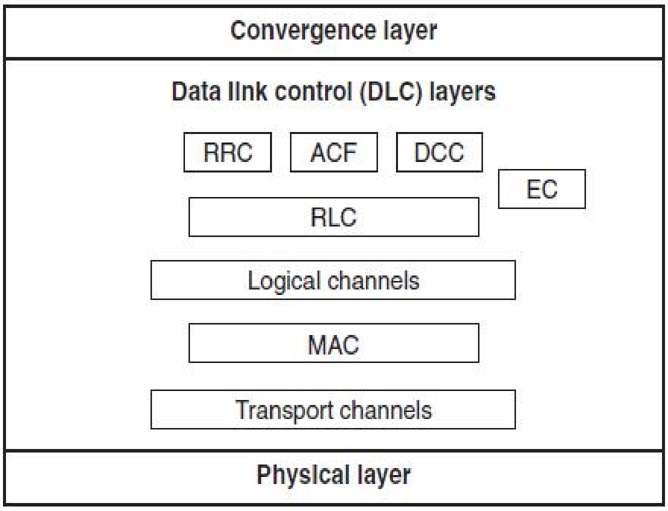

Figure 4: Relationship between logical and transport channels in HiperLAN/2 [5]

There is a Convergence layer (CL) present between the higher layers and the DLC layer of HiperLAN/2. The convergence layer is used for IP (Internet Protocol), UMTS (Universal mobile telecommunications systems), ATM (Asynchronous transfer mode) internetworking. The convergence layer also provides the QoS in HiperLAN/2. There are two types of convergence layers, cell-based and the packet-based.

1. Cell-based convergence layer handles higher layers with fixed-length packets like ATM-based networks.
2. Packet-based convergence layer handles higher layers with variable length packets like Ethernet [6].

The packet-based convergence layer can be further divided into two sub layers named as Service Specific Convergence Sublayer (SSCS) and Common Part Convergence Sublayer (CPCS).

The HiperMAN convergence layer called as Service Specific Convergence Sublayer (CS) for ATM or IP, Ethernet.

HiperLAN/2 MAC Protocol

As discussed above, the HiperLAN/2 DLC layer consists of the Medium Access Control (MAC), Error Control (EC) and the Radio Link Control (RLC) function. It is a centrally scheduled TDD/TDMA (Time Division Duplex/Time Division Multiple Access) scheme.

There is duration of 2ms in each MAC frame which consists of several phases as listed below and shown in the Fig: 6 [7].

1. Broadcast Phase
2. Downlink Phase
3. Uplink Phase
4. Random Access Phase.

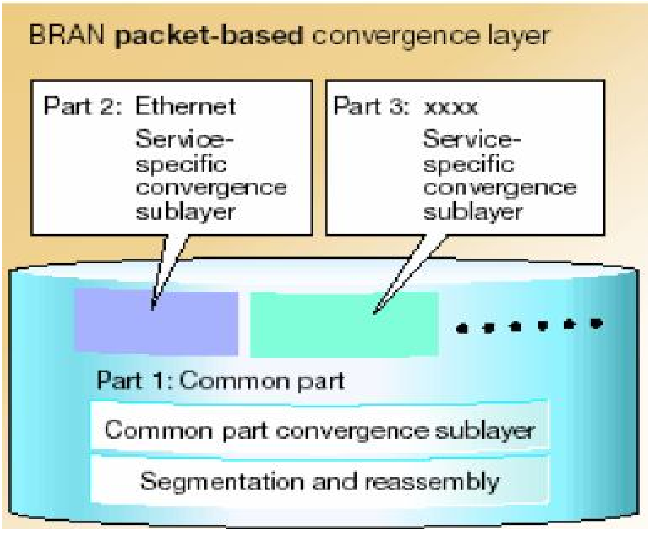

Figure 5: Structure of packet-based CL [6]

The broadcast phase carries the Broadcast Control CHannel (BCCH) and the Frame Control CHannel (FCCH) while the downlink phase consists of the Short CHannel (SCH) and the Long CHannel (LCH). In the downlink phase the control information and the user data is transmitted from the Access point (AP) to the mobile terminals (MTs) while in the uplink phase the transmission is from MTs to AP.

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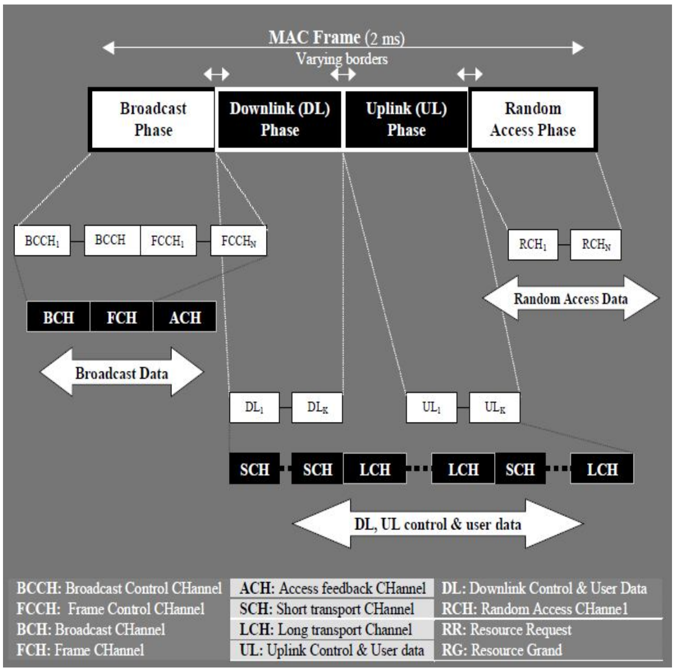

Figure 6: HiperLAN/2 MAC frame [7]

Modes of Operations in HiperLAN/2

There are two modes of operations IN HiperLAN/2, the centralized mode and the direct mode.

Centralized Mode: This mode is used for operating HiperLAN/2 as an access network via a fixed access point i.e. the MTs communicate with other MTs or the network through fixed AP as shown in Fig 7.

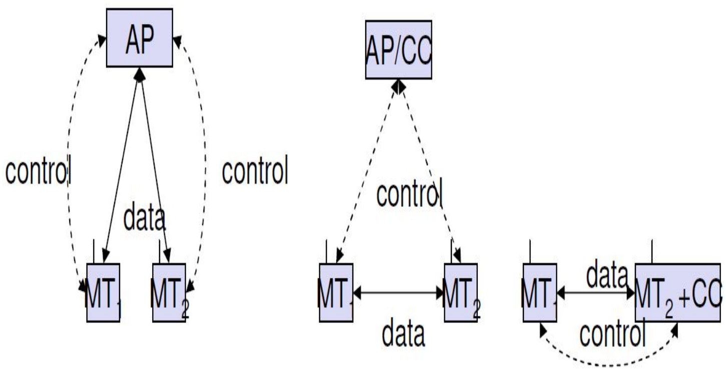

Figure 7: Centralized and Direct mode of operation

Direct Mode: This mode is used for the operation of HiperLAN/2 as an Ad-hoc network.

Quality of Service (QoS)

There are two QoS schemes in HiperLAN/2: the best-effort scheme and priority scheme which is based on IEEE 802.1p [5]. HiperLAN/2 allows implementation of QoS because of its connection-oriented nature. For specific network traffic, the QoS enhances the ability of a network. Giving one user priority over the other is the best way to provide QoS. To support variety of services, a quality of service mechanism is necessary that can support traffic classes and multiple services. There are four QoS classes as given below:

1. Conversational
2. Streaming
3. Background
4. Interactive

The above mentioned classes differ in terms of delay sensitiveness. While conversational class is very delay sensitive, the background class is one of the most delay insensitive class. Also, the conversational class supports bi-directional traffic with uplink and downlink QoS. In general QoS is implemented through time slots.

1. Simplistic scheme: Only using priorities
2. Specific QoS (parameters: bandwidth, delay, jitter, bit error rate)

Spectrum Allocation at 5 GHz

HiperLAN/2 systems are operated as private or public systems at 5 GHz band. Specific bands have been assigned to this system in Europe and in the US as given in Fig 8.

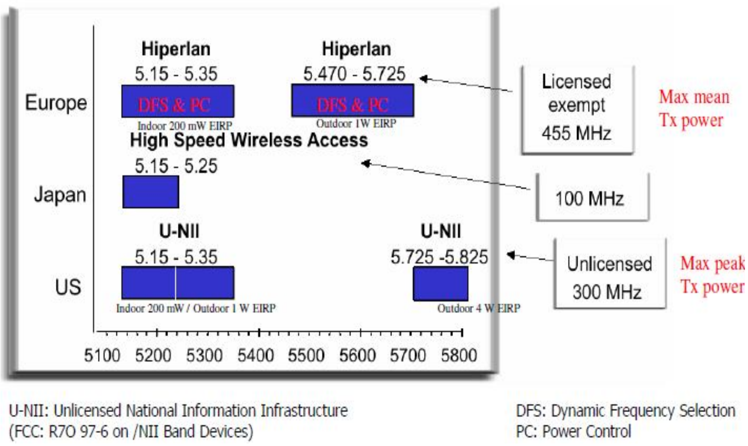

Figure 8: Spectrum allocations of HiperLAN/2

Comparison with IEEE Standards

As discussed earlier, the HiperLAN standard was developed as the counterpart of the IEEE 802.11 (Wi-Fi) while the HiperMAN was developed based of IEEE 802.16 (WMAN). HiperLAN/2 has many characteristics of IEEE 802.11 Wireless Local Area Network (WLAN). The detailed comparison is given in the Table 1 [5].

Table 1: Comparison of IEEE 802.11 and HiperLAN/2

Characteristic	IEEE 802.11	HIPERLAN/2
Spectrum	2.4 GHz	5 GHz
Max. physical rate	2 Mbps	54 Mbps
Max. data rate, layer-3	1.2 Mbps	32 Mbps
Medium access control/ media sharing	CSMA/CA	Central resource control, TDMA/TDD
Access scheme	DCF/PCF	Elimination yield non-preemptive priority multiple access
Connectivity	Connectionless	Connection-oriented
Multicast	Yes	Yes
QoS support	PCF	ATM/802.1p/Resource reSerVation Protocol/ Differential service (full control)
Frequency selection	Frequency hopping or DSSS	Single carrier with dynamic frequency selection
Authentication	No	Network access identifier/IEEE address/X.509
Encryption	40-bit RC4	Data Encryption Standard (DES), triple DES
Handover support	No	No
Fixed network support	Ethernet	Ethernet, IP, ATM, UMTS, Firewire, PPP
Management	802.11 MIB	HIPERLAN/2 MIB
Radio link quality control	No	Link adaptation

As we can see in the Table 1; the IEEE 802.11 differs in the maximum physical rate and mainly in MAC technique. Also, there is no MAC layer throughput limit in HiperLAN as in IEEE 802.11 networks. The HiperLAN/2 also provides better QoS. The advantages and disadvantages of HiperLAN networks is given as follows-

1. High data rates with quality of service support.
2. Security mechanism
3. Flexibility: dynamic frequency selection, link adaption
4. High cost
5. Limited outdoor mobility
6. No commercial success when compared to IEEE 802.11

Comparison of HiperLAN type 1 and type 2 with IEEE 802.11a/b/g is given in the Table 2. Another difference which must be noted is that the IEEE 802.11 uses CSMA/AC (Carrier sense multiple access with collision avoidance) while HiperLAN/2 performs centralized resource allocation.

Table 2: Comparison of various WLAN standards

	IEEE 802.11	IEEE 802.11b	IEEE 802.11a	IEEE 802.11g	HIPERLAN/1	HIPERLAN/2	MMAC HiSWAN
Rectification	June 1997	Sept. 1999	Sept. 1999	June 2003	Early 1993	Feb. 2000	April 1997
RF bandwidth (GHz)	2.4	2.4	5.0	2.4	5	5	5
Max. data rate (Mbps)	2	11	54	54	23.5	54	27
Physical layer (PHY)	FHSS, DSSS, IR	DSSS	OFDM	OFDM	GMSK	OFDM	OFDM
Range (m)	50-100	50-100	50-100	50-100	50	50 indoor, 300 outdoor	100-150

Features of HIPERLAN/2

Some of the important features of HiperLAN family of standards have been discussed below.

Power saving modes

There is comparatively low power consumption by using sleep mode, uplink power control and downlink power setting. It is based on mobile terminal initiated negotiation sleep periods i.e. short latency requirements.

High speed transmission

As mentioned earlier, HiperLAN/2 uses orthogonal frequency division multiplexing (OFDM) which is efficient in time-dispersive environments and has bit rates of 54Mbit/s (physical layer) and 35Mbit/s (network layer).

Connection oriented

The HiperLAN/2 network is a connected oriented network which has dedicated broadcast channel, time division multipoint connection.

Dynamic frequency selection (DFS)

The HiperLAN/2 network automatically selects an appropriate frequency within their coverage area. The best frequency is chosen depending on the current interface level and there is no frequency planning required.

Security support

HiperLAN/2 has strong encryption/authentication, access points and mobile terminals can authenticate each other. DES, triple-DES, AES, optional pre-shared or public-key authentication can be used for encryption of all user traffic. Also, the communicating nodes have a HiperLAN ID (HID) and a node ID (NID) whose combination restricts the way it can connect to other HiperLAN nodes.

Conclusion

In this paper, the technical specifications including network protocols, key features of ETSI HiperLAN and HiperMAN have been discussed. The comparison of these standards with their IEEE counterparts shows how efficient are these networks, though they have not gained much commercial success in all these years. The features of HiperMAN include high speed transmission and connection oriented dedicated networks which can give speeds up to 54 Mbps with QoS compared to lesser speeds of IEEE standards. The wireless standards have been mostly considered according to their application i.e. home or office, according to which the range and maximum/minimum bit rates are received. For home and office requirements, Wireless local area networks (WLANs) provide connectivity using IEEE 802.11 and HiperLAN. Whereas, ETSI HiperACCESS, ETSI, HiperMAN, WiBro provide broadband access in metropolitan areas.

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