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Application of HIPERLAN Type 2 Systems in Private Environments

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***Abstract* — The HIPERLAN type 2 (HIgh PEformance Radio Local Area Network) standard, a promising technology for Wireless LANs, has recently been approved by the BRAN (Broadband Radio Access Networks) Project within the European Telecommunications Standards Institute (ETSI). First products are likely to be available in early 2001. HIPERLAN type 2 will be the first wireless LAN with facilities for full support of quality of service (QoS) for different network types, along with interoperability of devices from different vendors. This paper gives a short introduction into the technology behind HIPERLAN type 2, followed by an explanation of the key issues to be considered when applying it in private environments. Firstly, the integration of HIPERLAN type 2 into networks is explained. Secondly, a number of issues related to radio propagation are described. The paper concludes with a summary and an outlook**

I. Introduction

The demand for bandwidth in private networks has grown tremendously during the last few years. At the same time, wireless connectivity becomes more and more natural. Another important trend is the convergence of data and voice communications networks.

HIPERLAN type 2 (H/2) which has recently been standardised by the ETSI Project Broadband Radio Access Networks (BRAN) has been designed to fulfil all these demands. It will operate in the 5 GHz band and will provide up to 54 Mbit/s data rate with mobility and full quality of service (QoS) support. H/2 will support various core network technologies. An important feature of the standard is full interoperability of devices from different manufacturers.

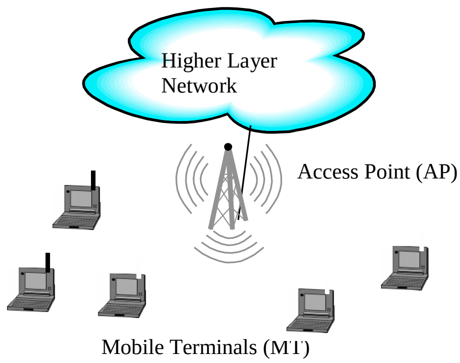
The second section of this publication gives a short overview of the technical features of H/2. The integration of H/2 into data networks is addressed in Section three. Some properties of radio propagation to be considered will be discussed in the fourth section . The paper concludes with Section five.

II. HIPERLAN/2 Technical Overview

The intention of this paper is not to introduce the technical properties of H/2 in detail. The interested readers are referred to [1], [2] and [3] for more detailed information.

II.1 *Basic Features and Service Model of HIPERLAN/2*

As the name suggests, H/2 is a radio-based LAN, as shown in Figure 1.



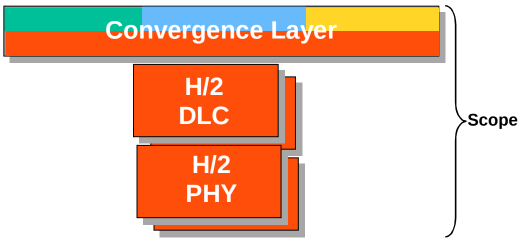


Figure 2: Basic H/2 layer model

II.2. ***Physical Layer***

OFDM was chosen as the basic technology for the PHY layer in the middle of 1998. For an explanation of OFDM see e.g. [4]. For more detailed descriptions of the H/2 physical layer technologies and performance analyses, see e.g. [5], [6] and [7]

The basic parameters of the PHY are shown in Table 1. In order to use the available bandwidth as efficient as possible, the H/2 system uses link adaptation, i.e. the adaptation of the data rate by using different modulation schemes on the sub-carriers and the variation of the code rate by puncturing the convolutional code. The parameters for modulation and channel coding can be chosen by the AP independently for each MT from the available link adaptation modes.

TABLE 1: BASIC PARAMETERS OF THE H/2 PHY LAYER

Parameter	Value
Channel spacing (and system clock)	20 MHz
FFT length	64
Number of used subcarriers	52
Number of data carriers	48
Number of pilot carriers	4
Modulation scheme on subcarriers	Various (from BPSK to 16 QAM; optionally 64 QAM)
Demodulation	Coherent
Guard Interval length	800 ns (optionally 400 ns)
Channel Coding	Convolutional Code, constraint length 7
Interleaving	Per OFDM symbol

II.3 ***DLC layer***

The DLC data transport functions and the RLC (Radio Link Control) protocol are described in [8] and in [9], respectively. A more easy-to-understand description can be found in [2] and [3]. The MAC scheme is based upon a centrally scheduled TDMA/TDD scheme. Centrally scheduled means that the AP controls all transmissions over the air interface. This concerns uplink and downlink equally.

The H/2 MAC (Medium Access Control) supports only two types of packets. The long packets have a size of 54 Bytes and contain control or user data. The DLC payload has a size of 49.5 bytes, the CL payload of 48 bytes. The short packets with a size of 9 bytes contain only control data and are always generated by the MAC or RLC. The same size of 9 bytes is also used in the RCH (Random access CHannel) which can also carry only control data.

The use of only one type of packet for data has the advantage of simplicity and is a major prerequisite for the provision of real quality of service. A major share of the control information is carried by the short packets. This contributes to the protocol efficiency. These features, together with the central scheduling, make sure that H/2 is well suited to support QoS and makes best use of the frequency resources. An evaluation of its efficiency is e.g. given in [10].

The H/2 DLC provides an Error Control (EC) function whose task is to increase the reliability of the radio link. It is based on selective repeat (SR) automatic repeat request (ARQ) scheme with partial bitmaps. It provides a retransmission efficiency as conventional SR, along with optimized overhead and delay of acknowledgements. A detailed description and evaluation can be found in [11].

The introduction of various CLs and, hence, the independence of H/2 from higher layer networks was one of the reasons to introduce an H/2 specific control protocol, the so-called Radio Link Control (RLC) Protocol. The RLC provides mechanisms for:

- Connection handling: Set-up and release of DLC connections, peer-to-peer, multicast
- Management functions: Mobility management (association/de-association, handover, location update), radio resource management (dynamic frequency selection), power management (sleep mode, downlink and uplink power control).
- Security: Authentication, encryption key distribution, alternative security negotiation.

Note that H/2 provides efficient means for encryption and decryption as well as for secure encryption key exchanges. Authentication and encryption key exchange mechanisms are well integrated with the association procedure. This is particularly important for enterprise networks where confidential data is handled and security mechanisms on higher layers are not widely implemented. The encryption uses the well-known DES algorithm with 56 or 168 bit keys.

II.4. ***Convergence Layers***

For each supported core network a special CL is designed. A specific CL adapts the corresponding core network to the requirements and interfaces of the H/2 DLC layer.. In the first step, support for packet based networks like Ethernet (IEEE 802.3), IP, PPP and IEEE 1394 (Firewire) as well as ATM will be available. The structure of the H/2 CLs is more precisely described in e.g. [2].

II.4. ***Network Management***

H/2 offers network management features that comply with the well-known SNMP standard. A MIB has been defined to control and monitor the most important parameters and features of APs and radio cells.

III. Integration into networks

This clause deals with the integration of an H/2 infrastructure into private networks. The primary focus of considerations is enterprise networks. However, since such networks are in general more complex than home networks, most of the statements given in the sequel are also valid for home networks.

Various reasons exist for installing a wireless LAN instead of laying cables. One of them is the increased flexibility of a wireless infrastructure. When staff is moving from one office to another, the number of required cables may increase resulting in the installation of additional cables or the relocation of jacks which is not necessary when using wireless connections. Another reason is the added value of mobility. Business travellers that do not have a permanent office can get connected without restriction throughout the building, be it at an arbitrary office desk or in meetings. Moreover, the interworking between UMTS and H/2 enables users to get connected also in public places using their H/2 capable device. This interworking is not yet finally defined but agreements between the standardisation bodies for H/2 and UMTS are in place and work has started.

On the other hand, the radio interface with its maximum capacity of 54 Mbit/s is a medium shared by all users in a radio cell. Therefore, special measures have to be taken into account in applications where H/2 is to be used for connecting computers with very high input/output requirements. Among these are servers, e.g. file servers, web servers or data base servers.

Another issue is the choice of the integration of H/2 into a network with respect to the higher layer technology. The packet based CL family of H/2 comprises IP and Ethernet type CLs. The first CL available has been the Ethernet CL. This makes sense from the perspective of QoS support, since a simple priority based scheduling mechanism in Ethernets was standardised known as 802.1p. Thus, the special properties of H/2 can be exploited. However, in view of the fact that Ethernet adds overhead to IP packets, one might wonder why we do not use native IP.

The problem with using IP is the way IP packets are routed. Routers usually use only subnet addresses in their routing tables. Thus, each AP builds a small IP subnet with its own subnet address. An H/2 MT that intends to perform a handover from one AP to another needs to change its IP address in order to remain reachable. The only standardised solution to this is Mobile IP (MIP), [12]. MIP, however, is not very well suited to support handovers and introduces significant signalling overhead. Another solution which would alleviate the situation is Cellular IP, [13], which is currently in a draft status.

The reason for choosing Ethernet, on the other hand, is the simplicity of integration into existing network infrastructures. 802.3 networks use the IEEE MAC address to identify terminals. This address does, in contrast to IP addresses, not contain any information how to reach a terminal. The packets are either broadcast and grabbed by the target terminal, or they are switched where the switches contain routes for every single MAC address for which they have recently received and forwarded packets. Thus, as long as a terminal stays within an IP subnet, no effort for mobility support beyond the H/2 specific procedures is necessary. Only in case of the rare event where the IP subnet is changed, IP mobility support is required.

IV. Radio Aspects

Despite a huge number of advantages of radio communications, the radio channel is far less friendly than its wired counterpart. It suffers (a) from attenuation which increases with at least the square of the distance between transmitter and receiver and (b) from multipath propagation. The attenuation is increased by obstacles, such as walls, doors and windows. Among the worst-case materials are reinforced concrete and metal coated windows. But other materials exist which are less critical for waves in the 5 GHz band. The penetration loss for some materials is listed in Table 2 which is taken from [14].

TABLE 2: PENETRATION LOSS OF SOME MATERIALS

Penetration loss	Materials
0 – 1 dB	Gypsum wall, PVC plate, plywood
1 – 3 dB	Veneer board, chipboard
3 – 10 dB	Simple glass plate, sound proof door
> 10 dB	Reinforced concrete, fire proof door, metal coated window

The issue of materials is directly connected with regional or national regulations and customs of building houses. In some regions of the world, most of the offices are open space offices partitioned by only light walls. In other areas, one or two persons share an office where the offices are separated by fixed lightweight or massive walls. In many cases, fire protection is a source of problems because it involves fire proof doors and often walls made of reinforced concrete.

An example for a floor in an office building as it might be found in middle Europe is shown in Figure 3. The outer walls consist of metal coated windows and concrete walls. The walls that are drawn thick are made of reinforced concrete. The inner part of the building contains elevators, store rooms and a room with a file server. Since the server is the only computer there, it wouldn't be worth while installing an own AP for this single computer. Therefore, it is connected by cables and the inner part needs no H/2 coverage. The coverage is required, however in the offices and laboratory that are located along the outer walls of the building. The walls that divide the floor in the middle are fire protection walls with a fire protection door. They are very critical due to their high penetration loss.

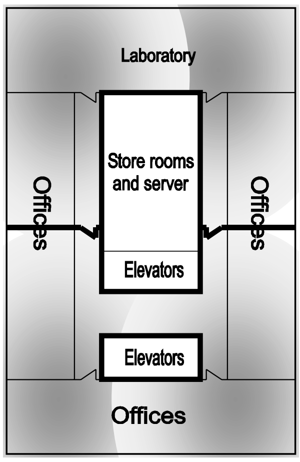


Figure 3: Example for an office building

In order to obtain full coverage of all offices and the laboratory, the H/2 APs are favourably located in the four corners of the floor. One can easily see that an installation of less APs would not result in the desired coverage due to the inner exclusion zones and the fire protection walls. This is shown by the grey shaded areas which have their centres in the four corners of the building.

Another situation is an open space office with a high density of users that need to be connected. Here, it is possible to have overlapping radio cells. An example for such an office is shown in Figure 4. The size assumed here is about 90m x 80m. The crosses are APs that are mounted to the ceiling and the circles indicate the coverage area of the APs. Most users now have the choice between several APs to connect to which yields positive effects. First, due to the low distance between MTs and APs, a Phy mode with high data rate can be chosen. Second, the load is distributed between more radio channels which results in a higher overall capacity. Note that no frequency planning is necessary but all APs choose their operating frequency automatically.

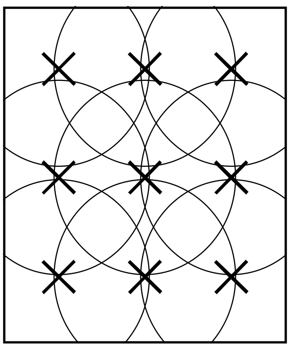


Figure 4: Example for overlapping radio cells

V. Summary and Outlook

HIPERLAN/2 is a novel wireless LAN technology offering high data rates and facilities to provide quality of service. It is very efficient and completely self-configuring. The network management is based on SNMP and, thus, standard network managament tools can be used. Through the definition of convergence layers, H/2 can be integrated with various existing network technologies. The interworking with UMTS is planned.

It has been explained that H/2 can easily be integrated into existing networks. Ethernet is the first choice but other networks will follow. Before installation, an analysis of the terminals and the users as well as of the building should be performed in order to obtain the desired radio coverage.

Another feature that is widely discussed is the ability to build ad hoc networks. The consumer electronics industry has chosen HIPERLAN/2 as the wireless bus system for home networks. The definition of the home environment profile is under way and shall be published in the middle of the year 2000. There, an ad hoc capability will be included where one of the terminals takes over the role of the AP with regard to the MAC protocol. Moreover, direct communication between MTs will be defined.

V. References

[1] TR 101 683, "HIPERLAN type 2; System Overview", *ETSI*, Feb. 2000

[2] M. Radimirsch, V. Vollmer, "HIPERLAN Type 2 Standardisation – an Overview", *European Wireless Conference*, Munich, Germany, Oct. 1999

[3] J. Khun-Jush, et al., "Overview and Performance of HIPERLAN/2 - A European Standard for Broadband Wireless Communication", to be published at *Vehicular Technology Conference*, Tokyo, Japan, May 2000

[4] W. Zou, Y. Wu, "COFDM: an overview", *IEEE Transactions on Broadcasting*, Vol. 41, No. 1, March 1995

[5] TS 101 475, "BRAN; HIPERLAN Type 2; Physical (PHY) Layer", *ETSI*, March 2000

[6] J. Khun-Jush, et al., "Link Performance of the HIPERLAN/2 Physical Layer in Fading Environments", *European Wireless Conference*, Munich, Germany, Oct. 1999

[7] J. Khun-Jush, et al., "Structure and Performance of the HIPERLAN/2 Physical Layer, *Vehicular Technology Conference (fall)*, Amsterdam, Sept. 1999

[8] TS 101 761-1, "BRAN; HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 1: Basic Data Transport Function", *ETSI*, March 2000

[9] TS 101 761-2: "BRAN; HIPERLAN Type 2; Data Link Control (DLC) Layer; Part 2: Radio Link Control Protocol Basic Functions", *ETSI*, March 2000

[10] A. Hettich, M. Schröther, "IEEE 802.11 or ETSI BRAN HIPERLAN/2: Who will win the race for a high speed wireless LAN standard ?", *European Wireless Conference*, Munich, Germany, Oct. 1999

[11] H. Li, et al., "Automatic Repeat Request (ARQ) Mechanism in HIPERLAN/2", *Vehicular Technology Conference*, Tokyo, Japan, May 2000

[12] RFC 2202, "*IP Mobility Support*", Proposed Standard, IETF, 1996

[13] Draft-ietf-mobileip-cellularip-00, "*Cellular IP*", Internet Draft, IETF, Jan. 2000

[14] Pei Lou, *Investigation of the Propagation Characteristics of Indoor Radio Channels in GHz Wavebands*, Ph.D. thesis, Cuvillier Verlag, Göttingen, Germany, 1977