HIPERLAN Type 2 Standardisation - An Overview

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***Abstract* — HIPERLAN type 2 (High PERformance Radio LAN, short H/2), a promising technology for R-LANs (Radio Local Area Networks), is currently being standardised at the European Telecommunication Standardisation Institute (ETSI). The standard is likely to be available at the end of 1999. H/2 will be the first wireless LAN with full support of quality of service for different network types, providing at the same time interoperability of devices from different vendors. This publication gives a short introduction into the history of wireless LANs with emphasis on HIPERLAN type 2. Afterwards, the current status of the H/2 standard is described. After the introduction of the basic service model, the functionalities of the physical layer, the DLC layer and the foreseen convergence layers are introduced. It 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, tetherless connectivity becomes more and more natural. Another important trend is the convergence of data and voice communication networks.

HIPERLAN type 2 (H/2) which is currently being 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 goal of the standard is full interoperability of devices from different manufacturers.

This publication will explain the standardisation process, its status and the technical solutions. The second section will give an overview over the history of radio LANs, especially of H/2. Afterwards, the basic H/2 functional model is presented, followed by descriptions of the physical, DLC and convergence layers. The publication concludes with a summary.

Please note that the following explanations refer to the status at the time of the delivery of this publication. Due to the rapid progress in the standardisation process, it may not necessarily reflect the status at presentation time.

II. HISTORY OF RADIO LANS

The first appearance of R-LAN type systems were dedicated systems of different manufacturers, such as wireless cashier systems or ordering systems for big stores. The manufacturers of these systems joined in a standardisation activity which resulted in the IEEE 802.11 system, a wireless LAN with data rates up to 2 Mbit/s in the 2,4 GHz band [1]. The standard was published mid 1997. Most R-LANs available on the market today comply to this standard.

Approximately at the same time, HIPERLAN type 1 (H/1) was standardised by the technical body RES 10 (Radio Equipment and Systems) at ETSI. H/1 provides a gross user data rate of about 23 Mbit/s and operates in the 5 GHz band. The standard was published in early 1997 [2]. Products have been announced by various manufacturers.

In the middle of 1996, several companies that were engaged in projects funded by the European Union, mainly the project WAND (Wireless ATM Network Demonstrator) [3], and the German research initiative ATMmobil, [4], became involved in RES10 work. The result was the definition of further HIPERLAN types, among them H/2. The initial focus of the H/2 work was wireless ATM according to the goals of the mentioned research projects. The first document that was published in early 1997 was a requirements document for H/2 [5].

In April 1997, RES10 was integrated into the newly created ETSI project BRAN (Broadband Radio Access Networks) [6]. The first year of BRAN was dedicated to a process of growing together of the merged activities from various technical bodies. Until the beginning of 1998, the driving force behind H/2 was research. Accordingly, this period was mainly devoted to gathering all knowledge about wireless ATM systems available so far. There was little or no progress in direction of a standard .

The actual targeted work towards the H/2 standard started in spring 1998 when the market opportunities became clearer to the participating companies. Since then, many decisions have been taken to make a choice out of the huge variety of technical proposals. Remarkably, the focus of the originally ATM-driven work was changed such that IP, Ethernet and related technologies can be supported easily. The driving force behind were the fact that the market forecasts for ATM to the desktop were not very optimistic and emerging technologies to support quality of service (QoS) in IP and Ethernet type networks.

Today, the shape of the H/2 standard is already clearly visible. Most important decisions have been made. What remains is a couple of details and the proper wording. It can be expected that a stable draft version of the basic standard will be available in autumn 1999.

III. BASIC FEATURES AND SERVICE MODEL OF HIPERLAN TYPE 2

As the name suggests, H/2 is a radio-based LAN, as shown in Fig. 1. An access point (AP) which is typically connected to a higher layer network covers a certain geographic area with radio services in the 5 GHz band. These services are used by mobile terminals (MTs) within reach of the AP. Typical environments are offices, hot spot areas and home environments.

A basic feature of H/2 is the automatic selection of a free frequency channel and the ability to change this frequency when appropriate, e.g. because of interference from other systems. This mechanism is called dynamic frequency selection (DFS).

The basic protocol stack and the scope of the H/2 standard is shown in Fig. 2. It will comprise the specification of a physical layer and a DLC layer for both the terminals and the access points. The DLC layer will accept SDUs (Service Data Units) from the higher layers which have a size appropriate for ATM cells.

One of the major properties of H/2 is the support of various network types on top of the DLC (Data Link Control) layer. Currently, packet based networks (IP, Ethernet, PPP, IEEE 1394), ATM and UMTS are considered. These are connected to the DLC layer by network convergence layers which adapt the packet formats to the requirements of the DLC layer. In case of higher network layers other than ATM, the CL contains among others a segmentation and reassembly function.

The model with the functions of H/2 and their allocation to layers is shown in Fig. 3. The physical layer (PHY) at the bottom provides a basic transport function for the DLC SDUs (Service Data Units).

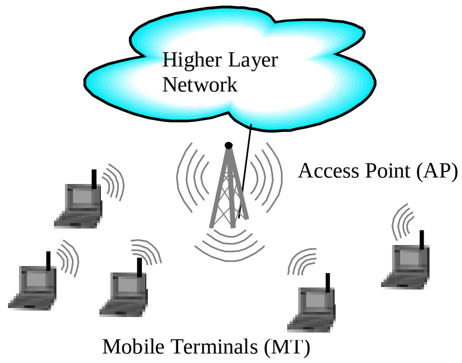

Fig. 1: Basic system architecture

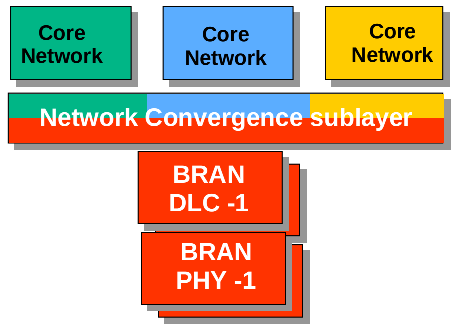

Fig. 2: Basic H/2 layer model

The DLC layer consists of the error control (EC, the medium access control (MAC) and the radio link control sublayer (RLC). The user data transport function on the right hand side is fed with user data packets from the higher layers via the user service access point (U-SAP). This part contains the Error Control (EC) which performs an ARQ (Automatic Repeat Request) protocol. The DLC protocol operates connection oriented which is shown by multiple connection end points in the U-SAP. One EC instance is created for each DLC connection.

The left part contains the Radio Link Control Sublayer (RLC) which delivers a transport service to the DLC connection control (DCC), the radio resource control (RRC) and the association control function (ASC). Please note that only the RLC will be standardised which defines implicitly the behaviour of the DCC, ASC and RRC. One RLC instance needs to be created per MT.

The user and the RLC data streams are passed to the MAC entity which multiplexes them and takes care of the transport channel access.

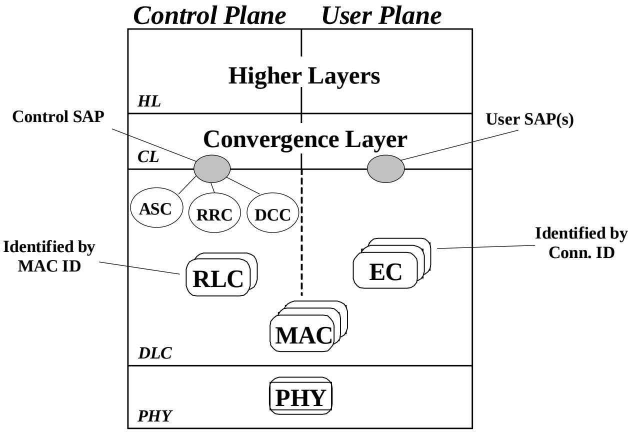

Fig. 3: Functions and their location

A. Documents and time schedule

In early 1999, a major effort was made by representatives of consumer electronics manufacturers to use H/2 as a wireless firewire (IEEE 1394, [7]) system. This required some extensions of the previously scheduled H/2 standard, e.g. the support of direct communication between terminals. This activity lead to the following structure of the DLC documents:

- PHY specification.
- DLC data transport functions basic specification. Contents will be the EC and MAC structure, the interfaces to the RLC , the CL and partly the layer.
- RLC basic specification.
- DLC Business extension. Contents will be the issues that are necessary for business networks that are not common for both business and home environments, e.g. handover. These extensions may concern both data transport and RLC functions.
- DLC extension for home environments. Contents will be extensions that are not common to the business products, e.g. direct communication between MTs, fixed rate services and IEEE 1394 clock propagation. These extensions may concern both data transport and RLC functions.
- CLs for packet and cell based networks. For each of these subjects, a common part and several service specific parts will be defined (see section VI)

IV. 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. [8]. The reasons for this choice were [9]:

- The implementation requires about half the amount of logic gates compared to a single carrier scheme.
- OFDM outperforms single carrier in most of the considered scenarios.

Another important reason was the harmonisation of the H/2 PHY layer with IEEE 802.11a where OFDM with similar parameters was chosen as PHY technology earlier in 1998. The drawbacks of OFDM, such as power amplifier backoff due to high signal dynamics and the required synchronisation accuracy to maintain orthogonality of subcarriers, were considered to be of minor importance. The basic parameters of the PHY are shown in TABLE 1.

TABLE 1: BASIC PARAMETERS OF 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

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 subcarriers and the variation of the code rate by puncturing the convolutional code. The modulation scheme as well as the channel codec can be chosen by the AP independently for each MT from the available link adaptation modes.

V. DLC LAYER

The selection of the DLC protocol was probably the most difficult and comprehensive part of the H/2 standardisation so far. The process was based on single decisions on a huge number of issues which can be solved in a number of different ways. This property made it very difficult to come to terms because many solutions were appropriate to solve the problems. Most of the issues have been resolved and current work is mainly focussed on resolving the remaining details.

A. Data transport functions: Medium Access Control (MAC)

The DLC layer will be based upon a centrally scheduled TDMA/TDD scheme, as described e.g. in [10]. Centrally scheduled means that the AP controls all transmissions over the air. This concerns uplink and downlink equally. Similar schemes have already been standardised for e.g. passive optical networks (PONs) [11] which are applied in access networks of public operators.

The data transport functions of the DLC layer consist of the MAC and the EC, as stated above. The basic structure on the air interface generated by the MAC is shown in Fig. 4. It consists of a sequence of MAC frames of equal length with 2 ms duration. Each MAC frame consists of several phases:

- Broadcast phase (BC). The BC phase carries the BCCH (broadcast control channel) and the FCCH (frame control channel). The BCCH contains general announcements and some status bits announcing the appearance of more detailed broadcast information in the downlink phase (DL). The FCCH carries the information about the structure of the ongoing frame, containing the exact position of all following emissions, their usage and content type. The messages in the FCCH are called resource grants (RG).
- Downlink phase (DL). The DL carries user specific control information and user data, transmitted from AP to MTs. Additionally, the DL phase may contain further broadcast information which does not fit in the fixed BCCH field.

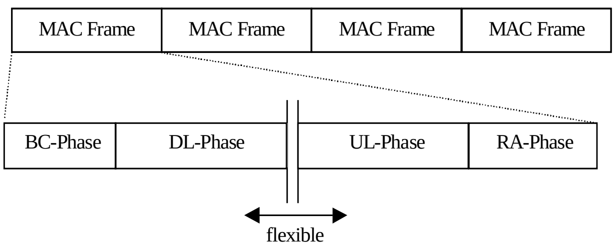

Fig. 4: Basic MAC frame structure

- Uplink phase (UL). The UL phase carries control and user data from the MTs to the AP. The MTs have to request bandwidth for one of the following frames in order to get resources granted by the AP.
- Random access phase (RA). MTs to which no capacity has been allocated in the UL phase, use this RA phase for the transmission of control information. Non-associated MTs get in first contact with an AP via the random channel (RCH). This phase is also used by MTs performing handover to have their connections switched over to a new AP.

The DL and UL phases consist of two types of packets. The long packets have a size of 54 Bytes and contain control or user data, see Fig. 3. The DLC SDU which is passed from or to the DLC layer either via the U-SAP or the interface to the RLC, has a length of 49.5 bytes. The remaining 4.5 bytes are used by the DLC for a PDU type field, a sequence number (SN) and a cyclic redundancy check (CRC). The purpose of the CRC is to detect transmission errors and is used, together with the SN, by the ARQ protocol.

The short packets with a size of 9 bytes contain only control data and are always generated by the DLC or RLC. They may contain resource requests in the uplink, ARQ messages like acknowledgements and discard messages or RLC information. The same size of 9 bytes is also used in the RCH. The RCH can only carry RLC messages and resource requests.

The structure is slightly different when the AP has a sectored antenna. The solution chosen distributes the available MAC frame duration between the sectors. This scheme is also known as switched sectored antenna. In this case, all phases are sent, separated in time direction, for each sector. This solution allows for a simple implementation, especially by still using only a single RF unit in the AP.

B. Data transport functions: Error Control (EC)

The EC is based on an automatic repeat request (ARQ) scheme. The additional forward error correction in the layer and the EC are complementary but do not cooperate.

For the selection of the ARQ scheme, efficiency of transmissions over the air interface was given priority over simplicity of implementation. This lead to the exclusion of a go-back-n scheme that is simple to implement, though, but shows rather poor efficiency. Further informations on ARQ protocols can be found e.g. in [12].

The ARQ scheme that was finally selected is based on a selective repeat mechanism. It requires a very careful transmission window handling in both sender and receiver. Therefore the receiver must notify the sender about (1) the sequence number below which all messages have been received correctly (bottom of window) and (2) which messages out of the received ones were not correct. Moreover, the sender may want to discard messages, e.g. because they have exceeded their maximum lifetime.

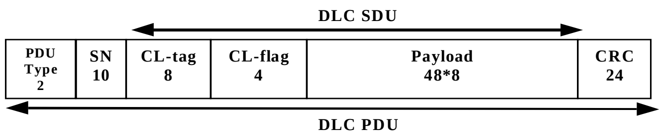

Fig. 3: Format of the long channel messages

Therefore the following ARQ messages are defined:

- Cumulative acknowledgements (ACKs), from the receiver to the sender. These ACKs move the bottom of the window to the next SN which the receiver expects to receive (i.e. the message with the lowest SN not yet correctly received).
- Bitmaps in which the receiver marks those SNs for which it has not yet (correctly) received a message. These bit maps are 8 bits wide. One message can carry up to 3 bit maps and several messages may be sent at a time.
- Discard messages. These discard messages carry the SN below which the sender has discarded all messages, regardless of whether they have been correctly received or not. This message type results in a move of the bottom of the window, caused by the sender.

The sequence number consists of 10 bits which allows a maximum transmission window size of 512 messages. A number of rules has been proposed to ensure interoperability between all kinds of H/2 devices.

It has been recognised that the specification of ARQ protocols is extremely difficult if interoperability shall be achieved. Therefore the specification of the ARQ protocol with SDL (specification and description language) has been started. However, depending on whether this model will be ready in time and mature enough, it may be included as the normative specification or as an informative add-on to the textual description of the ARQ rules.

C. Radio Link Control Sublayer (RLC)

The RLC supports the functions shown in Fig. 3. The DLC Connection Control (DCC) is responsible for the set-up and release of connections. H/2 is always connection oriented. For the case the core network is also connection oriented, a call reference is passed on with the RLC connection set-up request. This creates a relation between the connection set-up procedure on RLC and the one on higher layer level. In case the core network is connectionless, at least one DLC user connection must be set up.

Note that no ARQ is applied to RLC messages but the error handling is performed by the RLC itself.

The association control function (ASC) is responsible for the association procedure of an MT to an AP. The steps of the association procedure are:

- The MT requests to associate. The AP allocates this MT a MAC ID and both open up a predefined control connection for the RLC messages.
- MT and AP negotiate the so called link capabilities. This is an important procedure because in this step, all optional features of AP and terminal are exchanged. These include e.g. DLC versions, timing restrictions due to processing delays, supported link adaptation modes of the physical layer and convergence layer features that are supported. In this step both decide also whether they want to perform encryption and / or authentication.
- Based on the negotiation in the preceding step, the encryption key is exchanged and the authentication is performed. This step concludes the association procedure.

The default encryption scheme is based on DES in output feedback mode with 56 bit keys. Optionally, triple DES or no encryption can be selected [13]. The Diffie-Hellmann key exchange procedure is used for the creation of the encryption key. This key can be changed during operation on request of the AP. AP and MT perform a mutual authentication, based on either predefined identifiers or on a key server infrastructure.

The radio resource control (RRC) is responsible for the surveillance and efficient use of available frequency resources. One task is to perform radio channel quality measurements for handover purposes, link adaptation and DFS.

Since no frequency planning is foreseen in H/2 systems, the DFS has to select an appropriate frequency channel. The decision is, in the first step when no MTs are associated, based on the AP's own measurements. However, each terminal has a specific interference situation which may make it impossible for one or more MTs to communicate with the AP efficiently. Depending on the situation, the MT may perform a handover, the mode may be changed to a more robust one or the whole radio cell moves to a different frequency. Therefore the MTs must be able to perform several types of measurements:

- Measurements of the quality of the own channel. These measurements are performed during normal operation and include statistics of the perceived channel quality.
- Measurements of interference on the current channel. These measurements shall be performed when the own radio cell is not active. Typically, these measurements are requested by the AP, announcing a certain period of time during which the AP and all MTs are inactive.
- Measurement of other frequency channels. These measurements are typically initiated by the terminal in order to find alternative APs to which it can handover, if necessary.

The decision to perform a handover is made by the terminal itself. Hence, the measurements of other frequencies need not be reported to the AP. All other decisions are made by the AP and, hence, the MTs need to transmit the measurement reports to the AP.

Another important feature of the RRC is the support of power saving mechanisms. This power saving is necessary because the MTs will be battery driven in many cases. The terminal decides, based on its active connections and the current and previous traffic, that it wants to sleep and requests to be off for certain (periodic) sleep durations. After each period, the MT wakes up for a short time to find out whether the AP wants to send data. If this is not the case, it returns to sleep without further action. This scheme allows for very flexible and long sleep times.

The DLC connection control (DCC) is responsible for set-up and release of connections. The relation to a higher layer connection set-up procedure can be created by a call reference identifier in the DLC connection set-up request message. If any kind of QoS support is required by a higher layer, the necessary parameters for the scheduler in the DLC layer can be passed down from the higher layer. Since the scheduler will not be specified, these parameters will have to be vendor specific. Thus, no QoS related parameters on DLC level need to be defined in the standard.

The only DLC related parameters that are exchanged are a DLC connection ID and ARQ related values like maximum window size and number of allowed retransmissions.

All messages of the RLC are transported over one or more dedicated MAC connections. Message Sequence Charts (MSC) have been developed for the RLC functions which are currently being translated into a complete SDL model that will be a normative part of the standard.

VI. CONVERGENCE LAYER

The convergence layers (CL) adapt the core network to the H/2 DLC layer. For each supported core network a special CL is designed. 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. Later on an additional CL for UMTS is intended. The CL has to provide all functions needed for connection set-up and mobility support of the core network.

The convergence layers available at the AP are announced via broadcast in the DL phase. The MT chooses one of them during association. In combination with the QoS functions of H/2 it will be possible to use the QoS support for IP like RSVP, Differentiated Services or priority scheduling according to IEEE 802.1d [14].

A. Packet based convergence layer

The packet based convergence layer is used to integrate H/2 into existing packet based networks. To support the different technologies used nowadays, the Packet CL is structured hierarchically into a common part and service specific convergence sublayers (SSCS). The common part will mainly contain a segmentation and reassembly (SAR) function to fit the IP packets into the fixed length of a H/2 packet. The first SSCS to be specified is the Ethernet SSCS which will be followed by IEEE 1394, IP and PPP SSCSs in the course of the year 2000. For each part a specification will be created.

B. ATM convergence layer

The ATM CL will also consist of a common part and SSCSs. The common part will not contain a SAR function because ATM cells basically fit into the H/2 DLC SDU. Nevertheless, a compression of the ATM cell header will be necessary, transmitting only its most important parts. Currently an attempt is being made to align the mobility management between H/2 and ATM Forum.

VII. SUMMARY AND OUTLOOK

With H/2 it will be possible to have a wireless LAN with support of full mobility, QoS and various core networks. The standard aims at full interoperability between devices of different manufacturers.

At the time of delivery of this document, the basic parameters and functions are defined. Furthermore some additional functionalities are identified to be included in a later phase of the H/2 standard. The work on this later phase will start soon after the completion of the first phase.

VIII. ACKNOWLEDGEMENTS

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IX. REFERENCES

[1] IEEE 802.11, "Overview", see http://grouper.ieee.org/groups/802/11/index.html

[2] ETSI, "ETS 300 652: Radio Equipment and Systems (RES) HIgh PERformance Radio Local Area Network (HIPERLAN) Type 1 Functional specification", Sophia-Antipolis, France, 1996

[3] J. Mikkonen, J. Kruys, "The Magic WAND: a wireless ATM access system", in *ACTS Mobile Communications Summit*, Granada, Spain, 1996

[4] B. Walke, "Breitbandige Mobilkommunikation für Multimedia auf ATM-Basis", *VDE NTZ*, VDE-Verlag, Vol. 8, May 1998

[5] ETSI, "TR 101 031, Broadband Radio Access Networks (BRAN); HIgh PERformance Radio Local Area Network (HIPERLAN) Type 2; Requirements and architectures for wireless broadband access", Sophia-Antipolis, France, 1999

[6] ETSI project BRAN, *Terms of Reference*, see http://www.etsi.org

[7] IEEE P1394.1 - High Performance Serial Bus Bridges Working Group, see http://grouper.ieee.org/groups/1394/1/index.html

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

[9] J. Khun-Jush, "Modulation Schemes for HIPERLAN type 2 System: Single Carrier versus OFDM", in *3. OFDM Fachgespräch*, Braunschweig, Germany, 1998

[10] D. Petras, A. Krämling: "MAC protocol with polling and fast collision resolution for an ATM air interface", *IEEE ATM Workshop*, San Francisco, August 1996

[11] V. Jung, H.-J. Warnecke., *Handbuch für die Telekommunikation*, Springer Verlag, Berlin, 1998

[12] D. Bertsekas, R. Gallagher, *Data Networks*, second edition, Prentice Hall, 1992

[13] B. Schneier, *Applied Cryptography*, John Wiley & Sons, 1995

[14] IEEE 802.1 overview, see http://grouper.ieee.org/groups/802/1/projects.html