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HIPERLAN Type 2;
System Overview

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Project Broadband Radio Access Networks (BRAN).

The present document describes the top-level functional overview of HIPERLAN/2 systems. Separate ETSI documents provide details on the physical layer, data link layer, the convergence layers, network management, and the conformance test requirements defined for HIPERLAN/2.

Introduction

The purpose of the present document is to help system integrators, prospective users and spectrum management authorities to obtain a broad view of the scope and content of the HIPERLAN/2 Technical Specifications.

Subsequent clauses of the present document develop the following topics:

Clause 4: describes the use and applications of the HIPERLAN/2 systems;

Clause 5: describes the primary spectrum utilization factors of the HIPERLAN/2 systems;

Clause 6: describes the services and functions of the Data Link Control (DLC) Layer and the Physical (PHY) Layer of the HIPERLAN/2 systems;

Clause 7: describes the security aspects of the HIPERLAN/2 systems;

Clause 8: describes the network management aspects of the HIPERLAN/2 systems.

1 Scope

The basic approach taken by the ETSI project BRAN is to standardize only the radio access network and some of the convergence layer functions to different core networks. The core network specific functions will be left to the corresponding fora (e.g., ATM Forum, IETF and other ETSI projects). This is illustrated in figure 1.

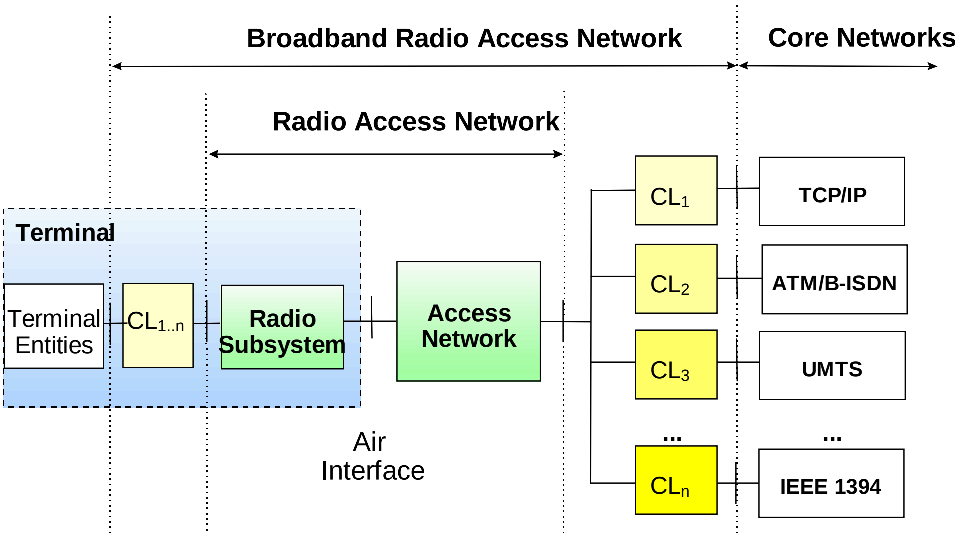

Figure 1: Reference Model

The scope of the HIPERLAN/2 Technical Specifications are limited to the air interface, the service interfaces of the wireless subsystem, the convergence layer functions and supporting capabilities required to realize the services. The air interface will be a multi-vendor interoperability interface.

Figure 2 illustrates the corresponding terminal stack in a more detailed manner.

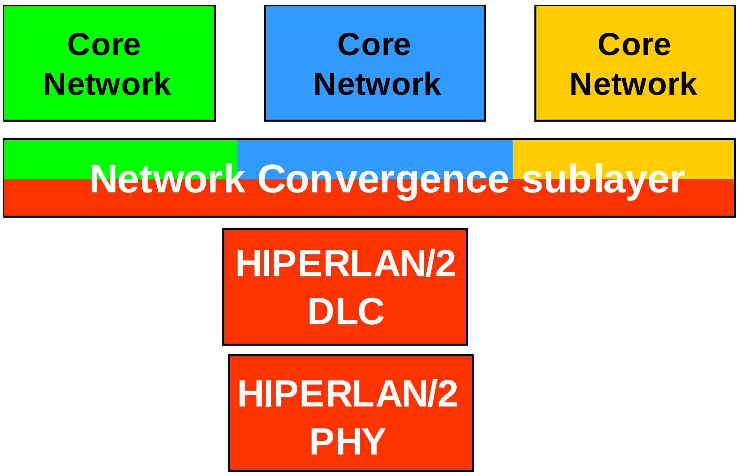

Figure 2: Terminal view

The HIPERLAN/2 Technical Specifications describe the PHY and DLC layers, which are core network independent, and the core network specific convergence layer. It should be noted that to specify a complete HIPERLAN/2 based system, other specifications, e.g. for the Network layer and higher layers are required. These specifications are assumed to be available or to be developed by other bodies. First options are:

- packet based networks with support of Ethernet [6], IP, PPP [17] and IEEE 1394 [18] services;
- cell based networks (i.e. ATM) which are standardized by the ATM Forum and the ITU;
- UMTS based services, developed by the ETSI partnership project 3GPP.

However, other specifications and / or standards may be chosen by system integrators. Such choices are outside the scope of the present document.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] TR 101 031: "Broadband Radio Access Networks (BRAN); HIgh PErformance Radio Local Area Network (HIPERLAN) Type 2; Requirements and architectures for wireless broadband access".

[2] TR 101 177: "Broadband Radio Access Networks (BRAN); Requirements and architectures for broadband fixed radio access networks (HIPERACCESS)".

[3] TR 101 378: "Broadband Radio Access Networks (BRAN); Common ETSI - ATM Forum reference model for Wireless ATM Access Systems (WACS)".

[4] TR 101 173: "Broadband Radio Access Networks (BRAN); Inventory of broadband radio technologies and techniques".

[5] ETR 069: "Radio Equipment and Systems (RES); HIgh PErformance Radio Local Area Network (HIPERLAN); Services and facilities".

[6] ISO/IEC DIS 8802-3: "Information technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Specific requirements - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications".

[7] ISO/IEC DIS 8802-5: "Information technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Specific requirements - Part 5: Token ring access method and physical layer specifications".

[8] ISO 7498-1: "Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

[9] ISO 10731: "Information Technology - Open Systems Interconnection - Basic Reference Model - Convention for the definition of OSI Services".

[10] ISO 10022: "Information Technology - Open Systems Interconnection - Physical Service Definition".

[11] ISO 8886: "Information Technology - Open Systems Interconnection - Data Link Service Definition".

[12] ISO/IEC DIS 802.11: "Information technology - Telecommunications and information exchange between systems - Local and Metropolitan Area Networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications".

[13] EN 300 652: "Broadband Radio Access Networks (BRAN); HIgh PErformance Radio Local Area Network (HIPERLAN) Type 1; Functional specification".

[14] CEPT/ERC TR/22-06: "Harmonised radio frequency bands for High Performance Radio Local Area Networks (HIPERLANs) in the 5 GHz and 17 GHz frequency range".

[15] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[16] CEPT/ERC Decision (99)23: "ERC Decision of 29 November 1999 on the harmonised frequency bands to be designated for the introduction of High Performance Radio Local Area Networks (HIPERLANs)".

[17] IETF RFC 1171 (1990): "The Point-to-Point Protocol for the Transmission of Multi-Protocol Datagrams Over Point-to-Point Links".

[18] IEEE 1394 (1995): "IEEE Standard for a High Performance Serial Bus".

[19] IEEE 802.1D (1998): "IEEE Standard for Local Area Network MAC (Media Access Control) Bridges".

[20] IETF RFC 2474: "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers".

[21] IETF RFC 2205: "Resource ReSerVation Protocol (RSVP) - Version 1 Functional Specification".

[22] IEEE 802.3: "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

function: a mechanism that performs a specific task as part of tasks performed by a layer

HIPERLAN/2 subsystem: the part of the HIPERLAN/2 reference model covered by the HIPERLAN/2 Technical Specifications

service: a set of functions provided by a layer to the next upper layer

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACF	Association Control Function
AP	Access Point
ARQ	Automatic Repeat Request
ATM	Asynchronous Transfer Mode
BC	Broadcast Phase
BCCH	Broadcast Control CHannel
BPSK	Binary Phase Shift Keying
BRAN	Broadband Radio Access Network
SSCS	Service Specific Convergence Sublayer
CC	Central Controller
CEPT	European Conference of Postal and Telecommunications Administrations
CF	Control Function
CL	Convergence Layer
CRC	Cyclic Redundancy Check
DCC	DLC Connection Control
DES	Data Encryption Standard
DFS	Dynamic Frequency Selection
DiL	Direct Link

DL	Downlink
DLC	Data Link Control
DM	Direct Mode
EC	Error Control
EIRP	Equivalent Isotropic Radiated Power
ERC	European Radiocommunications Committee
ETSI	European Telecommunication Standardization Institute
FCC	Federal Communications Commission (USA)
FCCH	Frame Control CHannel
HIPERLAN	HIgh PErformance Radio Local Area Network
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPR	Intellectual Property Right
MAC	Medium Access Control
MIB	Management Information Base
MT	Mobile Terminal
OFDM	Orthogonal Frequency Division Multiplexing
OSI	Open System Interconnection
PDU	Protocol Data Unit
PHY	Physical Layer
PPP	Point to Point Protocol
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	QuaternaryPhase Shift Keying
RA	Random Access
RCH	Random access CHannel
RLC	Radio Link Control
RF	Radio Frequency
RRC	Radio Resource Control
SAR	Segmentation And Re-assembly
SDU	Service Data Unit
SDL	Specification and Description Language
SNMP	Simple Network Management Protocol
SN	Sequence Number
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TPC	Transmit Power Control
TS	Technical Specification
UMTS	Universal Mobile Telecommunication System
UL	Uplink
U-SAP	User Service Access Point

4 Background

The increasing demand for "anywhere, anytime" communications and the merging of voice, video and data communications create a demand for broadband wireless networks. ETSI has created the BRAN project to develop standards and specifications for broadband radio access networks that cover a wide range of applications and are intended for different frequency bands. This range of applications covers systems for licensed and license exempt use.

The categories of systems covered by the BRAN project are summarized as follows:

HIPERLAN/1 provides high speed (20 Mbit/s typical gross data rate) radio local area network communications that are compatible with wired LANs based on Ethernet [6] and Token Ring [7] standards. Restricted user mobility is supported within the local service area only. The technical specification for HIPERLAN/1, ETS 300 652, was published by ETSI in 1996 (last revized version published as EN 300 652 [13]). HIPERLAN/1 systems are intended to be operated in the 5 GHz band.

HIPERLAN/2 [1] is a standard for a high speed radio communication system with typical data rates from 6 MHz to 54 Mbit/s. It connects portable devices with broadband networks that are based on IP, ATM and other technologies. Centralized mode is used to operate HIPERLAN/2 as an access network via a fixed access point. In addition a capability for direct link communication is provided. This mode is used to operate HIPERLAN/2 as an adhoc network without relying on a cellular network infrastructure. In this case a central controller (CC), which is dynamically selected among the portable devices, provides the same level of QoS support as the fixed access point.HIPERLAN/2 is capable of supporting multi-media applications by providing mechanisms to handle QoS. Restricted user mobility is supported within the local service area; wide area mobility (e.g. roaming) may be supported by standards outside the scope of the BRAN project. HIPERLAN/2 systems are intended to be operated in the 5 GHz band.

HIPERACCESS [2] provides outdoor, high speed (25 Mbit/s typical data rate) fixed radio access to customer premises and is capable of supporting multi-media applications (other technologies such as HIPERLAN/2 might be used for distribution within the premises). HIPERACCESS will allow an operator to rapidly roll out a wide area broadband access network to provide connections to residential households and small businesses. HIPERACCESS can be operated in either licensed or license exempted spectrum. The BRAN project is not considering the use of HIPERACCESS in the 5 GHz band.

HIPERLINK provides very high speed (up to 155 Mbit/s data rate) radio links for static interconnections and is capable of multi-media applications; a typical use is the interconnection of HIPERACCESS networks and/or HIPERLAN access points into a fully wireless network. It should be noted that for HIPERLINK the intended operation frequency is 17 GHz - this in view of the very limited EIRP allowed in CEPT/ERC TR/22-06 [14].

NOTE: The following clauses of the present document are only concerned with HIPERLAN/2.

5 Spectrum Utilization Parameters

HIPERLAN/2 systems are intended to be operated as private or public systems making use of the 5 GHz frequency range. Specific bands have been assigned to this type of system in Europe by the CEPT (HIPERLAN bands) and in the US by the FCC (U-NII bands).

5.1 Frequency Bands and Parameters

The HIPERLAN/2 Physical Layer specification will address operation in all of the frequency bands in the 5 GHz range in which operation is permitted by CEPT/ERC Decision (99)23 [16].

CEPT/ERC Decision (99)23 [16] covers both HIPERLAN/1 and HIPERLAN/2 and defines the frequency bands and power limits as follows:

Table 1

Frequency band	RF Power limit	Comments
5 150 MHz - 5 350 MHz	200 mW mean EIRP	Indoor use only and implementation of DFS and TPC.
5 470 MHz - 5 725 MHz	1 W mean EIRP	Indoor and outdoor use and implementation of DFS and TPC.

HIPERLAN/2 systems will have to be able to share with radar systems, some of which are mobile. This type of sharing requires dynamic adaptation - called Dynamic Frequency Selection (DFS) - to local interference conditions - a method that is also needed to facilitate uncoordinated sharing among HIPERLAN systems.

Further, HIPERLANs will be required to spread their emissions over the available frequency channels - this reduces the chance that a concentration of HIPERLAN emissions at a specific frequency channel results in interference more than the allowable one. The requirement to spread is a statistical requirement that should be satisfied on a large scale rather than the scale of a single HIPERLAN system.

Finally, HIPERLANs are required to implement Transmit Power Control (TPC) in uplink, downlink and direct link so as to minimize their potential interference. The objective of the TPC mechanism is to reduce the large scale average RF output by at least 3 dB relative to the RF output of systems not implementing TPC.

The means to implement TPC include the following:

- Adjustment of the RF power in the uplink to a level sufficient to achieve reliable communication between two HIPERLAN devices. This requirement also applies to direct link communications.

- Adjustment of the downlink RF power to a level sufficient to achieve reliable communication between the HIPERLAN Access Point and the most distant terminal device from the Access Point.

The realization of TPC and DFS requires the support of both DLC and PHY layer functions.

NOTE: Mean EIRP power is defined as the average RF power *delivered without interruption* when measured in a period that is long compared to the lowest frequency component of the transmitted signal.

5.2 RF Carriers

In the lower frequency band 5 150 MHz to 5 350 MHz, the first nominal carrier frequency is 5 180 MHz and the last one is 5 320 MHz. In the upper frequency band 5 470 MHz to 5 725 MHz, the first nominal carrier frequency is 5 500 MHz and the last one is 5 700 MHz. This allocation of nominal carrier frequencies is valid for Europe. For other regulatory domains it will be adapted to the corresponding rules. The consecutive nominal carrier frequencies are spaced 20 MHz apart regardless of the regulatory domain, i.e. the HIPERLAN/2 channel raster is 20 MHz. All transmissions are centered on one of the nominal carrier frequencies.

5.2.1 Spurious Emissions

HIPERLAN/2 will conform to the spurious emission levels defined in CEPT Recommendation 70-03 [15], outside the operating frequency range and measured in a 1 MHz bandwidth.

Table 2

Operating condition	< 1 GHz	> 1 GHz
Transmitter active	-36 dBm	-30 dBm
Transmitter not active	-57 dBm	-47 dBm

In addition, out of band emissions below 5 150 MHz shall be limited to less than -30 dBm/100 kHz in order to protect the Microwave Landing Systems (MLS) systems operating below 5 150 MHz.

6 HIPERLAN/2 Services and Functions

6.1 Introduction

A HIPERLAN/2 network for business environment consists typically of a number of APs each of them covers a certain geographic area. Together they form a radio access network with full or partial coverage of an area of almost any size. The coverage areas may or may not overlap each other, thus simplifying roaming of terminals inside the radio access network. Each AP serves a number of MTs which have to be associated to it. In the case where the quality of the radio link degrades to an unacceptable level, the terminal may move to another AP by performing a handover.

For home environment, HIPERLAN/2 network is operated as an adhoc LAN, which can be put into operation in a plug-and-play manner. The HIPERLAN/2 home system share the same basic features with the HIPERLAN/2 business system by defining the following equivalence between both systems:

- A subnet in the adhoc LAN configuration is equivalent to a cell in the cellular access network configuration.
- A central controller in the adhoc LAN configuration is equivalent to the access point in the cellular access network configuration. However, the central controller is dynamically selected from HIPERLAN/2 portable devices and can be handed over to another portable device, if the old one leaves the network.
- Multiple subnets in a home is made possible by having multiple CCs operating at different frequencies.

HIPERLAN/2 supports two basic modes of operation:

- Centralized mode: In this mode, an AP is connected to a core network which serves the MTs associated to it. All traffic has to pass the AP, regardless of whether the data exchange is between an MT and a terminal elsewhere in the core network or between MTs belonging to this AP. The basic assumption is that a major share of the traffic is exchanged with terminals elsewhere in the network. This feature is mandatory for all MTs and APs.
- Direct mode: In this mode, the medium access is still managed in a centralized manner by a CC. However, user data traffic is exchanged between terminals without going through the CC. It is expected that in some applications (especially, in home environment), a large portion of user data traffic is exchanged between terminals associated with a single CC. This feature is intended for use within home environment, and hence, is mandatory in DLC-home extensions.

NOTE 1: A central controller may also be connected to a core network and, thus, shall be able to operate in both direct and centralized mode.

The HIPERLAN/2 basic protocol stack on the AP/CC side and its functions are shown in figure 3. The convergence layer (CL) offers service to the higher layers which are out of the scope of this document.

The physical layer delivers a basic data transport function by providing means of a baseband modem and an RF part. The baseband modem will also contain a forward error correction function.

The DLC layer consists of the Error Control (EC) function, the Medium Access Control (MAC) function and the Radio Link Control (RLC) function. It is divided in the user data transport functions and the control functions, located mainly on the right hand side and on the left hand side of figure 3, respectively.

The user data transport function is fed with user data packets from higher layers via the User Service Access Point (U-SAP). This part contains the 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. In case the higher layer is connection oriented, DLC connections can be created and released dynamically. In case the higher layer is connectionless, at least one DLC connection has to be set up which handles all user data.

The left part contains the RLC Sublayer which delivers a transport service to the DLC Connection Control (DCC), the Radio Resource Control (RRC) and the Association Control Function (ACF).

NOTE 2: Only the RLC is standardized which defines implicitly the behaviour of the DCC, ACF and RRC. One RLC instance needs to be created per MT.

The CL on top is also separated in a data transport and a control part. The data transport part provides the adaptation of the user data format to the message format of the DLC layer (DLC SDU). In case of higher layer networks other than ATM, it contains a segmentation and re-assembly (SAR) function. The control part can make use of the control functions in the DLC, e.g. when negotiating CL parameters at association time.

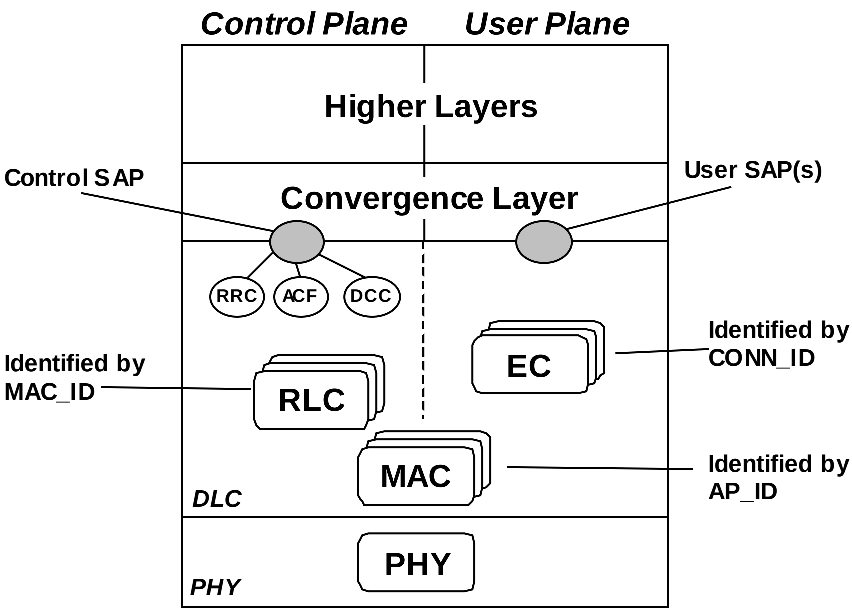

Figure 3: HIPERLAN/2 protocol stack and functions

This separation of basic DLC and CL services and functions allows a simple and modular approach to the specification of the HIPERLAN/2 air interface.

6.2 HIPERLAN/2 Physical Layer

The reference configuration of the transmission chain is shown in figure 4.

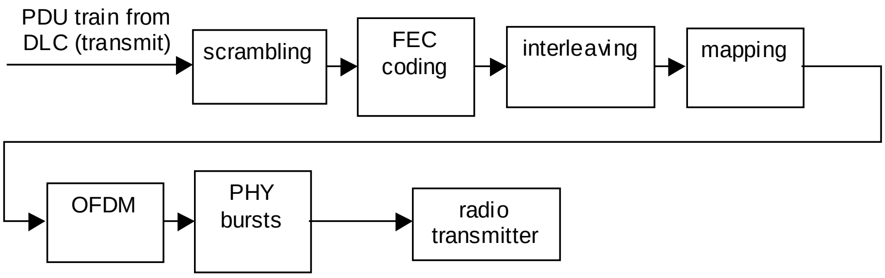

Figure 4: Reference Configuration of transmitter

The PHY layer of HIPERLAN/2 offers information transfer services to the DLC of HIPERLAN/2. For this purpose, it provides for functions to map different DLC PDU trains into framing formats called PHY bursts appropriate for transmitting and receiving management and user information between an AP/CC and an MT in the centralized mode or between two MTs in the direct mode. This includes the following functional entities at transmitter:

- configuring the transmission bit rate by choosing appropriate PHY mode based on the link adaptation mechanism;
- scrambling the PDU train content;
- encoding the scrambled bits according to the forward error correction set during PHY layer configuration;
- interleaving the encoded bits at the transmitter by using the appropriate interleaving scheme for the selected PHY layer mode;

- sub-carrier modulation by mapping the interleaved bits into modulation constellation points;
- producing the complex base-band signal by OFDM modulation;
- inserting pilot sub-carriers, appending appropriate preamble to the corresponding PDU train at the transmitter and building the PHY layer burst;
- performing radio transmission by modulating the radio frequency carrier with the complex base-band signal at transmitter.

The physical (PHY) layer of HIPERLAN/2 is based on the modulation scheme Orthogonal Frequency Division Multiplexing (OFDM). Numerical values for the OFDM parameters are given in table 2a. The symbol format is shown in figure 5 in which CP stands for cyclic prefix followed by a useful Data part.

Table 2a: Numerical values for the OFDM parameters

Parameter	Value	
Sampling rate f_s=1/T	20 MHz	
Symbol part duration T_U	64*T 3,2 µs	
Cyclic prefix duration T_{CP}	16*T 0,8 µs (mandatory)	8*T 0,4 µs (optional)
Symbol interval TS	80*T 4,0 µs (T_U+T_{CP})	72*T 3,6 µs (T_U+T_{CP})
Number of data sub-carriers N_{SD}	48	
Number of pilot sub-carriers N_{SP}	4	
Total number of sub-carriers N_{ST}	52 (N_{SD}+ N_{SP})	
Sub-carrier spacing Δ_f	0,3125 MHz (1/T_U)	
Spacing between the two outmost sub-carriers	16,25 MHz (N_{ST}*Δ_f)	

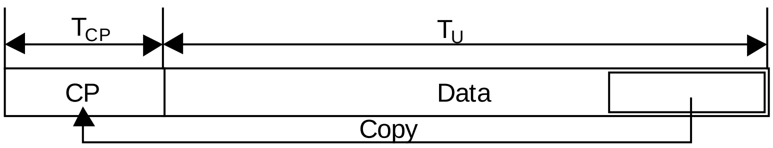

Figure 5: Illustration of an OFDM symbol with cyclic prefix

In order to improve the radio link capability due to different interference situations and distance of MTs to the access point, a multi-rate PHY layer is applied, where the "appropriate" mode will be selected by a link adaptation scheme. The data rate ranging from 6 Mbit/s to 54 Mbit/s can be varied by using various signal alphabets for modulating the OFDM sub-carriers and by applying different puncturing patterns to a mother convolutional code. BPSK, QPSK, 16QAM are used as mandatory modulation formats, whereas 64QAM is optional for both AP/CC and MT. The mode dependent parameters are listed in the following table.

Table 3: Mode dependent parameters

Modulation	Coding rate R	Nominal bit rate [Mbit/s]
BPSK	1/2	6
BPSK	3/4	9
QPSK	1/2	12
QPSK	3/4	18
16QAM	9/16	27
16QAM	3/4	36
64QAM	3/4	54 (Optional)

6.3 HIPERLAN/2 DLC Functions

The HIPERLAN/2 DLC functions are divided in data transport and data link control functions and will be described in two sub-clauses in the following

6.3.1 Data transport functions

6.3.1.1 Medium Access Control

The medium access control is a centrally scheduled TDMA/TDD scheme. Centrally scheduled means that the AP/CC controls all transmissions over the air. This concerns uplink, downlink and direct mode phase equally.

The basic structure on the air interface generated by the MAC is shown in figure 6. It consists of a sequence of MAC frames of equal length with 2 ms duration. Each MAC frame consists of several phases:

- Broadcast (BC) phase: 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 (DL) phase: The DL phase carries user specific control information and user data, transmitted from AP/CC to MTs. Additionally, the DL phase may contain further broadcast information which does not fit in the fixed BCCH field.

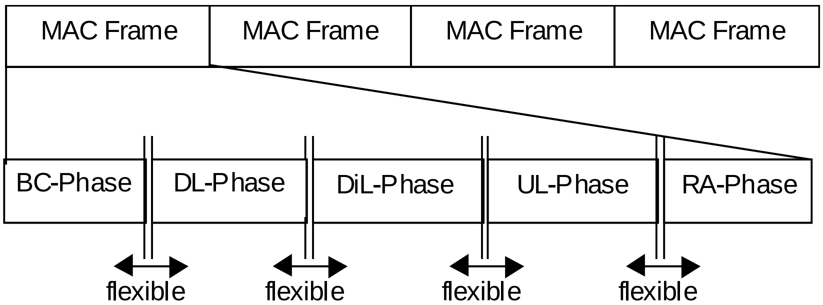

Figure 6: Basic MAC frame format

- Uplink (UL) phase: The UL phase carries control and user data from the MTs to the AP/CC. The MTs have to request capacity for one of the following frames in order to get resources granted by the AP/CC.

- Direct Link (DiL) phase: The DiL phase carries user data traffic between MTs without direct involvement of the AP/CC. However, for control traffic, the AP/CC is indirectly involved by receiving Resource Requests from MTs for these connections and transmitting Resource Grants in the FCCH.

NOTE 1: The DiL phase is mandatory in home environments.

- Random access (RA) phase: The RA phase carriers a number of RCH (random access channels). MTs to which no capacity has been allocated in the UL phase use this phase for the transmission of control information. Non-associated MTs use RCHs for the first contact with an AP/CC. This phase is also used by MTs performing handover to have their connections switched over to a new AP/CC.

The structure is slightly different when the AP/CC has a sectored antenna as shown in figure 7. The solution chosen distributes the available MAC frame duration over the sectors. In this case, each phase is repeated, in time, one for each sector.

NOTE 2: The use of DiL with sectored antennas is not specified.

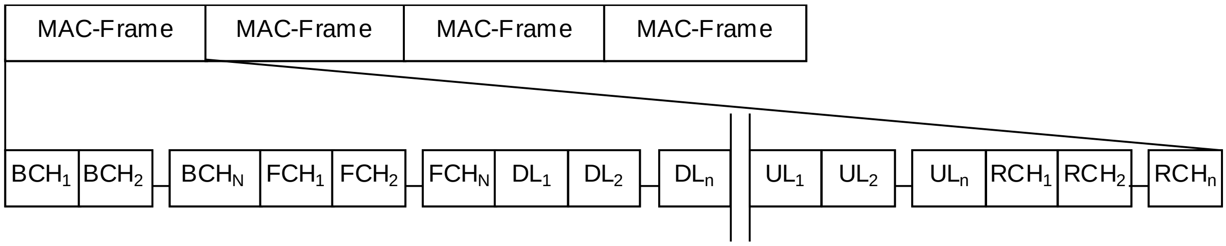

Figure 7: MAC frame format for sectored antennas

The DL, DiL and UL phases consist of two types of PDUs: long PDUs and short PDUs. The long PDUs have a size of 54 bytes and contain control or user data, see figure 8. The DLC SDU which is passed from or to the DLC layer via the U-SAP 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 EC.

The short PDUs with a size of 9 bytes contain only control data and are always generated by the DLC. 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 access method to the RCH is a slotted aloha scheme. The collision resolution is based on a binary backoff procedure which is controlled by the MTs. The AP/CC can decide dynamically how many RCH slots it provides per MAC frame.

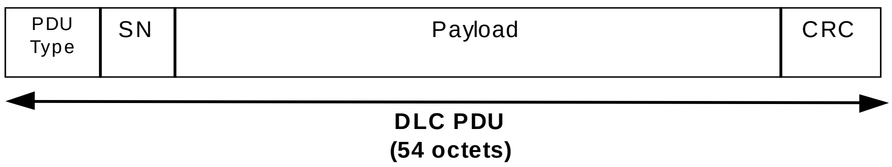

Figure 8: Format of the long PDUs

6.3.1.2 Error Control

The EC is based on an ARQ scheme. Additional forward error correction and the EC are complementary but do not collaborate.

The ARQ scheme is based on a selective repeat mechanism. It requires a very careful transmission window handling in both transmitter and receiver. Therefore the receiver has to notify the transmitter 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 transmitter may want to discard messages, e.g. because they have exceeded their maximum lifetime.

6.3.2 Radio Link Control functions

The control functions are specified in a separate TS. The specification is based on an SDL model.

NOTE: The control functions are closely related to the protocols defined in the RLC. Only the RLC will be specified, the control functions themselves are out of the scope of the standard. In the explanations below, the control functions and the actual RLC will be handled synonymously.

6.3.2.1 Association Control Function

A Terminal intending to communicate with an AP/CC has always to be associated to this AP/CC. The reasons are:

- The AP/CC always has to create some resources for each MT associated, e.g. the RLC connection and a MAC ID.
- The MAC protocol is centrally controlled by the AP/CC, regardless of whether it operates in centralized or in direct mode.

The tasks of the association control are:

- Association: The first step is the allocation of a MAC ID to a terminal, followed by the negotiation of the link capabilities. These comprise the selected CL and other features. AP/CC and MT decide in this step whether encryption and / or authentication are performed or not and which encryption and authentication mechanisms are used, respectively.

- Encryption key exchange: This step is performed after the link capability negotiation and is optional. It is based on the Diffie-Hellmann key exchange procedure. The Diffie-Hellmann secret and public values are used by both AP/CC and MT to generate and refresh the session key.

- Authentication: This step is performed after the encryption key exchange and is optional. The authentication affects both MT and AP/CC, i.e. they perform a mutual authentication.

- Beacon Signalling in the AP/CC: The beacon signalling provides basic information about essential features and properties of the AP/CC which are broadcast in each MAC frame. The ACF provides some of the values that are broadcast.

- Encryption key refresh: This feature is optional. It can happen periodically and is requested by the AP/CC.

- Dissassociation: This feature shall be performed by the MT if possible.

NOTE: This may not be possible if the MT power drops suddenly.

6.3.2.2 Radio Resource Control

The radio resource control (RRC) is responsible for the surveillance and efficient use of available frequency resources. The functions of the RLC for the support of the RRC are:

- Dynamic Frequency Selection: HIPERLAN/2 will operate in a "Plug-and-Play" manner and will not require frequency planning. The decision on the selection of a frequency channel is, in the first step when no MTs are associated, based on the AP/CC’s own measurements. During operation, the situation may change and the AP/CC has to switch to a different frequency channel. However, each terminal has a specific interference situation which may make it impossible for one or more MTs to communicate with the AP/CC efficiently. Therefore, the decision when to perform a frequency change and to which frequency has to be based on both measurements of the AP/CC and the associated MTs. The DFS supporting functions of the RLC allow for:

  - measurements of MTs and AP/CC: The terminal may do measurements on its own or on different channel, either based on its own decision or ordered by the AP/CC;

  - reporting of the obtained measurements from MTs to the AP/CC;

  - frequency change of the AP/CC and its associated MTs.

- MT alive procedure: In order to make sure that the AP/CC does not reserve resources unnecessarily for an MT, the AP/CC may request it to report if it is still alive.

- MT absence function: The MT may want to scan for a different frequency channel in order to find out whether it shall perform a handover and to which new AP/CC it shall change. This function is triggered by the MT.

- Power saving function: Many MTs will be battery driven. Therefore, HIPERLAN/2 will support an efficient scheme to support the conservation of battery power. The mechanism will be based on sleep intervals after which the terminal listens periodically whether the AP/CC wants it to receive data. If no data are pending in DL, or DiL, the MT remains in sleep modus without communication with the AP/CC in centralized mode, or with another MT in direct mode. The length of the sleep intervals can be negotiated between AP/CC and MT. This function is triggered by the AP/CC, the selection of the sleep interval is done by the AP/CC.

- Transmit Power Control: AP/CC and MT will support means to adapt their transmission power to the current requirements of the radio link.

- Handover: The handover function will be restricted to business and public applications and will not be supported in home networks in the first phase. The RRC will decide when to perform a handover and support its execution.

6.3.2.3 DLC control function

The DLC connection control (DCC) is responsible for set up and release of user 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 has to be provided by the higher layers. Since the scheduler will not be specified, the specification of these parameters is out of the scope of HIPERLAN/2 The only DLC related parameters to be exchanged are a DLC Connection ID and ARQ related values like maximum window size and number of allowed retransmissions.

The functions of DCC are:

- DLC connection set up: This feature comprises set up procedures for centralized mode, direct mode and multicasts all of which can be originated either by the AP/CC or the MT.
- DLC connection release: This feature comprises release procedures for centralized mode, direct mode and multicasts all of which can be originated either by the AP/CC or the MT.
- DLC connection modify: This feature comprises modify procedures for centralized mode, direct mode and multicasts all of which can be originated either by the AP/CC or the MT. The modification refers to the DLC specific connection parameters which are described above.
- Multicast join and leave: These features allow a terminal to join already existing multicast groups and leave one it belongs to.

6.4 Convergence Layer

The convergence layers (CL) adapt the core network to the HIPERLAN/2 DLC layer. The CL provides all functions needed for connection set-up and support mobility in the core network. For each supported core network a special CL is designed. Support for packet based networks like Ethernet (IEEE 802.3 [22]), IP, PPP and IEEE 1394 [18] (Firewire) as well as cell based networks like ATM and UMTS will be available.

The convergence layers available at the AP/CC are announced via broadcast. MT and AP/CC negotiate one of them during association. In combination with the QoS functions of HIPERLAN/2 it shall be possible to support various QoS schemes. Among others IP like RSVP [21], Differentiated Services [20] or priority scheduling according to IEEE 802.1D [19].

The packet based convergence layer is used to integrate HIPERLAN/2 into existing packet based networks. To support the different technologies used nowadays and to be open for future technologies, the Packet CL is structured hierarchically into a common part and a number of service specific convergence sub-layers (SSCS). The common part mainly contains a SAR function to fit the packets into the fixed length of a HIPERLAN/2 packet. The first SSCS to be specified is the Ethernet SSCS which is followed by IEEE 1394 [18], IP and PPP SSCSs in the course of the year 2000. For each part a specification will be created.

The ATM CL also consists of a common part and SSCSs. The common part shall not contain a SAR function because ATM cells basically fit into the HIPERLAN/2 DLC SDU. Nevertheless, a compression of the ATM cell header is necessary, transmitting only its most important parts.

7 Security

Each HIPERLAN/2 system is vulnerable to attack for the purpose of fraudulent use and transmission interception. The HIPERLAN/2 specification will, therefore, have strong security functions at the DLC level for protection against eavesdropping and misuse.

The security mechanisms have partly been described in subclause 6.3.2.1, "Association Control Function". The default encryption scheme is based on DES in output feedback mode with 56 bits key. Optionally, triple DES or no encryption can be selected. 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 pre-shared keys or public keys.

NOTE: Depending on the core network, additional higher layer security functions can be located in the MT and AP. These functions are out of the scope of the standard. However, the output of the higher layer security functions may affect the operation of the DLC layer. E.g., failure to authenticate the user at a higher layer may cause the related DLC connections and the underlying RLC association to be dropped. The interaction between higher layer security functions and the DLC layer are outside the scope of the HIPERLAN/2 specifications.

8 Network Management

The Network Management TS gives guidelines for network management of HIPERLAN/2 devices. A HIPERLAN/2 SNMP MIB located in the AP is defined. The MIB and related principles are applicable in centralized mode where a core (IP) network is available.

The purpose with defining a MIB and related principles is to provide a common view to the human network manager of HIPERLAN/2 devices from different vendors. Basic performance and fault monitoring is covered for network monitoring. A basic set of configuration parameters is defined for network control. Out of scope is systems management like device setup and software upgrade and also the manager side for network management. Those areas are vendor specific.

History

Document history		
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