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Technical Report

Broadband Radio Access Networks (BRAN);
HIgh PErformance Radio Local Area Network (HIPERLAN) Type 2;
Requirements and architectures for wireless broadband access

Reference

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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 requirements and architectures that are applicable to HIgh PErformance Radio Local Area Network (HIPERLAN) Type 2. HIPERLAN Type 3 has been subsumed by licence exempt HIPERACCESS [2f]. HIPERLAN Type 4 has been renamed to HIPERLINK. The latter two are described in separate reports.

Introduction

Wireless networks have enjoyed an increased demand from the general public as well as from business and other professional users.

Wireless networks in existence today range from cellular phones to high speed digital networks supporting high speed computer communications. They operate in licensed as well as in unlicensed frequency bands.

At the same time, wired telecommunications networks have shown a remarkable evolution towards higher transmission rate and support for multi-media applications rather than simple voice oriented services.

ETSI has recognized the trend towards better and faster wireless networking demands from all kinds of users. Working with the CEPT resulted, in the period 1990 through 1992, in spectrum designations in the 2,4 GHz ISM band, in the 5,2 GHz band and in the 17,1 GHz band to allow the development of a variety of standards for wireless networks. The 2,4 GHz ISM band was intended for medium speed "wide band data systems using spread spectrum techniques". The latter two bands were assigned to HIPERLANs, a collective reference to High Performance Radio Local Area Networks. ETSI has identified the need for a family of HIPERLAN standards that together support a wide variety of usage scenarios and applications.

HIPERLAN Type 1 provides an ISO/IEC 8802-1 [5] compatible wireless local area network.

HIPERLAN Type 2 is intended to provide short range broadband wireless access to Internet Protocol (IP), Asynchronous Transfer Mode (ATM) networks and Universal Mobile Telecommunications System (UMTS).

HIPERLAN Type 1 operates in the 5,2 GHz licence exempt band; Type 2 is intended to operate in the 5,2 GHz band and other 5 GHz bands (note 1); HIPERLINK is intended to operate in 17,2 GHz band. The CEPT has designated 100 MHz of spectrum in the 5 GHz band for HIPERLANs with a further 50 MHz available at the discretion of national administrations and 200 MHz in the 17 GHz band. (See CEPT Recommendation T/R 22-06 [1] and ERC Decision 96/03 [6]). Because the current allocation in the 5,2 GHz band is expected not to be sufficient for the projected needs of users and their applications, ETSI has initiated discussions with CEPT aimed at making more spectrum available in this range.

NOTE 1: Other frequency bands around 4 GHz to 6 GHz may be used on a licensed basis.

NOTE 2: The FCC has allocated in the USA 300 MHz of spectrum at 5 GHz band referred to as the U-NII (Unlicensed National Information Infrastructure) bands, in which HIPERLAN devices may be operated.

Developments in other types of wireless networks have increased the scope and potential applications of such networks. A primary example is UMTS (or IMT-2000 as it is known outside Europe). UMTS, in its various forms, supports a wide range of communications services, from cordless services to wide area cellular services. The range of bit rates, with a maximum of 2 Mbit/s, supported by UMTS is geared primarily towards voice and low quality video as well as data services. However, because of spectrum limitations as well as for economic reasons, UMTS will not be able to meet the bandwidth demands of true, high resolution multi-media communications. These require bit rates in the range of 10 Mb/s. The required bandwidth is not available in the planned UMTS frequency range and it is likely that the cost to users of such bandwidth would be excessive. Furthermore, it is not clear that there exists demand for such high speed services beyond the premises of a business or other organization. On premises, short range wireless networks that do not share spectrum with UMTS are much more attractive and flexible as a solution to multi-media wireless networking. HIPERLANs fill that need. The following figure clarifies the relationship between HIPERLANs and UMTS:

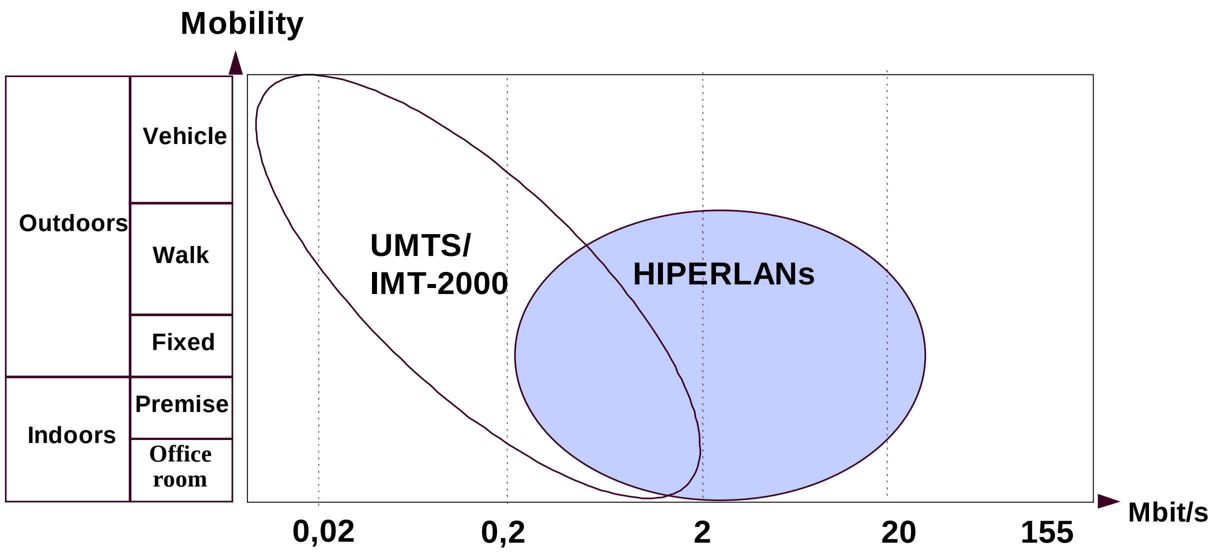

Figure 1: The relationship between HIPERLANs and UMTS/IMT-2000

It should be noted that the above does indicates that users may well perceive benefits form being able to access UMTS based services from HIPERLAN compatible devices and vice versa.

To date ETSI has published two standards: ETS 300 328 [3] which provides the type approval requirements for data networks operating in the 2,4 GHz ISM band and ETS 300 652 [2] which provides a functional specification of high speed ISO 8022 compatible wireless networks.

The present document has been written to assist the ETSI membership as well as the potential users of standards for high speed wireless data systems in understanding the applications and concepts that underlie the standards for HIPERLAN Type 2.

As this understanding develops during the writing of the actual standards, the present document is likely to require change. Therefore, it should be treated as a living document rather than a definitive text.

1 Scope

The scope of the present document is limited to the requirements and architectures for HIPERLAN Types 2. HIPERLAN Type1 is addressed by ETS 300 652 [2] and its related Conformance Test Specifications, [2a], [2b], [2c] and [2d]. HIPERLINK will be described in a TR produced by BRAN.

The requirements address subjects like applications, traffic volumes and traffic patterns that underlie the projected spectrum requirements as well as the chosen architectures. The architectures address the communications layer models as well as the Reference models that identify the key interfaces subject to standardization.

The architectures developed in the present document are intended to delineate the boundaries between HIPERLAN standards and standards for networks in which HIPERLANs may be used as subsystems or components.

Scope of standardization

The scope of the standards for HIPERLAN Types 2 is limited to the air interface specifications, the Data Link Control (DLC) layer specifications, the specifications of the management functions and the interworking functions. The DLC layer specification includes a specification of the services to be provided.

The ETSI HIPERLAN/2 standards specify subsystems up to and including the DLC Layer. Interworking functions will be specified in liaison with other relevant technical standardization bodies.

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] CEPT Recommendation T/R 22-06: "Harmonized radio frequency bands for High Performance Radio Local Area Networks (HIPERLANs) in the 5 GHz and 17 GHz frequency range".

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

[2a] ETS 300 836-1: "Broadband Radio Access Networks (BRAN); HIgh PERformance Local Area Network (HIPERLAN) Type 1; Conformance testing specification; Part 1: Radio type approval and Radio Frequency (RF) conformance test specification".

[2b] ETS 300 836-2: "Broadband Radio Access Networks (BRAN); HIgh PERformance Local Area Network (HIPERLAN) Type 1; Conformance testing specification; Part 2: Protocol Implementation Conformance Statement (PICS) proforma specification".

[2c] ETS 300 836-3: "Broadband Radio Access Networks (BRAN); HIgh PERformance Local Area Network (HIPERLAN) Type 1; Conformance testing specification; Part 3: Test Suite Structure and Test Purposes (TSS&TP) specification".

[2d] ETS 300 836-4: "Broadband Radio Access Networks (BRAN); HIgh PERformance Local Area Network (HIPERLAN) Type 1; Conformance testing specification; Part 4: Abstract Test Suite (ATS) specification".

[2e] Void.

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

[2g] TR 101 378: "Broadband Radio Access Networks (BRAN); Common ETSI - ATM Forum reference model for Wireless ATM Access Systems (WACS)".

[3] ETS 300 328: "Radio Equipment and Systems (RES); Wideband transmission systems; Technical characteristics and test conditions for data transmission equipment operating in the 2,4 GHz ISM band and using spread spectrum modulation techniques".

[4] ITU-T Recommendation Q.2931 (1995): "Broadband Integrated Services Digital Network (B-ISDN) - Digital subscriber signalling system no. 2 (DSS 2) - User-network interface (UNI) - Layer 3 specification for basic call/connection control".

[5] ISO/IEC 8802-1: "Information technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks -- Specific requirements -- Part 1: Overview of Local Area Network Standards".

[6] ERC Decision 96/03: "ERC Decision on the harmonized frequency band to be designated for the introduction of High Performance Radio Local Area Networks (HIPERLANs)".

[7] ATM Forum Specification UNI 3.1: "User-Network Interface Specification".

[8] ITU-T Recommendation I.356 (1996): "B-ISDN ATM layer cell transfer performance".

3 Definitions and abbreviations

3.1 Definitions

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

[local] access: This term is used in the telecommunications sense: short range (< 100 m) wireless access to other, possibly wired, networks.

[remote] access: This terms is used in the telecommunications sense: long range (< 10 km) wireless access to other, possibly wired, networks. Remote access networks are also referred to as "local loop networks".

[wireless] access subnetwork: A [wireless] subnetwork that is a physical subset of an access network. It is serviced by a single [wireless] access point.

[wireless] access network: The combined [wireless] subnetworks providing access to a single external network, e.g. an ATM switch.

[wireless] access point: A device controlling a single [wireless] access subnetwork.

asynchronous traffic: Data traffic that characteristically has a statistical arrival and delay distribution. This typifies most LAN data traffic.

Business Premises Network (BPN): A network covering a privately owned network.

convergence sublayer: A sublayer that generates no protocol but that provides the wireless DLC layer with the information it needs to perform its QoS management functions as required.

data confidentiality: Provisions for the protection of transmitted data from observation by unauthorized stations or other monitoring means. One measure for doing that is to implement encryption.

Data Link Control (DLC): Layer 2 of the ISO/OSI reference model.

Domestic Premises Network (DPN): A network covering home environment.

downlink: The incoming data direction from a wireless terminal adapter perspective.

encryption: A means of obtaining data confidentiality. See also: Data confidentiality.

handover: The changing of the path over which information flows between two communicating HIPERLAN nodes without being disconnected.

HIPERLAN: HIgh PErformance Radio Local Area Network.

interworking: Interaction between dissimilar sub-networks, end systems, or parts thereof, providing a functional entity capable of supporting end-to-end communications.

Local Area Network (LAN): A group of user stations, each of which can communicate with at least one other using a common transmission medium commonly managed.

Protocol Data Unit (PDU): Data unit exchanged between entities at the same ISO layer.

Physical Layer (PHY): Layer 1 of the ISO/OSI reference model. The mechanism for transfer of symbols between HIPERLAN nodes.

Service Data Unit (SDU): Data unit exchanged between adjacent ISO layers.

time-bounded services: Time-bounded services denotes transfer services with low delay and low delay variance for use with voice and other real-time services.

[wireless] terminal adapter: The functional components of a network node that provide the communications services and the related control functions.

transceiver coverage area: The physical area serviced by a single transceiver.

uplink: The outgoing data direction from wireless terminal adapter perspective.

3.2 Abbreviations

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

AAL	ATM Adaptation Layer
AP	Access Point
ARQ	Automatic Retransmission reQuest
ATM	Asynchronous Transfer Mode
BER	Bit Error Rate
B-ISDN	Broadband Integrated Services Digital Network
BPN	Business Premises Network
CATV	Community Antenna TeleVision
CEPT	Conférence Européenne des administrations des Postes et des Télécommunications
DLC	Data Link Control
DPN	Domestic Premises Network
DSDU	DLC Service Data Unit
EY-NPMA	Elimination-Yield Non-pre-emptive Priority Multiple Access
FEC	Forward Error Correction
FPLMTS	Future Public Land Mobile Telecommunications System
HDTV	High Definition TeleVision
HIPERACCESS	HIgh PErformance Radio ACCESS
HIPERLAN	HIgh PErformance Radio Local Area Network
HIPERLINK	HIgh PErformance Radio LINK
IP	Internet Protocol
ISM	Industrial, Scientific and Medical
LAN	Local Area Network
LLC	Logical Link Control
LME	Layer Management Entity
MAC	Medium Access Control
N/A	Not Applicable
OSI	Open Systems Interconnection
PCMCIA	Personal Computer Memory Card Interface Association

PDA	Personal Digital Assistant
PDU	Protocol Data Unit
PHY	Physical Layer
QoS	Quality of Service
RF	Radio Frequency
SDTV	Standard Definition TeleVision
SDU	Service Data Unit
TCP	Transport Control Protocol
UMTS	Universal Mobile Telecommunications System
UNI	User Network Interface
UTRAN	UMTS Terrestrial Radio Access Network
VCR	Video Cassette Recorder

4 Overview

The BRAN family of standards includes: HIPERLAN Type 1 (high speed wireless LANs), HIPERLAN Type 2 (short range wireless access to IP, ATM and UMTS networks) both operating in the 5 GHz band, HIPERACCESS (fixed wireless broadband point-to-multipoint) and HIPERLINK (wireless broadband interconnection) operating in the 17 GHz band. This is represented in the figure below together with the operating frequencies and indicative data transfer rates on the air interface.

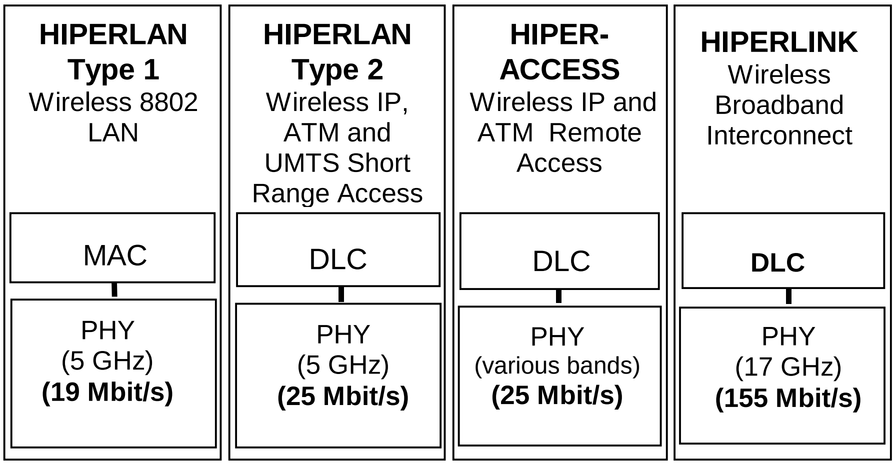

Figure 2: Overview of HIPERLAN Types, HIPERACCESS and HIPERLINK

4.1 HIPERLAN Type 1, Wireless 8802 Local Area Networks

HIPERLAN Type 1 (HIPERLAN/1) is a wireless local area network that is ISO/IEC 8802-1 [5] compatible. It is intended to allow high performance wireless networks to be created, without existing wired infrastructure. Multiple HIPERLANs can co-exist in the same geographical area with equitable bandwidth sharing without co-ordination between them. In addition HIPERLAN Type 1 can be used as an extension of a wired local area network.

HIPERLAN/1 offers unconstrained connectivity based on directed one-to-one communications as well as one-to-many broadcasts. The channel provides both self configurability and flexibility of use thanks to a distributed channel access (EY-NPMA) and standardized forwarding feature.

The HIPERLAN/1 Functional Specification is given in ETS 300 652 [2].

4.2 HIPERLAN Type 2, short range wireless access to IP, ATM and UMTS networks

HIPERLAN Type 2 (HIPERLAN/2) is intended to provide local wireless access to IP, ATM and UMTS infrastructure networks by both moving and stationary terminals that interact with access points which, in turn, usually are connected to an IP, ATM or UMTS backbone network. A number of these access points will be required to service all but the smallest networks of this kind and therefore the wireless network as a whole shall support hand-overs of connections between access points. Further, such a wireless access network shall be able to provide the Quality of Service (QoS), including required data transfer rates, that users expect from a wired IP or ATM network.

4.3 HIPERACCESS, remote wireless access to IP and ATM networks

HIPERACCESS provides outdoor, high speed (25 Mbit/s typical data rate) radio access, it provides fixed radio connections to customer premises and is capable of supporting multimedia 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. However, HIPERACCESS may also be of interest to large organizations wishing to serve a campus and its surroundings and to operators of large physical facilities such as airports, universities, harbours etc.

4.4 HIPERLINK, wireless interconnection

Interconnecting high data rate sources such as (access) networks requires high bit rates and large channel capacities. HIPERLINK provides point-to-point interconnection at very high data rates, e.g. up to 155 Mbit/s over distances up to 150 m.

5 Requirements

This clause deals with the general requirements that underlie the development of the HIPERLAN standards for wireless broadband access.

5.1 Application environments

The following subclauses describe a number of application environments. The common denominator of these environments is that:

- they are used in a geographically limited area;
- they support multimedia services.

5.1.1 Types of HIPERLAN application environments

Domestic Premises Network (DPN) environment

The DPN environment covers the home and its immediate vicinity; it typically includes a localized radio extension to a broadband network. It is characterized by spot coverage areas, perhaps individual cells, one per home or building. Support for mobility beyond the coverage area is outside the scope of the present document.

Business Premises Network (BPN) environment

The BPN environment covers a network covering e.g. a company area, university campus hospital, industrial premises, airports, train stations, etc. It may offer access, switching and management functions within an arbitrary large coverage area serviced by multi-cellular wireless communications facilities. Thus, functions like handover and paging may be necessary within this environment.

5.1.2 Types of networks

HIPERLANs may be used in a number of ways, for example:

Wireless Access to Public Network

HIPERLAN Type 2 may be used to gain access to a public network, for example, to provide Telepoint services.

Wireless Access to Private Network

HIPERLANs may be used to gain access to a private network, for example, business premises or campus networks.

Temporary Network

HIPERLANs may be used to create temporary networks, independent of an established wired local network. Such a network may be used semi-permanently, as an alternative for a wired network, and for ad-hoc purposes, for example for people to communicate and work on documents during a meeting.

5.1.3 Usage environments.

The table below shows various examples of usage and applications in the networks types given above. A number of these application environments are analysed in the following subclauses.

Table 1: Examples of usage environments

	Wireless Access to Public Networks	**Wireless Private Networks (access- and infrastructure)**	**Temporary networks**
DPN	- education - security, (sensors) - multimedia, e.g. radio CATV access point - mobile access to IP, ATM or UMTS network	- education security (surveillance and sensors) - domestic cordless multi-media distribution	- education - meetings - fairs - exhibition
BPN	- emergency networks telepoint - education - security, (sensors) - multimedia, e.g. radio CATV access point - mobile access to IP, ATM or UMTS network	- manufacturing - office automation - education - financial transactions - medical/hospital - security (surveillance and sensors) - broadcast studios - maintenance of large objects - stock control - aircraft gate link	- large meetings - offices - maintenance of large objects - industrial - emergency networks - exhibition

5.2 User scenarios

This subclause describes different scenarios in which HIPERLAN Type 2 may be used.

- Infrastructure replacement scenario, i.e. when HIPERLANs could be used instead of cabling.
- Cordless access scenario, in which users need to use HIPERLANs in different locations at different times possibly maintaining connectivity while in transit.
- Wireless access to infrastructure scenario.
- Specialized portable applications scenario, i.e. user uses a PDA type device mainly for specialized applications, e.g. maintenance or surveillance.
- Domestic premises scenario, i.e. HIPERLANs are used in the home environment.

- Wireless manufacturing automation scenario, i.e. HIPERLANs are used in a factory or a large assembly / building facility.
- Inter network communication scenario.

5.2.1 Infrastructure replacement scenario

HIPERLANs can be used for wired infrastructure replacement in a number of scenarios including the replacement of wired premises networks. Typical cases could be temporary office installations or installations into spaces where building characteristics or protection prohibit the extensive use of a cabling.

The infrastructure to be replaced includes stationary backbone networks operating at high speeds as well as wireless network terminations.

Terminals typically connected to infrastructure networks typically are designed for fixed use. Such a terminal could, for example, be a workstation, a PC or any other purpose specific terminal. The applications are typically broadband applications. In this scenario the user device is mostly stationary and the main benefit derived from HIPERLANs is the wireless dimension. Thus, HIPERLANs shall provide or approximate fixed network QoS to a stationary user. The user should not be able to notice the difference between using the wireless system and a wired system.

Table 2: An example of a wired infrastructure replacement scenario

Attribute	
End-user equipment	PC or work station
Usage environment	Offices etc.
Range	Up to 50 meters for indoor systems;
QoS expectation	Same as desktop
Applications	Same as desktop
Mobility	Limited
Coverage	Continuous
User Density	High

5.2.2 Cordless access scenario

In this scenario, the HIPERLAN user needs to perform his or her work at different locations at different times. The main end-user equipment would be a portable computer. Typically such a user would carry a portable computer to various places within the office and then use the computer while stationary. Typical places for using the HIPERLAN system outside a office room would be meeting rooms, dining facilities, patient wards, class rooms and auditoria as well as waiting rooms/halls. A cordless user will also access the public network, through base stations installed in locations such as railway stations, airports and shopping centres. In some cases, connectivity has to be maintained while the user is in transit from one location to another.

The terminals in this scenario are movable. A typical terminal could be built around a laptop computer and a HIPERLAN card. The mobile node will in many cases be a battery driven device so that an economic consumption of power is required.

Table 3: An example of a cordless access scenario

Attribute	
End-user equipment	Portable computer, e.g. Notebook or Palmtop.
Usage environment	Offices, schools, hospitals, airports, railway stations, shopping centres, etc.
Range	Up to 50 meters for indoor systems; Up to 150 meters for outdoor systems.
QoS expectation	Similar to desktop
Applications	Similar to desktop
Mobility	none during use
Coverage	Continuous
User Density	High (e.g. in a meeting room)
Power consumption	Low

5.2.3 Specialized portable applications scenario

In the third scenario a user has a small (possibly dedicated) system like a PDA to access services. The applications are typical broadband applications, which shall be supported for mobile users with an acceptable QoS by the mobility functions in the network, e.g. handover. The QoS expected from the HIPERLAN system in this scenario could however be somewhat lower than the QoS of a fixed system. The user can be assumed to realize that a small loss in QoS is the price paid for the mobility gained. For example, the connection might tolerate a short interruption because of a handover (resulting in momentary disturbance in the video picture) etc.

The terminal in this scenario is a mobile handheld terminal e.g. a PDA with a wireless network card or a dedicated mobile node. The applications are mostly dedicated mobile applications that are capable of operating at a lower QoS, as they would use mobile specific features to compensate for some mobile related problems.

The mobile node will in many cases be a battery driven device so that an economic consumption of power is required.

Table 4: An example of a specialized portable scenario

Attribute	
End-user equipment	Hand portable unit, PDA
Usage environment	Anywhere within or near private premises
Range	Up to 50 meters for indoor systems; Up to 150 meters for outdoor systems.
QoS expectation	Modest, but maintained during movement
Applications	Dedicated, could be mobile specific
Mobility	Walking speed or slow vehicle (e.g. forklift)
Coverage	Continuous
User Density	Low
Power consumption	Very low

5.2.4 Domestic premises scenario

In the domestic network scenario, many appliances, e.g. PC laptop, printer/fax machines, security systems, home appliances, digital HDTV/SDTV sets, digital Video Cassette Recorder (VCR), speakers and more could be linked in various ways. A typical scenario would be:

1) An entertainment cluster (video and sound) located in the living room transmitting to television sets located in the living room, kitchen and bedroom.

2) A music system in the living room transmitting to speakers located in the living room, bedroom or dining room.

3) Security features outside the home such as wireless security camera or remote sensors. These could either be located on the external walls of the property or at the boundary wall or a remote building such as a garage or recreation facility.

4) Outdoor speakers for barbecue/party. Assuming that the music system is located in the entertainment cluster in the living room, the transmission path and length may extend into the garden.

From the above, it is obvious that the domestic network shall allow access to external networks e.g. digital television or be capable of working with no external links e.g. a music system with remote speakers. This system should be easily installable by non-technical people.

A domestic network generally covers a much smaller area than either factory or office environments. The rooms in a domestic premises tend to be smaller when compared to work environments and have more compartmentalized structure (storage spaces and en-suites).

Table 5: An example of a domestic premises scenario

Attribute	
End-user equipment	Computer, television, entertainment cluster, security systems, etc.
Usage environment	Domestic premises, i.e. small rooms with high attenuation
Range	Up to 15 meters
QoS expectation	Consistent with real-time multi-media services
Applications	Real-time multi-media
Mobility	Walking speed
Coverage	Continuous
User Density	Low

5.2.5 Industrial and transportation scenario

In manufacturing scenarios such as process automation, commissioning systems, baggage transfer, distribution systems, warehouse storage and retrieval services we have a large number of intelligent transportation elements which may move autonomously and automatically in a factory hall, a storage building, or in an airport. Such a system should cover approximately an area of 250 m × 250 m. Delay values and data losses are critical. The ability to support highly reliable real-time control and alarm data as well as other time bounded services is mandatory. Power consumption and the physical size of the communication device are not as critical as in other scenarios.

Table 6: An example of a manufacturing scenario

Attribute	
End-user equipment	Intelligent transportation elements, autonomous, automatic vehicles, surveillance systems, monitors
Usage environment	Factory halls, airports, storehouses, industrial environments
Range	Up to 50 meters. Shadowing, highly variable radio channels
QoS expectation	Low delay, high error sensitivity, time bounded, real-time, short packets
Applications	Mobile, file transfer, control, alarms, surveillance, monitoring
Mobility	< 10 m/s
Coverage	Continuous
User Density	High (variable)
Power consumption	Not critical

5.3 Application requirements

There are many applications that together form the requirements for wired as well as wireless systems. Many of these will be covered in later clauses, but a general application type, the multimedia application deserves special attention. Multimedia applications are becoming popular and are already beginning to demand wireless transport with a high quality of service. Multimedia applications shall be taken into account when defining the HIPERLAN family.

Multimedia covers anything from basic messaging through to audio, video or any combination thereof. At the transport layer multimedia consists of two types of information flow; firstly the delivery of fixed packages of information and secondly the delivery of a stream of information which can be described by a certain data rate and delay tolerance.

IP has been designed to cater specifically for data packet traffic with no specific QoS guarantees, i.e. best effort. However, new applications and protocols have been and are being developed which demand or provide QoS guarantees over IP networks. Examples of this are integrated services using RSVP and differentiated services. As users get accustomed to this level of service in their wired systems they are going to demand the same QoS on wireless systems. HIPERLAN/2 shall support IP applications and QoS.

ATM is a transport mechanism, which has been designed to cater specifically for multimedia by being able to support very different kinds of connections with different QoS parameters. New applications will be developed which fully exploit the capabilities of the ATM transport technology, especially the availability of high bandwidth. Also for ATM, as users get accustomed to this level of service they are going to demand the same QoS on wireless systems. HIPERLAN/2 shall support ATM applications and QoS.

The following subclauses describe a number of scenarios for HIPERLAN deployment. Two main scenarios are described, corresponding to an office and an industrial application. Each scenario is broken down further into typical activities and shows estimated data rate requirements for each activity. The purpose of this analysis is to provide a thorough basis for an estimate of HIPERLAN spectral requirements.

5.3.1 Office HIPERLAN deployment scenario

The following activities are expected in an office deployment scenario for HIPERLAN over the next two or three years. The required data rates for each activity are given in a spreadsheet (table 7). Table7 also shows the calculation of an average data rate required to support the listed activities for each person in the office. These figures will be used shortly to compute estimates of the spectrum required to support typical office use of HIPERLANs. A list and brief description of office related activities that could be supported by HIPERLANs follows:

Multimedia conference (large video displays)

High quality video/audio channels with multiparty data links for the transmission of still images as well as the exchange of computer data including shared multi-user appplications.

Telephone/Audio

From toll quality telephone service to higher quality audio.

General networked computing applications

Examples of applications are: Client-server, Processing, Printing, E-mail, Messaging, Fax, Groupware, Games and Simulations, Network file systems, etc. The transfers are generally asymmetric and highly bursty. The data rate requirements are quite dependent on the level of mobility, i.e. the quality should be very similar to that one offered by a fixed LAN on a static mobile node, and temporarily degraded while on the move. Moreover, the bit rate should correspond to the processing speed of the terminal i.e. PDA, portable computer or workstation.

The requirements for a wired-LAN QoS are upper bounds and may be considered as a basis for a wireless LAN:

Multimedia database

Encyclopaedia browsing, medical diagnosis records, electronic newspaper, bulletin board, World Wide Web, manuals, etc. Includes asymmetric, resource demanding applications and bursty non-real-time data.

Security and monitoring

Surveillance video/audio, Industrial or office security service, Alarms, etc.

Internet and Intranet Browsing

The Internet has gained prominence far beyond the expectations expressed by experts only a few years ago. Today businesses of all kinds make extensive use of Internet and Intranet as a means to disseminate information about their products and services. Similarly, government institutions are getting ready to put their information on the Net. With the emergence of electronic payment the Net will become a commercial environment as well. For many international organizations, including ERO and ETSI, the Net has become an indispensable tool. As a consequence users spend hours a day "surfing" the Net to find and exchange information. This information is typically not just text form but includes extensive graphics as well as, in some cases, video and audio sequences.

Teleworking

Less prominent but gaining ground is the notion of teleworking. Teleworking may mean working at home but being in contact with colleagues at work and with customers through video/voice/data sessions. It also means collaboration between geographically separated persons, possibly a group of them. Here too, the ability of telecommunications to deliver high quality video and sound as well as real time data allows users to avoid costly and time consuming travel. Application developers have caught on to this opportunity. A variety of "screen sharing" tools is being developed that provide users with the means to work together in real time on the same electronic documents while being in eye and ear contact. Much like the Net browsers opened up the demand for Internet services so these sharing tools will create a large demand for teleworking services.

Table 7: Predicted average data rate per HIPERLAN, office deployment

Office application	Link direction	Average data rate	Typical peak/average ratio	Peak data rate	Office application usage	Weighted average data rate	
		bits/s		bits/s	%	bits/s/HIPERLAN	
1. Video applications							
General Multimedia conferencing, including voice, video and computer data							
	Uplink	1,00E+06	2,00	2,00E+06	7,00%	7,00E+04	
	Downlink	4,00E+06	1,50	6,00E+06	7,00%	2,80E+05	
2. Telephone	Uplink & downlink	3,40E+04	1,00	3,40E+04	10,00%	3,40E+03	
3. General networked computing applications							
	Uplink & downlink	2,50E+06	10,00	n/a	10,00%	1,25E+05	
4. Multimedia database							
	Uplink	1,00E+04	10,00	1,00E+05	7,00%	7,00E+02	
	Downlink	1,00E+05	10,00	1,00E+06	7,00%	7,00E+03	
5. Security and monitoring							
	Uplink	7,50E+05	2,00	1,50E+06	1,00%	7,50E+03	
	Downlink	6,40E+04	1,20	7,68E+04	1,00%	6,40E+02	
6. Internet and intranet browsing							
	Uplink	2,40E+03	10,00	2,40E+04	15,00%	3,60E+02	
	Downlink	1,00E+05	10,00	1,00E+06	15,00%	1,50E+04	
7. Teleworking							
	Uplink	1,00E+05	15,00	1,50E+06	10,00%	1,00E+04	
	Downlink	5,00E+05	5,00	2,50E+06	10,00%	5,00E+04	
				TOTALS:	**100,00%**	**5,70E+05**	**bits/s/HIPERLAN**
Note: Peak data rates are not applicable where applications are insensitive to the data transfer delay.							

5.3.2 Industrial HIPERLAN deployment scenarios

Table 8 provides a breakdown of the data rate capacity required to support a typical industrial deployment of a HIPERLAN network on a piece of industrial plant or machinery assumed to contain 50 separate HIPERLAN equipments operating in a single radio locale defined by the operating radio range. A more general list of industrial activities that can be supported by HIPERLAN follows:

Gatelink

Gatelink is a typical example of multimedia networking in an industrial environment. The applications are in aircraft maintenance support, software loading of airborne systems, passenger service and entertainment, pilot briefing and backup of aircraft maintenance systems. The data rate requirements of Gatelink are not analysed further in the present document.

Manufacturing Applications

In process automation, commissioning systems, baggage transfer and distribution systems we will find a mixture of services. Services will include non-real-time data for file transfer, software and configuration data download, as well as very time critical (real time) data transfer for control and alarm data. Also a mixture of conversational multimedia services for surveillance and monitoring purposes is needed.

Industrial Remote control

Remote control of some device. High quality asymmetric video/audio (MPEG-1 or MPEG-2, possibly multichannel and/or stereo picture), control information and computer data.

Industrial monitoring

Industrial monitoring is a specific application in industrial environments. The applications are for instance monitoring of oil pipelines or monitoring of production processes and resources like tanks in chemistry plants. Data is typically generated by a sensor, is very small as well as specific and has very stringent delay bound and variance. Normally the bandwidth needs are low. However, in certain circumstances (for instances fire or explosions) a very bursty and strongly correlated traffic can be generated by hundreds (thousands) of sensors which has to be handled by the network according to the QoS requirements.

Table 8: Predicted average data rates per HIPERLAN for an industrial deployment

Industrial application	Link direction	Average data rate	Typical peak/average ratio	Peak data rate	Industrial application usage	Weighted average data rate	
		bits/s		bits/s	%	bits/s/plant	
1. File transfer							
	Uplink & downlink	2,00E+06	5,00	1,00E+07	2,00%	4,00E+04	
2. Software transfer							
	Uplink & downlink	4,00E+05	2,00	8,00E+05	1,00%	4,00E+03	
3. Configuration data							
	Uplink & downlink	6,00E+05	20,00	1,20E+07	1,00%	6,00E+03	
4. Control data							
	Uplink	2,10E+07	2,00	4,20E+07	25,00%	5,25E+06	
	Downlink	2,10E+07	2,00	4,20E+07	25,00%	5,25E+06	
5. Alarms							
	Uplink & downlink	2,00E+04	20,00	4,00E+05	1,00%	2,00E+02	
6. Surveillance							
	Uplink & downlink	1,40E+07	2,00	2,80E+07	3,00%	4,20E+05	
7. Monitoring							
	Uplink & downlink	5,00E+05	1,00	5,00E+05	20,00%	1,00E+05	
8. Video multipoint monitoring							
	Uplink	7,50E+05	2,00	1,50E+06	10,00%	7,50E+04	
	Downlink	2,25E+06	1,50	3,38E+06	10,00%	2,25E+05	
9. High bandwidth video multipoint monitoring							
	Uplink	1,50E+06	2,00	3,00E+06	1,00%	1,50E+04	
	Downlink	7,50E+06	1,50	1,13E+07	1,00%	7,50E+04	
		TOTALS:			**100,00%**	**1,15E+07**	**bits/s/plant**
		Assuming there are 50 HIPERLANs per plant:				**2,29E+05**	**bits/s/HIPERLAN**

5.3.3 Public HIPERLAN deployment scenario

In table 9 the required data rates for the applications in a public deployment scenario are shown. Just as in the office scenario, the average data rate per person is also listed. The listed applications are the same as in the office scenario, since public access will mostly be available in geographically small (hot spot) areas. These hot spot areas will be at e.g. airports, hospitals, conference sites etc., i.e. areas in which the same access network can be used for both public (guests, customers etc.) and private (employees of the operator) access. For simplicity, the same figures can be used for pure public access networks, e.g. in city centres.

Table 9: Predicted average data rate per HIPERLAN, public deployment

Public application	Link direction	Average data rate	Typical peak/average ratio	Peak data rate	Office application usage	Weighted average data rate	
		bits/s		bits/s	%	bits/s/HIPERLAN	
1. Video applications							
General Multimedia conferencing, including voice, video and computer data							
	Uplink	1,00E+06	2,00	2,00E+06	10,00%	1,00E+05	
	Downlink	4,00E+06	1,50	6,00E+06	10,00%	4,00E+05	
2. Telephone	Uplink & downlink	3,40E+04	1,00	3,40E+04	5,00%	1,70E+03	
3. General networked computing applications							
	Uplink & downlink	2,50E+06	10,00	n/a	5,00%	1,25E+05	
4. Multimedia database							
	Uplink	1,00E+04	10,00	1,00E+05	5,00%	5,00E+02	
	Downlink	1,00E+05	10,00	1,00E+06	5,00%	5,00E+03	
5. Security and monitoring							
	Uplink	7,50E+05	2,00	1,50E+06	5,00%	3,75E+04	
	Downlink	6,40E+04	1,20	7,68E+04	5,00%	3,20E+03	
6. Internet and intranet browsing							
	Uplink	2,40E+03	10,00	2,40E+04	15,00%	3,60E+02	
	Downlink	1,00E+05	10,00	1,00E+06	15,00%	1,50E+04	
7. Teleworking							
	Uplink	1,00E+05	15,00	1,50E+06	10,00%	1,00E+04	
	Downlink	5,00E+05	5,00	2,50E+06	10,00%	5,00E+04	
				TOTALS:	**100,00%**	**7,48E+05**	**bits/s/HIPERLAN**
Note: Peak data rates are not applicable where applications are insensitive to the data transfer delay.							

5.3.4 Other HIPERLAN deployment scenarios

HIPERLAN can support many other activities and deployment scenarios other than those listed above. A number of the more prominent examples of alternative HIPERLAN deployments are described below and a TV, radio or recording studio deployment containing about 60 separate HIPERLAN equipments is analysed further in table 10:

- Audio distribution.
- High quality audio.
- High quality Audio distribution.
- High quality e.g. delivery of audio or wireless equipment for programme production (possible multiparty).
- Database services.

Inventory of available goods, On-floor customer services in shops, Menu of the company cafeteria, Telephone and contact information directory, etc. This deployment scenario is identified, but not analysed further in the present document.

Table 10: Predicted average data rates for broadcast or recording studio HIPERLAN deployments

TV, radio or recording studio HIPERLAN application	Link direction	Average data rate	Typical peak/average ratio	Peak data rate	Studio application usage	Weighted average data rate	
		bits/s		bits/s	%	bits/s/deployment	
1. Audio distribution, 8 channels							
	Uplink & downlink	3,07E+06	1,00	3,07E+06	10,00 %	3,07E+05	
2. High quality audio uplink, 1 stereo channel							
	Uplink	3,84E+05	1,00	3,84E+05	10,00 %	3,84E+04	
3. Telephone headsets, 10 lines							
	Uplink & downlink	6,40E+05	1,00	6,40E+05	10,00 %	6,40E+04	
4. Radio microphones, 30 off							
	Downlink	1,15E+07	1,00	1,15E+07	30,00 %	3,46E+06	
5. High quality video distribution, 8 channels							
	Downlink	1,20E+07	1,00	1,20E+07	30,00 %	3,60E+06	
6. High quality video uplink, 1 channel							
	Uplink	1,50E+06	1,00	1,50E+06	10,00 %	1,50E+05	
				TOTALS:	**100,00 %**	**7,62E+06**	**bits/s/deployment**
		Assuming there are 60 HIPERLANs per deployment:				**1,27E+05**	**bits/s/HIPERLAN**

5.4 Summary of data rate requirements for HIPERLAN deployments

A summary of the data rate requirements based on the example deployments listed above and analysed in tables 7, 8, 9 and 10, is given in table 11. The table includes some reasonable assumptions for the numbers of HIPERLAN terminals that would exist in each deployment and shows how the total data rate is calculated in each case. The table also includes factors for the efficiency of the network protocol (e.g. TCP/IP) and for the protocol efficiency of the air interface which takes into account the signalling traffic generated by the operation of the HIPERLAN MAC protocol which reduces the available channel capacity.

Table 11: Summary of data rate requirements for HIPERLAN deployments

Deployment example:	**Average data rate required per HIPERLAN**	**Number of HIPERLANs per deployment**	**Network access duty cycle**	**Useful data rate required per deployment**	**Approx. protocol efficiency**	**Total data rate required per deployment**
	bits/s/HIPERLAN		%	bits/s/deployment	%	bits/s/deployment
	D_u	N_h	A_u	$D_u*N_h*A_u$	P_e	$D_u*N_h*A_u/P_e$
Office	5,6960E+05	1200	31%	2,1189E+08	50%	4,2378E+08
Public	7,4826E+05	1200	10%	8,9791E+07	50%	1,7958E+08
Industrial	2,2920E+05	250	100%	5,7301E+07	50%	1,1460E+08
Studio	1,2693E+05	60	100%	7,6156E+06	50%	1,5231E+07

5.5 Spectrum requirements

5.5.1 Wireless access networks for office use

The spectrum requirements presented below are based on the required useful data rates analysed above for a large office area with access to a wired network scenario and certain assumptions about spectrum re-use factor and the spectral efficiency of the modulations that can be used. The following spectral requirements should be treated as typical values to guide decisions about present and future spectrum designations.

- Total area covered: 24 000 m^2, (approx. 160 metres × 160 metres).
- Number of users: 1 200 (at 20 square metres per user).
- Total data rate required: 424 Mbit/s/deployment (see table 11).

- Modulation efficiency: 1 bit/s/Hz.
- Access point bandwidth: 25 MHz (governed by peak data rates needed for multimedia conferencing, as shown in table 7).
- Minimum number of access points = 424 / 25 = 17.
- Access point spacing = SQRT(24 000 / 17) = approx. 40 metres at most.

Frequency re-use factor: 1/14 (see note).

Therefore 14 × 25 = 350 MHz of spectrum is required to support this scenario.

NOTE: Assuming a C/I requirement of 20dB and a propagation exponent of 3,5 gives us the following:

$C/I=3{,}5*10\log(R/r)=20\text{dB}$, where

r is the cell radius and R is the frequency separation distance.

The area covered by one cell is proportional to $r^2$and the cluster area is proportional to R^2.

The cluster size is given by $R^2/ r^2 = (10^{20/35})^2 = 14$.

5.5.2 Wireless access networks for public use

The spectrum requirements can be calculated in a similar way for this scenario. A crucial point in these calculations is the choice of propagation exponent. A reasonable assumption is to use the same value as above and thus ending up with the same amount of needed spectrum. It should be noted, however, that in large open areas a smaller propagation exponent is likely, resulting in increased spectrum requirements.

6 General considerations

6.1 Regulatory constraints

Spectrum has been designated by the CEPT for the licence exempt use of HIPERLAN systems. At the time of writing the present document, 100 MHz of spectrum has been designated in the 5,2 GHz band for HIPERLAN Type 1, with a further 50 MHz available at the discretion of National Administrations (see CEPT Recommendation T/R 22-06 [1]). Licence exempt use implies the HIPERLAN systems should be able to co-exist with each other and with other radio services in the band and not cause undue interference. This will have implications for the design and specification of medium access methods and for type approval regimes for HIPERLAN equipment. Where different HIPERLAN types are required to share the same frequency band, equitable spectrum sharing rules are required as part of the type approval regime.

Licensed use of HIPERLAN Type 2, preferably for public access, shall also be considered. Which frequency bands that may be appropriate for licensed use is for further study, but it is likely that such frequency bands should be found somewhere in the 4 GHz to 6 GHz band.

6.2 Radio technology constraints

Technically, the lower frequencies are better suited for the mobile components because antenna efficiency is sufficient to allow the use of omni-directional antennas at the permitted RF power level of 1 Watt peak EIRP (see CEPT Recommendation T/R 22-06 [1]). With extensive signal processing, it is possible to achieve a range of 20 m to 50 m indoors at 5 GHz, depending on the environment. Outdoors at 5 GHz the range may be greater.

In the 17 GHz band , only 100 mW EIRP RF power is allowed (see CEPT Recommendation T/R 22-06 [1]). With omni-directional antennas, range would be limited to a few meters. This makes its use for portable applications costly and inefficient. However, at these frequencies, the use of directional antennas is very effective and less cumbersome physically than at 5 GHz or lower frequencies. Therefore the 17 GHz band is best suited for infrastructure type networks, i.e. HIPERLINK.

Other considerations that govern the choice of frequency for mobile or stationary applications are:

1) RF component efficiency: the higher the operating frequency, the lower the efficiency of the RF power stage and other components. Stationary applications can bear this inefficiency much easier than mobile applications where (battery) power is a major factor.

2) RF component cost: the cost goes up with frequency. Here too it is the stationary applications that bear these higher costs more easily.

3) Wall attenuation: this too goes up with frequency, making continuous coverage difficult to achieve for systems supporting mobility. Point-to-point links, on the other hand, can be engineered to avoid this problem.

6.3 User data security and privacy requirements

Users of HIPERLAN/2 systems may require protection of their transmissions from being intercepted by other users operating possibly co-located HIPERLAN/2 sub-networks. In addition they may require protection against misuse of their wireless networks by third parties. This requires the implementation of a data confidentiality service and therefore a specification of such a service as part of the HIPERLAN/2 standards. It should be noted that HIPERLAN/2 based systems may be used for public access networks which have their own security systems. Interworking between these and the HIPERLAN/2 confidentiality service should be taken into account.

The level of protection provided shall be consistent with the protection provided by wired systems that do not implement a data confidentiality service. Further, the cryptographic algorithm shall not be subject to export controls and therefore allow world-wide use.

ETSI has developed a cryptographic algorithm for HIPERLANs, the HIPERLAN Security Algorithm. This algorithm is designed to operate at 20+ Mbits/s and is available to ETSI members under a Confidentiality Agreement. The HIPERLAN/2 standard shall include functions for the selective use of encryption. The synchronization of the use of cryptographic keys between wireless terminals of a HIPERLAN is for further study.

NOTE: Confidentiality services may be available within the host systems that make use of HIPERLAN/2 subsystems. Therefore, a confidentiality service within the HIPERLAN/2 subsystem should be an optional feature that users can activate as required.

The protection from misuse by third parties is a systems concern that is common to all communications systems. This cannot be completely addressed within the scope of the HIPERLAN standards since these cover only the lower layers of the communications architecture.

Network level security capabilities are addressed by IP, ATM and UMTS standards (in development); these are outside the scope of the HIPERLAN/2 Functional Standard.

6.4 Human safety

HIPERLAN standards shall reference and comply with any appropriate human safety standards. It should be noted that HIPERLAN systems may not be suitable for use in safety critical applications.

7 Reference Model and Architecture

HIPERLAN Type 2 (HIPERLAN/2) systems provide short range, wireless access to multi-media services over IP or ATM. The scope of HIPERLAN/2 is limited to the air interface, the service interfaces of the wireless subsystem, the interworking functions and supporting capabilities required to realize these services.

The following text outlines requirements, to be used as basis for the development of a functional standard.

Currently available standards for TCP/IP systems include the link or physical layer, the network layer, transport layer and the application layer. The link and physical layers provide a means for transmitting a sequence of bits between a pair of nodes, but are not part of the TCP/IP protocol suite. The network layer consists of procedures that allow connection-less data to be transported across multiple networks, i.e. procedures for routing, segmentation etc. The transport layer supports connection-oriented or connection-less data to be exchanged between two hosts, which includes functions for connection set up, flow control, error control etc. The application layer contains protocols for resource sharing, remote access, message exchange etc.

Currently available standards for ATM systems include the ATM Physical Media layer (the bit transport), the ATM layer itself (cell processing and switching) and signalling protocols to support the connection set-up and release procedures (Signalling AAL), and a number of ATM Adaptation Layers (AALs) that enhance the basic ATM service to a level required by specific ATM service classes.

7.1 Reference model

7.1.1 Services and capabilities

7.1.1.1 Services

HIPERLAN/2 shall provide the following services:

1) Connection set-up with parameter negotiation for QoS guarantees in conjunction with respective core network layers. Outgoing and incoming connections shall be supported. Device addressing shall be consistent with world-wide roaming.

2) Releasing incoming connections and outgoing connections.

3) Unit data transfer subject to QoS parameters.

NOTE: Unit Data transfer comprises both Request (= transmit) and Indication (= receive) primitives.

HIPERLAN/2 shall implement traffic management within each access subnetwork to maximize adherence to QoS parameters established at connection set-up.

7.1.1.2 Supporting capabilities

HIPERLAN/2 shall provide the following capabilities in support of the above services:

1) Association of wireless terminals in a logically distinct access subnetwork.

2) Informing the core network that hosts an access subnetwork of the changes in the population of associated wireless terminals.

3) Monitoring of radio conditions as basis for handover between access sub-networks and for informing user and hosting core network of the prevailing radio/traffic conditions.

NOTE: This capability is required to support Terminal initiated handover between access sub-networks without loss of connection and with limited loss of Quality of Service.

4) Support for Battery Power Conservation.

5) Dynamic allocation of radio link frequencies and/or capacity.

6) Ad hoc functionality. A capability for communication without the presence of a fixed access point. The fixed access point mode shall have higher preference over ad hoc functionality.

7.1.2 Reference model

HIPERLAN/2 comprises the following functional entities:

NOTE 1: The entities are taken from the Common Reference Model (CRM) [2g], and in case of any differences CRM takes precedence.

- **Access Points (APs)**, which are the interface points to core networks. The AP may be decomposed into InterWorking Functions (IWFs) and an Access Point Controller (APC) controlling one or multiple Access Point Transceivers (APTs).

- **Access Point Controllers (APCs)** which present network-specific interfaces to the core network via InterWorking Functions (IWFs) which comply with appropriate standards. The APC provides methods to facilitate intra-AP handover and to control the routing of traffic through the HIPERLAN/2 network.

- **InterWorking Functions (IWFs)**, which translate the internal (B.2) interface of the HIPERLAN/2 network into network specific interfaces of the external core network and translate the internal (B.1) interface of the HIPERLAN/2 network to higher protocol layers within the wireless terminal.

- **Access Point Transceivers (APTs)**, distributed so as to be able to provide coverage throughout the service area of the Broadband Radio Access Network. These communicate via the air interfaces (W.1) with Radio Terminations (RTs).

- **Terminal Adapter (TAs)**. A terminal adapter comprises an RT and an IWF, and it presents connections for customers' terminal.

- **Radio Terminations (RTs)** are the radio parts of the TAs.

The reference model is intended to align with the ITU IMT2000 and ETSI UMTS models of the radio access network and identifies the following reference points:

Reference point WI.1: internal proprietary or standard interface of the terminal node that supports relevant core networks.

Reference point B.1: a service interface which is defined in terms of abstract services and parameters for the User, Control and Management planes of the HIPERLAN/2 air interface protocol stack. This interface is expected to be a common definition for HIPERLAN/2 systems and for those HIPERACCESS systems which define interoperation via a common air interface. It may not actually exist, and is therefore not required to be present in any real implementation, but forms the basis for specification and testing.

Reference point W.1: defines the radio interface between the Access Point Transceiver and the Radio Termination. It is an interoperability interface that includes a standardized air interface and can be used as a radio coexistence interface.

Reference point B.2: a service interface which is defined in terms of abstract services and parameters for the User, Control and Management planes of the HIPERLAN/2 air interface protocol stack. This interface is expected to be a common definition for HIPERLAN/2 and those HIPERACCESS systems which define interoperation via a common air interface. It may not actually exist, and is therefore not required to be present in any real implementation, but forms the basis for specification and testing.

NOTE 2: The Access Point may be considered to comprise one or more Access Point Transceivers connected to a single Access Point Controller. The interface between these two elements is not necessarily visible and is not specified.

Reference point W.2: the interface is the supported standard interface to the relevant core network. It is in principle possible to specify interfaces for all core networks that BRAN systems support (see subclause 7.1.4).

Reference point B.3: an interface over which are specified the mechanisms for communicating with the Element Management System, specific to the management of the radio access network.

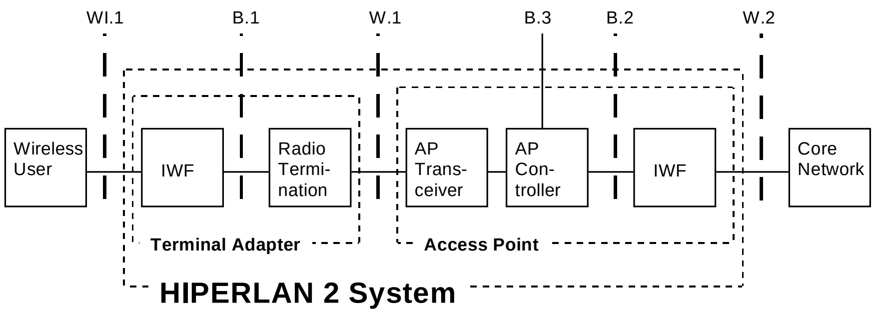

Figure 4: HIPERLAN/2 generic reference model

7.1.3 Layer architecture

The following figure shows the generic layer architecture model for HIPERLAN/2 systems.

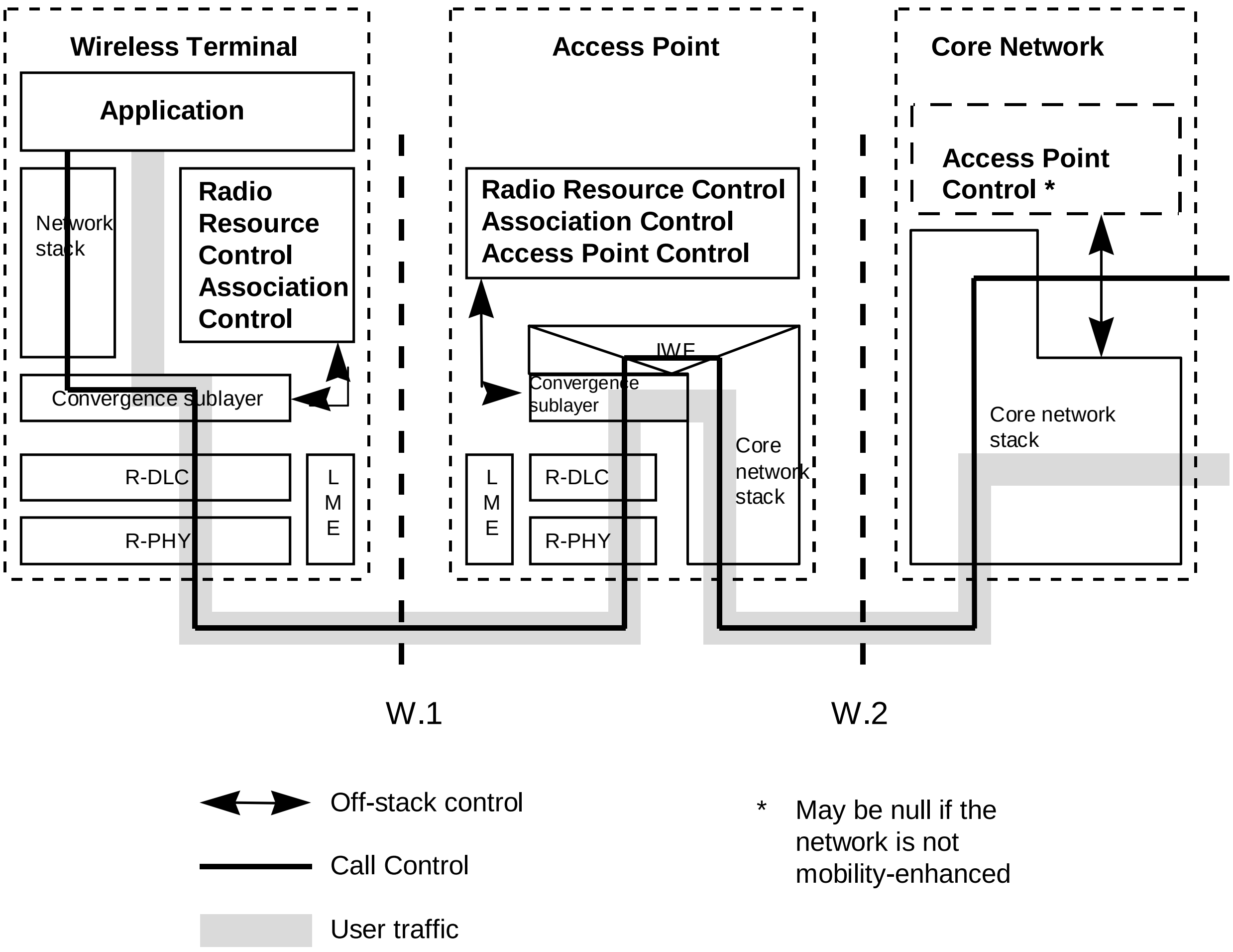

Figure 5a: HIPERLAN/2 layer architecture

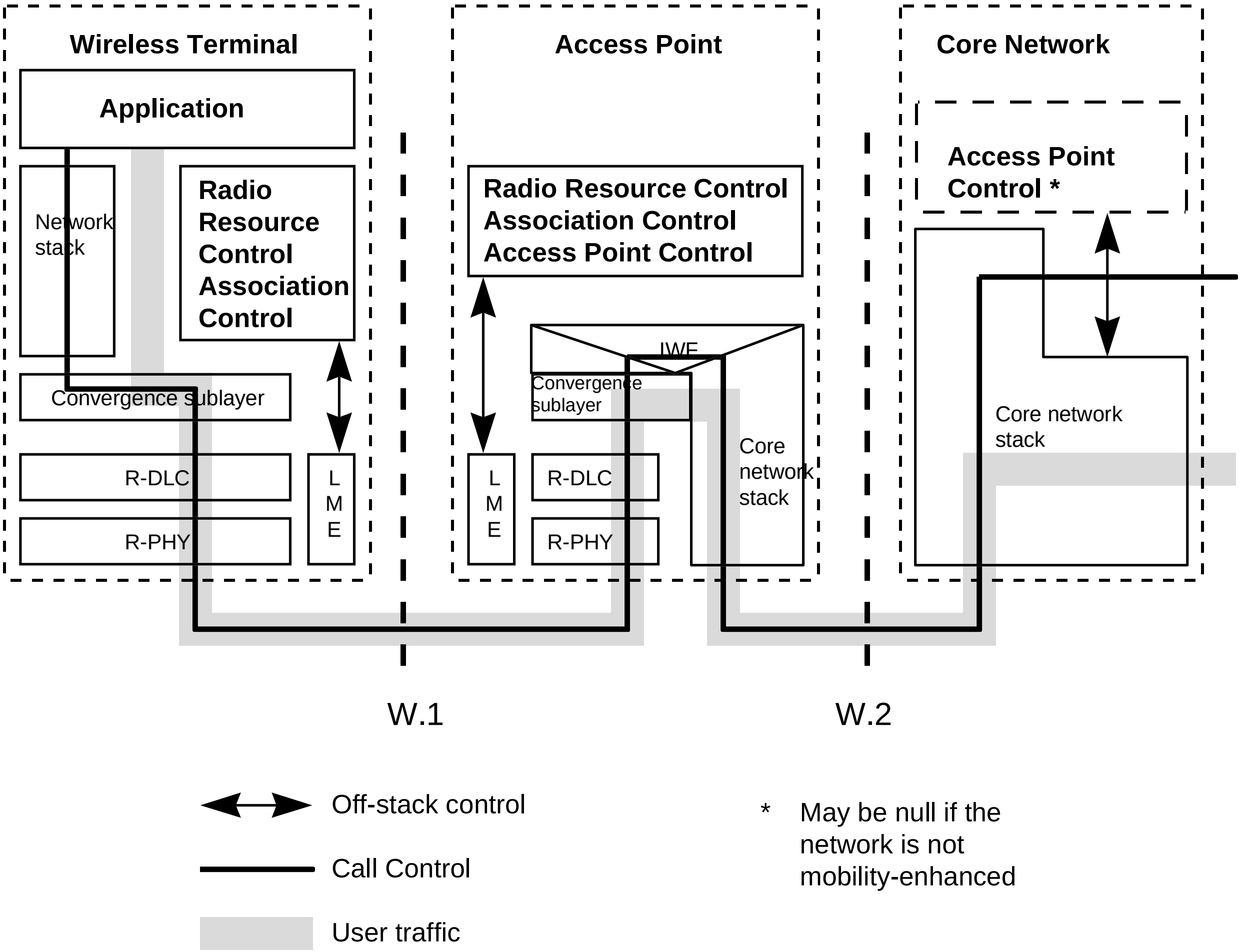

Figure 5b: HIPERLAN/2 layer architecture

The thick black line indicate call control flows and the grey band indicates user data flow. The thin arrowed black lines show the "off stack" control interfaces that allow user provided functions to control Radio DLC functions like (DLC) connection set-up and releasing.

The access point acts as a multiplexer that supports mobility of wireless terminals within the access subnetwork serviced by the access point. It also provides information to the core network that is needed to support wireless terminal mobility with the access network.

NOTE 1: The functions needed to support roaming between different access networks are outside the scope of the present document.

The Radio DLC layer implements a service policy that takes into account such factors as Quality of Service per user connection, channel quality, number of terminal devices and medium sharing with other access sub-networks. It also maintains the quality of service on a virtual circuit basis. Depending on the type of service provided and channel quality, capacity and utilization, the DLC layer will implement a variety of means including FEC, ARQ and flow pacing to optimize the service provided to the (DLC) user.

The Convergence Sublayer is defined as a sublayer that generates no protocol but that e.g. provides the wireless DLC layer with the information it needs to perform its QoS management functions as required and functionality for segmentation and reassembly.

The Layer Management Entity (LME) of the DLC layer is used to convey traffic contract information and performance requirements between the DLC layer and the higher, connection control functions.

NOTE 2: The wireless DLC and PHY layers are intended to be generic enough to support the services of at least those networks listed in subclause 7.1.4 by providing appropriate connection types and service qualities.

NOTE 3: The figure above (and figure 4) shows an "Access Point Control" function in the core network. This function may be provided in certain future core networks (e.g. UMTS) or may not be.

7.1.4 Interworking

Radio dependent/core network independent and radio independent/core network dependent parts shall be distinguished. This will minimize the number of different radio specifications and also allows the same radio specifications to be used for a number of core networks. Furthermore, this approach will allow for an independent evolution of access and core networks. This general approach is illustrated in figure 6.

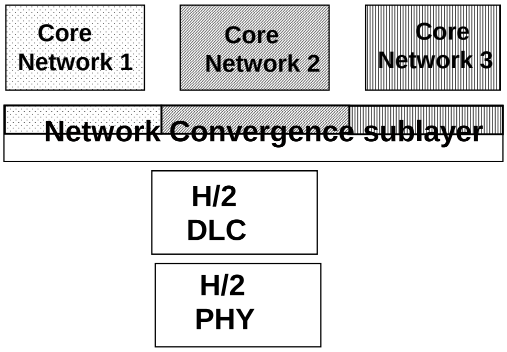

Figure 6: HIPERLAN/2 approach

The convergence sublayer is a part of the interworking functionality. Interworking functions will be produced for at least IP, ATM and UMTS.

7.1.4.1 IP Interworking

HIPERLAN/2 IP interworking requirements include:

Interworking at the IP layer so as to provide a transparent service to the IP service users; mobility must be supported at the IP and the lower (radio) levels.

It shall be possible to map IP QoS guarantees, whether it is RSVP, Differentiated Services or another alternative, to the radio DLC layer QoS mechanisms.

7.1.4.2 ATM Interworking

HIPERLAN/2 ATM Interworking requirements include:

1) Interworking at the ATM layer so as to provide a transparent service to the ATM service users; this includes extension of ITU-T Recommendation Q.2931 [4] and the ATM Forum specification UNI 4.0 [7] for signalling and connection set-up and releasing functions. The extensions to ITU-T Recommendation Q.2931 [4] and the ATM Forum specification UNI 4.0 [7] are outside the scope of HIPERLAN/2; these specifications are expected to be developed by the ATM Forum.

2) Interworking between the access point and the ATM switch Resource management functions in support of mobile (as opposed to stationary) terminals.

7.1.4.3 UMTS Interworking

The Universal Mobile Telecommunications System (UMTS) is the European version of IMT-2000 (3rd generation mobile systems). UMTS will incorporate a new generic radio access network, the UMTS Radio Access Network (URAN). The URAN may include several different realizations, of which the UTRAN (UMTS Terrestrial Radio Access Network) is one. The Iu interface forms the boundary between UTRAN and the UMTS core network. By connecting BRAN to the Iu interface, BRAN will form a complimentary realization of the URAN concept for broadband data services. UMTS interworking will provide BRAN with roaming support using the UMTS mobility infrastructure.

A BRAN realization of URAN should provide the same logical interface to the higher layers (i.e. layers belonging to the non-access stratum) as UTRAN. Hence, no changes in higher layers should be required. UMTS authentication, security and location management can be used over HIPERLAN/2. UMTS bearer setup requests should be mapped to the corresponding HIPERLAN/2 DLC connection by the convergence layer. A USIM (User Service Identity Module) may be needed in a HIPERLAN/2 terminal supporting UMTS interworking. Handovers within a BRAN subsystem should be invisible to the UMTS core network. Handovers between UTRAN and BRAN, in case of dual mode terminals, should be supported via the core network.

The standard shall be specified so that it is attractive to facilitate dual-mode terminals for UMTS and GSM.

7.1.5 Addressing

HIPERLAN/2 wireless terminals shall be addressable by their global address (so as to support world-wide and nomadic use).

Internally, an access subnetwork may use abbreviated addressing of some kind in order to reduce protocol overhead.

Broadcast and multicast mode shall be supported via DLC procedures for sending unacknowledged control and user data.

7.2 Mobility support

HIPERLAN/2 shall support:

1) Roaming between access networks (with connection release and (re) set-up).

2) Continuous service while in motion within the contiguous area covered by the access network connected to a given switch or router.

The rate of movement to be supported is:

1) 10 m/s linear;

2) 180 deg/sec rotation.

7.3 Requirements imposed on radio sub-system

7.3.1 Radio range

HIPERLAN/2 shall provide a range of 30 m in a typical indoor environment and up to 150 m in a typical outdoor or large open indoor (e.g. large factory hall, airport) environment.

7.3.2 Data rate

HIPERLAN/2 shall provide a peak data rate of at least 25 Mbit/s on top of the PHY layer.

7.3.3 Delay spread

The system shall support rms delay spreads up to 220 ns in a range of different environments incorporating short range indoor, large open space indoor and outdoor environment.

7.3.4 Antennas

The H/2 standard shall support different types of antennas, i.e. omni-directional, directional and smart antennas. The use of smart antennas shall not be precluded by the standard.

7.3.5 Capacity and coverage

The capacity in terms of bits/s/hect of a HIPERLAN/2 network is limited by the number of RF channels available and the loading of these channels by HIPERLAN/2 networks or other systems operating within radio range of each other.

Further, the actual capacity of a HIPERLAN/2 system depends on the protocol overhead, on the ratio between protocol overhead and traffic payload size and on the effective channel isolation.

In 95 % of the coverage area (i.e. within the radio range) the MT should be able to provide at least 8 Mbit/s throughput (uplink+downlink data rates) above the PHY layer.

In a single operated multicell environment the average system throughput (per AP) should at least be 20 Mbit/s above PHY layer. In 95% of the area the MT should be able to provide at least 4 Mbit/s throughput above the PHY layer.

7.3.6 QoS, user data rate, transfer latency and transfer delay variance

When operating in an environment that does not vary, HIPERLAN/2 systems shall be able to maintain the data rate and QoS values of connections established at connection set up. (For the applicable QoS parameters, see ITU-T Recommendation I.356 [8] and equivalent ATM Forum documents). The following values are provided as guidelines for the Transfer Delay and Delay Variance:

1) Transfer Delay: < 5 msec;

2) Delay Variance: < 1 msec.

These figures may not be realizable under all conditions and for all service categories.

1) They are based on the following: since transfer delay and delay variance accumulate along a communications path, these values are reasonable target values that allow additional delay in other network components.

2) The transfer delay of 5 msec allows a wireless terminal time to scan for activity on another channel - e.g. for acquisition of another access point for handover purposes. See also subclause 7.2.1.

7.3.7 Residual errors

7.3.7.1 Detected errors

The error detection and correction capabilities of ATM and IP stacks are typically low since they are designed for a basically reliable physical network. HIPERLAN/2 will make a best effort attempt to maintain the QoS of connections over time. However, link conditions and handover procedures may cause cells or packets to be lost or delayed beyond their intended delivery time. In the latter case HIPERLAN/2 may discard such data units. Recovery of this kind of error condition is outside the scope of HIPERLAN/2 and belongs to the higher layers of the protocol stack and/or application level recovery mechanisms.

7.3.7.2 Undetected errors

The residual undetected error rate of HIPERLAN/2 should be in the same range as that of a wired IP or ATM system. This equates to an undetected DSDU error rate of $<5 \times 10^{-14}$ [IEEE 802].

HIPERLAN/2 shall meet these requirements through the use of the appropriate error detection mechanisms.

7.3.8 Radio Resource Management

The standard shall support the following features:

1) **Automatic Frequency Assignment:** Automatic frequency assignment shall be supported, i.e. the system shall adapt to the radio propagation environment and interference conditions.

2) **Link adaptation:** The system shall be able to handle different interference and propagation environments, with the aim to maintain the QoS for a connection. E.g. for **data rate scalability:** The system shall be able to operate

with multiple modulation alphabets and channel coding rates to enable adaptation to local propagation and interference conditions.

3) **Power Control:** The output power of the mobile terminal shall be minimized while still maintaining agreed transmission and reception quality.

7.4 End user requirements

HIPERLAN/2 implementations are targeted at portable applications such as Notebooks and Personal Digital Assistants. This puts constraints of size (PCMCIA Type 2 or 3), cost (should be a fraction of the user device cost) and power consumption (because of host battery limitations).

These constraints may impact the functionality provided by the HIPERLAN/2 specification. For example, the wireless terminal adapter may have different modes of operation with different levels of power consumption. These modes of operation may have implications for the specification of the HIPERLAN/2 protocols, e.g. to support the signalling of mode transitions.

7.5 Network management

The HIPERLAN/2 Functional Standard shall define Managed Objects for all the major functions and the monitoring of their performance.

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