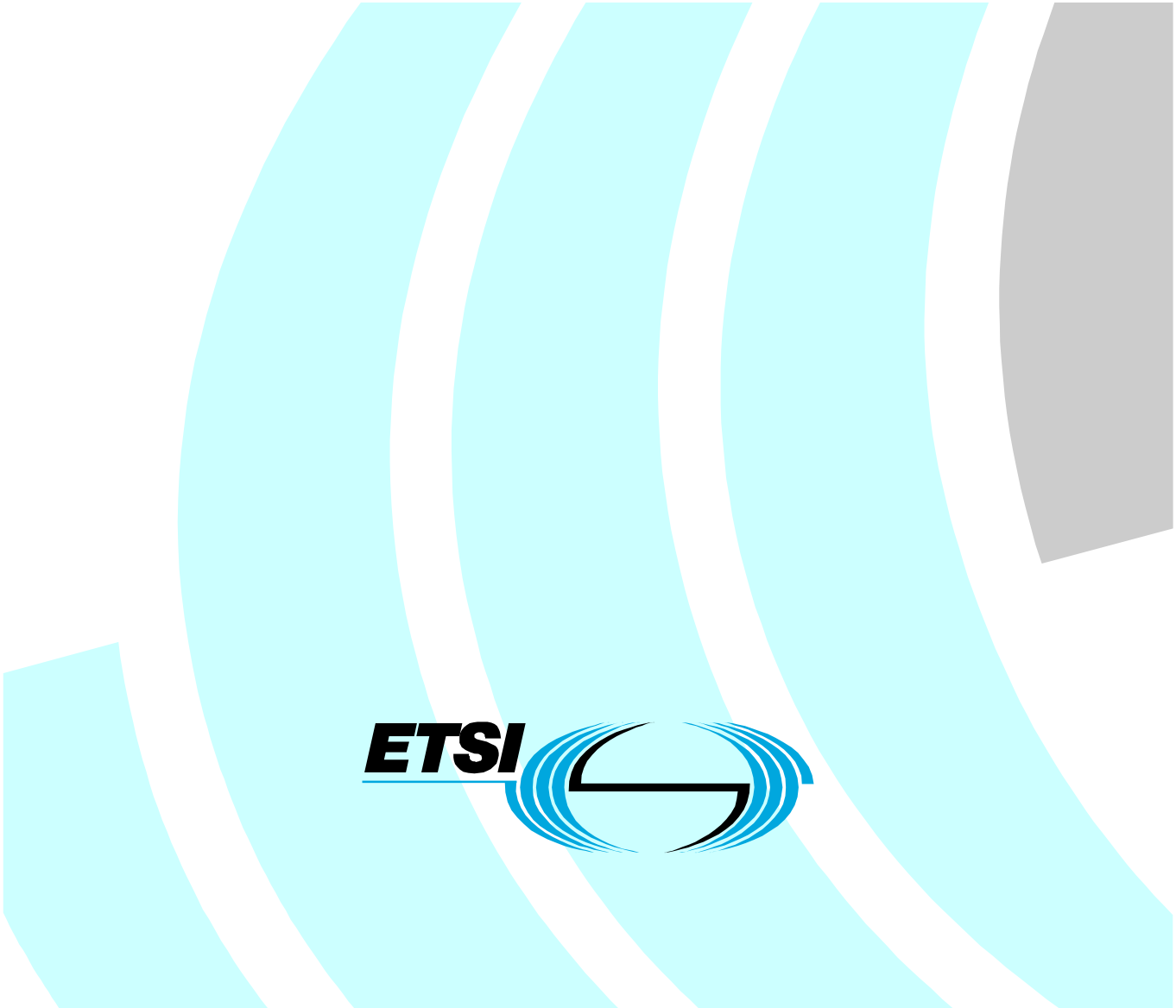
ETSI TR 102 049 V1.1.1 (2002-05)

Technical Report

PowerLine Telecommunications (PLT); Quality of Service (QoS) requirements for in-house systems



Reference
DTR/PLT-00008

Keywords
QoS

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights 4
Foreword 4
Introduction 4
1 Scope 5
2 References 5
3 Definitions and Abbreviations 6
3.1 Definitions 6
3.2 Abbreviations 8
4 User scenarios and applications 9
4.1 Categories of home applications and home devices 9
4.1.1 Categories of home applications 10
4.1.2 Categories of home devices 10
4.1.3 In-home device connectivity between consumer products 11
5 User and market requirements on a PLC-HN system 12
6 Service classes 13
7 Traffic classes 13
8 Control and management service requirements of a PLC-HN 14
8.1 Network installation and configuration requirements 14
8.2 PLC-HN operation and maintenance requirements 14
8.3 PLC-HN resource management 15
8.4 Session management requirements 15
8.5 Network monitoring 15
8.6 Admission control 17
9 Quality of Service requirements 17
9.1 QoS profiles 18
9.2 Generic QoS performance parameter 18
9.3 Network QoS performance parameter 18
9.4 Network security 19
9.5 End-to-end QoS model 19
9.6 End-to-End QoS Budget 20
9.7 End-to-end QoS parameter of application types 21
9.8 QoS Budget on the PLC-HN 22
9.9 Session description on session layer 22
9.10 Real-time applications 22
9.11 Resource reservation protocols 22
9.11.1 Resource reservation on network layer 22
9.11.2 Resource reservation on data link layer 23
10 QoS profile mapping for in-house PLC systems 24
History 25

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Powerline Telecommunications (PLT).

The present document describes the Quality of Service (QoS) requirements of PLT in-house systems.

Introduction

The present document contains a definition of Quality of Service (QoS) parameters and QoS requirements for an in-house PowerLine Communications (PLC) network system needed for applications in the home environment (HE). Such a system is here called a PLC home network (PLC-HN). Input to the present document came from company contributions and from ETSI, IEEE, IETF, and ITU-T standards documents. The QoS requirements and definitions are derived from well-known and industry wide accepted standards.

The performance of the PLC-HN has to be predictable, i.e. the QoS requirements of each application supported by the PLC-HN have to be guaranteed in order to satisfy the user and market requirements. Even under an overload condition of the network, a lifeline service like telephony and network control services have still to be assured. Services with a minor priority have to draw back its network arbitration to keep lifeline services alive.

1 Scope

The scope of the present document is to achieve a consistent view on the quality of a service (QoS) on a PLC home network. The main focus will be on CE applications in the home, typical examples for CE-in-home applications are Voice, Audio/Video and Data services.

The QoS requirements shall be described in a layered view according to the ISO-OSI model. The mapping of the QoS description across layers shall be non-ambiguous. A parameterized and prioritized QoS description shall be used as found in the literature.

The user QoS requirements on the services have to be described by QoS parameters on the application layers.
A non-ambiguous mapping will be defined to map the application QoS profile to a network QoS profile. Each profile is defined by a set of parameters. These parameters shall be uniquely used for traffic engineering, resource reservation and media arbitration.

The restrictions of the Powerline medium shall be taken into account. An over-provisioning might not be possible due to the limited throughput of the PLC network and the broadband services used at home. The network shall be aware of network capacity bottlenecks and shall provide means to maintain the limited resources. No central server, no manual configuration or network operator support should be needed. The network shall provide a distributed auto-configuration concept and shall reconfigure itself after erroneous events.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] ETSI TR 101 329 (V2.1.1) : "Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON); General aspects of Quality of Service (QoS)".

[2] ETSI TR 101 329-5 (V1.1.1): "Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON) Release 3; End-to-end Quality of Service in TIPHON systems; Part 5: Quality of Service (QoS) measurement methodologies".

[3] ETSI TR 101 329-2 (V1.1.1): "Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON) Release 3; End-to-end Quality of Service in TIPHON systems; Part 2: Definition of speech Quality of Service (QoS) classes".

[4] ITU-T Recommendation I.211 (1993): "B-ISDN service aspects".

[5] ITU-T Recommendation I.350 (1993): "General aspects of quality of service and network performance in digital networks, including ISDNs".

[6] ITU-T Recommendation H.323 (1998): "Packet-based multimedia communications systems".

[7] ITU-T Recommendation E.800 (1994): "Terms and definitions related to quality of service and network performance including dependability".

[8] ITU-T Recommendation G.1010 (2001): "End-user multimedia QoS categories".

[9] ITU-T Recommendation E.164: "The international public telecommunication numbering plan".

[10] ITU-T Recommendation G.711:"Pulse code modulation (PCM) of voice frequencies".

[11] ITU-T Recommendation G.726:"40, 32, 24, 16 kbit/s adaptive differential pulse code modulation (ADPCM)".

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

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

[14] IETF RFC 2209: "Resource ReSerVation Protocol (RSVP) - Version 1 Message Processing Rules".

[15] IETF RFC 2210: "The Use of RSVP with IETF Integrated Services".

[16] IETF RFC 2211: "Specification of the Controlled-Load Network Element Service".

[17] IETF RFC 2212: "Specification of Guaranteed Quality of Service ".

[18] IETF RFC 2215: "General Characterization Parameters for Integrated Service Network Elements".

[19] IETF RFC 2327: "SDP: Session Description Protocol".

[20] IETF RFC 2475: "An Architecture for Differentiated Service ".

[21] IETF RFC 2814: "SBM (Subnet Bandwidth Manager): A Protocol for RSVP-based Admission Control over IEEE 802-style networks".

[22] IETF RFC 2815: "Integrated Service Mappings on IEEE 802 Networks ".

[23] IETF RFC 2543: "SIP: Session Initiation Protocol".

[24] IETF RFC 1889: "RTP: A Transport Protocol for Real-Time Applications".

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

[26] IETF RFC 2401: "Security Architecture for the Internet Protocol".

[27] IETF RFC 2402: "IP Authentication Header".

[28] IETF RFC 2406: "IP Encapsulation Security Payload (ESP)".

[29] IETF RFC 2816: "A Framework for Integrated Services Over Shared and Switched IEEE 802 LAN Technologies".

3 Definitions and abbreviations

3.1 Definitions

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

adhoc network: In an adhoc network, direct connections between User Terminals are established without the need of a central station.

Application Programming Interface (API): set of inter-layer service request and service response messages, message formats, and the rules for message exchange between hierarchical clients and servers

NOTE: API messages may be executed locally by the server, or the server may rely on remote resources to provide a response to the client.

authentication: means of identifying the participants of the system in order to find all information about them, including namely billing and user profile

bridge: interconnection between two fixed (sub-)networks

confidentiality: the protection of information from unauthorized disclosure or the protection of content related to usage and user profile in the system against unauthorized participants

core network: portion of the Delivery System composed of networks, systems, equipment and infrastructures, connecting the Service Providers to the Access Networks

corporate network: IP-based network under the administration of one single company (i.e. an infrastructure consisting basically of LAN, wireless LAN and routers)

direct link: direct connection terminal to terminal

encryption: mathematical technique used to ensure the confidentiality of security management information

end user: a user, either human or machine, whose primary interaction with the system is through the User Terminal

function: feature that is realized through the system

home network: network comprising a PLC-HN with optionally a wireless network and/or Ethernet sub-network

NOTE: The PLC-HN may also have a network termination.

interface: point of demarcation between two blocks through which information flows from one block to the other

key management: the generation, storage, distribution archiving, deletion, revocation, registration, and de-registration of cryptographic keys

latency: the perceived delay between an action and the corresponding reaction

NOTE: Different elements of an overall system may contribute to the overall latency of an action. Latency is very much implementation specific, and may vary with system load.

logical interface: interface where the semantic, syntactic, and symbolic attributes of information flows is defined. Logical interfaces do not define the physical properties of signals used to represent the information. A logical interface can be an internal or external interface. It is defined by a set of information flows and associated protocol stacks.

mobility: nomadic mobility of terminals is involved

Network Termination (NT): the element of the Access Network performing the connection between the infrastructure owned by the Access Network operator and the Consumer System (ownership de-coupling). The NT can be passive or active, transparent or not.

NOTE 1: The NT provides for termination of the interface towards the Service Provider (SP) network and for connection services for terminals the Home Network to/from the SP network

NOTE 2: NTs can be based on Access PLC, xDSL, CATV, and Radio in the Local Loop (RLL).

physical interface: where the physical characteristics of signals used to represent information and the physical characteristics of channels used to carry the signals are defined

NOTE 1: A physical interface is an external interface and it is fully defined by its physical and electrical characteristics.

NOTE 2: Logical information flows map to signal flows that pass through physical interfaces.

port: abstraction used by transport protocols to distinguish among multiple destinations associated with particular applications running on a host computer; an application can specify the ports it wants to use; some ports are reserved for standard applications/services such as e-mail (also known as well-known ports)

privacy: protects authorized participants from illegal utilization or knowledge of information related to their components in the system

protocol: set of message formats (semantic, syntactic, and symbolic rules) and the rules for message exchange between peer layer entities (which messages are valid when)

Quality of Service (QoS): qualified and quantified description of what is needed by a service or what is respected from a network

security: involves functions like: authentication, encryption, levels, Privacy, SIM card

server: any service providing system

Service Provider (SP): entity that provides a service to a client

NOTE 1: An operator of a network providing different types of network services, e.g. TV broadcasting, Internet connectivity, telephony etc.

NOTE 2: The network services actually provided depends both on the Service Provider as well as type of network used and deployed by the Service Provider.

session: interval during which a logical, mutually agreed correspondence between two objects exists for the transfer of related information. A session defines a relationship between the participating users in a service instance.

session control: responsible for establishing and terminating the environment in which an application will operate

NOTE: This environment may include the quality of service requirements for both the application and product entities.

socket: communications transport API that provides applications inter-process communication services using the underlying services provided by TCP/IP; the API allows an application to open a socket, request delivery services, and bind the socket to the desired destination and then send or receive data

system: collection of interacting objects that serves a useful purpose; typically, a primary subdivision of an object of any size or composition (including domains)

transparent information: information that is not significant semantically to an object used to transport the information

3.2 Abbreviations

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

API	Application Programming Interface
BER	Bit Error Rate
CE	Consumer Electronics
DS	Differentiated Service
EPG	Electronic Program Guide
FEC	Forward Error Correction
HVAC	Heating Ventilation Air Conditioning
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISO	International Standards Organization
ITU	International Telecommunication Union
LAN	Local Area Network
MAC	Medium Access Control
MIB	Management Information Base
MSDU	MAC Service Data Unit
NT	Network Termination
OSI	Open Systems Interconnection
PC	Personal Computer
PER	Packet Error Rate
PLC	PowerLine Communications
PLC-HN	PowerLine Communication Home Network
PLT	PowerLine Telecommunications
QoS	Quality of Service
RLL	Radio in the Local Loop
RSVP	ReSource reserVation Protocol
RTP	Real-time Transport Protocol
SDP	Session Description Protocol
SIM	Subscriber Identity Mode
SNR	Signal to Noise Ratio
t.b.d.	to be defined (written)
TCP	Transmission Control Protocol
ToS	Type of Service
TV	TeleVision
VCR	Video Cassette Recorder

4 User scenarios and applications

The requirements for the PLC-HN shall be derived from user scenarios and the applications to be offered to the user over the PLC-HN.

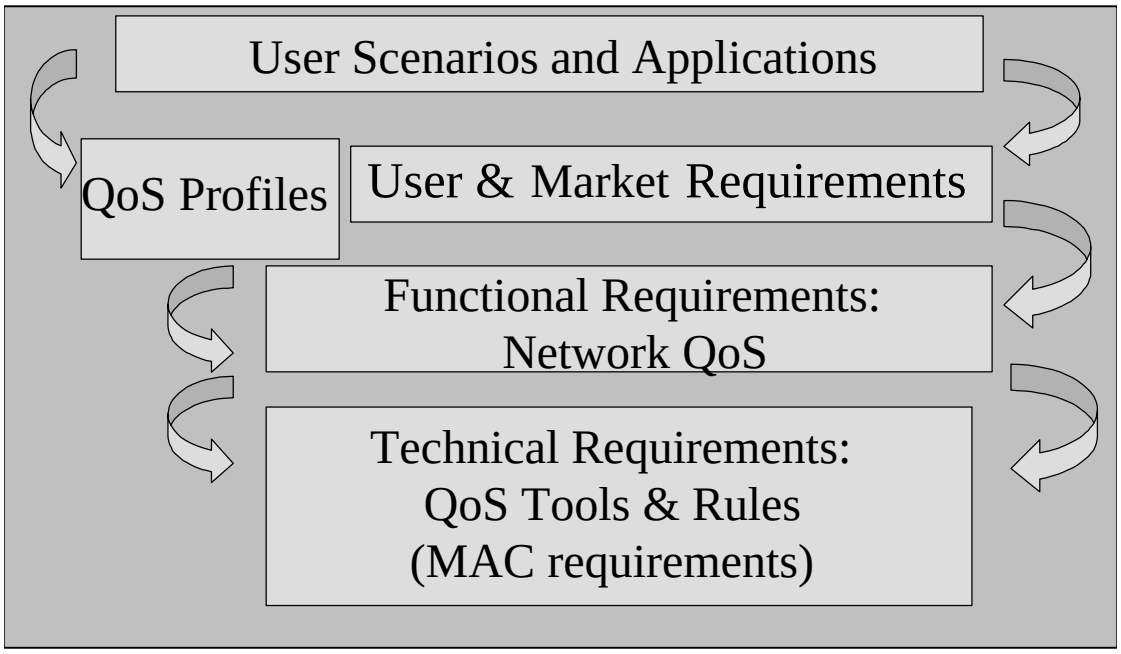


Figure 4.1: User scenarios and applications determine requirements for the MAC layer of the PLC-HN

Applications and Services to be provided on an In-house PLC Network:

- home automation
- in-house data and file transfer services
- internet retrieval and messaging services
- telephony and voice-services
- interactive multimedia incl. video-conferencing
- audio/video distribution

The QoS requirements of each service have to be defined. Each service either has to be:

- prioritized by a service class description or
- parameterized by a QoS profile or flow specification

4.1 Categories of home applications and home devices

Domestic electronics like televisions, set-top boxes, cameras, stereo equipment and computers are connected to the mains. Devices equipped with a PLC interface shall automatically establish a connection in an ad-hoc modus. Ad-hoc networking is ideal, where low cost, plug-and-play, and flexibility of the system architecture are essential requirements.

Powerline networks, both for low and high frequencies may be used to provide a range of services within a building. We have to be aware that more and more Internet and Intranet services will be interactive, real-time applications, which cannot be served on a network offering best-effort only. Audio/video services and voice telephony services require a sustainable QoS on the PLC network.

The system will not interfere with narrow-band Powerline control systems operating in the CENELEC bands below 150 kHz. Home control applications may optionally be provided in the frequency bands addressed by ETSI-PLT.

4.1.1 Categories of home applications

Entertainment:

- Audio
- Video
- Games

Infotainment:

- Internet
- EPG
- E-Commerce
- Tele-Services

Communication (email, voice, gaming, collaboration):

- Voice Telephony
- Video-phone
- Mailing

Home automation and device control:

- HVAC - Heating, Ventilation, Air-Conditioning
- Domestic appliance control

Security and Surveillance:

- Observation camera, fire detector, motion detector

4.1.2 Categories of home devices

To ease the definition of Quality of Service profiles, the devices in a home environment will be grouped in categories to distinguish between clients and servers. Clients are the sink or source of a data stream or are controlled devices. Clients, e. g. loudspeakers, shall not establish a communication session itself. Servers shall set up connections, they are responsible to prioritize or parameterize a service and interact with a network resource management system.

Clients:

Input Devices

- Camera
- Microphone
- Keyboard/Keypad
- Scanner

Output Devices

- TV
- PC monitor
- Loudspeaker
- Printer

Storage Devices

- VCR
- DVD-RW
- Hard disc
- Optical disc

Controlled devices

- Domestic appliances

Servers:

- Residential gateway
- Modem
- PC
- STB

4.1.3 In-home device connectivity between consumer products

The limited resources have to be managed on the shared Powerline medium. A fair and prioritized access to the medium has to be guaranteed. To manage and control the access efficiently, the traffic flows have to be studied and the originators of traffic flows have to be identified.

On an in-home Powerline network there are several devices, either from within one Powerline technology or from different technologies, which will not or cannot interact. These different services and technologies shall be aware of each other and shall coexist on the medium, i.e. respect their resource and QoS needs. Low cost, non QoS enabled Powerline network technologies shall not prevent QoS enabled in-home Powerline network technologies to deliver their services according their QoS performance requirements ("in-house/in-house coexistence"). A detailed list of services, the location they reside and the devices they interact with have still to be defined and categorized. The arbitration is determined by the network layer user priority of each service and the resource and QoS requirements. Each device, which asks for a sustainable QoS, shall be aware of the traffic load on the PLC medium and shall decide autonomously whether the available resources are high enough to set up a new connection.

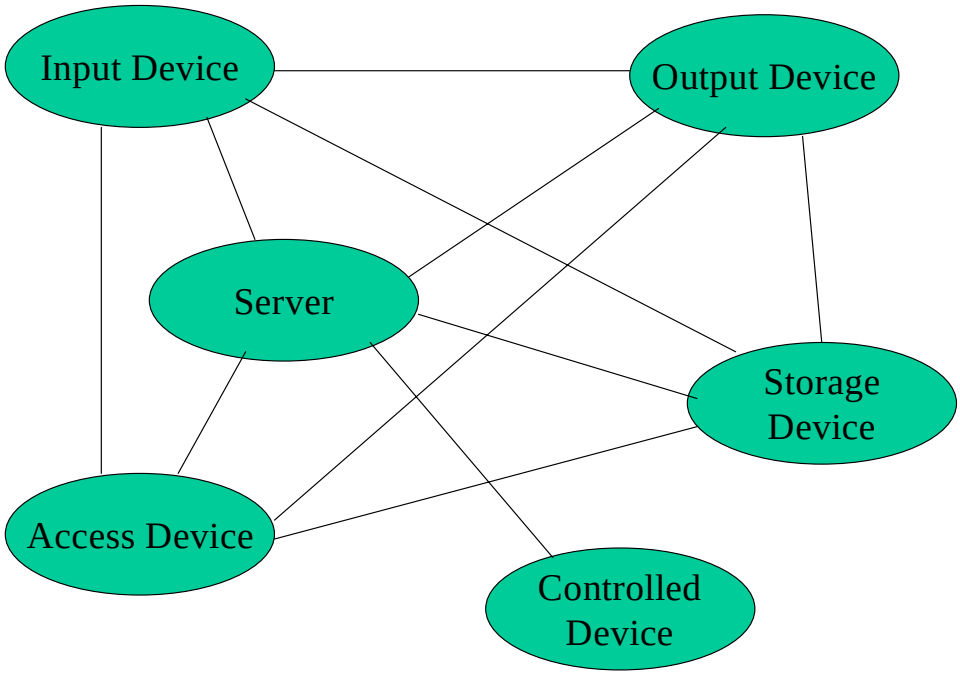


Figure 4.2: PLC-HN device connectivity

5 User and market requirements on a PLC-HN system

Some important requirements for the PLC home network environment from a user and Consumer Electronics (CE) perspective are:

- Predictable service delivery (QoS)
- Connection to an Access network via home gateways, e.g. set-top box (STB)
- Assured channel to Content Service Provider
- Interconnection to CE device cluster
- Mobility and freedom of placement of PLC network nodes
- No wiring hassle
- Efficient delivery of audio and video streams
- Security and user-friendly security management
- Extensibility and scalability
- No network and frequency planning
- Auto/Re-configuration does not involve user. New products are added automatically
- Low cost
- Network resources shall be managed carefully and efficiently
- Graceful degradation under network congestion

Bandwidth resources available in PLC home networks are limited compared to high-speed wire line networks like e.g. Gigabit Ethernet. An over-provisioning of the PLC-HN will not be possible. Therefore it is mandatory to manage the powerline network resource carefully in order to prevent network congestion causing unacceptable quality of service degradation for the user.

6 Service classes

The classification shall be according to the ITU-T Recommendation I.211 [4]. Two main service categories have been specified: interactive services and distribution services.

The interactive services are subdivided into three classes:

- Conversational services
  - telephony, video conferencing, collaborative working, interactive games, command and control
- Messaging services
  - E-mail, voice/video mail
- Retrieval services
  - Data, audio, video retrieval

The distribution and streaming services are subdivided into two classes:

- Distribution service without user presentation control
  - Audio/TV broadcasting
- Distribution service with user presentation control
  - video distribution services, remote education, tele-services

7 Traffic classes

On the data link layer we shall distinguish between seven traffic classes according IEEE 802.1D [12], which are grouped regarding their timing behaviour in *time critical* and *non-time critical* as follows:

- Time critical services (real-time services)
  - Network control
  - Voice (and video conferencing)
  - Video (and audio)
- Non-time critical services (non-real-time services)
  - Controlled load
  - Excellent effort
  - Best effort
  - Background

For priority controlled services the Differentiated Services Field [25] ("DS" byte) (which supersedes the IPv4 Type of Service "ToS" byte) in the IPv4 or IPv6 header has to be set: the PLC Network Interface module shall process the IP header and shall set this network layer User Priority. The value for the network layer user priority is determined by the QoS profile of each service.

The mapping of the user priorities (given by the DS (ToS) byte of the IP header) will be mapped to the traffic class on the data link layer according to IEEE 802.1D [12]. The mapping of the traffic classes onto the DS byte is applicable both in IPv4 and IPv6.

Services, which do not provide the DS byte will be treated as best effort services.

Service set-up by real-time protocols, e. g. RSVP [13], [14] and [15], or ITU-T Recommendation H.323 [6], should be assured the highest arbitration access right. The resource manager through interaction with the load monitoring system has to guarantee that during call set-up the network resources for guaranteed services are not overbooked to keep the performance of the network predictable.

8 Control and management service requirements of a PLC-HN

In this clause, important higher layer, network and session management requirements are given.

8.1 Network installation and configuration requirements

The PLC-HN shall provide to the user the capability of transmitting data to each outlet in the home.

Minimal or preferable no user intervention shall be required.
Automatic set-up and plug and play ad-hoc networking should be possible.

Hot plugging/unplugging of devices shall be supported.

Network Management functionality shall be offered to the user by the PLC-HN system, e. g:

- Start and stop of applications
- Maintain resources
- Disable devices
- Configuration of devices

8.2 PLC-HN operation and maintenance requirements

The PLC-HN should allow network maintenance and should supply information for a PLC-HN management system.

The PLC-HN should provide auto-recovery mechanisms to detect failures and to restore the network after failure events.

The PLC-HN should provide a failure management tool that shall monitor the system, capture erroneous states, store failure statistics and shall send alarm messages to a network management system.

The PLC-HN should provide a performance management tool. It shall provide network performance parameter (bit error rate, average network load, collisions) for the network resource management and resource reservation protocols.

Low cost devices which may not request for QoS may not monitor the network. Low cost devices shall only have a best effort access to the network, but shall be compliant with the ETSI PLT in-house/in-house co-existence standard in order to not prevent co-existing QoS enabled powerline communications network technologies from delivering QoS.

Devices that ask for a certain QoS shall monitor the network behaviour. QoS- capable devices shall store in a local Management Information Base (MIB) all statistical information which are needed for the applications running on the device.

There might optionally be an Operation and Maintenance device. This OAM device (if available) should store all statistical information on the network in a central MIB. All devices may retrieve data from the central MIB resp. send data or events to the OAM device.

8.3 PLC-HN resource management

Due to the limited bandwidth resources compared to high-speed wire-line networks, the limited network resources shall be managed carefully and efficiently to avoid network congestion and service degradation.

Each application session must be able to announce a flow specification or parameterized QoS profile for each connection depending on the type of the application.

During an active application session the traffic flow specification or parameterized QoS profile of this application has to be stored in the local MIB of the device.

Services requesting for a certain QoS have to check with the performance and the resource management system on the availability of the needed resources before an arbitration to the media is permitted.

It shall back-off its request, if its needs cannot be granted. It may start arbitrating the medium later on when the needed resources are again available.

The principle of the media arbitration is "first come first serve". This basic principle is the general rule in all managed transport networks. When the network resources are exhausted a further arbitration request has to be rejected.

8.4 Session management requirements

Point-to-point, point-to-multipoint, multipoint-to-point and multipoint-to-multipoint connections shall be supported.

The user shall be able to interrupt a service (e. g. viewing a movie) and:

- return to the original (previous) service
- use another service, then return to the original service
- cancel and not view the remainder of the program.

There shall be a time-out limit whenever a session is temporarily inactive.

Session Mobility: the transfer of a session between terminals within a house shall be supported.

The Session Description Protocol (SDP) [19] may be used to announce the service and its needed resources.

The Session Description Protocol (SDP) may inter-operate with the Resource Management system and the RSVP.

The Real-time Transport Protocol (RTP) [24] may be used to monitor the performance of the network.

The Session Initiation Protocol (SIP) [23] may be used to set up a telephony application on the packet switched PLC-HN.

The session Initiation Protocol (SIP) may inter-operate with the Performance and Resource Management system.

The SIP protocol shall back-off the session initiation, if the resources are not available.

8.5 Network monitoring

The paradigm of the PLC-HN is to assure predictable network behaviour. This demands that on the shared PLC media the QoS requirements of all running services shall be maintained. The admission to the network shall be based on the principle "first come first service". This means that terminals cannot establish new connections for a certain traffic class if the needed resources are not available for this class. This principle guarantees that the performance of running applications cannot be degraded by new services.

Network Monitoring should be done on all devices, which need a predictable QoS for the applications served by this device. The monitored information is stored in a local MIB. Only that information has to be stored in the local MIB that are needed by the running applications. The local MIBs on the different devices have not to be consistent, because each devices is responsible for its own MIB and the kind of information it collects. A Network Management Agent (residing anywhere in the network) may read the local MIBs of all devices on demand.

The monitor has to provide for each terminal all information that is needed to set up a new connection without hampering running services with the same or higher service class. Each terminal shall decide autonomously whether an access according to the given network load conditions is permitted.

The monitor function, which shall be contacted by the session initiation process, could either reside locally in the terminal or could be provided by a monitor agent elsewhere in the PLC-HN. All new services, which do not use a session initiation process, should only run as a best effort service. All best effort services can be blocked by any service with a higher priority.

The monitor should provide the statistical status information as follows:

- Bit error rate (BER)
- Packet error rate (PER)
- Collisions
- Retransmissions
- Round trip time for retransmissions
- Bandwidth occupied by time critical real time services
- Unused network capacity
- Bandwidth used per priority class

The statistical information is a snapshot of the network performance of the recent time interval. The duration of the time interval has to be defined. These statistical information are stored in a local MIB in each device. Devices that do not provide delay sensitive or bandwidth sensitive traffic do not need to have a local MIB. However, such devices cannot request any QoS. The Medium Access Control (MAC) protocol for these devices can only provide best-effort services.

8.6 Admission control

Each station decides either autonomously or with the use of an agent whether an arbitration is permitted. The managers engaged in the admission control process are illustrated in figure 8.1.

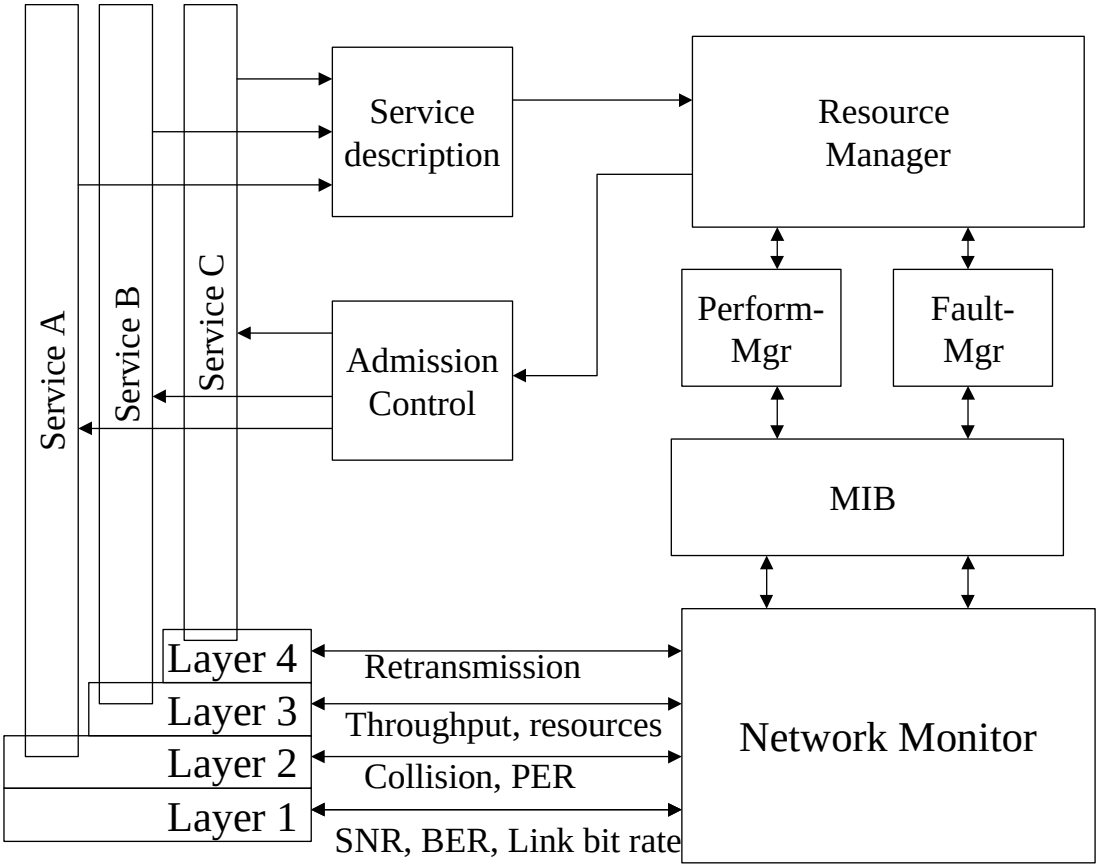


Figure 8.1: Management Architecture on PLC-HN

9 Quality of Service requirements

All requirements on the quality of a service are driven by the application and the user needs. In the present document, general aspects of QoS will be defined to achieve a consistent view on the quality of a service on a PLC home network.

The QoS requirements shall be described in a layered view according to the ISO-OSI model. The mapping of the QoS description across layers shall be non-ambiguous. A parameterized and prioritized QoS description shall be used as defined by ITU-T and IETF.

For a parameterized QoS profile a guaranteed, absolute QoS will be achieved by mapping the flow specification of RSVP onto shared media [21], [22], [29]. Admission Control and Bandwidth Management will be done to achieve predictable network behaviour.

For prioritized QoS profiles the User Priority to Traffic Class mapping will be used as recommended by IEEE 802.1D [12].

The restrictions of the powerline medium shall be taken into account. An over-provisioning might not be possible due to the limited throughput of the PLC network and the broadband services used at home. The network shall be aware of network capacity bottlenecks and shall provide means to maintain the limited resources.

9.1 QoS profiles

The purpose is to describe first the application specific user requirements by a set of QoS parameters, which form the QoS profile of a particular service. A non-ambiguous mapping will be defined to map the application specific user requirements onto the parameters of the QoS profile. A QoS profile has to be determined for each service and is then used for traffic engineering, resource reservation and media arbitration.

Certain applications (e.g. MP3 audio files, DVD videos) may use predefined fixed profiles. The relation between application and profile shall be unique for these applications.

The QoS profiles may be used by session description protocols (SDP) as defined in RFC 2327 [19] to announce the QoS request to the network. The network arbitration has to be done with respect to the given service class and may use Network Resource Reservation Protocols and a Resource Manager to announce their needs. If the network cannot guarantee the requested QoS due to the actual load being monitored, the start of a new session shall be withdrawn. All services, which have not announced their needs, will be transported as best effort service.

The services provided on an in-home LAN shall be split according to its QoS profile in prioritized services and parameterized services. The IETF Internet proposed recommendation RFC 2475 [20] will be used for prioritized services. The IETF Internet proposed recommendation RFC 2210 [15] may be used for parameterized services.

9.2 Generic QoS performance parameter

The QoS parameters are according ITU-T Recommendation I.350 [5]. These generic parameters describe the QoS performance in a qualitative manner. Quantitative figures for these parameters have to be specified before the connection could be set-up.

The generic parameters are as follows:

- Access speed
- Access accuracy
- Access dependability
- Information transfer speed
- Information transfer accuracy
- Information transfer dependability
- Disengagement speed
- Disengagement accuracy
- Disengagement dependability
- Availability

9.3 Network QoS performance parameter

The Network QoS is defined by the following parameter:

- Throughput
- Delay (latency)
- Delay variation (Jitter)

- Reliability (affected by Loss)
  - Bit Error Rate (BER)
  - Packet Error Rate (PER)
  - Packet discard probability
    (due to lifetime expiration)

9.4 Network security

Security should be provided by an authentication service and an encryption of the MAC Service Data Unit (MSDU). The security is limited to device-to-device data exchange. Encryption keys are predefined private keys, which have to be defined.

The security services provided on a PLC-HN are as follows:

- Confidentiality
- Privacy
- Authentication
- Access control

IP capable devices may optionally use the IPSec transport mode to achieve a higher level on security. The key exchange protocol, the authentication and the encryption algorithm should be according RFC 2401 [26], RFC 2402 [27], and RFC 2406 [28].

9.5 End-to-end QoS model

For IP traffic the Internet Engineering Task Force (IETF) has defined the following three service models:

- Best effort service
  - Basic connectivity with no QoS guarantees
  - Application sends data whenever it has to and in any quantity, without requesting permission or informing the network
  - The network delivers the data as best as it can without assurance of delay bounds, throughput, and reliability
- Differentiated services
  - Traffic is grouped in service classes that are served differently by the network
  - One service class may be treated better than another
  - Results in a statistical preference and not in a hard guarantee
  - Problem: within one service class, only best effort service is possible
  - QoS class indication e.g. by
    - Type of service field in the IPv4 header
    - Traffic class field in the IPv6 header
  - No explicit signalling by application before sending data

- Integrated services
  - Absolute reservation of network resources for specific traffic
  - Application requests a specific kind of service from the network before sending data
  - Explicit signalling, e.g. by use of Resource Reservation Protocol (RSVP) (RFC 2209 [14], RFC 2210 [15])
  - Support
    - **Controlled Load Services** (RFC 2211 [16])
      - Provides level of service equivalent to best effort service in a lightly loaded network, regardless of the actual network load
      - Work well on low-loaded networks, but their performance degrades quickly under overloaded conditions
    - **Guaranteed Service** (RFC 2212 [17], RFC 2215 [18])
      - Guarantees a maximum end-to-end delay and bandwidth
      - Intended for voice (telephony), audio- and voice applications with strict bandwidth and delay requirements
      - Application is expected to send data only after it gets confirmation from the network. The network performs admission control based on the service flow specification and the available network resources.

9.6 End-to-End QoS Budget

The overall transmission Quality Rating and the QoS budgets shall be according to TR 101 329-2 [3] and TR 101 329 [1].

Both the end-to-end delay and the connection set-up delay is defined by TR 101 329 [1].

Table 9.1: End-to-end QoS classes for TIPHON systems (from [1])

		4 (Best)	3 (High)	2 (Medium)	1 (Low)
TIPHON Speech Quality (one way, non interactive measurement)		Better than ITU-T Recommendation G.711 [10]	Equivalent or better than ITU-T Recommendation G.726 [11] at 32 kbit/s	Equivalent or better than GSM-FR	
End-to-end delay		< 150 ms	< 250 ms	< 350 ms	< 450 ms
Call setup time	Direct IP addressing	< 1,5 s	< 4 s	< 7 s	< 7 s
	ITU-T Recommendation E.164 [9] Number translation to IP address (scenario 1)	< 2 s	< 5 s	< 10 s	< 10 s
	ITU-T Recommendation E.164 [9] Number translation to IP via clearing house or roaming (scenario 1)	< 3 s	< 8 s	< 15 s	< 15 s
	ITU-T Recommendation E.164 [9] Number translation to IP address (scenario 2)	< 4 s	< 10 s	< 20 s	< 20 s
	ITU-T Recommendation E.164 [9] Number translation to IP via clearing house or roaming (scenario 2)	< 6 s	< 15 s	< 30 s	< 30 s
	E-mail alias translation to IP address	< 4 s	< 13 s	< 25 s	< 25 s

NOTE 1: These classes have been defined by reference to existing codec types to facilitate comparative measurements and to provide classifications that are easy for users to understand.
NOTE 2: The descriptions in this table include the effects of packet loss.
NOTE 3: 'est effort' connections may also be provided without giving any guarantee for end-to-end QoS values.
NOTE 4: Call setup times for scenarios 3 and 4 are for further study.

9.7 End-to-end QoS parameter of application types

Table 9.2: End-to-end QoS parameters of application types (partly taken from ITU-T Recommendation G.1010 [8])

	QoS Profile					
application type	**data rate**	**end-to-end one way delay**	**delay jitter**	**loss sensitivity**	**privacy**	**data integrity**
voice	< 64 kb/s	< 150 ms (preferred) < 400 ms limit	< 1 ms	low, packet rate < 10E-3	encryption needed	no FEC, no retransmission
gaming	t.b.d. Mb/s	< 200 ms	not specified	medium packet loss rate	no	FEC
audio + video streaming DVD	t.b.d. Mb/s	< 10 s < 20 ms	<<1 msec < 2 ms	low, < 1 %	authentication	FEC, fault monitoring, L2 retransmission
mailing	low	Preferred < 2 s Acceptable < 4 s	not specified	high	high, encryption needed	FEC, L3 retransmission
Internet	low	Preferred < 2 s/page Acceptable < 4 s/page	not specified	high		retransmission
E-commerce	low	Preferred < 2 s Acceptable < 4 s	not specified	high	authentication, authorization, encryption	L3 retransmission
Tele-Services	high	< 400 ms	< 600 ms	high	authentication,	retransmission
Home automation	low	< 400 ms	< 600 ms	high	authorization	L3 retransmission

9.8 QoS Budget on the PLC-HN

The following estimates for the delay budget of different application types on the PLC-HN take TR 101 329 [1] and table 9.2 for end-to-end delay budgets into account:

Table 9.3: QoS delay budget on the PLC-HN

application type	delay budget
voice	20 ms
gaming	20 ms
audio + video streaming DVD	100 ms 20 ms
mailing	not specified
Internet	200 ms
E-commerce	100 ms
Tele-Services	200 ms
Home automation	200 ms

9.9 Session description on session layer

Services that are asking for a certain quality have to specify their requirements for a controlled usage of the network resource. It will be distinguished between well-known services and unknown services.

Well-known services, like MP3 streaming, telephony, are predefined by a fixed QoS profile. The service will be recognized by a service type identifier. The reservation will be done by the predefined QoS profile. No session description protocol is needed for predefined services.

An unknown service has to be described by the Service Description Protocol (SDP) according to RFC 2327 [19].

Services which are not able to announce their needs shall be run only as best-effort services.

9.10 Real-time applications

Real-time audio, video or data services, which request a guaranteed Quality of Service shall use the Real-time Transport Protocol (RTP) [24] within the PLC-HN.

Real time applications provided by a Service Provider across a public access network may use the ITU-T Recommendation H.323 standard [6]. The real-time services according to ITU-T Recommendation H.323 shall be transported on the PLC-HN by the RTP protocol as described in [6]. This standard describes the provisioning of real-time services on packet switched networks that may not provide guaranteed QoS. The Usage of the Resource Reservation Protocol (RSVP) shall be according to the annex II of ITU-T Recommendation H.323.

9.11 Resource reservation protocols

9.11.1 Resource reservation on network layer

It has to be distinguished between services requesting an absolute, guaranteed QoS and a relative, priority-controlled QoS.

A guaranteed service has to use the RSVP protocol according RFC 2205 [13]. The requested QoS - either requested by the Service Description Protocol (SDP) or described by the predefined QoS profile of well-known services - have to be mapped onto the FlowSpec of the RSVP protocol according to RFC 2210 [15].

The network monitor captures the RSVP messages to calculate which parts of the network resources are reserved by guaranteed services.

A priority controlled service shall use the DiffServ Architecture defined in RFC 2475 [20]. The priority should be determined by the sending terminal. The Priority will be set in the DS byte of the IP header.

Connections set-up by the RSVP protocol will always have a higher access priority than services classified by the DiffServ Architecture.

9.11.2 Resource reservation on data link layer

The mapping of the *network layer (OSI layer 3) user priority* onto the *data link layer (OSI layer 2) access priority* on a shared media should be according to the RFC 2815 [22] and RFC 2816 [29] standards.

IEEE 802.1D [12] recommends the following mapping of the user priority onto the traffic classes:

Table 9.4: Recommended user priority to traffic class mapping according IEEE 802.1D [12]

		Number of available traffic classes (= Number of available data link layer access priorities)							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Network layer user priority	0 (default)	0	0	0	1	1	1	1	2
	1	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	1
	3	0	0	0	1	1	2	2	3
	4	0	1	1	2	2	3	3	4
	5	0	1	1	2	3	4	4	5
	6	0	1	2	3	4	5	5	6
	7	0	1	2	3	4	5	6	7

A consequence of the mapping shown is that frames carrying the default user priority 0 are given preferential treatment relative to user priority 1 and 2.

The number of available traffic classes on PLC-HN has still to be defined.

The arbitration to the medium should be controlled by a bit resolution protocol. The number of the available traffic classes should be exactly the number of the priorities of the bit resolution protocol. The mapping is uniquely a one-to-one mapping.

The splitting of the network resources between the traffic classes has to be defined.

10 QoS profile mapping for in-house PLC systems

The mapping of the proposed traffic parameter and service classes on the IEEE 802.1D [12] traffic types is described as follows:

Table 9.4: Mapping of traffic parameters and service classes to IEEE 802.1D [12]

IEEE 802.1D [12] traffic type	Acronym	Traffic type description	Traffic parameters	Corresponding end-to-end QoS model	Associated QoS mechanism (QoS tools and rules)
Background	BK	Non-time-critical and loss insensitive, but of lower priority than best effort. This type includes bulk transfers and other activities that are permitted on the network but that should not impact the use of the network by other users and applications.	nothing specified (non-time-critical, loss insensitive)	**Best effort**	**Relative priority levels:** prio: lowest
Spare	-		nothing specified	**Differentiated**	prio: low
Best Effort	BE	Non-time-critical and loss insensitive. This is LAN traffic handled in the traditional fashion.	nothing specified (non-time-critical, loss insensitive)		prio: medium
Excellent Effort	EE	Also non-time-critical but loss sensitive, but of lower priority than controlled load. This is a best-effort type of service that an information services organization would deliver to its most important customers.	- non-time-critical - loss sensitive		prio: high
Controlled Load	CL	Non-time-critical but loss sensitive, such as streaming multimedia and business-critical traffic. A typical use is for business applications subject to some form of reservation or admission control, such as capacity reservation per flow.	- non-time-critical - loss sensitive **- sustainable net bit rate**	**Integrated services -** Controlled Load	**Resource reservation**
Video (and Audio)	VI	Time critical, characterized by less than 100 ms delay, such as interactive video.	- time critical **- delay < 100 ms** **- sustainable net bit rate**	**Integrated services -** Guaranteed Service	
Voice (and Video Conferencing)	VO	Time critical, characterized by less than 10 ms delay, such as interactive voice.	- time critical **- delay < 10 ms** **- sustainable net bit rate**		
Network Control	NC	Both time critical and safety critical, consisting of traffic needed to maintain and support the network infrastructure, such as routing protocol frames.	- time critical - safety critical		**Interrupt based arbitration**

History

Document history		
V1.1.1	May 2002	Publication