

Hybrid Fiber Coax (HFC) access networks; Part 1: Interworking with PSTN, N-ISDN, Internet and digital mobile networks



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Contents

Intellectual Property Rights.....	5
Foreword	5
Introduction	5
1 Scope	6
2 References	6
3 Definitions, symbols and abbreviations	9
3.1 Definitions	9
3.2 Symbols	10
3.3 Abbreviations	10
4 Service Requirements	11
5 Functional requirements.....	11
6 Reference Configuration and Reference Points	13
6.1 The HFC access network general architecture and boundaries	13
6.2 Digital section for HFC access network.....	14
6.3 General reference configuration for HFC Access Networks	15
6.3.1 User Port Function	15
6.3.2 Service Port Function	16
6.3.3 Core Function.....	16
6.3.4 HFC User Interface Function	16
6.3.5 HFC Access Node Function	17
6.3.6 HFC Transport Network Function.....	17
6.3.7 AN System Management Function.....	17
6.4 HFC Access Network configuration for the considered networks	17
6.5 Reference Points	18
6.5.1 Reference points at the user interface side	18
6.5.2 Reference points at the network interface side	19
7 User Interfaces	19
7.1 Broadcast UNI	19
7.1.1 Analogue Broadcast UNI	19
7.1.1.1 Interface references.....	20
7.1.1.2 Protocol stack reference.....	20
7.1.2 Digital Broadcast UNI.....	21
7.1.2.1 Interface references.....	21
7.1.2.2 Protocol stack and peer communication stack reference	21
7.2 PSTN UNI	22
7.2.1 Interface references	23
7.2.2 User Interface functions - POTS Cable Network Termination.....	23
7.2.3 Protocol stack and peer communication stack reference configuration.....	23
7.3 N-ISDN UNI.....	24
7.3.1 Interface references	25
7.3.1.1 Basic access	25
7.3.1.2 Primary access	25
7.3.2 User Interface functions - N-ISDN Cable Network Termination	25
7.3.3 Protocol stack and peer communication stack reference	26
7.4 Internet Terminal UNI	27
7.4.1 Interface references	28
7.4.2 User interface functions - IP Cable Network Termination	28
7.4.2.1 Definition.....	28
7.4.2.2 Functions and Technology	28
7.4.3 Protocol stack and peer communication stack reference	29
7.5 Leased Lines UNI	30

7.5.1	Interface references	31
7.5.2	User Interface functions - Leased Cable Network Termination	31
7.5.3	Protocol stack and peer communication stack reference	31
8	Service Node Interfaces (SNI) (Access Node Interface)	32
8.1	Broadcast Service	32
8.2	PSTN Service specific Service node.....	32
8.2.1	Interface references	32
8.2.2	Network interface functions - PSTN Cable Line Termination	32
8.2.3	Protocol stack and peer communication stack reference configurations	33
8.2.3.1	Protocol stacks.....	33
8.2.3.1.1	V5.1 _N interface.....	33
8.2.3.1.2	V5.2 _N interface.....	33
8.2.3.2	Protocol peer configurations.....	34
8.2.3.2.1	V5.1 interface.....	35
8.2.3.2.2	V5.2 interface.....	35
8.3	N-ISDN Service specific Service node	36
8.3.1	Interface references	36
8.3.2	Network interface functions - N-ISDN Cable Line Termination.....	36
8.3.3	Protocol stack and peer communication stack reference configurations	36
8.3.3.1	Protocol stacks.....	36
8.3.3.1.1	V5.1 _N interface.....	36
8.3.3.1.2	V5.2 _N interface.....	37
8.3.3.2	Protocol peer configurations.....	38
8.3.3.2.1	V5.1 interface.....	38
8.3.3.2.2	V5.2 interface.....	39
8.4	PSTN/N-ISDN Modular Service node.....	40
8.4.1	Interface references	40
8.4.2	Network interface functions - PSTN/N-ISDN Cable Line Termination.....	40
8.4.3	Protocol stack and peer communication stack reference configurations	40
8.4.3.1	Protocol stacks.....	40
8.4.3.1.1	V5.1 _N interface.....	40
8.4.3.1.2	V5.2 _N interface.....	41
8.4.3.2	Protocol peer configurations.....	42
8.4.3.2.1	V5.1 interface.....	42
8.4.3.2.2	V5.2 interface.....	43
8.5	Internet network	44
8.5.1	Interface references	44
8.5.2	Network interface functions - IP Cable Line Termination	45
8.5.3	Protocol stack and peer communication stack reference	45
8.5.3.1	Protocol stacks.....	45
8.5.3.2	Protocol peer communication	46
8.6	Leased lines Specific Service network.....	46
8.6.1	Interface references	46
8.6.2	Network interface functions - Leased Line Cable Line Termination.....	46
8.6.3	Protocol stack and peer communication stack reference configurations	46
9	Internal HFC Access Network Aspects.....	47
9.1	Interface references	47
9.2	Internal HFC Access Network Structure.....	47
9.3	HFC Access network channel structure and protocols.....	48
	Bibliography	49
	History	50

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Foreword

This ETSI Guide (EG) has been produced by ETSI Technical Committee Network Aspects (NA).

The present document is part 1 of a multi-part EG covering the Hybrid Fiber Coax (HFC) access networks, as identified below:

Part 1: "Interworking with PSTN, N-ISDN, Internet and digital mobile networks";

Part 2: "Interworking with B-ISDN Networks".

Introduction

Cable TV networks are more and more used for other services than just broadcast service. At the user side service terminals other than TV and radio are attached. At the terminal side, the head end needs to interwork with a number of service related networks. The present document presents a number of different interfaces at the user side and the network side and shows how the HFC access network interconnects them, both for user and signalling data.

1 Scope

The present document is focussed on the interworking between HFC networks and other networks. The different user equipment and the different user network interfaces to the access network have an influence on the interworking, and as such, are also considered.

It may be the case that an independent cable operator operates an HFC access network that has no interface to a switching network at all. In this case the HFC network is maybe not regarded as an access network, but nevertheless the network may provide services to its customers beyond just Broadcast services. This case is beyond the scope of the present document, since no interworking is involved. If, on the other hand, an independent cable operator has interfaces to other switching networks, the contents of the present documents applies.

The present document considers the following public telecommunication networks:

- public switching telephone network;
- narrowband ISDN network;
- internet;
- leased lines networks.

Other public telecommunication networks will be considered in a later document.

Looking at broadcasting, it is considered as a service rather than as a network. The interfaces for broadcast services at the HFC access network are however also considered. Analogue and digital broadcasting are handled separately.

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] ETR 306: "Transmission and multiplexing (TM); Access networks for residential customers".
- [2] ITU-T Recommendation G.960 (1993): "Access digital section for ISDN basic rate access".
- [3] ITU-T Recommendation G.962 (1993): "Access digital section for ISDN primary access at 2 048 kbit/s".
- [4] ITU-T Recommendation G.963 (1993): "Access digital section for ISDN primary access at 1 544 kbit/s".
- [5] ITU-T Recommendation G.964 (1994): "V-interfaces at the digital local exchange (LE) - V5.1 interface (based on 2 048 kbit/s) for the support of access network (AN)".
- [6] ITU-T Recommendation G.965 (1995): "V-interfaces at the digital local exchange (LE) - V5.2 Interface (based on 2 048 kbit/s) for the support of access network (AN)".
- [7] ISO/IEC 10038 (1993): "Information technology - Telecommunications and information exchange between systems - Local area networks - Media access control (MAC) bridges".

- [8] ISO/IEC 8802-2 (1997): "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks- Specific requirements - Part 2: Logical link control".
- [9] ISO/IEC 8802-3 (1997): "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications".
- [10] ITU-T Recommendation G.902: "Framework Recommendation on functional access networks (AN) – Architecture and functions, access types, management and service node aspects".
- [11] ETR 148: "Private Telecommunication Network (PTN); Integrated services architecture for high speed private networks".
- [12] ITU-T Recommendation N.51: "Definitions for application to international television transmissions".
- [13] ITU-T Recommendation I.112: "Vocabulary of terms for ISDNs".
- [14] ITU-T Recommendation Q.512: "Digital exchange interfaces for subscriber access".
- [15] ITU-T Recommendation Q.551: "Transmission characteristics of digital exchanges".
- [16] ITU-T Recommendation Q.552: "Transmission characteristics at 2-wire analogue interfaces of digital exchanges".
- [17] EN 50083-1: "Cabled distribution systems for television and sound signals - Part 1: Safety requirements".
- [18] EN 50083-2: "Cabled distribution systems for television and sound signals - Part 2: Electromagnetic compatibility for equipment".
- [19] EN 50083-3: "Cabled distribution systems for television and sound signals - Part 3: Active coaxial wideband distribution equipment".
- [20] EN 50083-4: "Cabled distribution systems for television and sound signals - Part 4: Passive coaxial wideband distribution equipment".
- [21] EN 50083-5: "Cabled distribution systems for television and sound signals - Part 5: Headend equipment".
- [22] EN 50083-6: "Cabled distribution systems for television and sound signals - Part 6: Optical equipment".
- [23] EN 50083-7: "Cabled distribution systems for television and sound signals - Part 7: System performance".
- [24] ETS 300 429: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".
- [25] ITU-T Recommendation J.83: "Digital multiprogramme systems for television, sound and data services for cable distribution".
- [26] ITU-T Recommendation H.222.0: "Information technology - Generic coding of moving pictures and associated audio information: Systems".
- [27] EN 300 001: "Attachments to the Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN".
- [28] ITU-T Recommendation I.411: "ISDN user-network interfaces - Reference configurations".
- [29] ITU-T Recommendation Q.921: "ISDN user-network interface - Data link layer specification".
- [30] ITU-T Recommendation Q.931: "ISDN user-network interface layer 3specification for basic call control".

- [31] ITU-T Recommendation I.430: "Basic user-network interface - Layer 1 specification".
- [32] ITU-T Recommendation I.431: "Primary rate user-network interface - Layer 1 specification".
- [33] ETS 300 288: "Business TeleCommunications (BTC); 64 kbit/s digital unrestricted leased line with octet integrity (D64U); Network interface presentation".
- [34] ETS 300 418: "Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S); Network interface presentation".
- [35] ETS 300 448: "Business TeleCommunications (BTC); Ordinary quality voice bandwidth 2-wire analogue leased line (A2O); Connection characteristics and network interface presentation".
- [36] ETS 300 449: "Business TeleCommunications (BTC); Special quality voice bandwidth 2-wire analogue leased line (A2S); Connection characteristics and network interface presentation".
- [37] ETS 300 451: "Business Telecommunications (BTC); Ordinary quality voice bandwidth 4-wire analogue leased line (A4O); Connection characteristics and network interface presentation".
- [38] ETS 300 452: "Business Telecommunications (BTC); Special quality voice bandwidth 4-wire analogue leased line (A4S); Connection characteristics and network interface presentation".
- [39] ETS 300 766: "Business TeleCommunications (BTC); Multiple 64 kbit/s digital unrestricted leased lines with octet integrity presented at a structured 2 048 kbit/s interface at either or both ends (D64M); Connection characteristics and network interface presentation".
- [40] ETS 300 686: "Business TeleCommunications (BTC); 34 Mbit/s and 140 Mbit/s digital leased lines (D34U, D34S, D140U and D140S); Network interface presentation".
- [41] ETS 300 687: "Business TeleCommunications (BTC); 34 Mbit/s digital leased lines (D34U and D34S); Connection characteristics".
- [42] ETS 300 688: "Business TeleCommunications (BTC); 140 Mbit/s digital leased lines (D140U and D140S); Connection characteristics".
- [43] ETS 300 689: "Business TeleCommunications (BTC); 34 Mbit/s digital leased lines (D34U and D34S); Terminal equipment interface".
- [44] ETS 300 690: "Business TeleCommunications (BTC); 140 Mbit/s digital leased lines (D140U and D140S); Terminal equipment interface".
- [45] TBR 25: "Business TeleCommunications (BTC); 140 Mbit/s digital unstructured and structured leased lines (D140U and D140S); Attachment requirements for terminal equipment interface".
- [46] ETS 300 166: "Transmission and Multiplexing (TM); Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2 048 kbit/s - based plesiochronous or synchronous digital hierarchies".
- [47] ETS 300 167: "Transmission and Multiplexing (TM); Functional characteristics of 2 048 kbit/s interfaces".
- [48] ETS 300 347: "V interfaces at the digital Local Exchange (LE); V5.2 interface for the support of Access Network (AN)".
- [49] ETS 300 324: "V interfaces at the digital Local Exchange (LE); V5.1 interface for the support of Access Network (AN)".
- [50] ITU-T Recommendation I.361: "B-ISDN ATM layer specification".
- [51] ITU-T Recommendation I.363: "B-ISDN ATM Adaptation Layer specification".
- [52] ITU-T Recommendation I.432: "B-ISDN User-Network Interface – Physical layer specification".
- [53] ETS 300 800: "Digital Video Broadcasting (DVB); Interaction channel for Cable TV distribution systems (CATV)".

- [54] ITU-T Recommendation J.112: "Vocabulary of terms for ISDNs".
- [55] EN 50083-9: "Cable networks for television signals, sound and interactive services --Part 9: Interfaces for CATV/SMATV headends and similar equipment for DVB/MPEG-2 transport streams".
- [56] EN 50083-8: "Cabled networks for television signals, sound signals and interactive services -- Part 8: Electromagnetic compatibility for networks".
- [57] EN 50083-10: "Cable networks for television signals, sound signals and interactive services -- Part 10: System performance for return paths".
- [58] IETF RFC 894 (1984): "A standard for the transmission of IP Datagrams over Ethernet Networks".
- [59] IETF RFC 1042 (1988): "A standard for the Transmission of IP Datagrams over IEEE 802 Networks".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Access Network: an implementation, comprising those entities which provide the required transport bearer capabilities for the provision of telecommunication services between a Service Node Interface and each of the associated user-network interfaces. An Access Network can be configured and managed through a Q3 interface. In principle there is no restriction on the types and the number of UNIs and SNIs which an Access Network may implement. The access network does not interpret (user) signalling.

Access Node (AN): a node providing access to the public network [ETR 148].

broadcast organisation: organisation which is concerned with sound and/or television broadcasting [ITU-T Recommendation N.51].

broadcast network: network providing sound and/or television signals to the user, either directly to the user or via an HFC access network.

CATV: used as a general term for "cable television" (historically used to indicate "Community Antenna TeleVision" - a centralized installation of television antennas that serves a community of users).

downstream direction: direction from the network towards the subscriber.

digital section: the whole of the means of digital transmission of a digital signal of specified rate between 2 consecutive reference points. The term should be qualified by the type of access supported, or by a prefix denoting the V interface at the digital section boundaries.

Head End (HE): (definition in HFC access network context): equipment in an HFC access network, providing interfaces between the HFC Access network and one or more other networks, and providing an RF communication interface with the user interface functions.

Hybrid Fiber/Coax (HFC) Access Network: a mixed fibre and coaxial network architecture using FDM transmission technology based on RF frequencies, in which fibre links are used for the main distribution path, while coaxial links are used as the final link into the users' premises.

network interface functions: functions belonging to the Head End in a HFC access network.

service node: a network element that provides access to various switched and/or permanent telecommunication services. In case of switched services the SN is providing access call and connection control signalling, and access connection and resource handling [ITU-T Recommendation G.902].

service node interface: the interface between an Access Network and a Service Node. (ITU-T Recommendation G.902: The interface which provides customer access to a service node).

telecommunication network: a set of nodes and links that provides connections between 2 or more defined ports to facilitate telecommunication between them [ITU-T Recommendation I.112].

upstream direction: direction from the subscriber towards the network.

User Interface Functions (UIF): functions in an access network, interacting with the user equipment, and providing a RF communication interface with the Head End it is connected to.

User Network Interface (UNI): the interface at which the user equipment is connected to the network.

3.2 Symbols

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

<R> _C	Reference point related to BroadCast service
<R> _I	Reference point related to IP-based service
<R> _L	Reference point related to Leased Line Service
<R> _N	Reference point related to Narrowband ISDN service
<R> _T	Reference point related to Telephony service
C64	User channel of 64 kbit/s
D16	Data channel of 16 kbit/s
D64	Data channel of 64 kbit/s
M	Reference point at a service interface residing in a network
P	Reference point at a service interface residing at the border of a network
Q3	Telecommunication Network Management Interface
V5	Reference point at the SNI interface of an Access Network
Z	Reference point at the UNI interface of analogue telephony

3.3 Abbreviations

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

AN	Access Network
ANI	Access Network Interface
CATV	Community Antenna TeleVision
CF	Core Function
FDM	Frequency Division Multiplex
FE	Function Element
HFC	Hybrid Fiber Coax
HE	Head End
LE	Local Exchange
PC	Personal Computer
PRA	Primary Rate Access
SN	Service Node
SNI	Service Node Interface
SPF	Service Port Function
UIF	User Interface Functions
UPF	User Port Function
UNI	User Network Interface

4 Service Requirements

An HFC Access Network may support a number of telecommunication services and telecommunication service components. The basic function of an HFC Access Network is that it uses RF frequencies for transportation of the information between the user side and the network side of the access network. As such, the information, including both signalling and user information, must be mapped in one way or another into the RF frequency spectrum and the traditionally used frequency bands for Radio and Television. In addition to the downstream traffic, some upstream traffic may be required. Depending upon the type and bandwidth of the information, different solutions may be required for different services to be supported.

HFC Access Networks may support (but are not required to support) the following Telecommunication services.

Supporting" means that the HFC AN does not provide the services itself, but provides the necessary channels, control, management and security functions for transporting the service information between Service Node and User equipment.

- Basic service: Radio and TV distribution service.
- Telephony service, its supplementary services, and all value added services such like telefax, DECT and voice data modem services.
- Internet services: basic TCP/IP en UDP/IP communication and Internet services ftp, telnet, e-mail, usenet, www and gopher.
- Mobile services as defined for GSM, DCS 1800 and IMT-2000.
- B-ISDN services as defined in the F.700 and F.800 series.
- X25 based data services (PSPDN services).

The service component information types to be supported are:

- Sound: voice, music, etc.;
- Video: TV-programme, movie, etc.;
- Data: files, static pictures, text, low speed data, high speed data, real-time data, etc.

5 Functional requirements

The fundamental principles of an access network and a HFC access network in particular are reflected by the following functional requirements:

- an (HFC) AN is used in order to **multiplex/demultiplex** the signalling and data streams from UNIs in a cost effective manner and then to present this information stream to the SN in a manner such that the SN can determine the source or sink UNI;
- **concentration** shall be supported across a V5 reference point as an **option** (although it shall always be possible to guarantee bandwidth for user ports who require such a facility such as the security services);
- the HFC AN does **not interpret (user) signalling**. Signalling for Telecommunication services should be handled as near to transparently as possible. This means that the contents of signalling messages should not be checked unless it is unavoidable;
- the V5 reference point shall not be limited to a single physical interface (for redundancy and to allow more user ports to be connected);
- it is not a requirement for local switching to be carried out within the Access Network itself, either under SN control or under local control;
- the responsibility for call control and associated connection control resides in the SN (i.e. the HFC AN may have no knowledge of ongoing services and the call state during normal operation);

- tones and announcements should be generated in the service node(s) and not in the access networks themselves, except for local ringing and some kind of announcement when the user is not reachable from the service node (e.g. all access network lines busy);
- selection of the service provider by the HFC AN based on user signalling information shall not be possible, because this would require SN functionality in the HFC AN.

However, for ATM based access types the HFC AN shall support access to different SNs through a single UNI at the same time by using the corresponding VPs associated to these SNs via provisioning. In this case the selection of the service provider is a matter of the user terminal and does not concern the HFC AN or the SNI;

- time critical management functions which require real time co-ordination between HFC AN and SN shall be performed by communication across the V5 reference point;
- technology specific functions, such as control of echo cancellers which might be required in a radio based access network, shall not be supported unless they are already supported by either V5 (in the case of narrowband services) or B-ISDN (in the case of broadband services);
- charging information is only provided by the SN. This information may be passed over the V5 reference point when a user requires it as part of the service to which he has subscribed and is not passed over the V5 reference point as a means of providing information for use by the HFC AN. Also tones and announcements shall be generated in the SN and not in the HFC AN;
- if multicasting is provided in the HFC AN, this shall be allowed to be performed in the SNI to UNI direction only. Otherwise multicasting is presumed to be a service provided by the SN;
- the V5 reference point at the SN has a signal structure which is a multiplex of several accesses of the same or of different access types.

The HFC AN may serve service specific SNs or modular SNs as defined in ITU-T Recommendation G.902.

Service affecting faults in the AN need to be advised to the SN in real time.

Signalling streams need to be protected.

A HFC AN makes use of RF signals for user, signalling, and maintenance information in the HFC Transport Network.

A HFC AN supports basically distribution (analogue and digital audio/video) services, but may be bi-directional and may support (not provide!) telephony service, IP based service, data services, video on demand services.

The downstream bandwidth (towards the user) of an HFC is in principle much bigger than the upstream bandwidth.

6 Reference Configuration and Reference Points

6.1 The HFC access network general architecture and boundaries

The following figure shows a general architecture of the HFC access network, in relation to its surrounding entities.

The figure is based on figure 1/ITU-T Recommendation G.902.

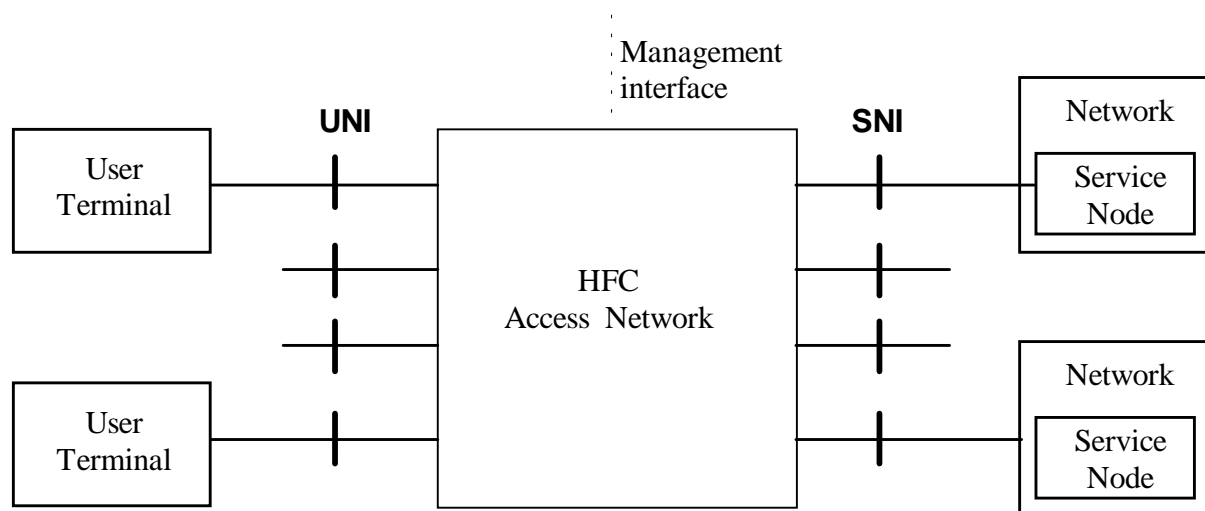


Figure 1: General Access Network architecture and boundaries

This picture shows:

- that the HFC Access Network is able to connect multiple users to multiple networks; the relation is a many to many relation, where only some users can be connected to one network, and otherwise a user can only be connected to some networks, depending upon subscription;
- the interface to the user is in general called **UNI (User Network Interface)**, whatever the interface;
- the interface to a network is called **SNI (Service Node Interface)**, whatever the telecommunication network.

ATM Forum uses **ANI (Access Network Interface)**, the difference is that signalling interpretation in the AN is allowed. It is possible that the access network has a interface for management purposes.

6.2 Digital section for HFC access network

It is possible that the HFC access network is located at a certain (medium or long) distance from the service node. To this purpose a digital section may be used, which may be called a "Feeder digital section", since it is there to 'feed' access networks located closer to the user. The digital section is guaranteeing that what goes in, also comes out in the same format. So the (V-) interface at both ends of the digital section is the same. The digital section can be SDH-based, PDH-based, or any other transmission scheme preserving the format. The Feeder digital section can be either point-to-point or point-to-multipoint.

The following figure shows the Feeder digital section at the SNI.

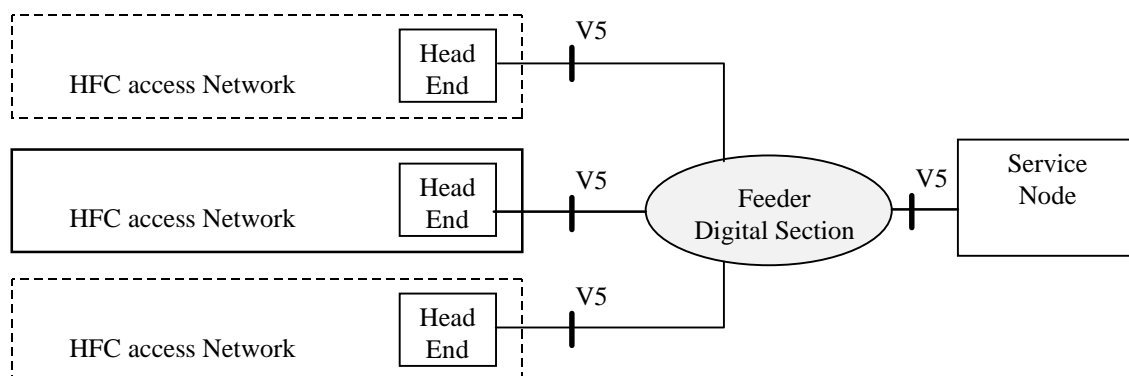
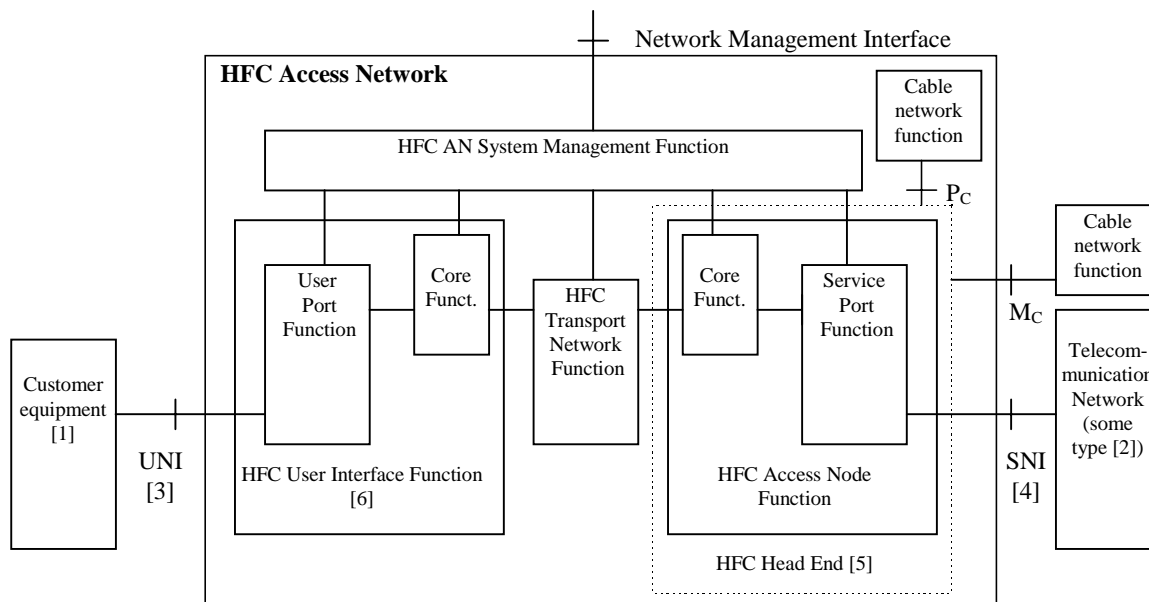


Figure 2: Feeder Digital section

6.3 General reference configuration for HFC Access Networks

The following figure shows the reference configuration for an HFC Access Network Based. It is based on the functional architecture of a general Access Network as shown in ITU-T Recommendation G.902, figure 3.



NOTE: The customer equipment may consist of some terminals, possibly interconnected by private switching equipment; terminals may be connected in a wireless way.

The access network may be connected to the following telecommunication network types: PSTN, N-ISDN, B-ISDN, PSPDN, Internet, Mobile and Digital Mobile networks, Satellite networks, and Cable networks.

One Access network in general serves multiple UNI interfaces.

One Access network in general may serve multiple telecommunication networks, of the same or different types; a specific HFC Access Node type is needed for a specific telecommunication network type.

The Head End may group a number of access nodes providing the interfacing to a number of telecommunication networks of the same or different type.

One Access network in general may serve multiple customer equipment, of the same or different types; a specific HFC User Interface Function type is needed for a specific customer equipment type.

Figure 3: General HFC Access Network reference configuration

6.3.1 User Port Function

The User Port Function (UPF) adapts the specific UNI requirements to the core and management functions. The AN may support a number of different accesses and user network interfaces which require specific functions according to the relevant interface specification and the access bearer capability requirements, i.e. bearers for information transfer and protocols. The User Port Function functionality are related to the terminal (customer) equipment connected to it. Other terminal equipment in general needs different User Port Function functionality.

Examples of User Port general functionality are:

- termination of the UNI functions;
- A/D conversion;
- signalling conversion;
- activation/deactivation of UNI;

- handling of the UNI bearer channels/capabilities;
- testing of UNI;
- maintenance of UPF;
- management functions;
- control functions.

6.3.2 Service Port Function

The Service Port Function (SPF) adapts the requirements defined for a specific SNI to the common bearers for handling in the core function and selects the relevant information for treatment in the AN system management function. The SPF functionality's are related to the Telecommunication Network type connected to it. Other Telecommunication Network type in general needs different SPF functionality's.

Examples of Service Port general functions are:

- termination of the SNI functions;
- mapping of the bearer requirements and time critical management and operational requirements into the core function;
- mapping of protocols if required for particular SNI;
- testing of SNI;
- maintenance of SPF;
- management functions;
- control functions.

6.3.3 Core Function

The Core Function (CF) is located between the UPF and SPF to adapt the individual user port bearer or service port bearer requirements into common transport bearers. This includes the handling of protocol bearers according to the required protocol adaptation and multiplexing for transport through the AN. The core function can be distributed within the AN.

Examples of core functions are:

- access bearer handling:
 - conversion of the information to/from RF format;
 - bearer channel concentration;
 - signalling and packet information multiplexing;
 - circuit emulation for the ATM transport bearer.
- management functions;
- control functions.

6.3.4 HFC User Interface Function

The HFC UIF is the combination of the UPF and the CF at the user side of the HFC Access Network. It interfaces to (a) specific user equipment(s) and converts/deconverts signals into/from a format suitable for the HFC Transport network.

6.3.5 HFC Access Node Function

The HFC Access Node Function is the combination of the SPF and the CF at the network side of the HFC Access Network. It interfaces to (a) specific telecommunication network(s) and converts/deconverts signals into/from a format suitable for the HFC Transport network.

6.3.6 HFC Transport Network Function

The HFC Transport Network Function (TF) provides the paths for the transport of common bearers between different locations in the AN and the media adaptation for the relevant transmission media used.

Examples of transport functions are:

- multiplexing function;
- cross connect function including grooming and configuration;
- management functions;
- physical media functions.

6.3.7 AN System Management Function

The AN System Management Function (AN-SMF) co-ordinates the provisioning, operations and maintenance of the UPF, SPF, CF and TF within the AN. Further it co-ordinates operation functions with the SN via the SNI and the user terminal via the UNI as defined in the relevant interface specifications.

Examples of AN system management functions are:

- configuration and control;
- provisioning co-ordination;
- fault detection/indication;
- usage information and performance data collection;
- security control;
- co-ordination of time critical management and operation requirements for the UPF and the SN via SNI;
- resource management.

The AN-SMF communicates with a Telecommunication management network via a Network Management interface for the purpose of being monitored and/or controlled and with the SN-SMF via the SNI for real-time control requirements according to the AN management functions and the SNI specification.

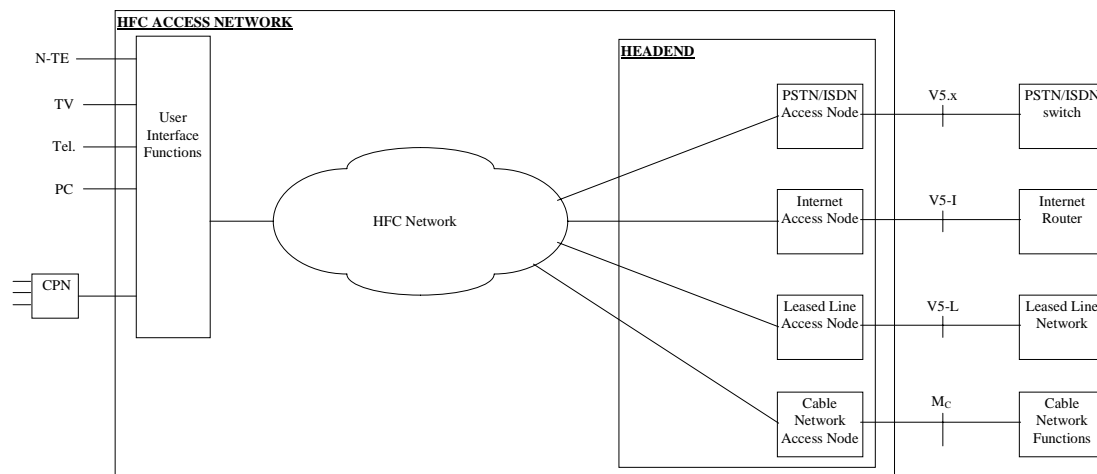
6.4 HFC Access Network configuration for the considered networks

The HFC Access Network configuration in figure 3 is based on the general architecture and reference configuration, and is applied to the different considered telecommunication networks in the present document.

The configuration shows interworking between an HFC access network and the following other networks (see note):

- PSTN;
- N-ISDN;
- Internet;
- Leased Lines Network.

NOTE: The interworking between an HFC access network and B-ISDN or satellite networks is outside of the scope of the present document



NOTE: This figure only shows a functional architecture. It does not indicate which functions may belong to which network operator. Depending on the choice of the boundary between operators, there may be additional features required in the interface definition.

Figure 4: HFC Access Network configuration for the considered networks

The figure also identifies some of the interfaces and the interworking units.

The interworking configuration outlined in figure 3, illustrates the situation where different networks interconnects with a common node access node headend. This headend acts as the focal point into the HFC network.

6.5 Reference Points

6.5.1 Reference points at the user interface side

The definitions and references found in ITU-T on UNI are mainly related to the I (and G) series, and apply to ISDN (N-ISDN or B-ISDN).

The "UNI" or "User Network Interface" terminology could be extended to any interface between a (access) network and the user equipment.

However, in that case, it is necessary to identify different reference points for the different user equipment, in order to be able to distinguish among different UNI interfaces, e.g.

- UNI at the T_N (T) reference point = N-ISDN UNI;
- UNI at the T_T reference point = Telephone UNI;

NOTE: For ITU-T this is the Z interface/reference point. See ITU-T Recommendation Q.512; it is a country specific interface; minimally specified in ITU-T Recommendations Q.551 and Q.552.

- UNI at the T_I reference point = IP-based network UNI;
- UNI at the T_L reference point = Leased Line UNI;
- UNI at the T_C reference point = broadcast ("CATV") UNI.

6.5.2 Reference points at the network interface side

The definitions and references for Service Node Interface (SNI) are found in ITU-T. According to this definition there is no on-demand switching in the access network.

The definitions and references for Access Network Interface (ANI) can be found in ATM Forum.

In principle the SNI and the ANI are the same interface (exact functions may however be different).

The reference point corresponding with SNI is the V5 reference point.

However, for different terminals, it is necessary to identify different reference points for the different networks, in order to be able to distinguish among different SNI interfaces, e.g.

- SNI at the V5_N reference point = N-ISDN SNI;
- SNI at the V5_T reference point = PSTN SNI;
- SNI at the V5_I reference point = Internet SNI;
- SNI at the V5_L reference point = Leased Line SNI.

Depending on the fact whether the access network supports multiplexing or concentration, the V5 Interface is a V5.1 or a V5.2 Interface.

The SNI supported for broadcast is rather a Service related interface than a network related interface. Depending upon the fact whether it is inside or outside a network, it can be considered as either a M or a P reference point.

7 User Interfaces

7.1 Broadcast UNI

The HFC access network offers always broadcasting service to the subscriber, since this was its primary function.

There are two kinds of Broadcast: analogue and digital.

7.1.1 Analogue Broadcast UNI

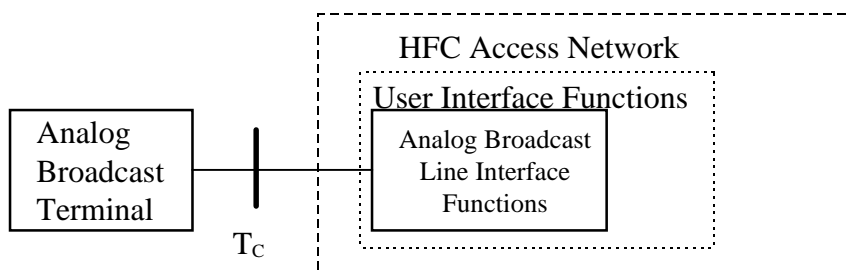


Figure 5: Reference configuration at UNI for analogue broadcast

The Analogue Broadcast UNI is the interface between the HFC access network and a Broadcast terminal. The Broadcast terminal is a Television Set, a Radio, or any equipment that is compatible to it (e.g. a Pay-TV decoding box).

The Interface is situated at the T_C reference point. ITU-T does not provide reference configurations for Broadcast access (although the N and J series provides Recommendations on sound and television matters).

With regard to basic functions, the Analogue Broadcast terminal is not different from an analogue Broadcast Terminal connected to a Broadcast distribution network in the same domain.

The Analogue Broadcast Physical interface is conform to CATV documents as defined by CENELEC.

7.1.1.1 Interface references

Standard Number	Short title
EN 50083-1	Cabled distribution systems for television and sound signals - Part 1: Safety requirements
EN 50083-2	Cabled distribution systems for television and sound signals - Part 2: Electromagnetic compatibility for equipment
EN 50083-3	Cabled distribution systems for television and sound signals - Part 3: Active coaxial wideband distribution equipment
EN 50083-4	Cabled distribution systems for television and sound signals - Part 4: Passive coaxial wideband distribution equipment
EN 50083-5	Cabled distribution systems for television and sound signals - Part 5: Headend equipment
EN 50083-6	Cabled distribution systems for television and sound signals - Part 6: Optical equipment
EN 50083-7	Cabled distribution systems for television and sound signals - Part 7: System performance
EN 50083-8	Cabled networks for television signals, sound signals and interactive services - Part 8: Electromagnetic compatibility for networks
EN 50083-9	Cable networks for television signals, sound and interactive services - Part 9: Interfaces for CATV/SMATV headends and similar equipment for DVB/MPEG-2 transport streams
EN 50083-10	Cable networks for television signals, sound signals and interactive services - Part 10: System performance for return paths

7.1.1.2 Protocol stack reference

The following figure shows the stack architecture for the analogue cable TV interface.

Functions performed by the analogue TV physical level are:

- analogue signal detection;
- TV channel delineation.

Functions performed by the analogue TV channel level are:

- synchronisation;
- video extraction;
- sound extraction.

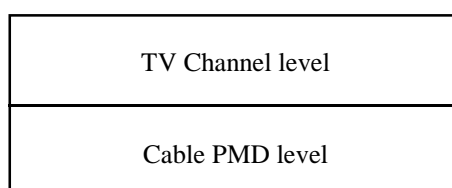


Figure 6: Analogue TV stack

The analogue broadcast data is sent unidirectional from head end to the user. At the UNI the Digital TV stack level functions are performed from bottom to top of the stack. The analogue TV data signal is embedded in the HFC transport signal. No core functions nor user interface functions are necessary.

7.1.2 Digital Broadcast UNI

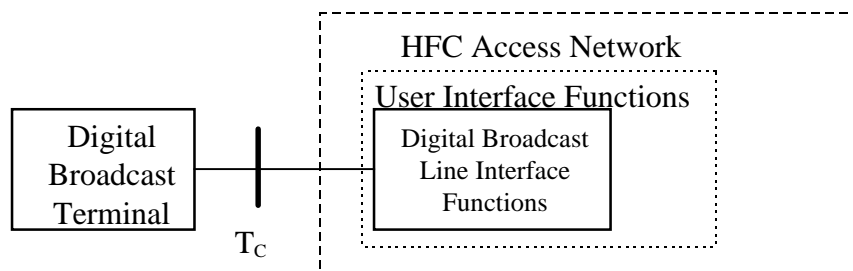


Figure 7: Reference configuration at UNI for digital broadcast

The Digital Broadcast UNI is the interface between the HFC access network and a Digital Broadcast terminal. The Digital Broadcast terminal is a Television Set, a Radio, or any equipment that is compatible to it (e.g. a Pay-TV decoding box).

The Interface is situated at the T_C reference point. ITU-T does not provide reference configurations for Broadcast access (although the N series provides Recommendations on sound and television matters).

With regard to basic functions, the Digital Broadcast terminal is not different from a Digital Broadcast Terminal connected to a Digital Broadcast distribution network in the same domain.

The Digital Broadcast Physical interface is conform to ITU-T Recommendations J.83 and H.222.0 or ETS 300 429.

7.1.2.1 Interface references

Standard Number	Short title
ETS 300 429	Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems
J.83	Digital multiprogramme systems for television, sound and data services for cable distribution
H.222.0	Information technology - Generic coding of moving pictures and associated audio information: Systems

7.1.2.2 Protocol stack and peer communication stack reference

The following figure shows the stack architecture for the analogue cable TV interface.

Functions performed by the MPEG-2 TS level are:

- digital coding of video signal, audio signal and service signals;
- video synchronisation.

Functions performed by the Reed Solomon level are:

- generate error-protected data.

Functions performed by the Convolution interleaving level are:

- interleaving data, resulting in interleaved frames.

Functions performed by the Symbol/byte encoding level are:

- conversion between bytes and QAM symbols.

Functions performed by the Differential encoding level are:

- assign coding points into a constellation diagram supporting differential encoding, so that the constellation is rotation invariant.

Functions performed by the QAM level are:

- square root raised cosine filtering;
- QAM modulation/demodulation.

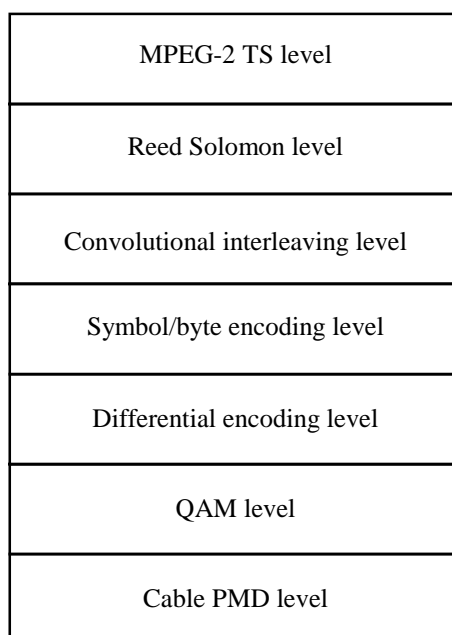


Figure 8: Digital TV stack

The digital broadcast data is sent unidirectional from head end to the user. At the UNI the Digital TV stack level functions are performed from bottom to top of the stack. The digital TV data signal under QAM format is embedded in the HFC transport signal.

7.2 PSTN UNI

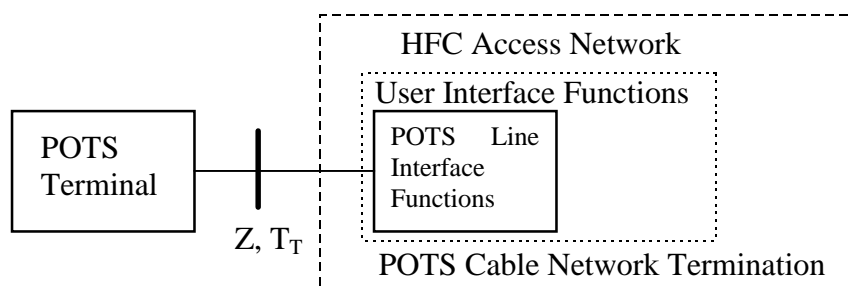


Figure 9: Reference configuration at UNI for POTS

The PSTN UNI is the interface between the HFC access network and the POTS (Plain Old Telephone Service) terminal. The POTS terminal is a POTS Telephone or any equipment that is compatible to it (fax, data modem, ...).

The Interface is situated at the $Z (T_T)$ reference point.

With regard to the basic telephony functions, the PSTN Terminal is not different from a PSTN Terminal connected to a PSTN in the same domain.

The POTS interface is historically a country specific interface.

7.2.1 Interface references

Standard Number	Short title
EN 300 001	Attachments to the Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN

7.2.2 User Interface functions - POTS Cable Network Termination

The User interface functions for the POTS services over HFC Access network is fulfilled by a functional grouping called POTS Cable Network Termination. The POTS Cable Network Termination fulfils the interface between the digital exchange and analogue line terminal.

The functions related to control for an analogue subscriber line are related to ringing, supervision and signalling by means of line state changes, pulses, tones. These have to be communicated over the access network in some way. The pulses and changes of line state are interpreted by the POTS Network Termination. The tones are transparently passed over the access network and transferred to the local exchange; also reverse.

The network side of the POTS Cable Network Termination needs to sent out/receive the different signals related to POTS and to communicate the user voice (or other information) signal.

7.2.3 Protocol stack and peer communication stack reference configuration

Protocol stacks are not applicable to analogue POTS lines. There is however a PSTN protocol for communication of the POTS signalling information over the V5 interface.

The PSTN protocol on the V5-interface is basically a stimulus protocol; i.e. it does not control the call procedures in the AN. It rather transfers information about the analogue line state over the V5-interface. The V5-PSTN protocol shall be used in conjunction with the national protocol entity in the LE. The national protocol entity in the LE, which is used for customer lines which are connected directly to the LE, will also be used to control calls on customer lines which are connected via the V5-interface. For time critical sequences it is also required to extract certain signalling sequences (e.g. compelled sequences) from the national protocol entity into an "AN part" of the national protocol entity. However, the V5-PSTN protocol has a relatively small functional part which is concerned with path set-up, release of the path on the V5-interface, call collision resolution on the V5-interface and handling of new calls in case of overload conditions in the LE. The majority of line signals will not be interpreted by the V5-PSTN protocol, but simply transferred transparently between the user port in the AN and national protocol entity in the LE.

Signalling information related to line state changes and pulses are handled via so-called Function Element (FE) groups, which are signals containing phone line information.

The LE shall be responsible for providing the service (call control, supplementary services). DTMF senders, receivers, tone generators and announcements shall be located in the LE. This implies that address information using DTMF shall be carried transparently between user port and LE whereas line state signalling shall be interpreted in the AN and then carried over the V5-interface by means of layer 3 messages.

It shall be the responsibility of the AN to handle access specific parameters related to the protocol such as recognition times of analogue signals, duration, voltage and frequency of meter pulses, ringing current or the specific details of a signalling sequence (AN part of the national protocol entity).

For time critical responses to customer signalling it is necessary for the AN to respond autonomously. This shall be explicitly required for ring trip and dial tone suppression. There may be other time critical responses required in national PSTN protocols which shall be defined in the national PSTN protocol mapping specification.

For time critical signalling sequences (e.g. autonomous seizure acknowledge for ground start PBXs) it shall also be necessary for the AN to control the time-critical part of the signalling sequence autonomously. In this case, the autonomous signalling sequence shall be triggered by the national protocol entity in the LE. After executing the autonomous signalling sequence, the AN may return a response to the LE.

For the protocol peer configuration, some diagrams can be given. A first diagram is related to the control information, which is transferred over the cable network and used as a primitive for the V5 PSTN Protocol.

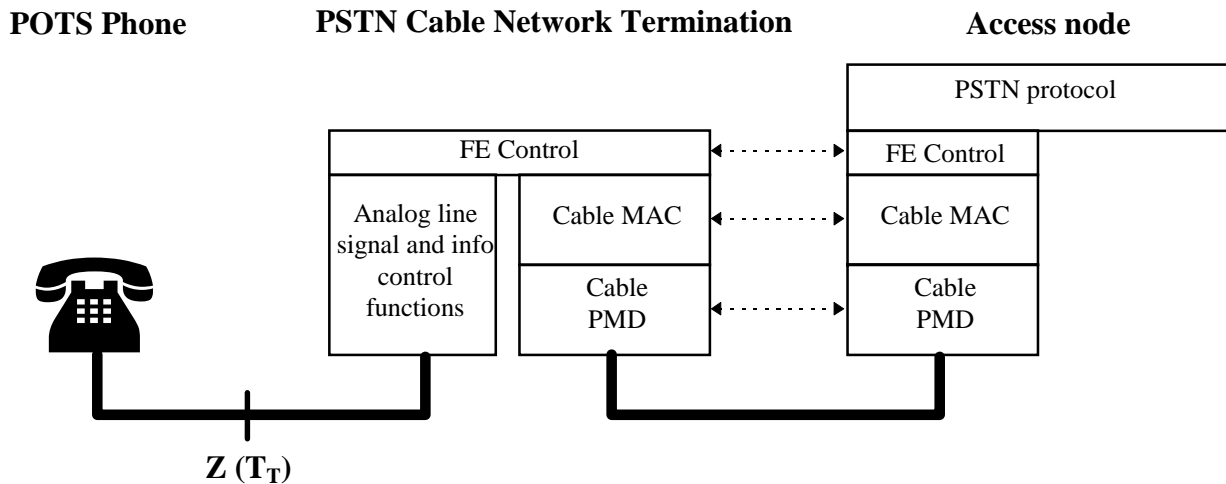


Figure 10: Protocol peer configuration for POTS signalling

A second diagram is related to the user analogue signal and tones.

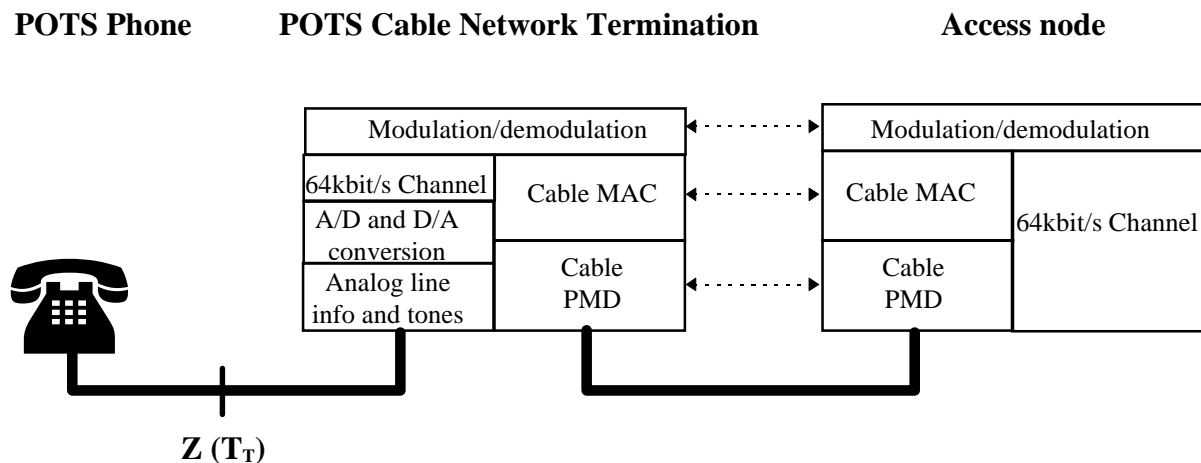


Figure 11: Protocol peer configuration for POTS user info and tones

7.3 N-ISDN UNI

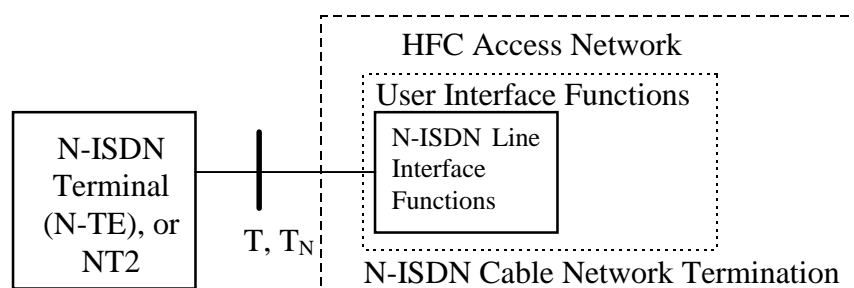


Figure 12: Reference configuration at UNI for N-ISDN

The N-ISDN UNI is the interface between the HFC access network and the N-ISDN terminal or NT2. The N-ISDN terminal is an N-TE terminal or any equipment that is compatible to it (possibly with Terminal Adapter).

The Interface is situated at the T (T_N) reference point. The Reference configurations of ITU-T recommendation I.411 apply.

With regard to basic functions, the N-ISDN terminal is not different from a N-ISDN Terminal connected to a N-ISDN local exchange in the same domain (see reference [3]).

The N-ISDN Physical interface is described in the ITU-T Recommendations I.430 for the Basic Access (BA) and ITU-T Recommendation I.431 for the Primary Rate Access (PRA).

7.3.1 Interface references

Standard Number	Short title
I.411	ISDN user-network interfaces - Reference configurations
Q.921	ISDN user-network interface - Data link layer specification
Q.931	ISDN user-network interface layer 3 specification for basic call control

7.3.1.1 Basic access

I.430	Basic user-network interface – Layer 1 specification
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7.3.1.2 Primary access

I.431	Primary rate user-network interface – Layer 1 specification
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7.3.2 User Interface functions - N-ISDN Cable Network Termination

The User interface functions for the N-ISDN services over HFC Access network is fulfilled by a functional grouping called N-ISDN Cable Network Termination. The N-ISDN Cable Network Termination fulfils the interface between the network and the N-ISDN TE or NT2.

The type of accesses supported for a single customer are the following:

- multipoint layer 1 passive bus configuration at the coincident S and T reference point; any N-ISDN teleservice or bearer service to be supported;
- NT2 support.

7.3.3 Protocol stack and peer communication stack reference

The protocol stacks for N-ISDN UNI, for basic and primary access are the following.

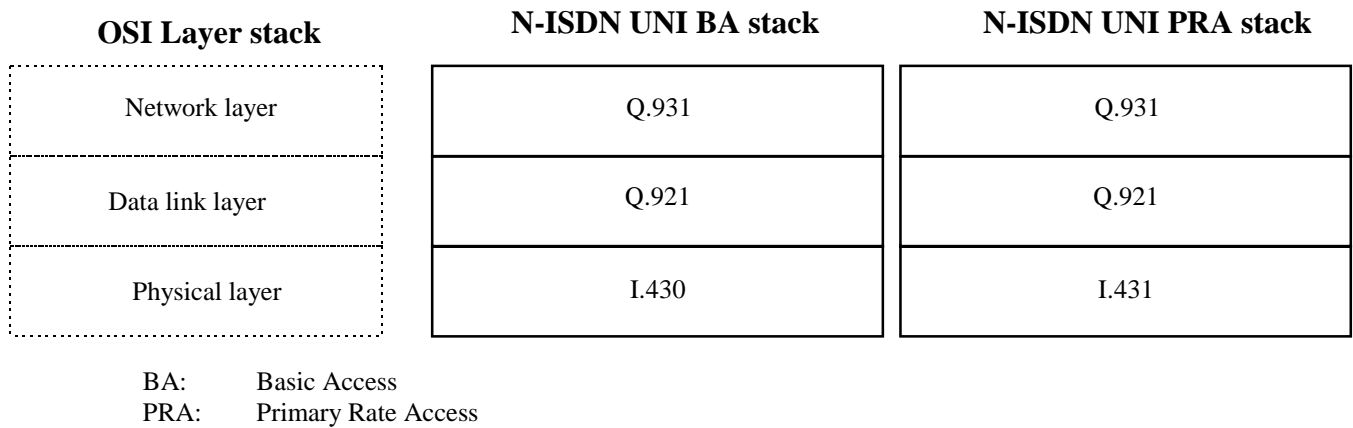


Figure 13: Protocol stack at N-ISDN UNI at T_N reference point

The peer communication stack configuration for signalling, from NT1 view, is given in the following figure. Signalling at layer 2 and layer 3 is not interpreted in the HFC access network.

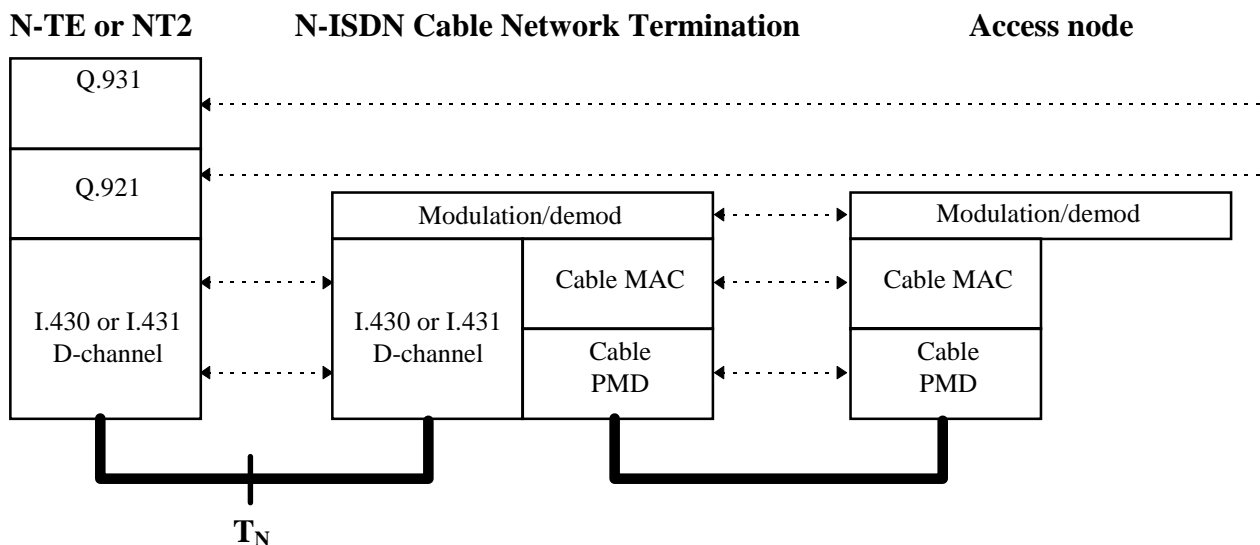


Figure 14: Protocol peer configuration for N-ISDN signalling

The peer communication stack configuration for B-channel info, from NT1 view, is given in the following figure. The information is transported over the access network to the telecommunication network.

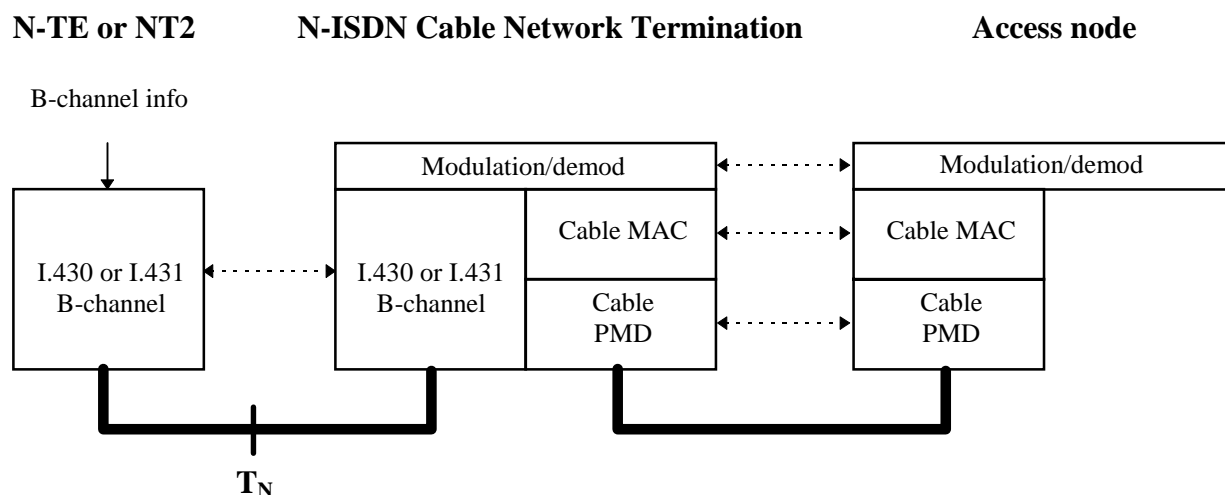


Figure 15: Protocol peer configuration for N-ISDN user information

7.4 Internet Terminal UNI

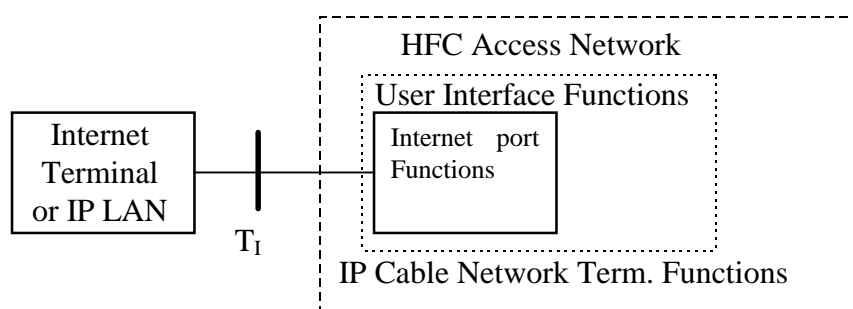


Figure 16: Reference configuration at UNI for Internet

The Internet UNI at the T_I reference point is the interface between the HFC access network and an Internet terminal. A Internet terminal is a PC or any other workstation or digital equipment that has external communication capability based on a (the) standard IP protocol and underlying layers.

The User Interface functions are practically realised by a device called "IP Cable Network Termination".

7.4.1 Interface references

Standard Number	Short title
IETF RFC 894	IP Datagrams over Ethernet Networks
IETF RFC 1042	IP Datagrams over IEEE 802 Networks
IETF Internet-draft draft-ietf-ipcdn-ipcabledata-spec-00.txt	IP Over Cable Data Network service
ISO/IEC 10038 [7] (IEEE Std 802.1D)	Information technology - Telecommunications and information exchange between systems - Local area networks - Media access control (MAC) bridges
ISO/IEC 8802-2 [8]	Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks- Specific requirements - Part 2: Logical link control
ISO/IEC 8802-3 [9]	Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications
ETS 300 429	Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems
ETS 300 800	Digital Video Broadcasting (DVB); Interaction channel for Cable TV distribution systems (CATV)

7.4.2 User interface functions - IP Cable Network Termination

The User interface functions for the IP data over HFC Access network is fulfilled by a functional grouping called IP Cable Network Termination. The IP Cable Network Termination used at the customer premises is called IP Cable Network Termination.

7.4.2.1 Definition

IP Cable Network Termination

A IP Cable Network Termination is a device that allows high-speed access to the Internet via a HFC access network. A IP Cable Network Termination will typically have two connections, one to the cable wall outlet to the network and the other to the Internet CPE equipment.

7.4.2.2 Functions and Technology

The IP Cable Network Termination technology provides an "always on" feature for individuals to have a high-speed access to the Internet.

IP Cable Network Termination capabilities vary widely.

In the downstream direction (from the network to the CPE), data rates can be anywhere up to 38,1 Mbit/s per 8 MHz channel. Few terminals will be capable of connecting at such high data rates, so a more realistic number is 6 Mbit/s - 9 Mbit/s.

In the upstream direction (from computer to network), data rates can be 3,088 Mbit/s, 1,544 Mbit/s or 256 kbit/s.

In case of IP Cable Network Termination deployment, an asymmetric set-up will probably be more common than a symmetric set-up. In an asymmetric scheme, the downstream channel has a much higher bandwidth allocation (faster data rate) than the upstream. Current Internet applications tend to be asymmetric in nature. Activities such as World Wide Web navigating and newsgroup reading send much more data down to the computer than to the network. Image files and audio and video files are very bandwidth intensive in the downstream direction. Mouse clicks (URL requests) and e-mail messages are not bandwidth intensive in the upstream direction.

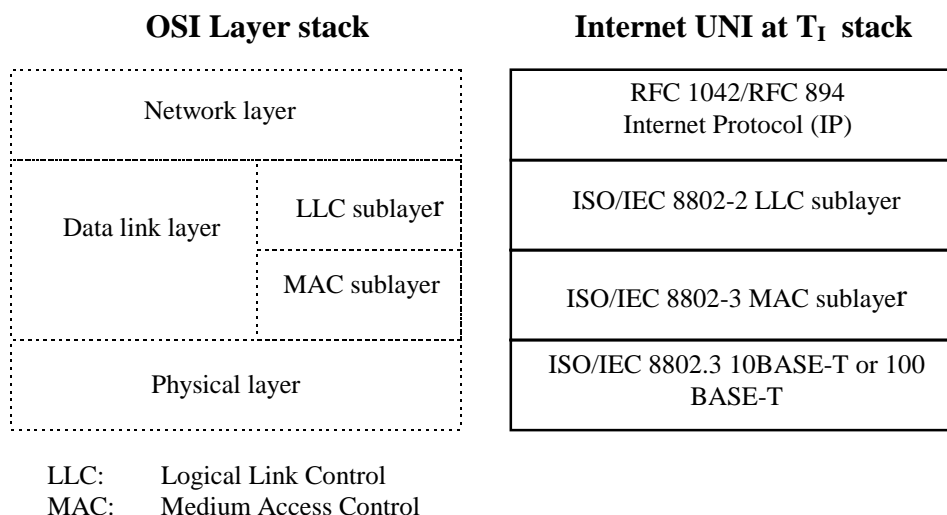
The fact that the word "modem" is used to describe this device can be a little misleading. Yes, it is a modem in the true sense of the word - it MODulates and DEModulates signals. But the similarity ends there because IP Cable Network Terminations are more complicated than the traditional telephone modems. IP Cable Network Terminations can contain modem functions, but also tuner, encryption/decryption, medium access, and other functions.

Typically, a IP Cable Network Termination sends and receives data in two slightly different fashions:

- In the downstream direction, the digital data is modulated and then placed on a typical (e.g. 6 MHz to 8 MHz) television carrier, somewhere between 47 MHz and 860 MHz. There are several modulation schemes, but the two most popular are QPSK (up to ~10 Mbit/s) and QAM64 (up to ~36 Mbit/s). This signal can be placed in a channel adjacent to TV signals on either side without disturbing the cable television video signals.
- In a two-way activated cable network, the upstream (also known as the reverse path) is transmitted between 5 MHz and 65 MHz. The lower part of this bandwidth tends to be a noisy environment, with lots of interference from, e.g. CB radios and impulse noise from home appliances. Since cable networks are tree and branch networks, all this noise gets added together as the signals travel upstream, combining and increasing (noise funnelling). Due to this problem, QPSK or a similar modulation scheme will be used in the upstream direction, because QPSK is more robust scheme than higher order modulation techniques in a noisy environment. QPSK is however "slower" than QAM.

7.4.3 Protocol stack and peer communication stack reference

The Internet IETF recommends multiple datalink/ physical link combinations on which the IP is able to run. A typical protocol stack is given in the following figure. Ethernet 10BaseT is a commonly used method.



NOTE: Other options below the IP protocol are possible; when used, the underlying IP protocol stack needs to be replaced in all appropriate figures.

Figure 17: Protocol stack at Internet UNI on T₁ reference point

The peer communication stack configuration, from the IP Cable Network Termination viewpoint is given in figure 18.

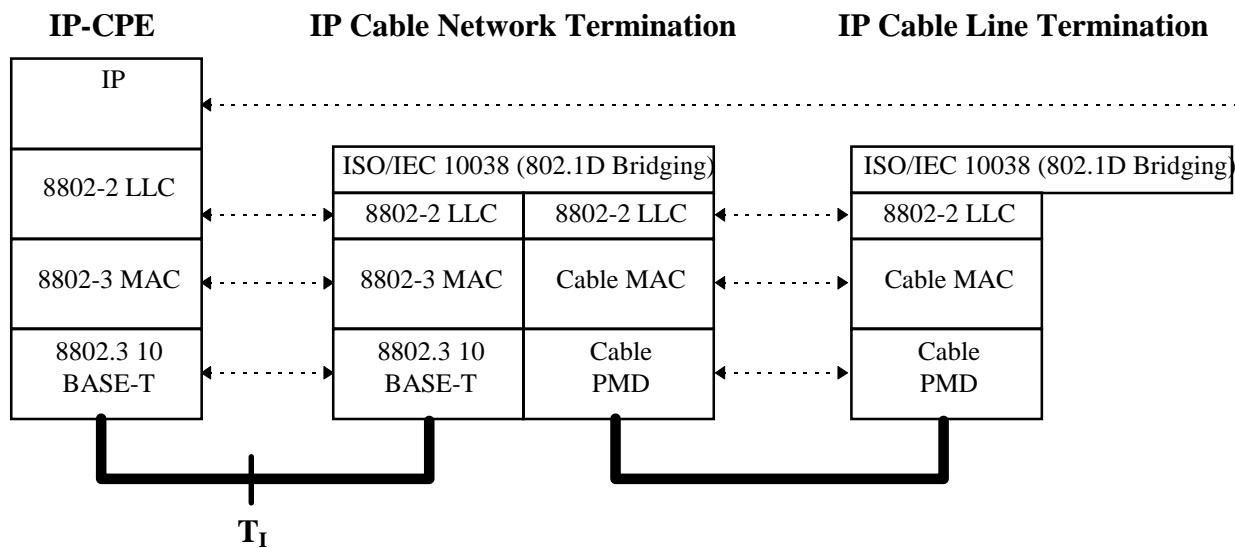
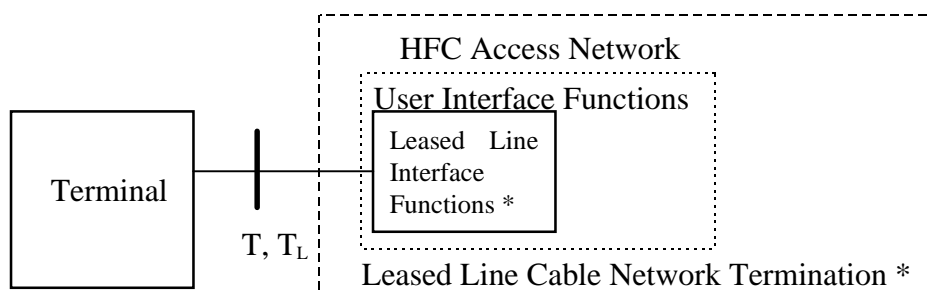


Figure 18: Protocol peer configuration

7.5 Leased Lines UNI



* Analogue or digital

Figure 19: Reference configuration at UNI for Leased Lines

The Leased line UNI is the interface between the HFC access network and a terminal or NT2. The terminal is any service terminal that is supported by the service network(s) that the HFC access network is serving.

The Interface is situated at the T (T_L) reference point.

With regard to basic functions, the service terminal is not different from a same terminal directly connected to the corresponding service network.

There are a number of leased line interfaces standardised.

7.5.1 Interface references

Standard Number	Short title
ETS 300 288	Business TeleCommunications (BTC); 64 kbit/s digital unrestricted leased line with octet integrity (D64U); Network interface presentation
ETS 300 418	Business TeleCommunications (BTC); 2 048 kbit/s digital unstructured and structured leased lines (D2048U and D2048S); Network interface presentation
ETS 300 448	Business TeleCommunications (BTC); Ordinary quality voice bandwidth 2-wire analogue leased line (A2O); Connection characteristics and network interface presentation
ETS 300 449	Business TeleCommunications (BTC); Special quality voice bandwidth 2-wire analogue leased line (A2S); Connection characteristics and network interface presentation
ETS 300 451	Business Telecommunications (BTC); Ordinary quality voice bandwidth 4-wire analogue leased line (A4O); Connection characteristics and network interface presentation
ETS 300 452	Business Telecommunications (BTC); Special quality voice bandwidth 4-wire analogue leased line (A4S); Connection characteristics and network interface presentation
ETS 300 766	Business TeleCommunications (BTC); Multiple 64 kbit/s digital unrestricted leased lines with octet integrity presented at a structured 2 048 kbit/s interface at either or both ends (D64M); Connection characteristics and network interface presentation
ETS 300 686	Business TeleCommunications (BTC); 34 Mbit/s and 140 Mbit/s digital leased lines (D34U, D34S, D140U and D140S); Network interface presentation
ETS 300 687	Business TeleCommunications (BTC); 34 Mbit/s digital leased lines (D34U and D34S); Connection characteristics
ETS 300 688	Business TeleCommunications (BTC); 140 Mbit/s digital leased lines (D140U and D140S); Connection characteristics
ETS 300 689	Business TeleCommunications (BTC); 34 Mbit/s digital leased lines (D34U and D34S); Terminal equipment interface
ETS 300 690	Business TeleCommunications (BTC); 140 Mbit/s digital leased lines (D140U and D140S); Terminal equipment interface
TBR 25	Business TeleCommunications (BTC); 140 Mbit/s digital unstructured and structured leased lines (D140U and D140S); Attachment requirements for terminal equipment interface

7.5.2 User Interface functions - Leased Cable Network Termination

The User interface functions for the leased line services over HFC Access network is fulfilled by a functional group called Leased line Cable Network Termination. The leased line Cable Network Termination fulfils the interface between the network and the User plane functions of TE. Signalling is not an issue.

Leased line user interface functions are limited to core functions.

7.5.3 Protocol stack and peer communication stack reference

This is depending upon the service offered. User information is modulated/demodulated and handled via the Cable MAC function and the cable PMD function transmitted over the HFC transport network, or reverse.

8 Service Node Interfaces (SNI) (Access Node Interface)

8.1 Broadcast Service

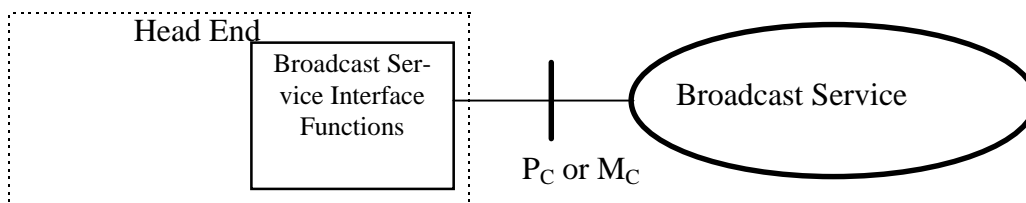


Figure 20: Reference configuration at SNI for Broadcast

This interface has no typical access network interfaces. The interface is identical to the interface on T_C . The interface can be analogue, but may support digital coded information.

8.2 PSTN Service specific Service node

A service specific service node is only dedicated to one single service (ITU-T Recommendation G.902). In this case the interface is dedicated to PSTN.

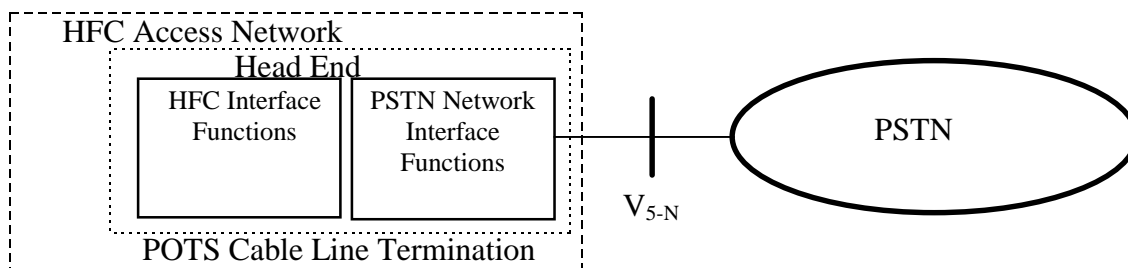


Figure 21: Reference configuration at SNI for PSTN

The $V_{5.1-N}$ interface consists of a 2 048 kbit/s interface as defined in ETS 300 166 and ETS 300 167.

The $V_{5.2-N}$ interface may have between 1 and 16 2048 kbit/s interface links.

Descriptions to be found in ETS 300 324 for $V_{5.1-N}$ and in ETS 300 347 for $V_{5.2-N}$.

8.2.1 Interface references

Standard Number	Short title
G.964 [5] / ETS 300 324	V5.1 Interface
G.965 [6] / ETS 300 347	V5.2 Interface

8.2.2 Network interface functions - PSTN Cable Line Termination

The Network interface functions for the PSTN information over HFC Access network is fulfilled by a functional grouping called PSTN Cable Line Termination. The PSTN Cable Line Termination is located at the Head End.

8.2.3 Protocol stack and peer communication stack reference configurations

8.2.3.1 Protocol stacks

8.2.3.1.1 V5.1_N interface

The following figure shows the protocol architecture for the V5.1 interface. The functions performed are defined as follows (more information can be obtained in the V5.1 recommendation).

- Envelope function sublayer of LAPV5 (LAPV5-EF).
- Data link sublayer of LAPV5 (LAPV5-DL).
- Sublayer-to-sublayer communication and mapping function.
- PSTN signalling protocol specification and layer 3 multiplexing.
- Control protocol.

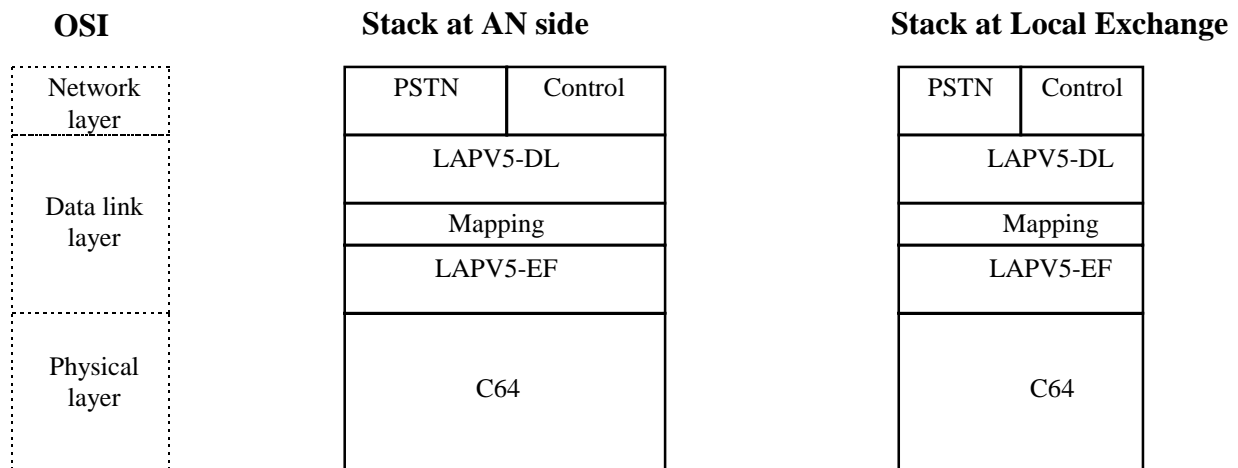
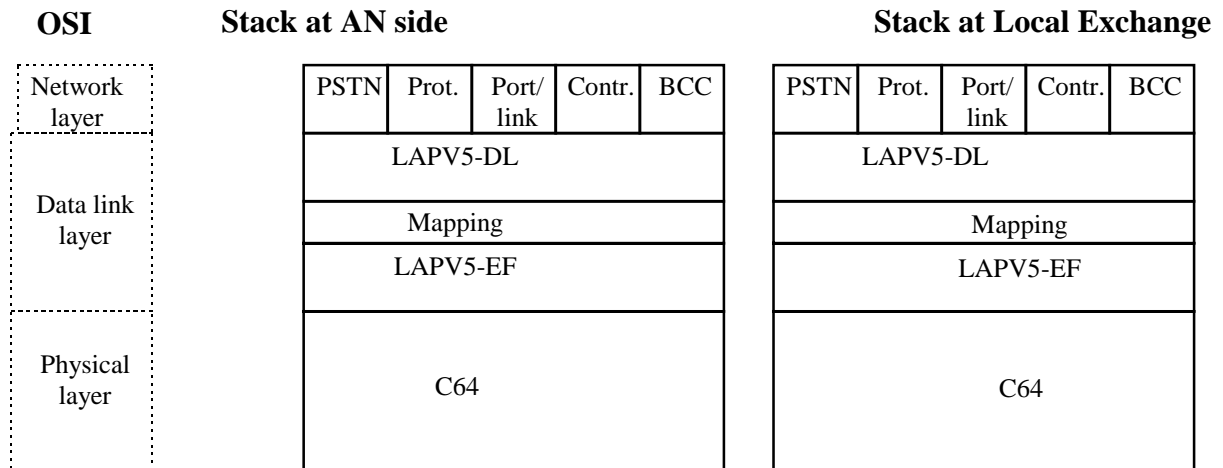


Figure 22: Protocol stacks for V5.1_N for PSTN

8.2.3.1.2 V5.2_N interface

The following figure shows the protocol architecture for the V5.2 interface. The functions performed are defined as follows (more information can be obtained in the V5.2 recommendation):

- envelope function sublayer of LAPV5 (LAPV5-EF);
- data link sublayer of LAPV5 (LAPV5-DL);
- sublayer-to-sublayer communication and mapping function;
- general layer 3 protocol structures;
- PSTN signalling protocol specification;
- control protocol;
- link control protocol;
- BCC protocol;
- protection protocol.

Figure 23: Protocol stacks for V5.2_N

8.2.3.2 Protocol peer configurations

The following figure shows the Protocol peer configuration for the User information for POTS.

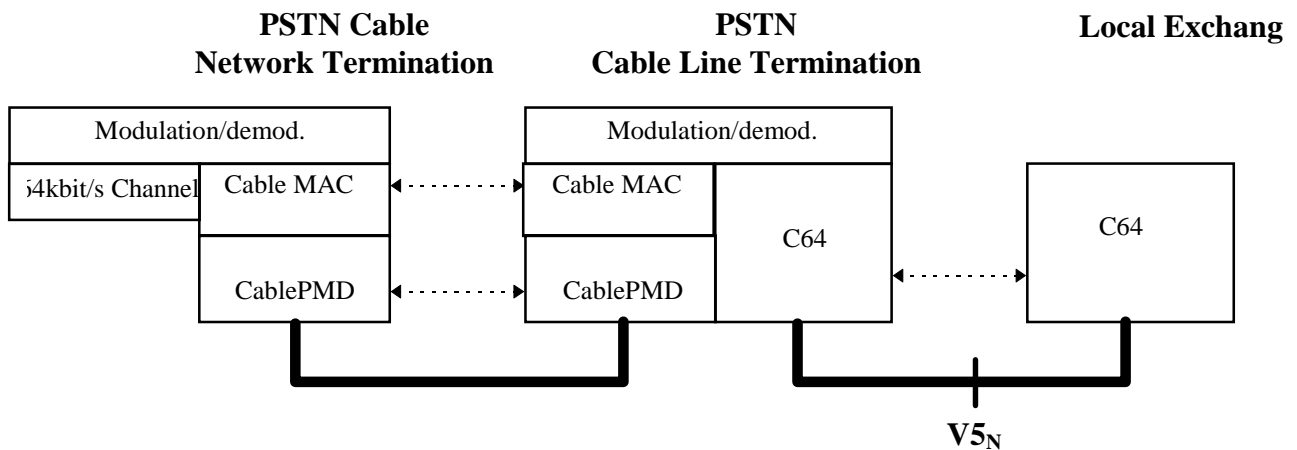


Figure 24: Protocol peer configuration for POTS User information

8.2.3.2.1 V5.1 interface

The following figures show different Protocol peer stack configurations for different contexts.

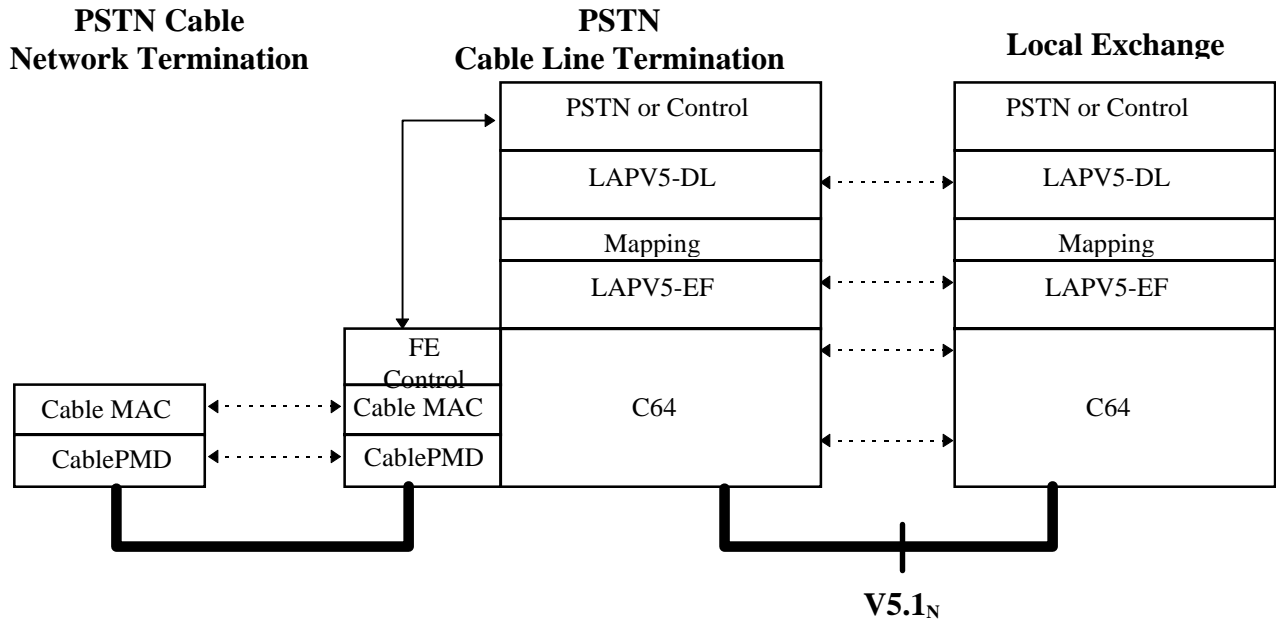


Figure 25: Protocol peer configuration for V5.1_N signalling functions for PSTN signalling

8.2.3.2.2 V5.2 interface

The following figures show different Protocol peer stack configurations for different contexts.

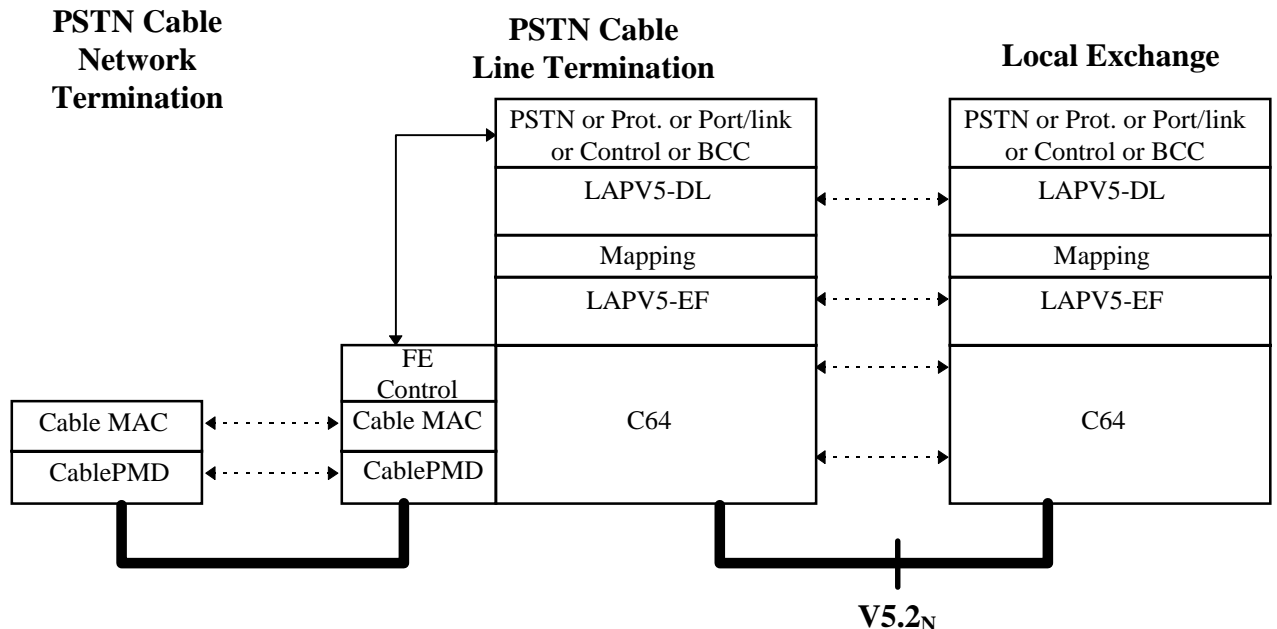


Figure 26: Protocol peer configuration for V5.2_N signalling functions for PSTN signalling

8.3 N-ISDN Service specific Service node

A service specific service node is dedicated to only one service (ITU-T Recommendation G.902). In this case the interface is dedicated N-ISDN services only.

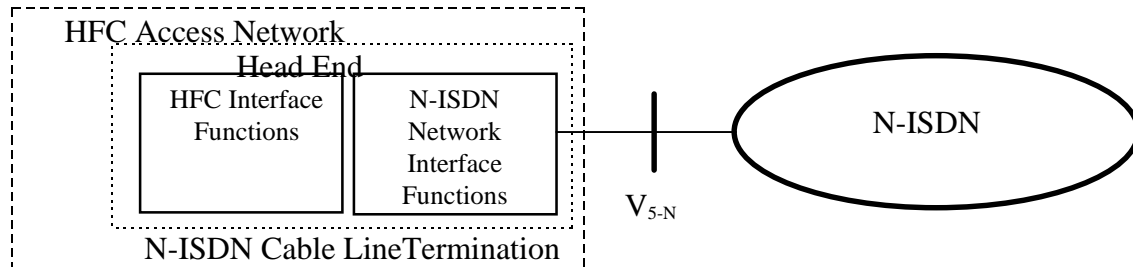


Figure 27: Reference configuration at SNI for N-ISDN

The V5.1_N interface consists of a 2 048 kbit/s interface as defined in ETS 300 166 and ETS 300 167.

The V5.2_N interface may have between 2 048 kbit/s and 16 x 2 048 kbit/s interface links.

Descriptions to be found in ETS 300 324 for V5.1_N and in ETS 300 347 for V5.2_N.

8.3.1 Interface references

Standard Number	Short title
G.964 [5] / ETS 300 324	V5.1 Interface
G.965 [6] / ETS 300 347	V5.2 Interface

8.3.2 Network interface functions - N-ISDN Cable Line Termination

The Network interface functions for the N-ISDN information over HFC Access network is fulfilled by a functional grouping called N-ISDN Cable Line Termination. The N-ISDN Cable Line Termination is located at the Head End.

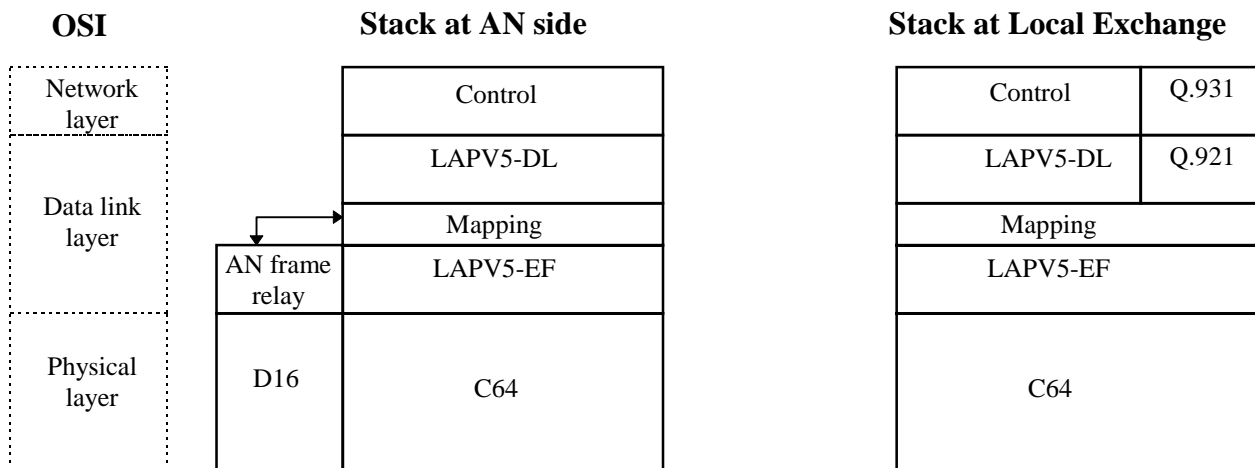
8.3.3 Protocol stack and peer communication stack reference configurations

8.3.3.1 Protocol stacks

8.3.3.1.1 V5.1_N interface

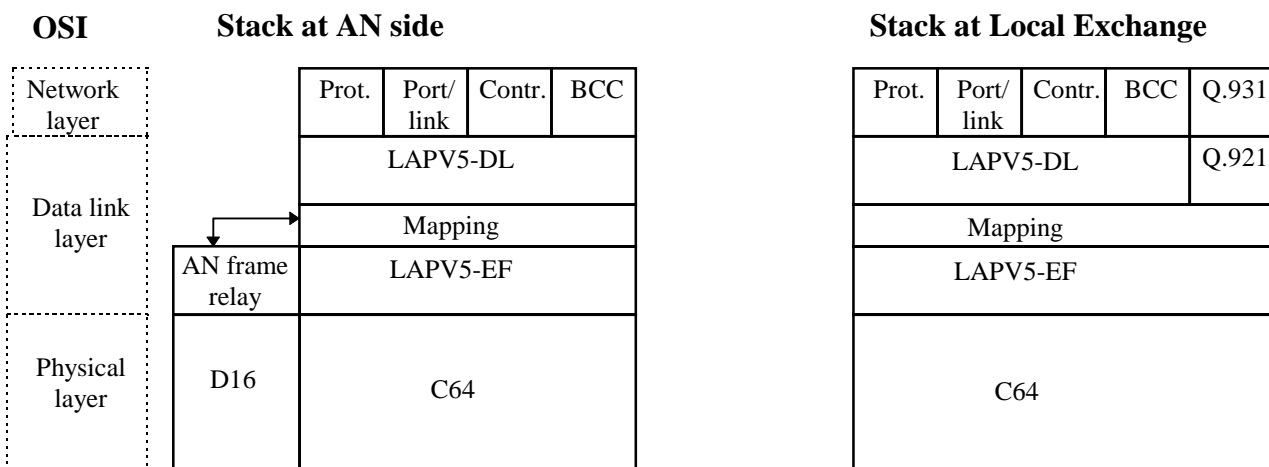
The following figure shows the protocol architecture for the V5.1 interface. The functions performed are defined as follows (more information can be obtained in the V5.1 recommendation):

- envelope function sublayer of LAPV5 (LAPV5-EF);
- data link sublayer of LAPV5 (LAPV5-DL);
- frame relaying sublayer of the AN (AN-FR);
- sublayer-to-sublayer communication and mapping function;
- layer 3 multiplexing;
- control protocol.

Figure 28: Protocol stacks for V5.1_N8.3.3.1.2 V5.2_N interface

The following figure shows the protocol architecture for the V5.2 interface. The functions performed are defined as follows (more information can be obtained in the V5.2 recommendation):

- envelope function sublayer of LAPV5 (LAPV5-EF);
- data link sublayer of LAPV5 (LAPV5-DL);
- frame relaying sublayer of the AN (AN-FR);
- sublayer-to-sublayer communication and mapping function;
- general layer 3 protocol structures;
- control protocol;
- link control protocol;
- BCC protocol;
- protection protocol.

Figure 29: Protocol stacks for V5.2_N

8.3.3.2 Protocol peer configurations

The following figure shows the Protocol peer configuration for the User information for N-ISDN.

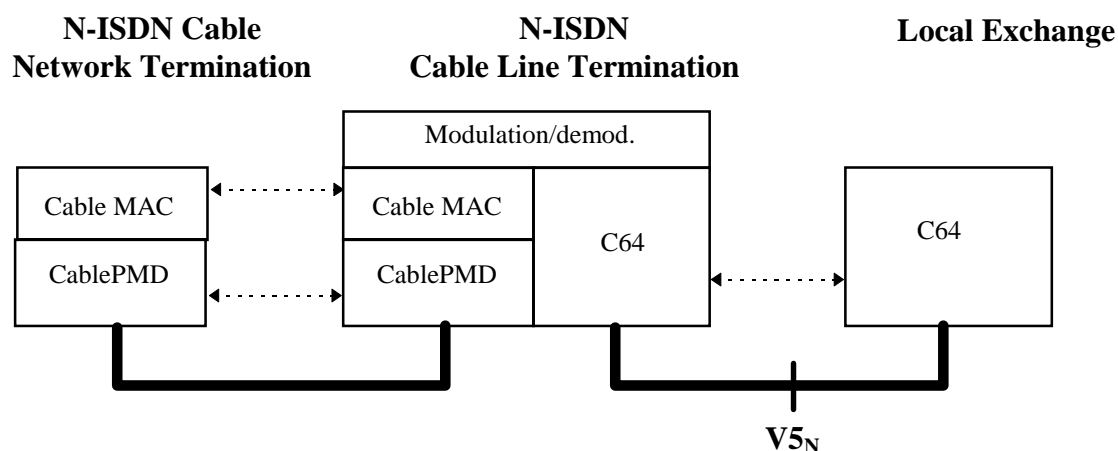


Figure 30: Protocol peer configuration for N-ISDN User information

8.3.3.2.1 V5.1 interface

The following figures show different Protocol peer stack configurations for different contexts.

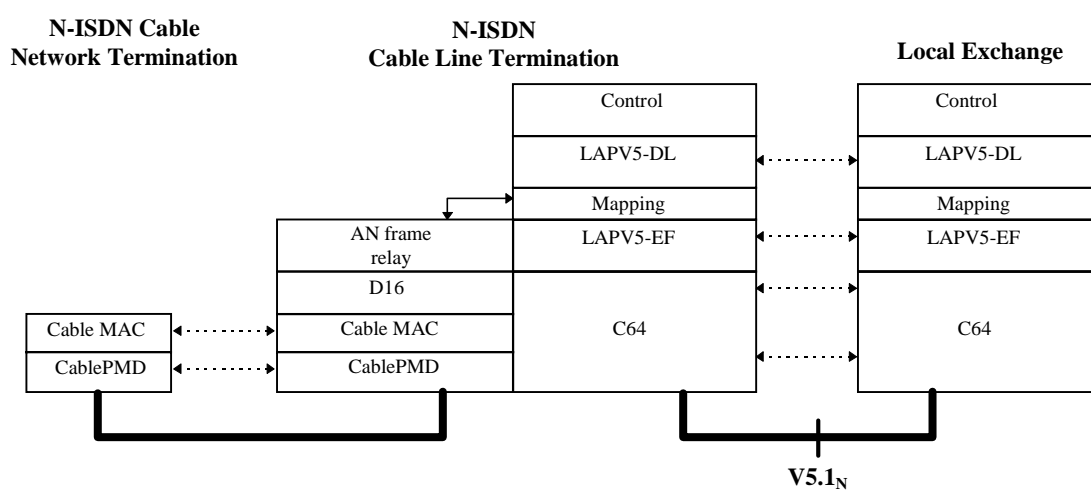


Figure 31: Protocol peer configuration for V5.1_N signalling functions except N-ISDN signalling

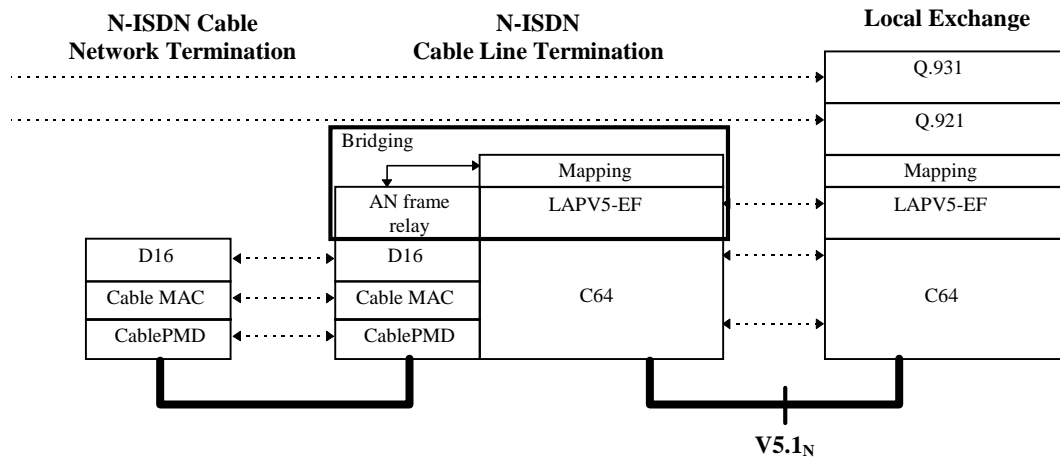


Figure 32: Protocol peer configuration for V5.1_N for N-ISDN signalling

8.3.3.2.2 V5.2 interface

The following figures show different Protocol peer stack configurations for different contexts.

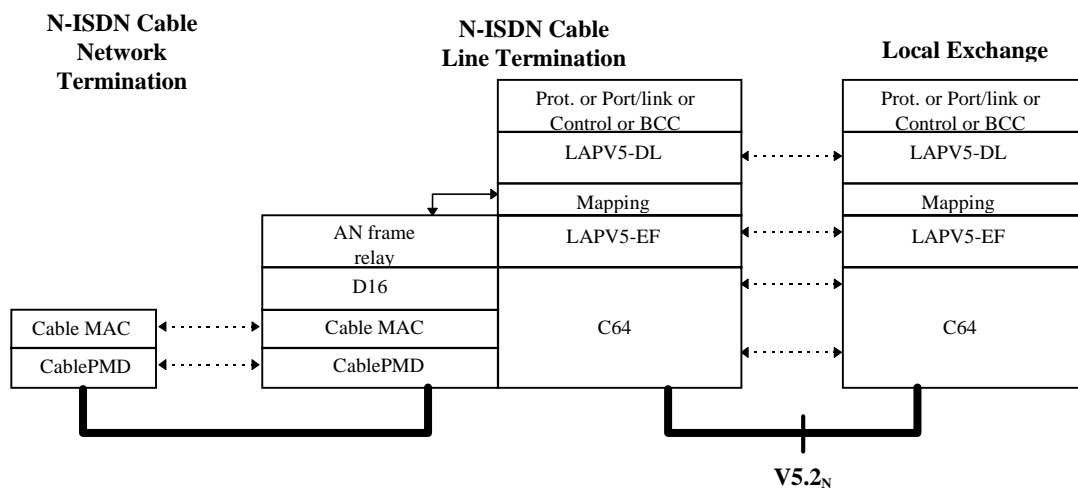


Figure 33: Protocol peer configuration for V5.2_N signalling functions except N-ISDN signalling

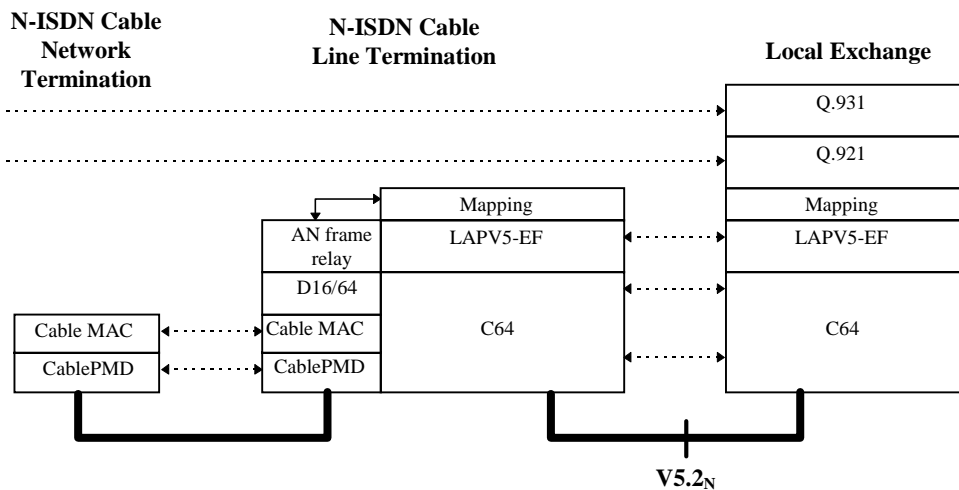


Figure 34: Protocol peer configuration for V5.2_N, for ISDN signalling

8.4 PSTN/N-ISDN Modular Service node

A modular service node may be dedicated to more than one service (ITU-T Recommendation G.902). In this case the interface is dedicated to both PSTN and N-ISDN services.

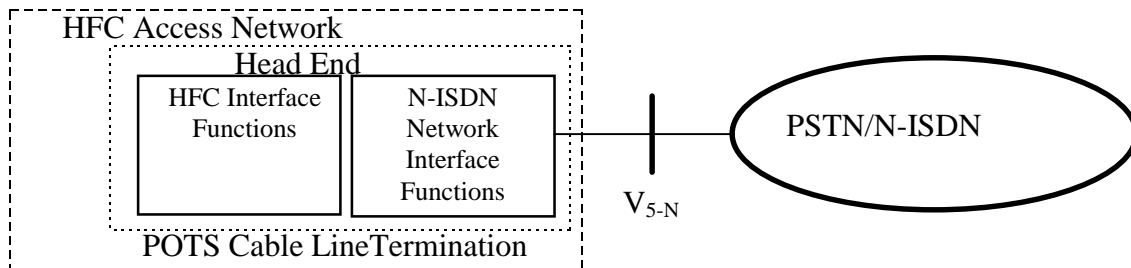


Figure 35: Reference configuration at SNI for PSTN/N-ISDN

The V5.1_N interface consists of a 2 048 kbit/s interface as defined in ETS 300 166 and ETS 300 167.

The V5.2_N interface may have between 1 and 16 2 048 kbit/s interface links.

Descriptions to be found in ETS 300 324 for V5.1_N and in ETS 300 347 for V5.2_N.

8.4.1 Interface references

Standard Number	Short title
G.964 [5] / ETS 300 324	N-ISDN V5.1 Interface
G.965 [6] / ETS 300 347	N-ISDN V5.2 Interface

8.4.2 Network interface functions - PSTN/N-ISDN Cable Line Termination

The Network interface functions for the PSTN or N-ISDN information over HFC Access network is fulfilled by a functional grouping called PSTN/N-ISDN Cable Line Termination. The PSTN/N-ISDN Cable Line Termination is located at the Head End.

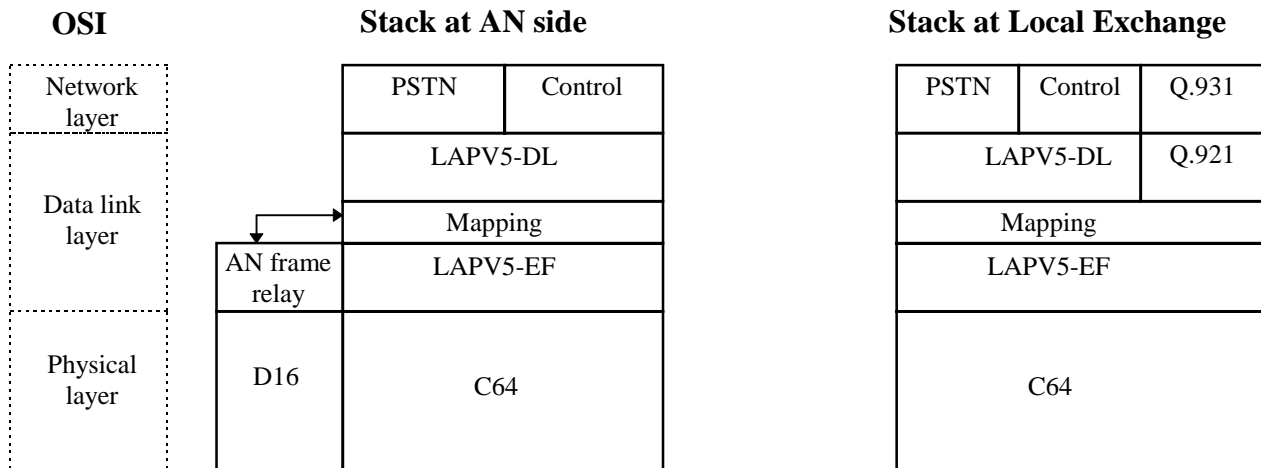
8.4.3 Protocol stack and peer communication stack reference configurations

8.4.3.1 Protocol stacks

8.4.3.1.1 V5.1_N interface

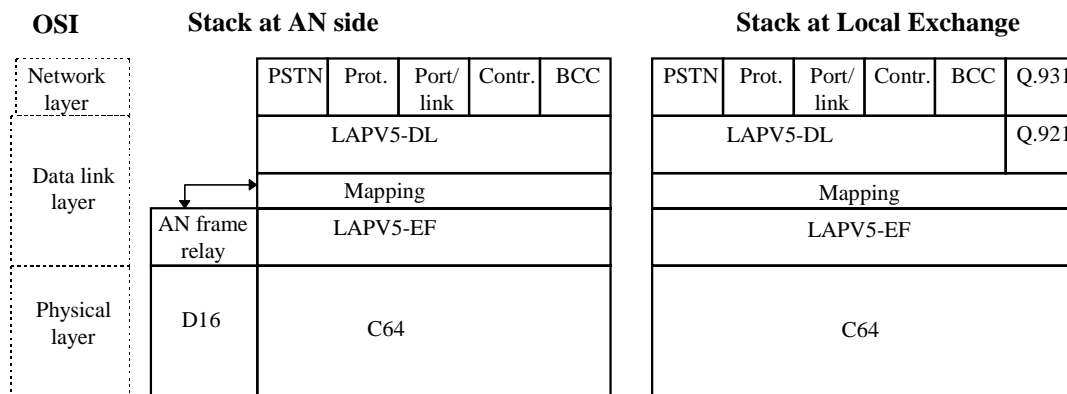
The following figure shows the protocol architecture for the V5.1 interface. The functions performed are defined as follows (more information can be obtained in the V5.1 recommendation):

- envelope function sublayer of LAPV5 (LAPV5-EF);
- data link sublayer of LAPV5 (LAPV5-DL);
- frame relaying sublayer of the AN (AN-FR);
- sublayer-to-sublayer communication and mapping function;
- PSTN signalling protocol specification and layer 3 multiplexing;
- control protocol.

Figure 36: Protocol stacks for V5.1_N8.4.3.1.2 V5.2_N interface

The following figure shows the protocol architecture for the V5.2 interface. The functions performed are defined as follows: (more information can be obtained in the V5.2 recommendation)

- envelope function sublayer of LAPV5 (LAPV5-EF);
- data link sublayer of LAPV5 (LAPV5-DL);
- frame relaying sublayer of the AN (AN-FR);
- sublayer-to-sublayer communication and mapping function;
- general layer 3 protocol structures;
- PSTN signalling protocol specification;
- control protocol;
- link control protocol;
- BCC protocol;
- protection protocol.

Figure 37: Protocol stacks for V5.2_N

8.4.3.2 Protocol peer configurations

The following figure shows the Protocol peer configuration for the User information (for both POTS and N-ISDN).

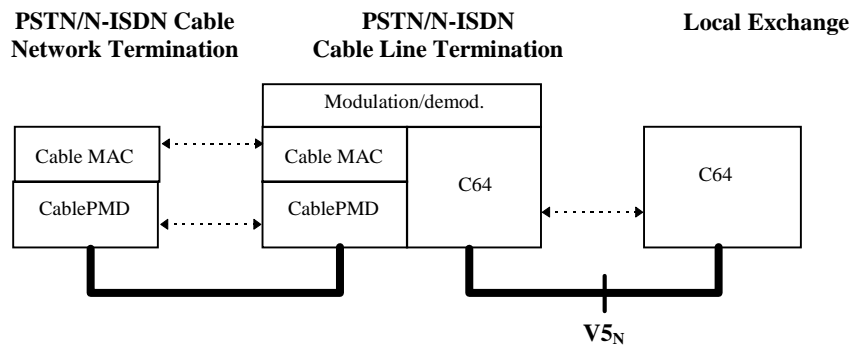


Figure 38: Protocol peer configuration for PSTN/N-ISDN User information

8.4.3.2.1 V5.1 interface

The following figures show different Protocol peer stack configurations for different contexts.

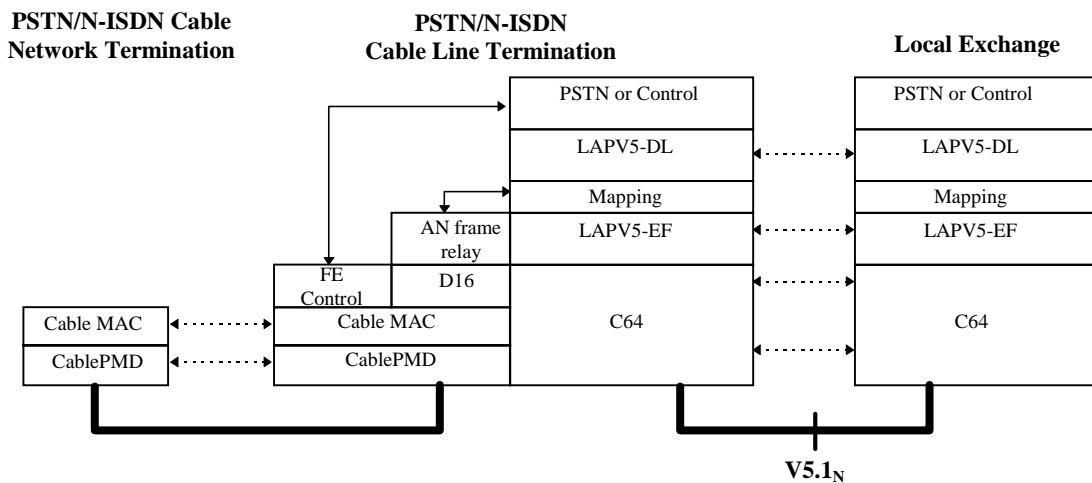


Figure 39: Protocol peer configuration for V5.1_N signalling functions except N-ISDN signalling

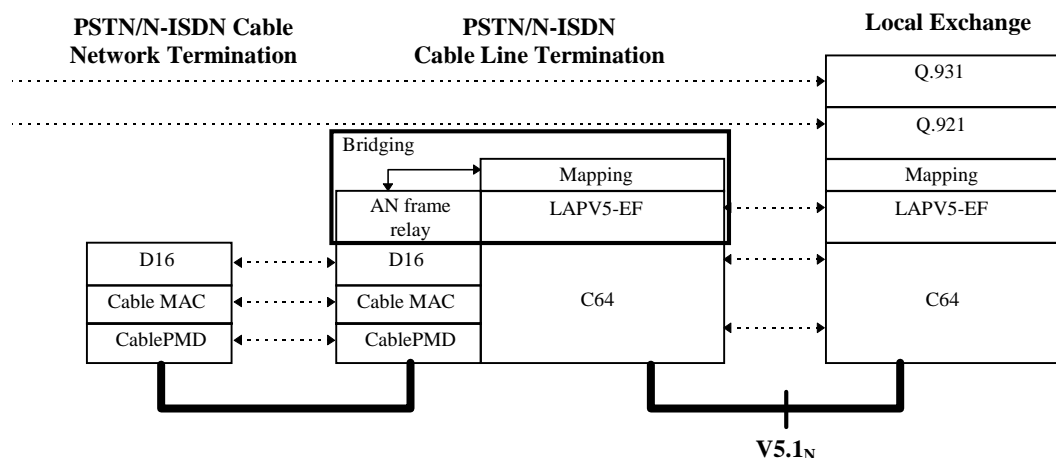


Figure 40: Protocol peer configuration for V5.1_N for N-ISDN signalling

8.4.3.2.2 V5.2 interface

The following figures show different Protocol peer stack configurations for different contexts.

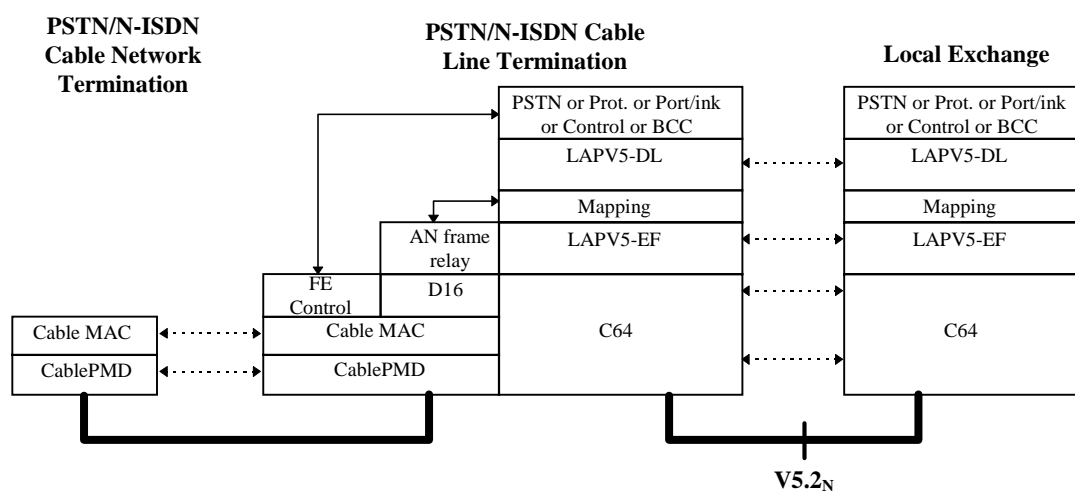


Figure 41: Protocol peer configuration for V5.2_N signalling functions except N-ISDN signalling

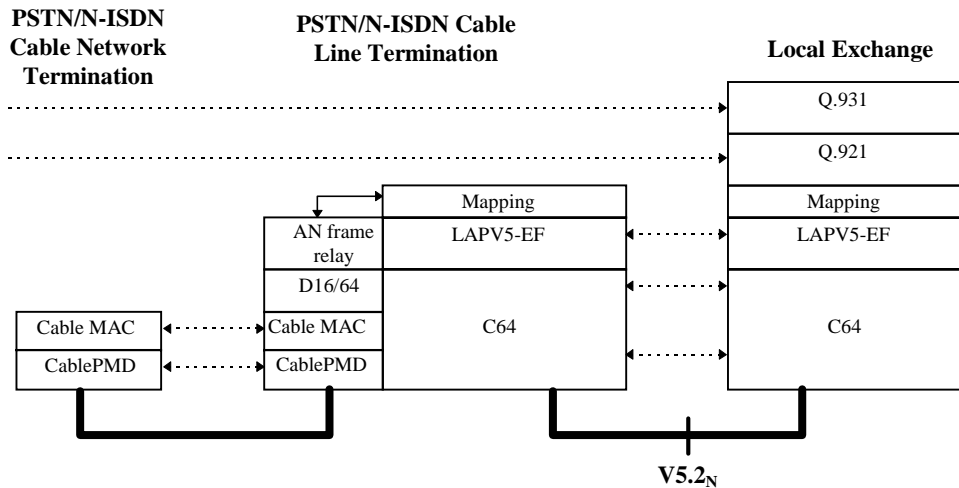


Figure 42: Protocol peer configuration for V5.2_N, for ISDN signalling

8.5 Internet network

The Internet network has the following interface from the access network.

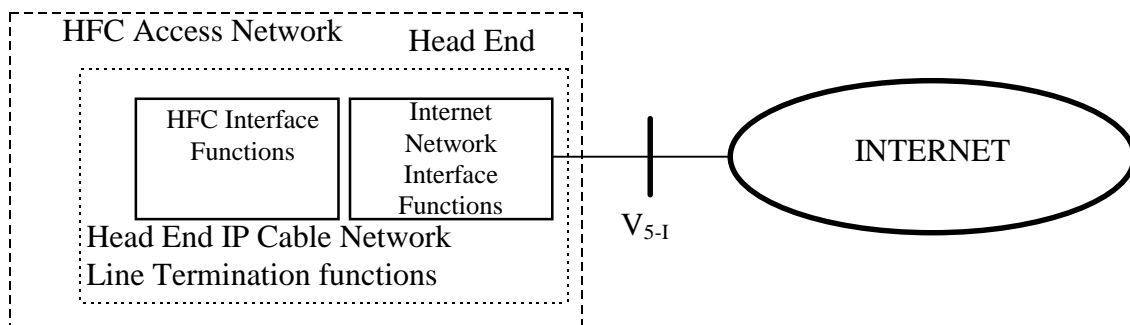


Figure 43: Reference configuration at SNI for Internet

This interface has no typical access network functions. The interface is identical to the interface on T_I (UNI for Internet), but lower layers may differ.

8.5.1 Interface references

Standard Number	Short title
IETF RFC 791	Internet Protocol
IETF RFC 894	IP Datagrams over Ethernet Networks
IETF RFC 1042	IP Datagrams over IEEE 802 Networks
IETF Internet-draft draft-ietf-ipcdn-ipcabledata-spec-00.txt	IP Over Cable Data Network service
ISO/IEC 10038 [7] (IEEE Std 802.1D)	Media Access Control Bridges
ISO/IEC 8802-2 [8]	Logical Link Control
ISO/IEC 8802-3 [9]	CSMA/CD)
ITU-T Recommendation I.361	B-ISDN ATM layer specification
ITU-T Recommendation I.363	AAL layer
ITU-T Recommendation I.432	ATM Physical interfaces

8.5.2 Network interface functions - IP Cable Line Termination

The Network interface functions for the IP data over HFC Access network is fulfilled by a functional grouping called IP Cable Line Termination. The IP Cable Line Termination used at the Head End is called IP Cable Line Termination.

8.5.3 Protocol stack and peer communication stack reference

8.5.3.1 Protocol stacks

There are several methods for computer connection. Some protocol stacks are shown in the following figures.

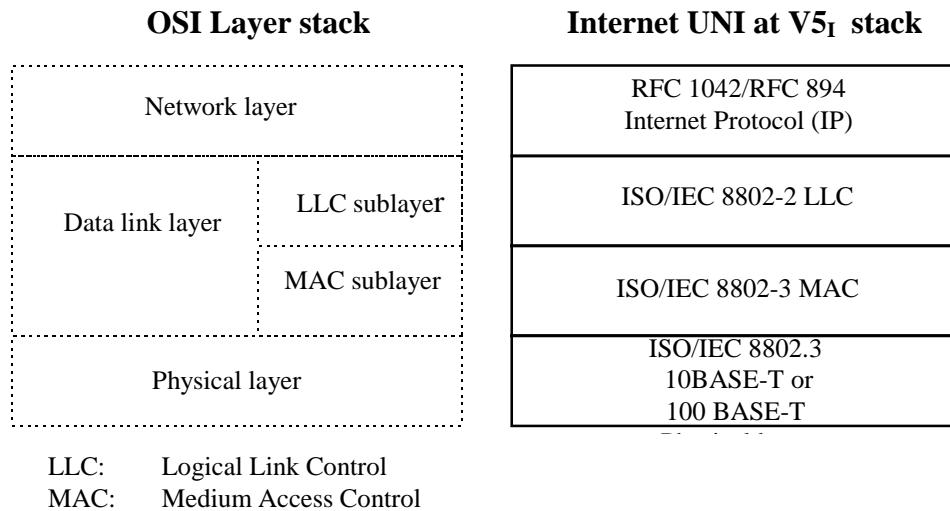


Figure 44: Protocol stack at Internet SNI on V5_I reference point (1)

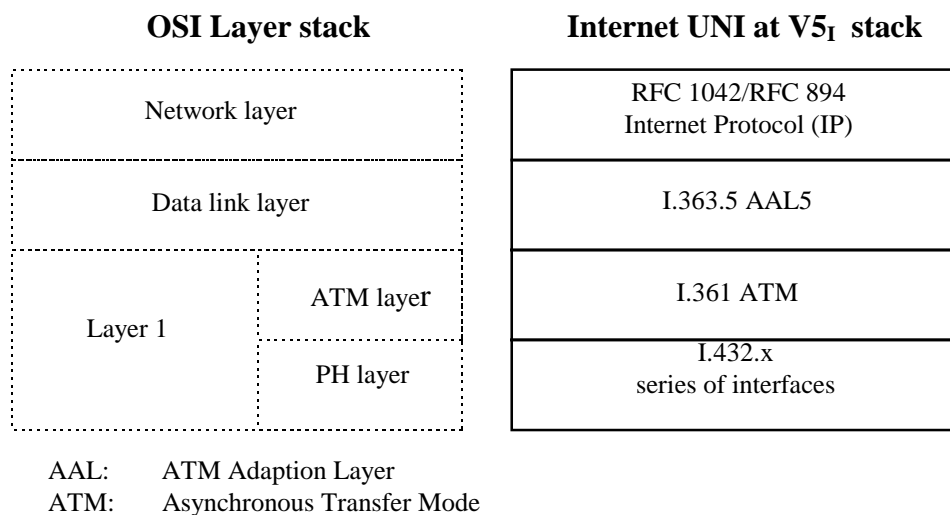


Figure 45: Protocol stack at Internet SNI on V5_I reference point (2)

8.5.3.2 Protocol peer communication

The peer communication stack configuration, from the IP Cable Line Termination viewpoint is given in figure 46.

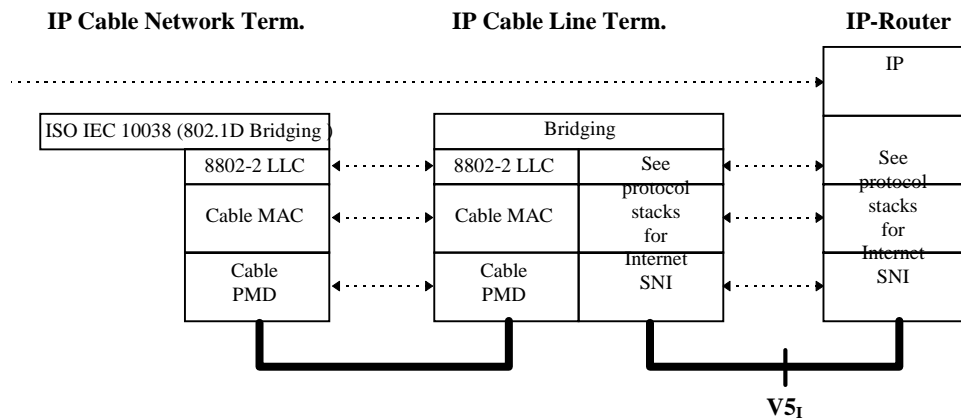


Figure 46: Protocol peer configuration

8.6 Leased lines Specific Service network

At the SNI the HFC Leased line may be connected to a specific service network, dedicated to the particular service, or to a leased line service network. The first case may be found in other subclauses dealing with the particular service network. The second case is handled in this subclause.

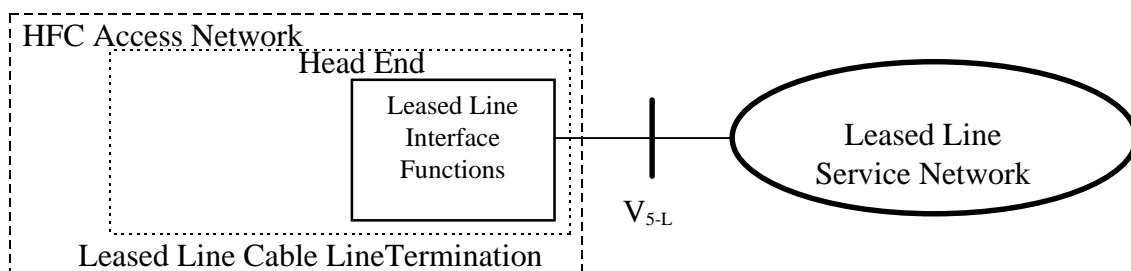


Figure 47: Reference configuration at SNI for Leased line

The V5.1_L interface is not defined in any standard. It is identical to the appropriate T_L.

8.6.1 Interface references

None

8.6.2 Network interface functions - Leased Line Cable Line Termination

The Leased Line Network interface functions for the leased line services over HFC Access network is fulfilled by a functional group called Leased line Cable Line Termination. The Leased Line Cable Line Termination is located at the Head End.

Leased line network interface functions are limited to core functions.

8.6.3 Protocol stack and peer communication stack reference configurations

This is depending upon the service offered. Service information is modulated/demodulated and handled via the Cable MAC function and the cable PMD function transmitted over the HFC transport network, or reverse.

9 Internal HFC Access Network Aspects

9.1 Interface references

Standard Number	Short title
ETS 300 429	DVB; Framing structure, channel coding and modulation for cable systems
ETS 300 800	DVB; Interaction channel for cable TV distribution systems

9.2 Internal HFC Access Network Structure

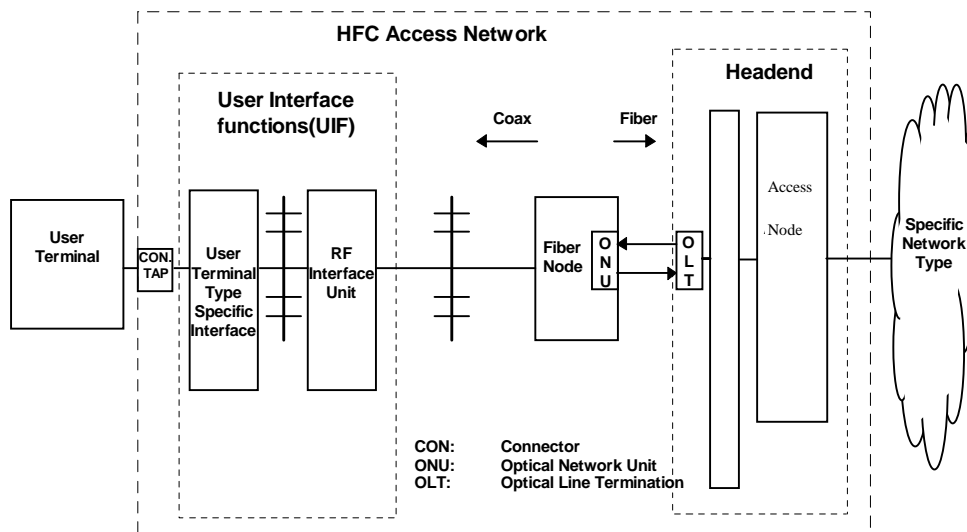


Figure 48: Internal HFC Access Network Structure

The User Interface Functions entity is located at the user side in the HFC Access Network and contains the interface to the User terminal equipment(s).

The Head End entity is located at the network side of the HFC access network, and contains interfaces to the specific telecommunication networks.

The internal HFC access network control communication between User Interface Functions and the Head End is by digital information which is packaged in RF frequencies. The HFC access network (transparent) information communication is also by RF frequencies.

The transmission of RF signals between Head End and User Interface Functions is over an HFC transmission network, partly consisting of fiber and partly consisting of coax. The fibre can go the Cabinet (FTTCab), to the Building (FTTB), to the Curb (FTTC), or to the Home (FTTH). The given optical access networks are described in ITU-T Recommendation G.983.

The Head End contains a combiner/splitter for combination/splitting of the RF frequency bands.

9.3 HFC Access network channel structure and protocols

The channel structure is not standardised all over Europe. There are a number of national specifications describing the channel structure for analogue TV. The channel structure on the fibre/cable for digital TV and the other services is not defined yet in Europe nor international.

The Cable PMD encoding schemes for the different services (except broadcast service) are also open.

The protocols used in the Cable MAC layer are described by the ITU-T Recommendation J.112. In this recommendation 3 standards are described. The 3 standards (Annex A-C) are intended for different regions of the world:

- A: Europe;
- B: North America;
- C: Japan.

The European version (annex A is identical with ETS 300 429 and ETS 300 800).

Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

IETF Internet-draft draft-ietf-ipcdn-ipcabledata-spec-00.txt (1996): "IP Over Cable Data Network service".

TR 101 615: "Network Aspects: Telecommunication Services and Networks Architecture".

ITU-T Recommendation G.983: "High speed optical access systems based on Passive Optical Network".

History

Document history		
V1.1.1	November 1998	Membership Approval Procedure MV 9901: 1998-11-03 to 1999-01-01
V1.1.1	February 1999	Publication