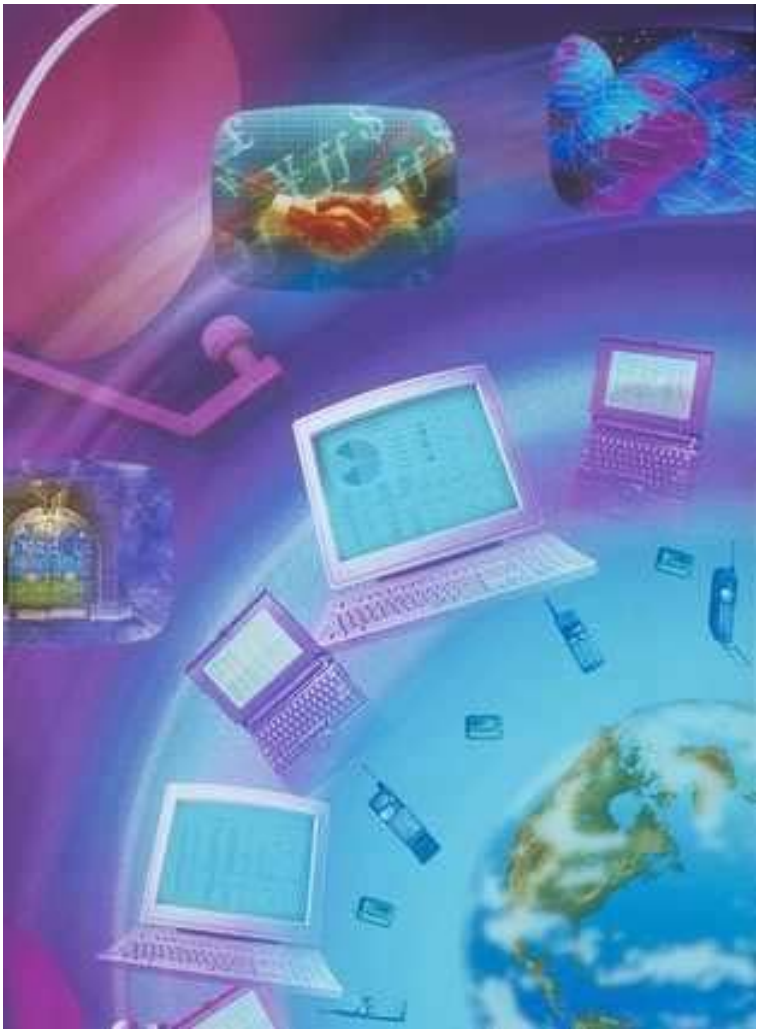
Access Technologies



Interworking

This report is the work of the Q.8 technical group which includes Telecom Services Providers (TSPs) in Switzerland who handle the technological aspects of the interworking between the various broadband access technologies, with OFCOM heading the group.

Final version: 18.04.01

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1 Introduction

The development of new broadband technologies raises new questions and technical challenges. The industry has an interest in finding a common understanding of the new technologies and to analyse the effects of these new developments.

A technical working group was created in Switzerland with the aim of forming a discussion and exchange platform for the industrial requirements concerning the three broadband technologies: CATV, xDSL and WLL.

Participation in the working group was voluntary and open to all telecom services providers (TSP) in Switzerland. Because the working group is a technical platform, discussions were exclusively concerned with technical problems to facilitate technical co-operation.

The output of the working group is the result of a common understanding of technical issues between the participants. The results do not have the status of an obligation.

To ensure technical neutrality and to concentrate on technical questions, OFCOM took the chair of the working group.

The working group focused the discussions on the following main issues:

Architecture of broadband access technologies: It is significant to define a model of reference independent of the type of technology used so that everyone speaks the same language. Thereafter, each examined technology will be introduced into this model of reference to simplify the identification of technical problems.

User Network Interface: The interpretation and relevance of the new Ordinance on Telecommunications Installations (stemming from the European R&TTE directive) for the user network interface (entry into force: 1st May 2000).

Interoperability of broadband services: All traditional interconnection problems were discussed, in relation to the type of service offered including universal service interoperability.

2 Expectations and needs

This report sets out to consider all three broadband access technologies:

- XDSL, the broadband technology for copper wire in the local loop
- CATV, the cable TV network
- WLL, the radio technology.

The demand for broadband services already exists and will strongly increase if the ratio between performance and cost is acceptable and the service supply is attractive. The players in this market are the customers, the service providers and the content providers. The expectations and needs of these three parties are specific and must be fulfilled as far as possible:

- Customers expect attractive and effective services with high quality and low prices, with the quality requirement depending on the customer segment in question
- Service providers need a flexible technology which allows the rapid and economical introduction of new services as well as effective service management to guarantee high service quality
- Content providers need low cost market-oriented services.

The technical aspects of these different objectives should be covered by this document.

With regard to the three access technologies, the crucial requirements are as follows:

- The access network may be based on copper, optical fibre or radio technology
- For common understanding the technical specifications should be based on the ITU-T Y.120 reference model
- Voice, data and video services may be supported over the same technology
- The standards of the user and network interfaces must be determined
- To ensure interoperability, the Points Of Interconnection (POIs) requirements should be defined with the physical layers, protocol layers and services
- Asymmetrical as well as symmetrical bandwidths should be available for downstream and upstream
- Security aspects such as line protection, redundancy and ring topologies should be considered
- An integrated management system based on standards (e.g. Q3, SNMP, CORBA) may be useful.

3 Definitions and terms used

Access Unit Wireless	The access unit wireless is the receiving part at the customer's site and connects the customer premises network (CPN) to local WLL distribution network of the WLL provider. Examples of access units are wireless-phones and WLL antennas.
ADSL	Asymmetric Digital Subscriber Line - modems attached to twisted pair copper wiring that transmit at up to 8 Mbit/s downstream (to the subscriber) and from 16 kbit/s to 640 kbit/s upstream, depending on line distance.
Base Station	The base station is a sender/receiver in the local network of the WLL provider that transmits the signals over radio frequencies to the customer's receiving unit.
Base Station Controller	The base station controller (BSC) is a device in the local WLL network that controls multiple base stations. The BSC is the interface to the core WLL network.
CATV	Community Access Television, also known as Cable TV.
DSLAM	Digital Subscriber Line Access Multiplexer: specifically, a device which takes a number of ADSL subscriber lines and concentrates these to a single ATM line.
Interface	(OIT, art. 2 , para. 1d) Termination point of a telecommunications network used in whole or in part for the provision of telecommunications services, i.e. a physical connection point by which users obtain access to such a network (interface of telecommunications networks used in whole or in part for the provision of telecommunications services), together with its technical specifications.
POTS	Plain Old Telephone Service: the only name recognised around the world for basic analogue telephone service. POTS takes the lowest 3.1 KHz of bandwidth on twisted pair wiring. Any service sharing a line with POTS must either use frequencies above POTS or convert POTS to digital and interleave with other data signals.
SDSL	Symmetrical single pair high bit rate Digital Subscriber Line: Technology to provide symmetrical broadband access up to 2,3 Mbit/s over unshielded twisted copper pairs.
Splitter	Filters which separate high frequency (ADSL) and low frequency (POTS) signals at the network end and the premises end. The splitter prevents mutual interference.
Terminal Station Indoor	The terminal station indoor (TSI) is the network access point at the customer's site. It connects the customer premises network (CPN) to the local network of the WLL provider. It may consist of multiple modules and allows the customer to connect LAN, PBXs, etc.
Terminal Station Outdoor	The terminal station outdoor (TSO) is a sender/receiver device in the local WLL network that transmits signals from/to the base station. It connects a building/campus to the local WLL network.
WLL	Wireless Local Loop - WLL technology connects subscribers to telephone and data services using radio signals instead of fixed lines (copper, coaxial, fibre).
XDSL	xDSL refers to different variations of a technology for digital data transfer over one or two copper line(s).

XDSL Line	Copper line between the subscriber and the supplier of an xDSL service, the transmission speed of which can be enhanced using digital technology.
XDSL modem	The xDSL modem enables the connection between the access network and the local network of the xDSL supplier. The modem generates the signals for transfer over the copper line and thereby enables voice and data transmission.

4 Abbreviations

2B1Q	2 Binary 1 Quaternary
AAL1	ATM Adaptation Layer 1
ABR	Available Bit Rate
ADSL	Asymmetric Digital Subscriber Line
af-phy	ATM Forum Physical Layer Working Group
AINI	ATM Inter-Network Interface Call Control
ATC	ATM Traffic Classes
ATM	Asynchronous Transfer Mode
ATMF	ATM Forum
ATMF25	ATM interface 25.6 Mbit/s at reference Point F
ATM-VPN	Asynchronous Transfer Mode - Virtual Private Network
AU	Access Unit
BA	Basic Access
BBCS	Broadband Connectivity Service
BICC	Bearer Independent Call Control
B-ISDN	Broad Band – ISDN
BRI	Basic Rate Interface
BS	Base Station
BSC	Base Station Controller
CATV	Community Antenna Television
CBR	Constant Bit-rate
CCS7	Common Channel Signalling N.7
CD	Compact Disk
CDMA	Code Division Multiple Access
CES	DS1/DS3 Circuit Emulation (CES)
CLI	Calling Line Identification
COM21	Company name
CORBA	Common Object Request Broker Architecture
CPE	Customer Premises Equipment
CPN	Customer Premises Network
Cu	Copper
DES encrypted	Data Encryption Standard
DHCP	Dynamic Host Configuration Protocol

DOCSIS CMTS	Data Over Cable Service Interface Specification - Cable Modem Termination System
DoV	Data over Voice
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DTS	Draft Technical Specification
DVB-C	Digital Video Broadcasting - Cable
E1	The European equivalent of a T1 circuit. It is a term for a digital facility used for transmitting data over a telephone network at 2.048 Mbps
E3	The European equivalent of a T3 circuit. It is a term for a digital facility used for transmitting data over a telephone network at 34 Mbps.
EN	Euro Norm
ETS	European Telecommunication Standard
ETSI TM6	European Telecommunication Standardisation Institute Transmission & Multiplexing group N.6
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
FDV	Fernmeldedienste Verordnung = Law on telecommunications (LTC)
FR	Frame Relay
FRF	Frame Relay Forum
GII	Global Information Infrastructure
HDLC	High Level Data Link Control
HDSL	High bit-rate Digital Subscriber Line
HF	High Frequency
HFC	Hybrid Fibre Coax
HPF	High Pass Filter
HW	Hardware
IAD	Integrated Access Devices
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IMA	Inverse Multiplexing over ATM
IP	Internet Protocol
IP-VPN	Internet Protocol – Virtual Private Network
ISDN SO	Integrated Service Digital Network
ISO	International Standardisation Organisation
ISP	Internet Service Provider
ISUP	ISDN User Part
ITU	International Telecommunication Union

kbps	kilobits / s
L1	Layer 1
L2	Layer 2
L2TP	Layer 2 Tunnelling Protocol
L3	Layer 3
LAC	L2TP Access Concentrator
LAN	Local Area Network
LLC/SNAP	Link Layer Control /
LNS	L2TP Network Server
LPF	Low Pass Filter
LTC	Loi sur les Télécommunications = Law on telecommunications (LTC)
Mbps	Megabits / s
MHz	Mega Herz
MII	Connector Type
MTP	Message Transfer Part
N/A	Not Available
NFR	Notes on Frequencies
N-ISDN	Narrow Band – ISDN
NNI	Network-Network Interface
NoD	News on Demand
nrt-VBR	Non Real Time Variable Bit Rate
NT	Network Terminal
NTP	Network Termination Point
OFCOM	Federal Office of Communications
OIT	Ordonnance sur les installation de télécommunication = Decree on Telecommunications Equipment
OOIT	Ordonnance de l'OFCOM sur les installations de télécommunication = OFCOM Decree on Telecommunications Equipment
OST	Ordonnance sur les services de télécommunication = Decree concerning Telecommunication Services
PAM	Pulse Amplitude Modulation
PBX	Private Branch Exchange
PC	Personal Computer
PE	Phone Equipment
PLC	Power Line Communication
PoI	Point of Interconnection
PoS	Packet over SONET

POTS	Plain Old Telephone Service
PPPoA	PPP over ATM
PPPoE	PPP over Ethernet
PRI	Primary Rate Interface
PSTN	Public Switched Telephone Network
PVC	Permanent Virtual Connection
Q.8	Question number 8
Q3	Management interface standard according TMN-Reference Model ITU M.3010
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase-Shift Keying
R&TTE	Radio & Telecommunication Terminal Equipment
RBE	Routed Bridge Encapsulation
REN	Ringer Equivalent Number
RF	Radio Frequency
RFC	Request for Comment
RITL	Radio in the Loop
RJ11	Connector specification
RJ45	Connector Type
rt-VBR	Real Time Variable Bit Rate
SAP	Service Access Point
SCCP	Signalling Connection Control Part
SCTP	Steam Control Transmission Protocol
SDSL	Symmetrical single-pair high bit-rate Digital Subscriber Line
SIP	Session Initiation Protocol
SNAP	Sub-Network Access Protocol
SNMP	Simple Network Management Protocol
SO	ISDN S-bus interface
SONET	Synchronous Optical Network
SR	Systematische Sammlung des Bundesrechts (Collection of Federal Laws)
SS#7	Signalling System Number 7
STE	Service Termination Equipment
STM1	Synchronous Transport Module Level 1 (155 Mbit/s)
SVC	Switched Virtual Connection
SW	Software

TA	Terminal Adaptor
TCAP	Transaction Capability Application Part
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TS	Technical Standard
TSI	Terminal Station Indoor
TSO	Terminal Station Outdoor
TSP	Telecom Services Provider
TSP	Telecom services provider
TV	Television
UBR	Unspecified Bit Rate
UC-PAM	Ungerboeck Pulse Amplitude Modulation
UMTS	Universal Mobile Communication System
UNI	User Network Interface
USB	Universal Serial Bus
VBR	Variable Bit Rate
VDSL	Very High Speed Digital Subscriber Line
VoD	Video on Demand
WLL	Wireless Local Loop
xDSL	Family of Digital Subscriber Line technologies

5 References

ADSL Forum
ATM Forum
ITU-T Recommendation Y.120
Broadband Access Technologies (Albert Azzam, Niel Ransom)
XDSL standardisation (asut-bulletin 5/99, Angus R. Carrick)

6 Mandate of the Q.8 working group

6.1 Mandate

The following points were discussed by the new working group “Broadband access technology interworking”:

a) General:

- Definitions, terms used
- Reference model if necessary (independent of the technology used)
- Evaluation of industry requirements for broadband services (List of requirements)

b) User Network Interface:

- Application of the new decree on telecommunications equipment which includes:
  - observation of the new technical and administrative specification entitled “Technische und - administrative Vorschriften betreffend die Schnittstellen von Fernmeldenetzen” (Technical and administrative regulations concerning telecommunications interfaces)
  - localisation of possible Network Termination Points
  - publication rules of the user network interfaces (UNI)

c) Interoperability of services in relation to broadband technologies (obligation only for universal service):

- Standards for the interconnection interfaces between the TSPs
- Points of interconnection (only technical aspects)
- Identification of the services for which the interworking is ensured at the interconnection interfaces
  - Issues related to carrier selection and pre-selection (for voice services)
  - Issues related to number portability (for voice services)
- Adaptation of the catalogue of recommended interconnection interfaces (Art. 35 OST in relation to art. 11, paragraph 2, LTC).

6.2 Subjects which are not part of the discussions

The following subjects are not part of the discussions held by the group and will not be supported by OFCOM:

- Total physical unbundling at the local exchange level
- Issues related to the dominance of the TSP
- Cost-related issues
- Transparency and non discrimination of the offers
- All commercial issues

6.3 Organisation of the project

Number of the question:	Q.8
Name of the working group:	“Broadband access technology interworking”
Rapporteur:	OFCOM, Michel Donzé, TC/FG section
Participants:	All TSPs are invited
Decision taking:	Unanimity of the participants
Publication of the results:	In the form of a final report
Regular information to the TSPs:	Plenary meetings
Frequency of meetings:	Every 3 weeks or to be defined
Location of meetings:	OFCOM or to be defined
Communication:	By e-mail
Language:	Mother tongue of the participants
End of the project:	Presentation of final report of working group at a plenary meeting

Part one: Architecture

7 Reference model independent of the technology used

The reference model which is independent of the type of technology used and represented below is based on the model described in the ITU Y.120 recommendation. This recommendation describes a set of techniques that can be used to graphically illustrate configurations of a variety of network technologies and user appliances that may be expected to be encountered in the context of the Global Information Infrastructure (GII). The term "scenario" has been adopted to denote a combined graphical and textual representation of such a configuration.

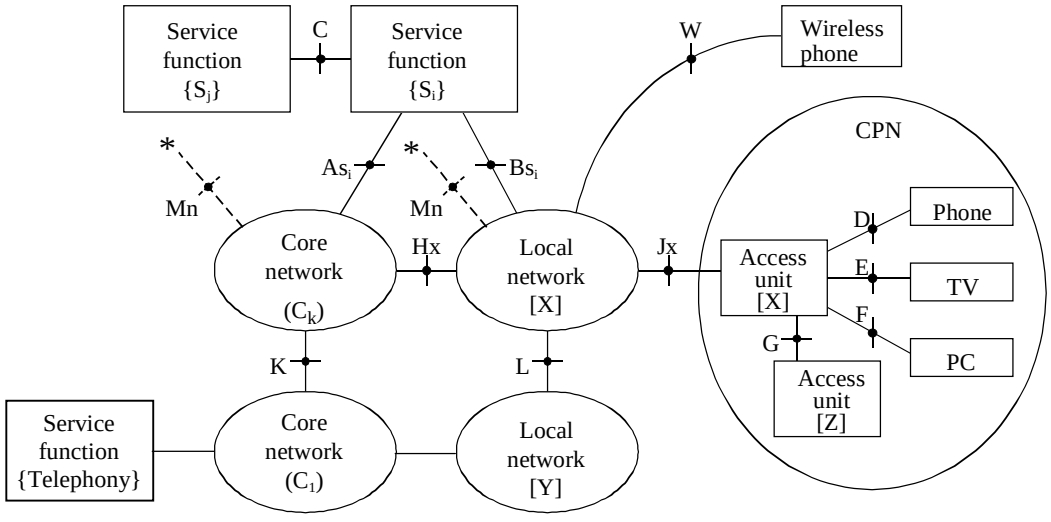


Figure 1: Reference model

Components:

– Service function: such as video server and video service provider for video services, and IP router and point of presence for Internet services.

– Core network: such as telecommunication network, PSTN, N-ISDN, B-ISDN, IP, etc.

– Local network: such as CATV network, ADSL/VDSL, fibre network, RITL, satellite and including access networks as described in ITU recommendation Y.120.

– Customer Premises Network (CPN): such as access unit, TV, PC, phone, wireless phone.

$\{S_i, S_j^*\}$ refers to the type of services.

(C_k, C_l^*) refers to the core network technology.

[X, Y*] refers to the local network technology (access technology).

Interface points:

Interface	Description
As	Between the service function and the core network (s: type of service)
Bs	Between the service function and the local network (s: type of service)
C	Between service functions
W	Terminal interface for wireless phone
D	Terminal interface for phone
E	Terminal interface for TV
F	Terminal interface for data equipment (PC, IP phone, etc.)
G	Interface between access units
Hx	Interface between core network and local network (x: type of access technology)
Jx	Interface between local network and CPN (x: type of access technology)
K	Interface between core networks
L	Interface between local networks
Mn	Interface between core/local network and management network (n: type of network)

Table 1: Different interface points

The following stage sets out to define a scenario for each of the four broadband access technologies which are ADSL, SDSL, cable-modem and WLL.

7.1 Priority of the interfaces in the reference model

The next stage is to define the priority interfaces on this reference model. The highest priority interfaces will be described for each technology. We will refer to existing standards or try to reveal the priority interfaces or the state of work in the standardisation groups.

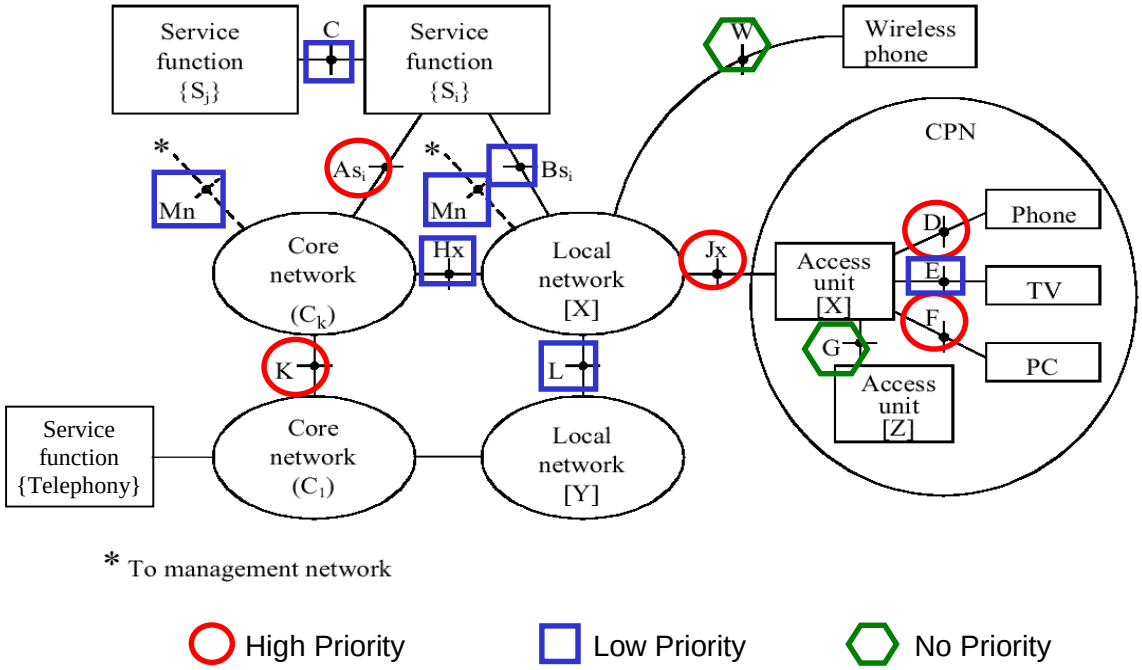


Figure 2: Priority of the interfaces in the reference model

Priority of the interfaces:

Interfaces with high priority

- As: Interface between Core Network and (Internet) Service Function / (I)SP
- D: Interface between Access Unit (Modem) and phone
- F: Interface between Access Unit (Modem) and data equipment
- Jx: Interface between Local Network and Access Unit (Modem)
- K: Interface between Core Network and Core Network

Interfaces with low priority

- Bs: Interface between (Internet) Service Function / (I)SP and Local Network
- C: Interface between (Internet) Service Functions / (I)SPs
- E: Interface between Access Unit (Modem) and TV
- Hx: Interface between Core Network and Local Network
- L: Interface between Local Network and Local Network
- Mn: Interface between Core / Local Network and Management Network

Interfaces with no priority

- G: Interface between Access Units (Modems)
- W: Interface between Local Network and Wireless Customer Access

8 Broadband access technologies

8.1 Digital Subscriber Line technologies (xDSL)

xDSL is a technology launched by telephone companies to provide next generation high bandwidth services for business and residential customers. The same copper wires carrying telephony can also be used to carry high-speed data and the amount of data that can be sent is dramatically increased. On the other hand the telephone switching systems and their trunks are spared data calls with long holding times.

There are different Digital Subscriber Line (DSL) techniques available and selection must be made according to requirements. If a much higher bit-rate is required for the downstream than for the upstream, an asymmetrical DSL technique such as ADSL or VDSL is preferred. For an equal bit-rate in both directions a symmetrical technique such as HDSL or SDSL is preferred. Depending on the loop length, DSL systems can provide bit-rates from 144 kbit/s up to 8 Mbit/s and even higher - up to 52Mbit/s is a planned target for VDSL.

The copper access network was originally developed for voice transmission in the frequency range from 0 to 4 kHz. Today it is used additionally for data transmission with high bit-rates using xDSL technologies. As the used frequency range was dramatically extended (at present up to 1.1 MHz) the transmission capacity of xDSL based systems is heavily dependent on the distance of the line and is also very sensitive to crosstalk. With a fixed distance the transmission capacity of a certain system on a twisted pair is critically dependent on the type of systems running on neighbouring pairs. It must be mentioned that the mutual influence of identical systems (e.g. ADSL on ADSL) is usually considerably smaller than the influence between different systems (e.g. HDSL on ADSL). Consequently it is obvious that the development of a "Spectrum Management" concept is essential: Specific rules for the optimal penetration of the different technologies must be set up, e.g. the penetration of each technology in one cable.

8.1.1 ADSL technology

As its name implies, ADSL transmits an asymmetric data stream with a much larger bit-rate going downstream to the subscriber and a much lower rate on the upstream. ADSL has to coexist with POTS/ISDN on the same pair. A POTS- or ISDN-splitter consisting of a low-pass filter (LPF) and high-pass filter (HPF) separates the telephone signal from the broadband data signal. In the downstream direction (towards the subscriber), it provides a capacity up to 8 Mbit/s, while in the upstream direction it provides up to 640 kbit/s. In general, the maximum ADSL rate depends upon the distance covered, wire diameter and interference (for uniform cable sections). ADSL technologies use a much larger range of frequencies and allow a greater bandwidth over the copper cable than traditional telephone services.

Overview of some ADSL characteristics:

Characteristic	Description
Definition	ADSL = Asymmetric Digital Subscriber Line
Technical Description	Modem technology on twisted copper pairs
Bit-rate	• Downstream: up to 8 Mbit/s • Upstream: up to 640 kbit/s → see figure 3
Distance Limit	Up to 8 km; longer distances result in lower bit-rates → see figure 3
Security	Relatively high security if no line sharing. Security against monitoring for DSL is generally high, depending on the coded signals.
Quality	Mechanism to discriminate between different qualities of service are for further study
Interface on CPE	E.g. ISDN S0, POTS with restrictions, Ethernet 10BaseT, ATMF25, etc.
Shared use of the copper line	Shared use of the copper line by different providers is possible, e.g. for voice and data
Mobility	The subscriber line has no mobility
Shared Media	No shared media

Table 2: Some technical characteristics of ADSL

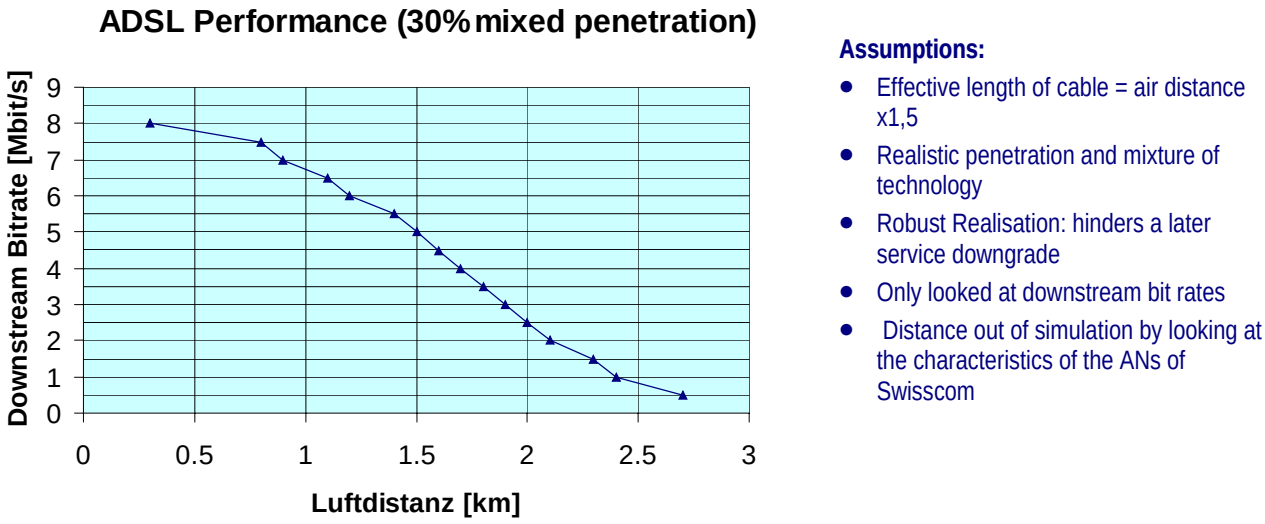


Figure 3: Bit-rate dependence on distance for ADSL-Technology

8.1.1.1 Scenario of ADSL architecture

Based on the ITU-T Recommendation Y.120, a logical and physical reference model are developed:

Logical representation:

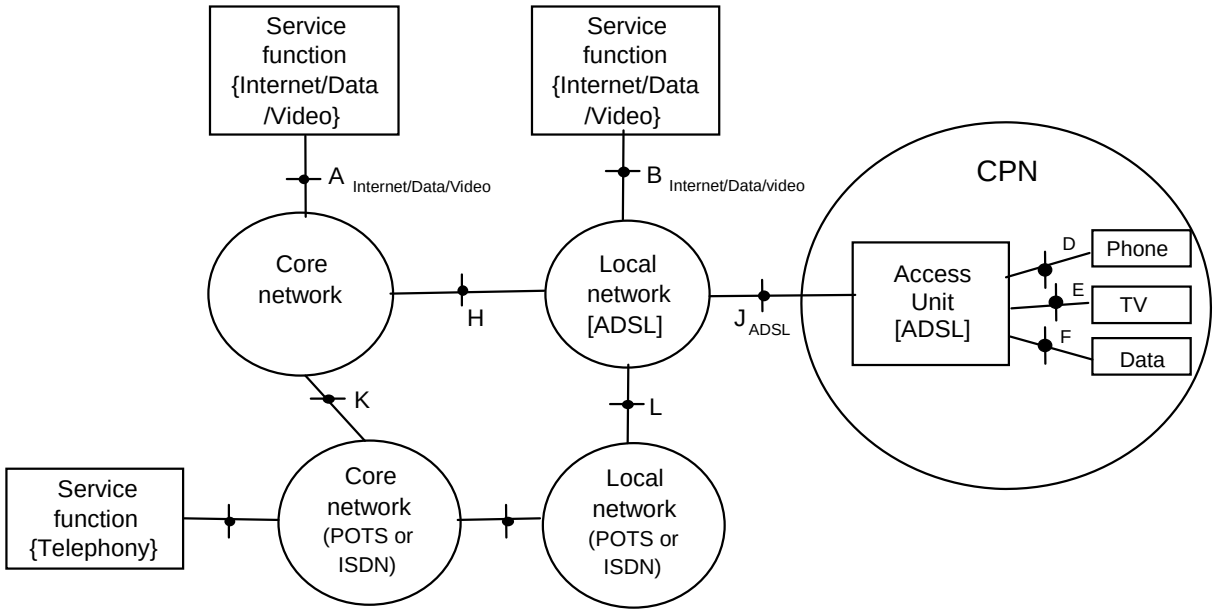


Figure 4: Provision of broadband services over ADSL, logical representation

Physical representation:

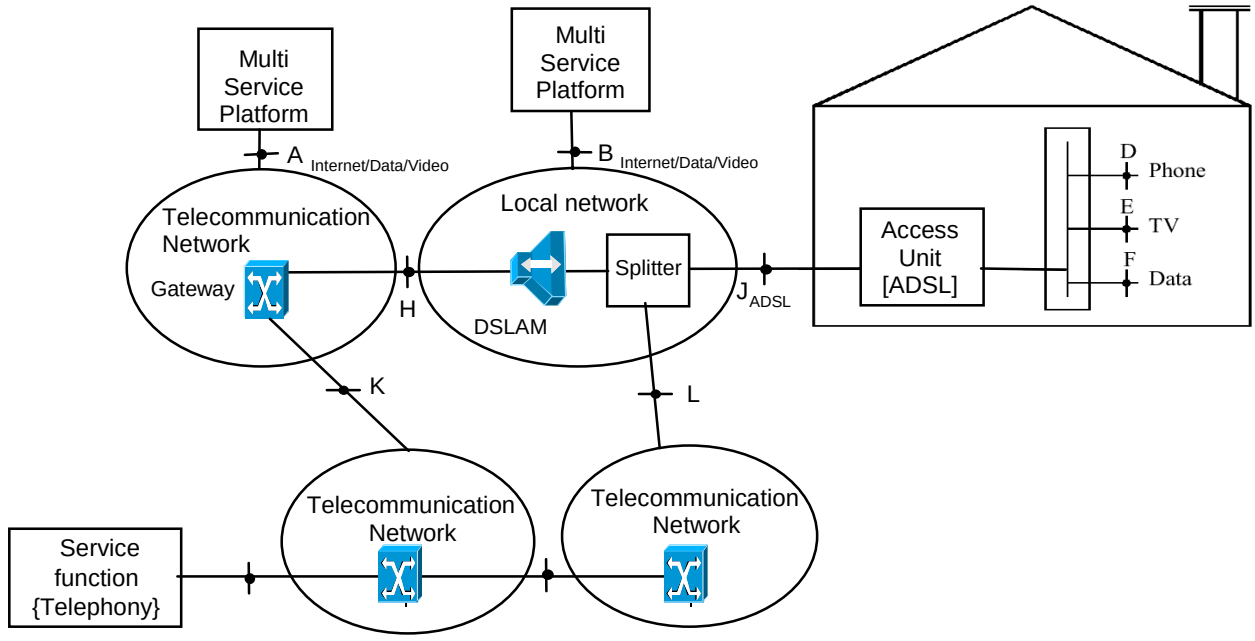


Figure 5: Provision of broadband services over ADSL, physical representation

Explanation of the figures:

Element	Description
Access Unit	The Access Unit is composed of an ADSL modem for the data traffic and a splitter to separate voice and data traffic (additional functions could be integrated)
Splitter	The splitter allows the separation of voice and data traffic
DSLAM	The Digital Subscriber Line Access Mulitplexer allows multiplexing of data traffic from digital subscribers to the network and demultiplexing of data traffic from the network towards the digital subscriber. In this case it supports only ADSL technology
Gateway	Entry and/or exit point in a network
Local Network	The local network is able to transport the broadband data traffic from the customer premises to the telecommunication network (e.g. IP) using ADSL connections
Telecommunication Network	The telecommunication network is a network capable of delivering different services, e.g. ATM, IP, digital telephony services, etc.
IP Router (for Multi Service Platform)	The IP router provides access to the service function of service providers, such as Internet access and video services
Telephony Service Function	The telephony service function concerns voice services only

Table 3: Explanation of the network elements for ADSL

8.1.1.2 Location of possible Network-Network Interfaces (NNI) for ADSL

Location of possible NNI	Applicable Standards
A	ATM based: - L1: E1, E3, STM-1, STM-4; - L2: UNI4.0, PVC only (with ATC) IP based: - L1: E1, E3, STM-1, STM-4, STM-16, IEEE 802.3 - L2: PPP, RFC 1483, L2TP - L3: IP with Class of Service (CoS), possibly some parameters for negotiation of QoS
K	TDM ATM IP

Table 4: Location of possible NNI for ADSL

8.1.1.3 Possible Network Termination Points / User Network Interfaces

NTP / UNI	Applicable Standards
D	POTS, ISDN-BA
F	Ethernet 10 Base T (IEEE 802.3), ATMF 25, USB
J	ADSL (ETSI TS 101 388 V1.1.1 FDD, ITU G.992.1)

Table 5: Possible Network Termination Points / User Network Interfaces for ADSL

8.1.1.4 Possible services with ADSL

- Fast Internet access
- Fast file transfer
- Fast remote access service
- Audio (CD quality)
- Video applications (VoD, NoD, videoconference, home shopping, medical video, ...)
- Gaming
- Education
- IP-VPN, ATM-VPN

8.1.1.5 Technical description of the interfaces and standards

8.1.1.5.1 The A interface

The A Interface from the network operator to the Service provider is provided on Layer 1 by a Rj45, 40-pin MII connector or any physical ATM Interface.

The Service Access Point is based on Ethernet according to IEEE 802.3, ATM PVC based on RFC 1483 LLC (routing configured between the DSL router and the PE or using the IETF emerging technology RBE) or according to the ATMF UNI4.0.

Physical interfaces: Ethernet, E1, E3, STM-1 or STM-4

Logical interfaces: IP, PPP, L2TP, ATM PVC without signalling

Services:

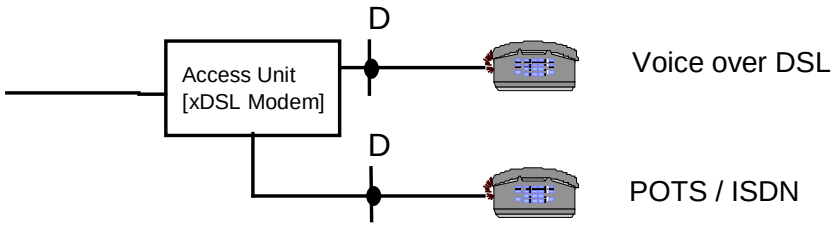
IP Services	IP routing
ATM Services	UNI4.0, PVC with ATC(i.e : UBR, CBR, VBR,...)

Standards:

- Ethernet — IEEE 802.3
- IP — RFC 791, RFC 2661 (L2TP), RFC 2364 (PPPoA), RFC 2516 (PPPoE)
- ATM/Layer 1 — RFC 1483 LLC (routed or bridge solution), ITU-T G.703, G707, G.804, I.363.1, I.363.5

8.1.1.5.2 The D_{Phone} interface (subscriber interface)

The drawing below illustrates two variants of D interfaces:



Possible interfaces are POTS / ISDN-BA or Voice over DSL. Connector type is RJ11 on micro filters for POTS or supplier specific connectors in the case of splitter configurations (POTS and ISDN-BA) or with an integrated access device (IAD).

Physical interface: RJ11/RJ45 connector

Logical interfaces: Signalling for POTS and ISDN

Services: POTS and ISDN-BA Services

Standards: POTS: Network Specific
ISDN: ITU-T I.430

Restrictions: The following services are not possible for POTS / ISDN-BA in parallel with ADSL on the same copper pair:

- Data over voice such as alarm systems, telemetry, etc.
- Taxpulse 12 kHz
- Payphone and publiphone
- Analogue ports of ISDN-NT cannot be used for ADSL over POTS

8.1.1.5.3 The F_{data} interface (subscriber interface)

The physical interface for asymmetrical data is Ethernet 10BaseT (IEEE 802.3) or USB. The logical connection is PPPoE (RFC 2516), PPPoA (RFC2364 LCC Encapsulation) or IP (RFC 791). Connector type is RJ45.

Physical interface: Ethernet 10BaseT, USB, ATMF25

Logical connection:

- Data traffic PPPoE, PPPoA, IP
- VoIP traffic SIP (Session Initiation Protocol; RFC 2543) or alternatively H.323

Services: IP Services,

Standards: IEEE 802.3, RFC 2516, RFC 2364, RFC 791, RFC 2543, H.323

8.1.1.5.4 The J_{ADSL} interface

DSL Interface for asymmetrical data according to table 1. The relevant standard for the physical interface is ETSI TS 101 388 V 1.1.1, FDD. The logical connections are either standard IP packets encapsulated over routed/bridge RFC 1483 LLC encapsulation method, PPPoE using RFC 1483 LLC (LLC/SNAP encapsulation method) or PPPoA using RFC 2364 (LLC encapsulation). Connector type is RJ11.

Physical interface: Copper

Logical interface: Standard IP (routed or bridge),PPPoE or PPPoA (encapsulation methods)

Services: UNI 4.0 PVC with ATC (i.e: CBR, VBR, UBR,...)

Standards: ITU 992.1, spectrum: ETSI TS 101 388 V1.2.1, FDD (Draft), RFC 1483, RFC 971

8.1.1.5.5 The K interfaces

TDM:

Physical interface: STMn, n x E1

Logical connection: 64 kbit/s circuit

Protocols: MTP, SS#7 ISUP, SCCP, TCAP (for access to databases)

Standards: ITU-T G.703, G.704, G.707, Q.701 - Q.707, Q.711 - Q.714, Q.761 - Q.767, ETSI ETS 300 356-1

IP:

Physical interfaces: STM-1, other to be defined

Logical connection: source/destination according to IP Header

Protocols:

User information: IP, Network Specific

Control information: BICC, Signalling Transport Converter via

a) MTP3b, SSCF at NNI, SSCOPMCE, IP, Network Specific
b) SSCOPMCE, IP, Network Specific
c) SCTP, IP, Network Specific
d) MTP, TDM (hybrid arrangement)

Standards:

User information: RFC 791

Control information: ITU-T Q.1901, Q.2150.X via

a) ITU-T Q.2210, Q.2140, Q.2111, RFC 791
b) ITU-T Q.2111, RFC 791
c) RFC 2960, RFC 791
d) ITU-T Q.701 – Q.707

ATM:

Physical interfaces: E1, E3, STM-1, STM-4

Logical connection: ATM Virtual Path/Channel (SVC)

Protocols: AINI (ATM Inter-Network Interface Call Control), SSCF at UNI, SSCOP, CPCS AAL5, ATM, Physical Layer

Standards: AF-CS-0125.000, ITU-T Q.2130, Q.2110, I.363.5, I.361, I.432.X

8.1.2 SDSL technology

SDSL technology enables the telephone companies to provide next generation symmetrical high bandwidth services to the customer premises using the existing telephone cabling infrastructure. SDSL over existing copper lines allows symmetric bit-rates of up to 2.3 Mbit/s depending on the distance and line quality. SDSL technology uses Ungerboeck Pulse Amplitude Modulation (UC-PAM) for transmission and the SDSL frame structure for multiplexing of the payload channels. This frame structure permits the transmission of variable payload bit-rates from 192 kbit/s up to 2312 kbit/s, depending on the allocation of the payload channels, and the simultaneous transmission of voice and data. Therefore no splitters are necessary to separate voice and data traffic. This technology is standardised by ETSI TS 101 524-1 and -2 with UC-PAM 16 coding and corresponding products were available at the end of 2000.

Overview of some SDSL characteristics:

Characteristic	Description
Definition	SDSL= Symmetrical single pair high bit-rate Digital Subscriber Line
Technical Description	Technology to provide symmetrical high bit rate access over existing unshielded twisted copper pairs
Bit-rate over one twisted pair	• Downstream: scalable up to 2.3 Mbit/s • Upstream: scalable up to 2.3 Mbit/s
Distance Limit	2 to 5 km; longer distances result in lower bit-rates, e.g. for 0.4 mm Cu according to ETSI simulation: • 2.3 Mbit/s at 1.9 km • 384 kbit/s at 4.7 km
Quality	Mechanisms to discriminate between different qualities of service are for further study. In principle for the ATM connection beginning from the Access Unit different traffic classes can be defined.
Crosstalk	According to first experiences the SDSL with 16 UC-PAM coding has similar crosstalk characteristics as the HDSL 2-pair variant, i.e. better than the 1-pair variant.
Modulation	UC-PAM 16
Standard	ETSI TS 101 524-1 and -2
Interface on CPE	E.g. ISDN S0, POTS, Ethernet 10/100 Base T, ATMF 25, V.35, V.36, X.21
Shared use of the copper line	Shared use of the copper line by different providers is possibly bitstream access e.g. for voice and data
Shared media	No

Table 6: Some technical characteristics of SDSL

8.1.2.1 Scenario of SDSL architecture

Based on the ITU-T Recommendation Y.120, a logical and physical reference model are developed:

Logical representation:

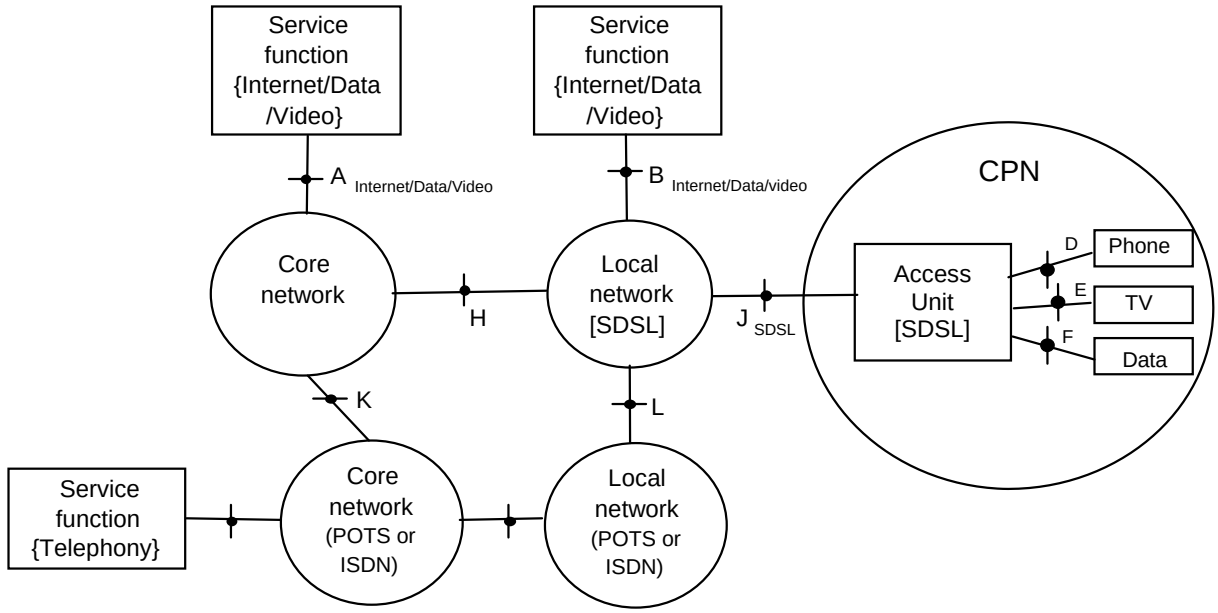


Figure 6: Provision of broadband services over SDSL, logical representation

Physical representation:

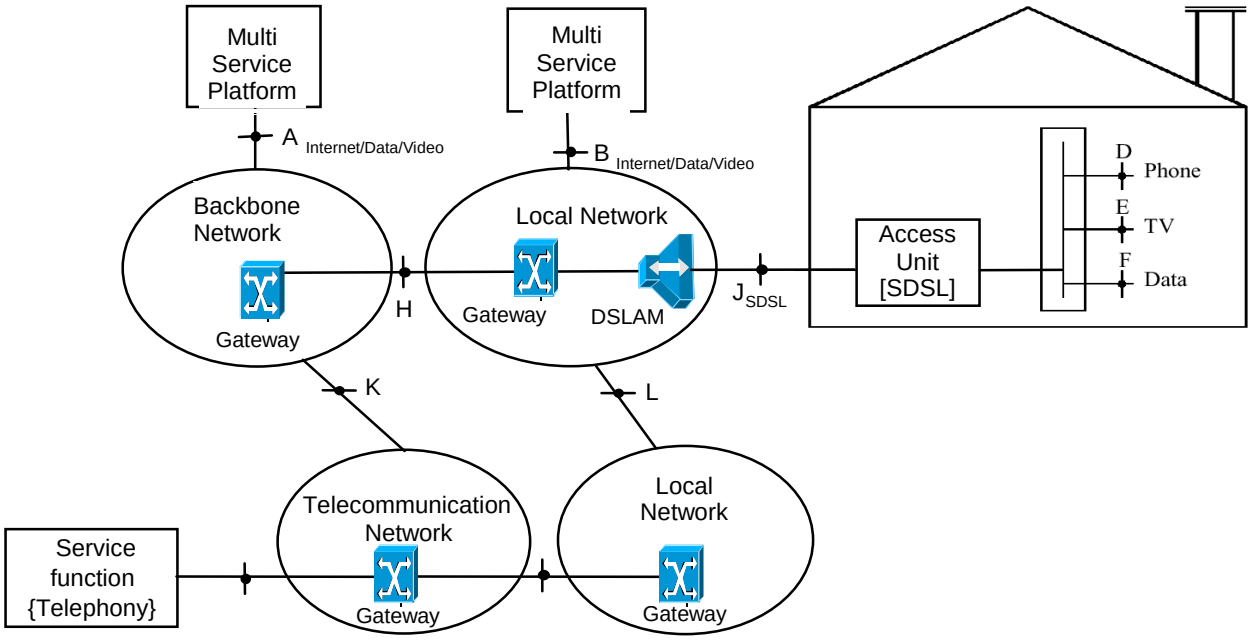


Figure 7: Provision of broadband services over SDSL, physical representation

Explanation of the figures:

Element	Description
Access Unit	Access device for multiple voice and data services over ATM. It supports voice interfaces for analogue and ISDN with SO and PRI interfaces as well as data interfaces such as Ethernet 10BaseT, X.21, V.35, G.703 and ATM 25.
DSLAM	The Digital Subscriber Line Access Multiplexer allows the multiplexing of traffic from the customer premise (line ports) towards to the core network (trunk ports) and the de-multiplexing of traffic in the opposite direction. The DSLAM can support a multi-service platform with different line port cards such as ADSL, SDSL, HDSL, VDSL whereas in this case SDSL is important. Trunk ports for nxE1/T1, E3/T3, STM1 electrical and optical are available.
IP Router (for Multi Service Platform)	The IP router provides access to the service function of service providers, such as Internet access and video services
Gateway	Entry and/or exit point in a network
Local Network	The local network is able to transport the broadband data traffic from the customer premises to the telecommunication network (e.g. IP) using SDSL connections
Telephony Service Function	The telephony service function concerns voice services only
Core Network	The core network can be the telecommunication network with POTS and ISDN services as well as the backbone network with IP and ATM (B-ISDN) services.

Table 7: Explanation of the network elements for SDSL

8.1.2.2 Location of possible Network-Network Interfaces (NNI) for SDSL

Location of possible NNI	Applicable Standards
A	ATM based: - L1: E1, E3, STM-1, STM-4; - L2: UNI4.0, PVC only (all ATM classes) IP based: - L1: E1, E3, STM-1, STM-4, STM-16, IEEE 802.3 - L2: PPP, RFC 1483 , L2TP - L3: IP with Class of Service (CoS), possibly some parameters for negotiation of QoS
K	TDM ATM IP

Table 8: Location of possible NNI for SDSL

8.1.2.3 Possible Network Termination Points / User Network Interfaces

The interfaces with high priority are:

NTP / UNI	Applicable Standards
D	POTS ISDN-BA, ITU-T I.430 ISDN-PRA, ITU-T I.431
F	E1: CES: ITU-T G.703, G.704, G.804; FR: EIA 530, ITU-T V.35/ X.21/ V36, I.365.1; FRF.5, FRF.8, FRF.10, FRF.11, etc. Ethernet: 10/100 BaseT IEEE 802.3
J	ETSI DTS/TM-06011-1 and -2, TS 101 524-1 and -2

Table 9: Possible Network Termination Points / User Network Interfaces for SDSL

8.1.2.4 Possible services with SDSL

Depending on the symmetric bit-rates, SDSL is capable of supporting applications with high upstream bit-rates, e.g. sending data files. The supported services with SDSL are:

- Fast Internet access
- Fast file transfer
- Audio (CD quality)
- Video applications
- Voice applications
- Frame Relay Services
- Leased Line Services
- ISDN Services
- IP LAN to LAN (LAN bridging, IP routing)
- IP-VPN
- Telephony

8.1.2.5 Technical description of the interfaces and standards

8.1.2.5.1 The A interface

The Service Termination Equipment (STE) providing the Internet connectivity is a Cisco router connected to an ATM switch with Multi-protocol Encapsulation over ATM Adaptation Layer 5.

The Service Access Point (SAP) can be an Ethernet, ATM or PoS (Packet over Sonet) interface depending on the requirements.

Physical interfaces: Ethernet, ATM E1, ATM E3, ATM IMA, STM-1 or higher, PoS

Logical interfaces: PPP, IP routed, ATM PVC

Services :

LAN Services: IP routing

ATM Services: UNI4.0, PVC with ATC(i.e : UBR, CBR, VBR,...)

Standards:

- Multi-protocol Encapsulation over AAL 5: RFC 1483
- Ethernet: IEEE 802.3
- ATM interface: ATMF UNI 4.0
- PoS: RFC 1619

8.1.2.5.2 The D_{Phone} interface (subscriber interface)

Physical interfaces: POTS (with TA), BRI, PRI

Logical interfaces: POTS with loop signalling, ISDN with DSS1 signalling

Standards:

- ISDN-BA: ITU-T I.430, Q.921, Q.931
- ISDN-PRA: ITU-T I.431, Q.921, Q.931

Services: POTS and ISDN Services

Restrictions:

The following services are not possible for POTS on the same copper pair:

- Data over voice such as alarm systems, telemetry, etc.
- Taxpulse 12 kHz
- Payphone and publiphone

8.1.2.5.3 The F_{Data} interface (subscriber interface)

Physical interfaces: Ethernet 10/100 BaseT, Frame Relay, E1

Logical interfaces: PPPoE, FR-PVC, IP, H.323, DSS1

Services: ISDN Services, Circuit Emulation CES, Frame Relay FRS, Transparent HDLC, LAN bridging/routing, IP-VPN, Leased Line

Standards:

- E1: ITU-T G.703, G.704
- Frame Relay: EIA 530, ITU-T V.35/ X.21/ V36, I.365.1; FRF.5, FRF.8
- Ethernet: IEEE 802.3, H.323
- ATM: ATMF25

8.1.2.5.4 The J_{SDSL} interface

Physical interfaces: Copper with SDSL

Logical interfaces: PPPoA, LLC, ATMF UNI 4.0, ATM with AAL 1, 2 and 5, IP bridged/routed

Services: UNI 4.0 PVC with ATC (i.e: CBR, VBR, UBR,...), SVC, FR

Standards: ETSI DTS/TM-06011-1 and -2, TS 101 524-1 and –2, G804. I.363.1, I.363.2, I.363.5, RFC 1483, RFC 2684

8.1.2.5.5 The K interface

TDM:

Physical interface: STMn, n x E1

Logical connection: 64 kbit/s circuit

Protocols: MTP, SS#7 ISUP, SCCP, TCAP (for access to databases)

Standards: ITU-T G.703, G.704, G.707, Q.701 - Q.707, Q.711 - Q.714, Q.761 - Q.767, ETSI ETS 300 356-1

IP:

Physical interfaces: STM-1, other to be defined

Logical connection: source/destination according to IP Header

Protocols:

User information: IP, Network Specific

Control information: BICC, Signalling Transport Converter via:

a) MTP3b, SSCF at NNI, SSCOPMCE, IP, Network Specific
b) SSCOPMCE, IP, Network Specific
c) SCTP, IP, Network Specific
d) MTP, TDM (hybrid arrangement)

Standards:

User information: RFC 791

Control information: ITU-T Q.1901, Q.2150.X via

a) ITU-T Q.2210, Q.2140, Q.2111, RFC 791
b) ITU-T Q.2111, RFC 791
c) RFC 2960, RFC 791
d) ITU-T Q.701 – Q.707

ATM:

Physical interfaces: E1, E3, STM-1, STM-4

Logical connection: ATM Virtual Path/Channel (SVC)

Protocols: AINI (ATM Inter-Network Interface Call Control), SSCF at UNI, SSCOP, CPCS AAL5, ATM, Physical Layer

Standards: AF-CS-0125.000, ITU-T Q.2130, Q.2110, I.363.5, I.361, I.432.X

8.2 Cable-modem / CATV technology

Cable modems are devices that attach to the cable TV network connection in a home. This broadband technology is being driven by the cable companies in order to provide services beyond traditional broadcast cable TV such as Internet access. Along with xDSL, it is still in the early stages of development. There are a number of challenges faced by this industry, including return path capabilities, customer service issues and standards. However, potential bandwidth estimates range upwards of 30Mbps from the service provider to subscriber. Cable networks are inherently different in design than telephone networks. Cable networks are broadcast oriented, with each subscriber in an area receiving the same signals as all others in that area. xDSL is circuit oriented so that each connection is independent of all others. Cable networks are inherently hierarchical in nature and thus require two paths, one for downstream and one for upstream. This requires either a second cable plant for upstream or a second frequency band allocated onto the existing system.

CATV is used for broadband distribution of digital and analogue TV channels.

CATV and DATA services differ in the kind of standards and protocols they use. The following chapters will describe the technologies used for those services.

Overview of some CATV characteristics:

Characteristic	Description
Definition	CATV = Community Antenna Television
Technical Description	Transmission technology based on coax cable, usually implemented as hybrid-fibre-coax (HFC) using tree-structures
Bit-rate	Up to 32 Mbits/sec
Distance Limit	Max. 1.5 km on the coax cable; signalling quality decreases drastically beyond this limit.
Standard	None applicable (see the following discussions)
Interface on CPE	POTS, Ethernet
Shared use of the line	Not yet available, technically feasible
Shared media	Yes

Table 10: Some technical characteristics of CATV

8.2.1 Scenario of Cable-modem/CATV architecture

Based on the ITU-T Recommendation Y.120, a logical and physical reference model are developed:

Logical representation:

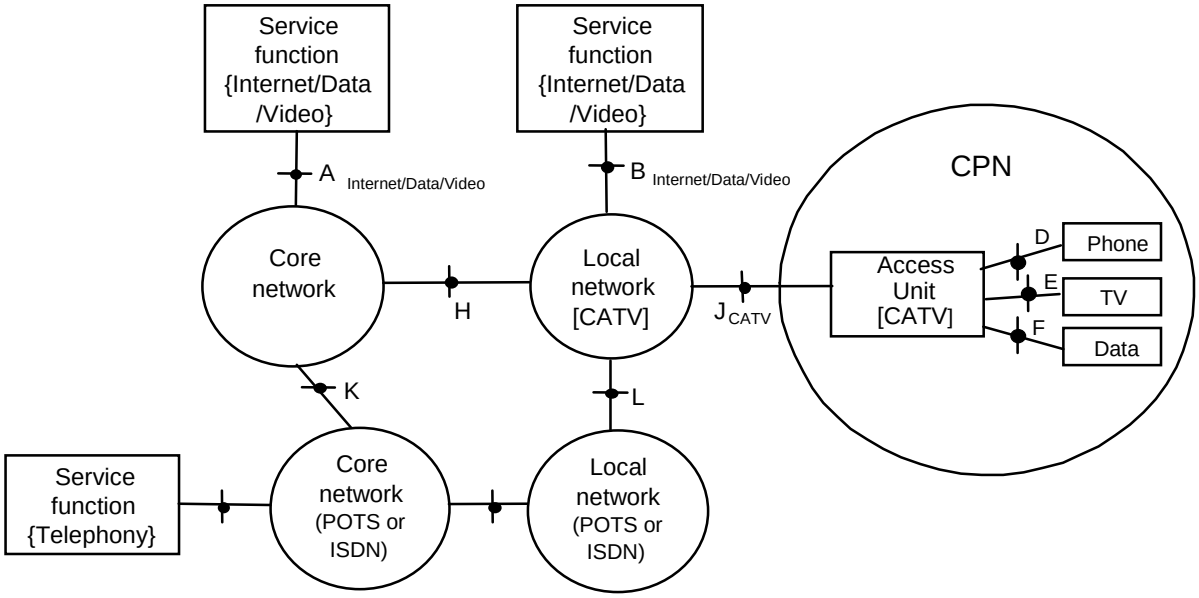


Figure 8: Provision of broadband services over CATV, logical representation

Physical representation:

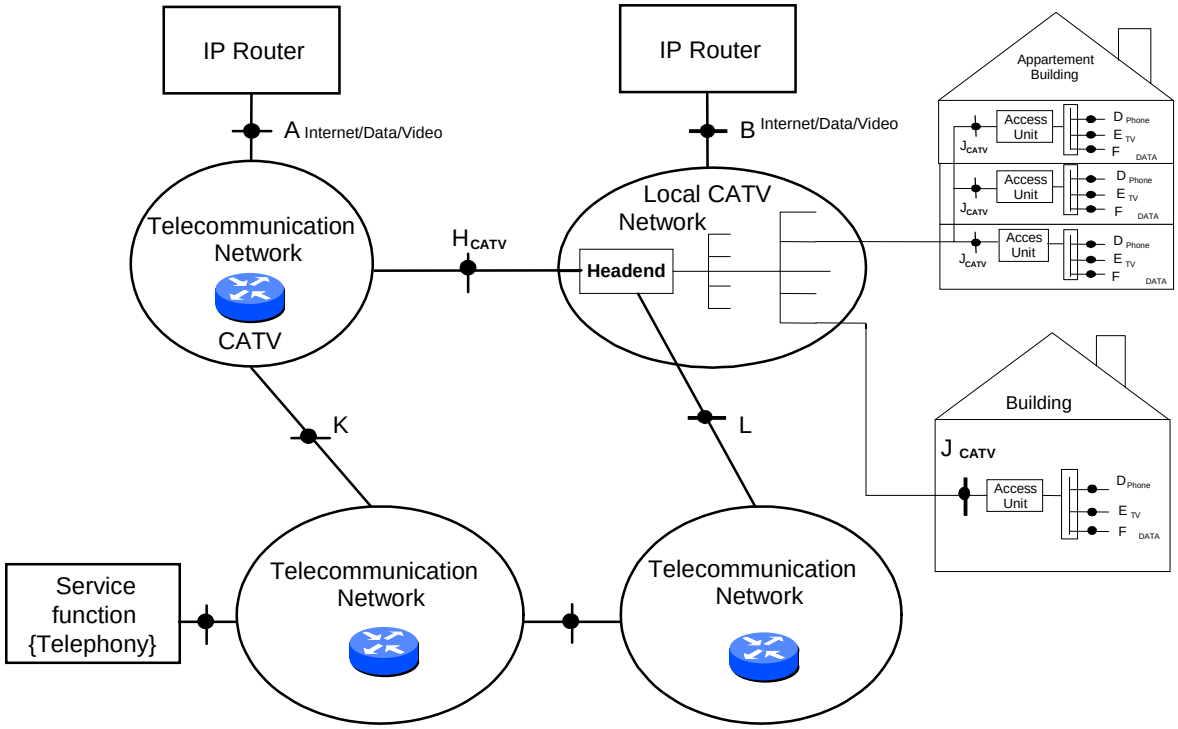


Figure 9: Provision of broadband services over CATV, physical representation

Explanation of the figures:

Element	Description
Access Unit	This is usually a cable modem or a set-top box that is capable of data services
Local CATV Network	This is the Hybrid-Fibre-Coax (HFC) network generally used as the distribution network for CATV
Headend	The headend equipment connects the core network to the HFC local network. It defines the parameters for the access unit that must match them in order to obtain access to the services
Telecommunication Network	The telecommunication network is a network capable of delivering different services, e.g. ATM, IP, digital telephony services, etc.
IP Router	The IP router is a device that controls the traffic flow between different IP networks, e.g. it transmits packets from network A to network B.
Telephony Service Function	The telephony service function concerns voice services only

Table 11: Explanation of the network elements for CATV

8.2.2 Location of possible Network-Network Interfaces (NNI) for CATV

Location of possible NNI	Applicable Standards
A	IP based: - L1: E1, E3, STM-1, STM-4, STM-16, IEEE 802.3 - L2: PPP, RFC 1483, L2TP - L3: IP with Class of Service (CoS), possibly some parameters for negotiation of QoS
K	TDM ATM IP

Table 12: Location of possible NNI for CATV

8.2.3 Possible Network Termination Points / User Network Interfaces

NTP / UNI	Applicable Standards
D	POTS
F	IEEE 802.3
J	No standards available, operator dependent (see detailed description of J interfaces)

Table 13: Possible Network Termination Points / User Network Interfaces for CATV

8.2.4 Possible services with Cable-modem

- Fast Internet access
- Fast file transfer
- IP-VPN
- IP-Streaming Services (Video, Audio)
- Voice over IP
- Video conferencing

8.2.5 Technical description of the interfaces and standards

8.2.5.1 The A interface

The equipment generally used for this point of interconnection is an IP-Router. The technical aspects of this interface have not been fully explored. However, it can be expected that the connection will be according to Ethernet (IEEE 802.3) standards.

The problem here is to associate a customer using a cable-modem on the shared network with a service provider. Different technologies could be used to implement a solution, e.g. IP-tunnelling, virtual private networks. The possible solutions today are vendor driven and to some degree vendor specific.

Physical interfaces: 10/100 BaseT, E1, E3, STM-1, STM-4, STM16

Logical interfaces: routed IP

Services: IP , IP VPN (MPLS, might not be available in all end-to-end implementations)

Standards: RFC791, RFC 2547

8.2.5.2 The D_{Phone} interface (subscriber interface)

This interface on the cable-modem is a POTS interface using RJ11 connectors.

Physical interfaces: POTS

Logical interfaces: Telephony circuit

Services: Telephony, depending on the network some services expected to be available on PSTN networks may not be supported

Standards: POTS

Note: for the support of POTS at D_{Phone}, the access unit implementations have different options available (e.g. SGCP/MGCP, H.323, DOCSIS, SIP, etc.)

8.2.5.3 The F_{DATA} interface (subscriber interface)

This interface on the cable-modem is an Ethernet interface (IEEE 802.3) using an RJ45 connector. Speeds of up to 10 Mbits/sec are available.

Further developments indicate the use of universal serial bus interfaces.

Physical interfaces: 10 BaseT (IEEE 802.3)

Logical interfaces: Bridged or routed IP

Services: IP

Standards: RFC 791

8.2.5.4 The J_{CATV} interface

The following sections describe the different implementations of a J_{CATV} interconnection point.

It should be noted that the J_{CATV} could be considered the NTP of a CATV network if a world-wide standard existed that allows the consumer to buy any brand of cable-modem and connect it to the CATV network of the operator in order to use the services subscribed to. This does not reflect the reality when this report was written. There is no standard that would allow such a scenario. The cable-modem must therefore conform to the parameters dictated by the headend chosen by the cable operator. Due to this fact the usable NTP of a CATV network are the D, E, F interfaces as outlined in the scenarios above.

A cable modem is used as STE for data services and telephony.

This connection is physically realised using a standard F connector.

8.2.5.4.1 J_{CATV} DOCSIS

Interface name	DOCSIS CMTS
Technical Specifications	RF outlet with a frequency range from 5 – 862 MHz HF output is high pass filtered Physical Medium is shielded coaxial cable Downstream: • 54 – 860 MHz frequency range • 6/8 MHz channel width • 75 ohms impedance • 64/256 QAM modulation • 30.336 - 57 Mbit/s signalling rate Upstream: • 5 – 42 MHz frequency range • 1.6/3.2 MHz channel width • 75 ohms impedance • 16 QAM or burst QPSK • 2.56 – 10 Mbit/s signalling rate/upstream channel
Relevant Network Standards	DOCSIS 1.0 The standard is an industry standard developed by Cable Labs (US). Needs to be supported by the headend
Options	----
Relevant Terminal Standards	DOCSIS 1.0 for cable modems

Table 14: Description of the J_{CATV} DOCSIS interface

8.2.5.4.2 J_{CATV} Com21

Interface name	COM21 CMTS
Technical Specifications	RF outlet with a frequency range from 5 – 862 MHz HF output is high pass filtered Physical Medium is shielded coaxial cable DES encrypted Downstream: • 88 – 800 MHz frequency range • 200 KHz steps • 6 MHz channel width • 75 ohms impedance • 64 QAM modulation • 30.336 Mbit/s signalling rate Upstream: • 5 – 40 MHz frequency range • 50 KHz steps • 1.8 MHz channel width • 75 ohms impedance • burst QPSK • 2.56 Mbit/s signalling rate/upstream channel (12 max.)
Relevant Network Standards	N/A proprietary system
Options	----
Relevant Terminal Standards	N/A proprietary system

Table 15: Description of the J_{CATV} COM 21 interface

8.2.5.4.3 J_{CATV} Terayon

Interface name	Terayon CMTS
Technical Specifications	RF outlet with a frequency range from 5 – 862 MHz RF output is high pass filtered Physical Medium is shielded coaxial cable DES encrypted Downstream: • 88-126/264-406, 120-175/264-406, 400-750 MHz ranges • 224 KHz steps • 6 MHz channel width • 75 ohms impedance • 64 QAM modulation • S-CDMA transmission scheme • 30.336 Mbit/s signalling rate Upstream: • 5 – 42 MHz frequency range • 112 KHz steps • 5 MHz channel width • 75 ohms impedance • 16 QAM modulation • 2.0 – 8.2 Mbit/s signalling rate/upstream channel
Relevant Network Standards	N/A proprietary system
Options	----
Relevant Terminal Standards	N/A proprietary system

Table 16: Description of the J_{CATV} Terayon interface

8.2.5.4.4 J_{CATV} EuroDocsis

Interface name	EuroDocsis CMTS
Technical Specifications	RF outlet with a frequency range from 5 – 862 MHz RF output is high pass filtered Physical Medium is shielded coaxial cable DES encrypted Downstream: • 110 - 862 MHz ranges • 8 MHz channel width • 75 ohms impedance • 64/256 QAM modulation • DVB-C framing • Up to 55 Mbit/s signalling rate Upstream: • 5 – 65 MHz frequency range • 0.2 - 4 MHz channel width • 75 ohms impedance • burst QPSK modulation • 2.0 – 8.2 Mbit/s signalling rate/upstream channel
Relevant Network Standards	DVB-C EN 300-192
Options	----
Relevant Terminal Standards	ETS 300-800

Table 17: Description of the J_{CATV} EuroDocsis interface

8.2.5.4.5 The K interfaces

TDM:

Physical interface: STMn, n x E1

Logical connection: 64 kbit/s circuit

Protocols: MTP, SS#7 ISUP, SCCP, TCAP (for access to databases)

Standards: ITU-T G.703, G.704, G.707, Q.701 - Q.707, Q.711 - Q.714, Q.761 - Q.767, ETSI ETS 300 356-1

IP:

Physical interfaces: STM-1, other to be defined

Logical connection: source/destination according to IP Header

Protocols:

User information: IP, Network Specific

Control information: BICC, Signalling Transport Converter via

a) MTP3b, SSCF at NNI, SSCOPMCE, IP, Network Specific
b) SSCOPMCE, IP, Network Specific
c) SCTP, IP, Network Specific
d) MTP, TDM (hybrid arrangement)

Standards:

User information: RFC 791

Control information: ITU-T Q.1901, Q.2150.X via

a) ITU-T Q.2210, Q.2140, Q.2111, RFC 791
b) ITU-T Q.2111, RFC 791
c) RFC 2960, RFC 791
d) ITU-T Q.701 – Q.707

ATM:

Physical interfaces: E1, E3, STM-1, STM-4

Logical connection: ATM Virtual Path/Channel (SVC)

Protocols: AINI (ATM Inter-Network Interface Call Control), SSCF at UNI, SSCOP, CPCS AAL5, ATM, Physical Layer

Standards: AF-CS-0125.000, ITU-T Q.2130, Q.2110, I.363.5, I.361, I.432.X

8.3 Wireless Local Loop technology

There are a number of different wireless schemes proposed, planned and implemented throughout the world. Wireless access technology can take a number of different forms, such as via a satellite TV service provider or a cellular phone network. Wireless systems can provide ubiquitous access to a large number of subscribers in a relatively large area. Bandwidth can range from a few kilobits per second to many megabits and be either symmetrical or asymmetrical. Like all other technologies, deployment issues such as spectrum licensing, bandwidth limitations, interference and noise problems may be relevant.

Overview of some WLL characteristics:

Characteristic	Description
Definition	WLL = Wireless Local Loop
Technical Description	Radio technology using point to multi-point connections.
Bit-rate	nx64 kBit/s up to nx2 Mbit/s symmetrical
	nx64 kBit/s / 25 Mbit/s asymmetrical
Distance Limit	Depending on the frequency band used; higher frequencies result in shorter distances (e.g. 26 GHz up to 3 km).
	Line of sight mandatory.
Security	High security because of proprietary modulation schemes and authentication procedures used. Interception with separate antenna causes a loss link or degradation of QoS which can be detected by the network management system.
Quality	dependent on radio planning aspects (e.g. modulation used, distance allowed, frequency band used, etc.).
Shared use of the access	Only possible by bitstream access
Mobility	No mobility of subscriber line but high flexibility with installation/de-installation of subscriber terminals.
Shared media	Several subscribers share a dedicated frequency spectrum. Bandwidth can be fixed allocated or shared.

Table 18: Some technical characteristics of WLL

8.3.1 Scenario of WLL architecture

Based on the ITU-T Recommendation Y.120, a logical and physical reference model are developed:

Logical representation:

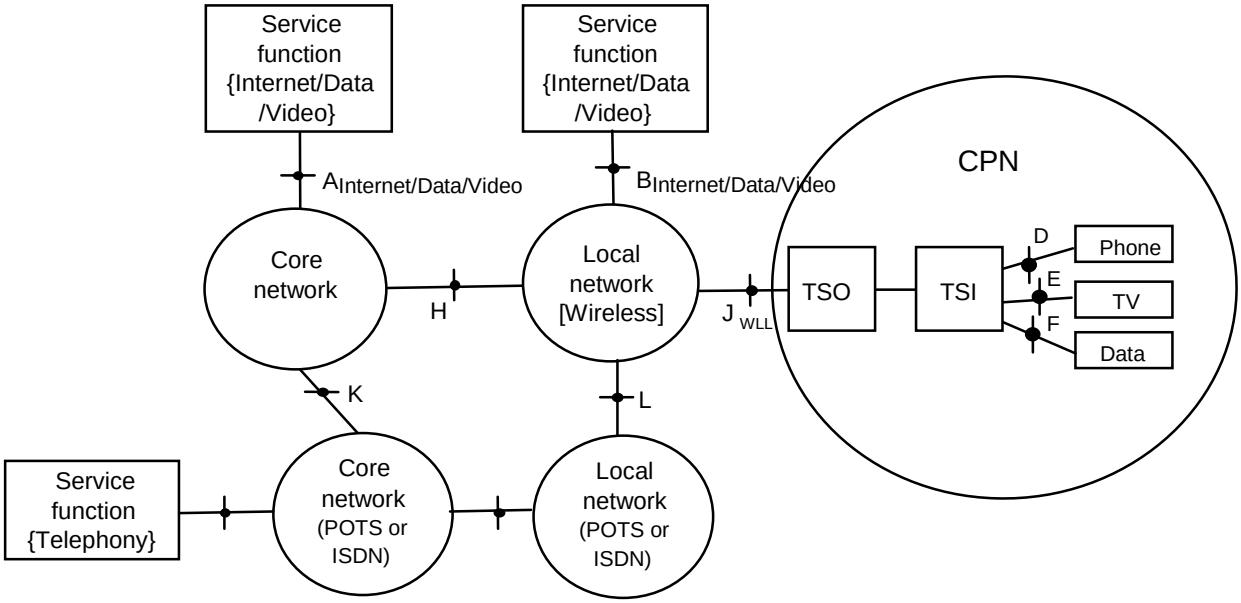


Figure 10: Provision of broadband services over WLL, logical representation

Physical representation:

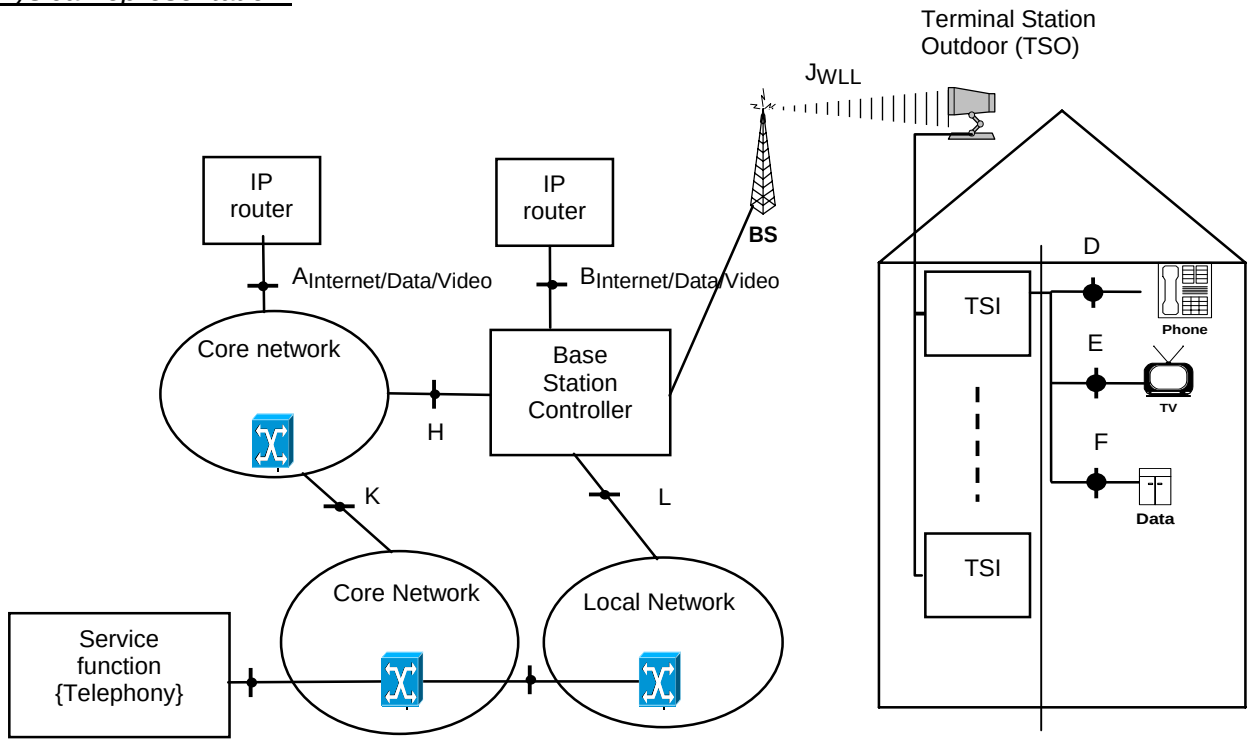


Figure 11: Provision of broadband services over WLL, physical representation

Explanation of the figures:

Element	Description
TSO	Terminal Station, Outdoor. The radio receiving antenna at the customer's premises.
TSI	Terminal Station, Indoor. The interface unit at the customer's premises. Sends and receives data at intermediate frequencies to and from the TSO.
BS	Base Station. Provides a common radio access point for the subscriber's traffic and is also the connection to the core network.
Base Station Controller	This unit processes traffic and addresses it to the correct base station and subscriber.
Local WLL Network	This is used to describe the TSP base station network. It incorporates a number of base stations and units of subscriber equipment covering geographic areas.
Core Network	Core network describes the TSP backhaul network used to connect subscriber traffic from the base stations to other networks or service functions i.e. the Internet or a telephony network.
IP Router	The IP router is the main unit of equipment used to connect to other telecommunication operators. It routes traffic at ISO layer 3.

Table 19: Explanation of the network elements for WLL

8.3.2 Location of possible Network-Network Interfaces (NNI) for WLL

Location of possible NNI	Applicable Standards
A	ATM based: - L1: E1, E3, STM-1, STM-4; - L2: UNI4.0, PVC only (with ATC) FR based: - FRF 5/8, etc. IP based: - L1: E1, E3, STM-1, STM-4, STM-16, IEEE 802.3 - L2: PPP, RFC 1483, L2TP - L3: IP with Class of Service (CoS), possibly some parameters for negotiation of QoS
K	TDM ATM IP

Table 20: Location of possible NNI for WLL

8.3.3 Possible Network Termination Points / User Network Interfaces

Point of Interconnection	Applicable Standards
D	POTS, ISDN-BA/PA
F	IEEE 802.3
J	No standards available, operator dependent (see detailed description of J interfaces)

Table 21: Possible Network Termination Points / User Network Interfaces for WLL

8.3.4 Frequency Spectrum Management

Spectrum allocation is the responsibility of the national regulation authority and follows the national frequency allocation plan.

http://www.bakom.ch/eng/subsubpage/document/82/927: NFR 23 Point-to-multipoint links (WLL) in the 26 GHz-frequency band.

OFCOM assigns licences and bandwidth from the frequency spectrum to the WLL operators according to the corresponding regulations. The Office also co-ordinates and guarantees interference-free operation of the networks.

8.3.5 Possible services with WLL

- Fast Internet access
- Fast file transfer
- IP-VPN
- IP-streaming services (Video, Audio)
- Voice over IP
- Video conferencing
- POTS/ISDN switched services
- nx64kbit/s – nxE1/T1 leased lines
- PBX interconnections
- Standard Ethernet with burst data capabilities (FR, LAN-I, ATM)
- Broadcast and pay-per-view services

8.3.6 Technical description of the interfaces and standards

8.3.6.1 The A interface

This point of interconnection is generally an IP Router. The full technical aspects of the interface have not been fully explored. It is expected that the connection will be Ethernet 10BaseT (IEEE 802.3) or Fast Ethernet 100BaseT (IEEE802.3u).

Physical interfaces: Ethernet, ATM E1, ATM E3, ATM IMA, STM-1 or higher, PoS

Logical interfaces: PPP, IP routed, ATM PVC

Services :

LAN Services: IP routing

ATM Services: UNI4.0, PVC with ATC(i.e : UBR, CBR, VBR,...)

Standards:

- Multi-protocol Encapsulation over AAL 5: RFC 1483
- Ethernet: IEEE 802.3
- ATM interface: ATMF UNI 4.0
- PoS: RFC 1619

8.3.6.2 The D interface (subscriber interface)

This interface provides a subscriber with nx64kbits/s to full 1 E1/T1 (G.703) leased lines. The level of bandwidth supplied to the subscriber is determined by the TSP.

Physical Interface: 120 Ohm balanced 4 wire cable, using RJ45 connectors

Logical Interface: E1 (ITU G.703), fractional E1

Services: PBX Interconnect, ISDN PRA/BRA

Standards: ISDN PRA: ITU-T I.431, Q.921, Q.931

8.3.6.3 The F_{DATA} interface (subscriber interface)

This interface on the TSI is an Ethernet interface (IEEE 802.3) using an RJ45 connector. The available data rate is up to 10baseT. As with the D interface, the bandwidth supplied to the subscriber depends on the level of service to which they subscribe.

Physical Interface: Ethernet 10baseT

Logical Interface: PPPoE

Services: Leased Line, Internet Access, LAN Interconnect

Standards: IEEE 802.3

8.3.6.4 The J_{WLL} interface

The J_{wll} interface is vendor specific, in accordance with ETSI EN 301 213-1.

The modulation, multiplexing and encoding methods used for this interface will be dependent on the service provider's choice of equipment manufacturer.

There is no subscriber access to this interface.

Operation of the terminal station is subject to a WLL operating license and access is not available to the subscriber.

Physical Interface:

The frequency band used is allocated in accordance with CEPT Recommendation T/R 13-02 [1]. Operation of a terminal station is subject to a WLL operating license.

One of 3 physical interface standards may be used:

- FDMA
- TDMA
- CDMA

Logical Connection:

Any digital modulation technique with a spectrum efficiency of at least 1 bit/Hz/s is permitted, e.g. QPSK, QAM etc.

ETSI EN 301 213-1 V1.1.1 (1999-11), Paragraph 1 states:

"Radio terminals from different manufacturers are not intended to interwork at radio frequency (i.e. no common air interface)".

Services: N/A Transparent transportation medium. No services offered over the J interface

Standards: ETSI EN 301 213-1/2/3

8.3.6.5 The K interfaces

TDM:

The K interface will connect the ATM core network to the telephony core network.

Physical Interface: 120 Ohm balanced 4 wire cabling, STM-n, n x E1, n x V5.X

Logical Interface: nxE1 (ITU G.703), AAL1, AAL5, ETS 300 324-1/347-1

Services: PBX Interconnect

Standards: SS7,ATM

IP:

Physical interfaces: STM-1, other to be defined

Logical connection: source/destination according to IP Header

Protocols:

User information: IP, Network Specific

Control information: BICC, Signalling Transport Converter via

a) MTP3b, SSCF at NNI, SSCOPMCE, IP, Network Specific
b) SSCOPMCE, IP, Network Specific
c) SCTP, IP, Network Specific
d) MTP, TDM (hybrid arrangement)

Standards:

User information: RFC 791

Control information: ITU-T Q.1901, Q.2150.X via

a) ITU-T Q.2210, Q.2140, Q.2111, RFC 791
b) ITU-T Q.2111, RFC 791
c) RFC 2960, RFC 791
d) ITU-T Q.701 – Q.707

ATM:

Physical interfaces: E1, E3, STM-1, STM-4

Logical connection: ATM Virtual Path/Channel (SVC)

Protocols: AINI (ATM Inter-Network Interface Call Control), SSCF at UNI, SSCOP, CPCS AAL5, ATM, Physical Layer

Standards: AF-CS-0125.000, ITU-T Q.2130, Q.2110, I.363.5, I.361, I.432.X

Part two: User Network Interfaces

9 Location of possible Network Termination Points (NTP)

In compliance with the European Directive, the Swiss Decree on Telecommunications Installations specifies in Paragraph 4a regarding interfaces:

[1] The Office shall determine the technical regulations applicable to interfaces and shall publish the list in the form of a decree.
[2] It shall determine, taking international practice into account, the location of the interfaces.

Regarding radio-based systems, interfaces are determined and specified by the Office (Appendix 1a, OOIT).

Regarding wire-based systems, the current situation concerning location is determined by the former regulations according to which terminal equipment was clearly defined (POTS, ISDN, etc.), which implies that the location of the interface was also specified. At present, OFCOM has no plans to publish a list of NTP locations because no need for this has been expressed so far.

Concerning broadband technologies dealt with in this report, locating the NTP before the users' modems offers the following advantages:

- For operators: this equipment is considered as terminal equipment, which means it is located outside of the network, thus it is not under the jurisdiction of the operator; also, the notification of interfaces is simplified (description of a single interface)
- For users: there is a greater choice of terminal equipment and the price is normally lower due to competition.

The only disadvantage for the users:

- The customer is responsible for acquisition, commissioning and maintenance of the terminal equipment.

10 Notification and publication rules of the UNI

With the entry into force of the amendments to the Decree on Telecommunications Services (SR 784.101.1, Verordnung über Fernmeldedienste (FDV)) dated 1 May 2000, telecommunications services providers who provide telecommunications services via their own physical network interfaces are subject to the obligation to notify these interfaces to the Federal Office of Communications and to publish accurate and adequate technical specifications.

The only exceptions to these regulations are interfaces which are used exclusively for interconnection of telecommunications networks or which are used within telecommunications networks (e.g. to provide access for access networks).

The interface characteristics to be published by the telecommunications service providers must be sufficiently detailed to allow the development of terminals which are capable of using **all** services provided across the corresponding interface. Therefore, information must be provided on both the hardware (HW) and software (SW) requirements and on specific parameter settings for the basic services and for all additional services offered across this interface.

For this purpose the telecommunications service providers must set up a link on their homepage where the necessary information can be retrieved. If this is not possible, the relevant information must be provided – on request – without delay and in an appropriate form.

Notification of the interfaces to the Federal Office of Communications must take place at least 4 weeks prior to commissioning, modification or decommissioning of an interface.

For further information on this subject, please refer to the technical and administrative regulations on interfaces of telecommunications networks (SR 784.101.113/1.4, Technische und administrative Vorschriften betreffend die Schnittstellen von Fernmeldenetzen), the registration form for the provision of telecommunications services and the corresponding guide.

A distinction is made between two scenarios:

1. TSP "A" provides subscriber (TE) with telecommunications services using its own NTP. TSP "A" must notify this subscriber-network interface, across which it provides its telecommunications services, to the Federal Office of Communications and publish the precise technical specifications of this interface.

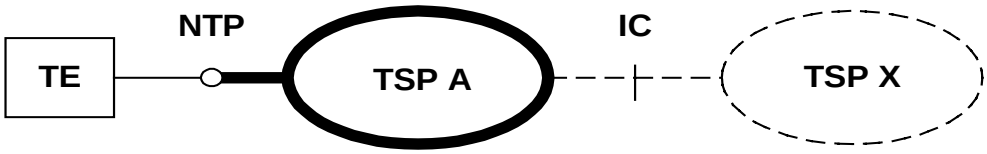


Figure 12: TSP "A" provides the telecommunications services directly to the subscriber (TE)

2. TSP "X" leases a certain transmission capacity for part of the connection between TSP "X" and the subscriber (TE) from TSP "A". TSP "X" provides its telecommunications services to the subscriber (TE) by means of an NTP which is provided by itself under these circumstances. TSP "X" must notify the subscriber-network interface, which it leases from TSP "A" and across which it provides its telecommunications services, to the Federal Office of Communications and publish the precise technical specifications of this interface.

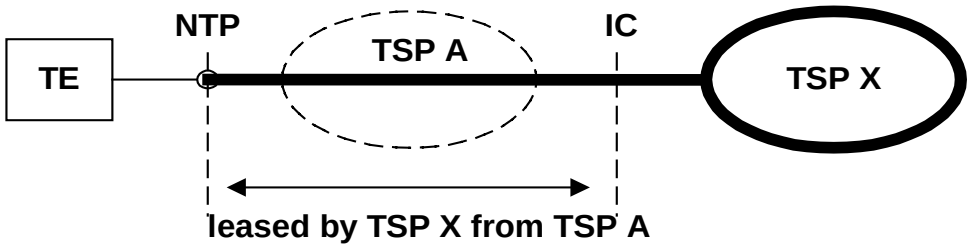


Figure 13: TSP "X" provides subscriber (TE) with telecommunications services by means of a transmission capacity which it leases from TSP "A"

11 Conclusion

11.1 Conclusions concerning the introductory chapters

11.1.1 Introduction

The introduction correctly states that the industry has an interest in a common understanding of the new technologies. The work within the working group has shown in particular that the technical standards are under development. The work, therefore, should not be concluded by the present report but should be periodically updated, for the first time by January 2002. At that time, other broadband technologies should be included (e.g. UMTS, Powerline).

11.1.2 Formal matters (definition, abbreviations, references)

The chapters entitled definition, abbreviations and references have shown themselves to be useful for achieving a common understanding. For subsequent versions, it remains to be considered whether these chapters should be extended by providing information on sources (a listing of judicature and administrative practice, a list of laws and decrees, a list of EU directives, a bibliography).

11.1.3 Mandate

In order not to have to discuss politically explosive questions of interconnection, the neutral term "interworking" has been introduced. However, the term itself remains undefined. The term interworking should be defined in more precise way.

11.2 Conclusions on architecture

11.2.1 Reference model

The reference model has proved itself in principle, even though in conceptual terms it is orientated towards conventional telephony. Representing the network structures in a physical and logical model has proved useful for improved understanding.

11.2.2 Common features

The discussions in the working group led to a common understanding of the actually three main broadband access technologies xDSL, CATV and WLL. In the area of the core networks mature standards are available for all technologies. It has been shown that interworking between the different access technologies (ADSL, SDSL, CATV and WLL) and the core network is possible, while the direct interworking between the access technologies themselves is not possible. For the technologies CATV and WLL the interface standard between local network and customer premise side is not available in the near future, because proprietary systems are in use. The Interoperability of services in relation with the different broadband technologies is possible and universal service calls based on the different technologies can be achieved. In the near future interworking for broadband access technologies can hardly be regulated appropriately.

11.3 Conclusions on User Network Interfaces (UNI)

11.3.1 Location of possible Network Termination Points (NTP)

On OFCOM's part, it would be premature to wish to draw up a list containing the location of the NTPs for the various technologies or services provided by the TSP. Indeed, the current situation in the European Union, where harmonisation has not yet been achieved on this problem, is not pushing OFCOM to take such a step.

ADSL services:

The location of the NTP for the ADSL service does not pose any problems at present and gives users a free choice of modem. The modem is therefore considered as user equipment and does not form part of the network.

SDSL service:

Currently the Access Unit (AU) is a part of the access network because the new SDSL technology requires a good adjustment of the AU with the DSLAM, e.g. layer 1 with SDSL and layer 2 ATM with AAL 1 and 5. Additional the Management of the AU is a service of the access provider. Therefore the NTP is the D and F interface (E is not considered).

But on the other hand the SDSL layer with UC PAM 16 is now standardised (ATM layer already before) and hence the AU could be a part of the CPN with the NTP at the J interface. The restriction will be that the management of the AU is not automatically a service of the access provider and must be negotiated with the customer and/or the vendor of the AU.

CATV service:

The description of the interfaces shows a number of different implementations for the "J" interface.

Currently a free choice of cable modems does not exist since it is always dependant on the technology a given provider has selected. As outlined in the chapter 8.3.5.4 the NTPs are defined as the interfaces "D,E,F".

Wireless Local Loop service:

As there are no guidelines for equipment manufacturers to implement a common standard for the J interface, locating the Network Termination Point before the customer premises terminal equipment would be impractical.

Legally obliging equipment manufacturers to publish detailed J interface specifications would benefit service providers by introducing competition in the market place and lowering network rollout costs. However, the possible lengthy delay between legislation being written and patent royalty agreements between equipment manufacturers being reached would decrease the impact of these benefits on the service providers.

11.3.2 Notification and publication rules of the UNI

In certain cases, notification and publication of the interfaces with the NTP poses a problem for the TSP. Indeed, for certain services, it is difficult to know precisely which TSP has to notify and publish the user-network interfaces. No precise guide yet exists on this topic within the European Community and each country is applying the rules in its own manner.

As far as the services analysed in this report are concerned, the location of the NTP for ADSL technology does not pose any problems in Switzerland.

11.4 Future tasks

The following tasks, which are linked with the Q.8 group, have been identified and might possibly be dealt with by this group in the future. *But, when the group will be reactivated, it will be necessary to make a new mandate which will determine with more exactitude the tasks to carry out*.

- Quality of service in general (the obligation of QoS is only available for the provision of universal service (art. 21 OST), but it could be useful to identify the QoS for all technologies)
- Quality of service on the interfaces (QoS of data transmission, as part of the technical specification of the interfaces)
- For the services falling within the universal service, it would also be necessary to analyse the following requirements (for each access technologies):

- Provision of directory enquiry services and the exchange of data for these services
- Access to emergency services
- CLI and malicious call tracing
- Advice of Charge (AoC)
- Blocking of outgoing calls
- Services for deaf people and partially-sighted persons
- Number portability
- Carrier selection and pre-selection, etc.

- Power supply to CPE in case of power failure in order to maintain emergency services
- Analysis and identification of new interface types for the "Power Line Communication (PLC)" DSL-technology, WLL, UMTS, Satellites, CATV-networks etc.
- Spectrum management for copper lines, PLC
- Analysis and identification of interface types in the event of "Local Loop Unbundling" (including bit stream access, line sharing, full unbundling)
- Description of core network functionality for “Broadband Access”-Core Network, similar to the “PSTN”-Core Network (C_x in the reference model)
- Analyses of other network interfaces (in converged future multimedia-networks) in the reference model ITU-T Y.120; example MGCP (IETF RFC; vertical model for further study;

Megaco-Typhon derivatives interfaces, etc. including QoS-CoS service/traffic requirements; ENUM impacts; further DSL networks; CATV-HFC Docsis 2.X-services etc.)

- Analyses and identification of interface types used for interconnection of any network OTHER than the type normally in ITU-T Y.120 model used for circuit-switched OR packet-switched networks.