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**Private Telecommunication Network (PTN);  
Integrated services architecture for high speed private networks**

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## Foreword

This ETSI Technical Report (ETR) has been prepared by the Business TeleCommunications (BTC) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

This ETR, which describes an integrated services architecture for high speed private networks, is mainly intended to serve as a framework document for the work of STC BTC4 "Private Network Aspects of High Speed Business Communication". Not all aspects of high speed private networks can be covered in this ETR in order to provide this baseline document in a timely manner. In particular, network management and signalling issues will require further documents.

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## 1 Scope

This ETSI Technical Report (ETR) describes an Integrated Services Architecture for High Speed Private Networks.

This ETR identifies relevant application scenarios and their characteristics for high speed communication in private networks.

Current network technologies are described and evaluated in terms of their suitability for the relevant application scenarios. It should be noted that only subnetwork technologies are described; the identification of network layer protocols for the interconnection of subnetworks is outside the scope of this ETR.

Based on the evaluation results reference configurations are developed and interworking requirements are derived.

Although it is understood that signalling and management aspects are essential in the context of an integrated services architecture, these topics are not covered in this ETR. The same applies to wireless communications. Additional documents will have to be developed that are dedicated to these topics.

## 2 References

For the purposes of this ETR, the following references apply:

- [1] ETS 300 211: "Network Aspects (NA); Metropolitan Area Network (MAN); Principles and architecture".
- [2] ETS 300 217: "Network Aspects; Connectionless Broadband Data Service (CBDS)".
- [3] ETS 300 278: "Network Aspects (NA); Support of existing services with guaranteed constant bit rate and specified transfer delay on Metropolitan Area Network (MAN)".
- [4] ITU-T Recommendation F.811: "Broadband connection-oriented bearer service".
- [5] ITU-T Recommendation F.812: "Broadband connectionless data bearer service".
- [6] ITU-T Recommendation G.103: "Hypothetical reference connections".
- [7] ITU-T Recommendation G.702: "Digital hierarchy bit rates".
- [8] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".
- [9] ITU-T Recommendation G.704: "Synchronous frame structures used at primary and secondary hierarchy levels".
- [10] ITU-T Recommendation G.707: "Synchronous digital hierarchy bit rates".
- [11] ITU-T Recommendation G.708: "Network node interface for the synchronous digital hierarchy".
- [12] ITU-T Recommendation G.709: "Synchronous multiplexing structure".
- [13] ITU-T Recommendation H.244: "Revised channel aggregation standard harmonized with ISO/IEC committee draft".
- [14] ITU-T Recommendation I.121: "Broadband aspects of ISDN".

- [15] ITU-T Recommendation I.150: "B-ISDN asynchronous transfer mode functional characteristics".
- [16] ITU-T Recommendation I.211: "B-ISDN service aspects".
- [17] ITU-T Recommendation I.233.1: "ISDN frame mode bearer services (FMBS) - ISDN frame relaying bearer service".
- [18] ITU-T Recommendation I.311: "B-ISDN general network aspects".
- [19] ITU-T Recommendation I.320: "ISDN protocol reference model".
- [20] ITU-T Recommendation I.321: "B-ISDN protocol reference model and its application".
- [21] ITU-T Recommendation I.324: "ISDN network architecture".
- [22] ITU-T Recommendation I.327: "B-ISDN functional architecture".
- [23] ITU-T Recommendation I.361: "B-ISDN ATM layer specification".
- [24] ITU-T Recommendation I.362: "B-ISDN ATM adaptation layer (AAL) functional description".
- [25] ITU-T Recommendation I.363: "B-ISDN ATM adaptation layer (AAL) specification".
- [26] ITU-T Recommendation I.364: "Support of broadband connectionless data service on B-ISDN".
- [27] ITU-T Recommendation I.365.1: "Frame relaying service specific convergence sublayer (FR-SSCS)".
- [28] ITU-T Recommendation I.370: "Congestion management for the ISDN frame relaying bearer service".
- [29] ITU-T Recommendation I.371: "Traffic control and congestion control in B-ISDN".
- [30] ITU-T Recommendation I.372: "Frame mode bearer service network-to-network interface requirements".
- [31] ITU-T Recommendation I.411: "ISDN user-network interfaces - reference configurations".
- [32] ITU-T Recommendation I.413: "B-ISDN user-network interface".
- [33] ITU-T Recommendation I.431: "Primary rate user-network interface - Layer 1 specification".
- [34] ITU-T Recommendation I.555: "Frame relaying bearer service interworking".
- [35] ITU-T Recommendation Q.922: "ISDN data link layer specification for frame mode bearer services".
- [36] ITU-T Recommendation Q.931: "Digital subscriber Signalling System No.1 (DSS1) - ISDN user-network interface layer 3 specification for basic call control".
- [37] ITU-T Recommendation Q.933: "Digital subscriber Signalling System No.1 (DSS1) - Signalling specification for frame mode bearer service".



- [38] ITU-T Recommendation Q.2931: "Broadband Integrated Services Digital Network (B-ISDN) - Digital subscriber Signalling System No.2 (DSS2) - User-network interface layer 3 specification for basic call/connection control".
- [39] ISO/IEC 8802-3: "Information technology - Local and metropolitan area networks - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications".
- [40] ISO/IEC 8802-5: "Information processing systems - Local and metropolitan area networks - Part 5: Token ring access method and physical layer specifications".
- [41] ISO/IEC 8802-6: "Information processing systems - Telecommunications and information exchange between systems - Local and metropolitan area networks - Part 6: Distributed Queue Dual Bus (DQDB) access method and physical layer specifications".
- [42] ISO 9314: "Information processing systems - Fiber distributed data interface (FDDI)".
- [43] ISO/IEC 11579-1: "Information technology - Telecommunications and information exchange between systems - Private Integrated Services Network - Part 1: Reference configuration for PISN Exchanges (PINX)".
- [44] ISO/IEC DIS 11801: "Information technology - Generic cabling for customer premises cabling".
- [45] ISO/IEC DIS 13871: "Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Private Integrated Services Network - Digital channel aggregation".
- [46] IEEE 802.9: "Integrated Services LAN (ISLAN) interface at the MAC and PHY layers".
- [47] IEEE 802.6.h: "Isochronous service on a Distributed Queue Dual Bus (DQDB) subnetwork of a Metropolitan Area Network (MAN)".

### 3 Definitions

Only those terms are defined in this clause which cannot easily be found in other standards or where different definitions exist. All other terms are used according to their definition in relevant standards. The definitions for Local Area Network (LAN), Metropolitan Area Network (MAN) technologies can be found in the ISO/IEC, IEEE 802 and ETSI standards that are listed in clause 2. The Integrated Services Digital Network (ISDN) and Broadband Integrated Services Digital Network (B-ISDN) terms are defined in the relevant ITU-T Recommendations.

**Access Facility (AF):** The network segment that connects the CPN to the MSS.

**Access Node (AN):** A node providing access to the public network.

**Broadband Integrated Services Private Branch eXchange (B-ISPBX):** An exchange of a B-PISN that is located on the customer premises.

**Broadband Private Integrated Services Network (B-PISN):** Connection oriented private broadband ISDN, with the possibility to include non-ISDN parts within the context of (non-ISDN) bearer capabilities.

**Customer Premises Equipment (CPE):** The equipment part of a CTN (i.e. a CTN excluding the private wiring or cabling).

**Customer Premises Network (CPN):** That part of a CTN that is located on a single premises.

**Corporate Telecommunication Network (CTN):** Private network, connection oriented and/or connectionless, of any kind of technology, e.g., LAN, MAN, nx64 kbit/s ISDN or B-ISDN.

**High-Speed Private Integrated Services Network (HS-PISN):** That part of a CTN that provides high-speed, connection oriented and/or connectionless, of any kind of technology suitable for high speed transmission.

**Interconnecting Network (ICN):** That part of a CTN that interconnects two CPNs in the context of an integrated scenario.

**Integrated Services Centrex (ISCTX):** An implementation of a PINX located on a third party premises.

**Integrated Services LAN (ISLAN):** LAN that provides asynchronous and isochronous services.

**Integrated Services Private Branch eXchange (ISPBX):** An implementation of a PINX located on the customer premises.

**Intervening Network (IVN):** That part of a CTN that interconnects two CPNs in the context of an overlay scenario.

**leased lines:** The telecommunications facilities provided by a public telecommunications network that provide defined transmission characteristics between network termination points and that do not include switching functions that the user can control (e.g. on demand switching).

**MAN Switching System (MSS):** A collection of functions that provides high-speed switching in the public MAN.

**Network Termination type 2 (NT2):** A functional group between S and T reference points in ISDN networks.

**private B-ISDN:** A private network providing B-ISDN services.

**Private Integrated Services Network (PISN):** Connection-oriented private 64 kbit/s ISDN with the possibility to include non-ISDN parts within the context of (non-ISDN) bearer capabilities.

**Private Integrated Services Network eXchange (PINX):** An exchange of the PISN.

**Terminal Equipment (TE):** The equipment attached to a network, via which the user accesses the network services.

**Transit Link (TL):** A link within the public network.

**Transit Node (TN):** A node within the public network.

**Virtual Private Network (VPN):** The emulation of transit node functionality and/or end node functionality by public network equipment.

## 4 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

10BASE2	10 Mbit/s Baseband 200 m segment length
10BASE5	10 Mbit/s Baseband 500 m segment length
10BASE-F	10 Mbit/s Baseband Fiber optic cable
10BASE-T	10 Mbit/s Baseband Twisted pair cable
AAL	ATM Adaptation Layer
AF	Access Facility
AN	Access Node
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
B-ISPBX	Broadband Integrated Services Private Branch eXchange
B-PISN	Broadband Private Integrated Services Network
CBDS	Connectionless Broadband Data Service
CBR	Constant Bitrate Video
CPE	Customer Premises Equipment

CPN	Customer Premises Network
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CTN	Corporate Telecommunication Network
DQDB	Distributed Queue Dual Bus
FDDI	Fiber Distributed Data Interface
FOIRL	Fiber Optic Inter Repeater Link
HS-PISN	High-Speed Private Integrated Services Network
ICN	Interconnecting Network
ISCTX	Integrated Services Centrex
ISDN	Integrated Services Digital Network
ISLAN	Integrated Services LAN
ISPBX	Integrated Services Private Branch eXchange
IVN	Intervening Network
LAN	Local Area Network
LAPD	Link Access Procedure on the D-channel
MAC	Medium Access Control
MAN	Metropolitan Area Network
MSS	MAN Switching System
NT2	Network Termination type 2
ONP	Open Network Provision
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PINX	Private Integrated Services Network eXchange
PISN	Private Integrated Services Network
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
STM-n	Synchronous Transport Module level n
TE	Terminal Equipment
TL	Transit Link
TN	Transit Node
VBR	Variable Bitrate Video
VPN	Virtual Private Network

## 5 Application scenarios and their characteristics

In accordance with the scope of this ETR and the terms of reference of STC BTC4, the following five applications are considered as most relevant in the context of high speed communication in private networks:

- LAN interconnection;
- high speed data transfer;
- video communication in real-time;
- video in store-and-forward;
- multimedia communication.

A more complete set of possible broadband services and applications in a Corporate Telecommunication Network (CTN) is contained in ITU-T Recommendation I.211 [16].

### 5.1 LAN interconnection

LAN interconnection is not an application from the end-user's point of view, but it is an important application of high speed communication networks. Typical LAN applications today are office systems, where most of the traffic results from data exchange between terminals (PCs, workstations) and servers. The data exchange between terminals over wide areas, i.e. attached to geographically separate LANs, is often restricted to occasional electronic mail messages. Whilst the attached terminals often communicate with each other at relatively low speeds, the LAN data rate needs to be high to accommodate the aggregate data from many terminals. Although Integrated services LANs and high speed LANs ( $\geq 100$  Mbit/s) are being developed, they are not yet significantly deployed. Therefore, in the context of LAN Interconnection, only well established LAN types are considered.

#### Single LAN traffic characteristics:

- data transmission (note 1);

- data rates 1 to 20 Mbit/s (note 2);
- bursty traffic;
- small volume data transfer in variable length frames;
- broadcast and multicast (group addressing).

NOTE 1: LANs have been designed for data transmission only. Whilst data transmission remains dominant, conversational voice and video transmission capabilities are emerging.

NOTE 2: Although there are networks in use with data rates of the order of 100 Mbit/s, (e.g. FDDI, see subclause 6.2.4), they are mostly used as LAN interconnecting networks, not as single LANs.

#### **Interconnected LAN traffic characteristics:**

- the traffic characteristics of interconnected LANs are basically the same as the traffic characteristics of single LANs. Depending on the configuration the data rates of the interconnected LANs are usually in the same range as for a single LAN, but in some circumstances may be greater.

#### **Service requirements of LAN interconnection:**

- transfer of small volume data in variable length data units (frames);
- support of connectionless mode traffic;
- data rates equal to or greater than LAN data rates (note 3);
- low undetected error rate (LAN applications are based on an undetected error rate of  $5 \times 10^{-14}$  per octet of Medium Access Control (MAC) service data unit);
- support of group addressing;
- variable delay is acceptable.

NOTE 3: The data rate of the interconnecting network may even be below the data rates of the individual LANs for availability or economic reasons. This may result in degraded performance.

## **5.2 High speed data transfer**

This application provides high speed data communication between end-users. Examples of high speed data transfer are file transfer, e.g. for CAD/CAM applications, remote image data base access and data exchange between super-computers, e.g. for weather forecasting.

#### **Traffic characteristics:**

- data transmission only;
- data rates > 1 Mbit/s;
- high volume data transfer in variable length frames or packets;
- point-to-point communication (note 1).

NOTE 1: Multicasting will be less common than in a typical LAN application.

#### **Service requirements:**

- transfer of high volume data in variable length data units (frames or packets);
- peak data rates > 1 Mbit/s (note 2);
- low undetected error rate;
- group addressing (note 3);
- variable delay is acceptable.

NOTE 2: High volume concurrent data transfer from several sources may be required, resulting in these high peak data rates.

NOTE 3: Group addressing will be required if multicasting is supported.

### 5.3 Video communication in real-time

Real-time video communication requires low delay and low delay variation of the transporting network. This type of video communication encompasses conversational video and video distribution.

#### Traffic characteristics:

- video transmission;
- data rates up to 140 Mbit/s per video connection, depending on the video coding. Widely used data rates today are 64 kbit/s, 128 kbit/s, 384 kbit/s, 1,5 Mbit/s, 2 Mbit/s, 7 to 10 Mbit/s and 45 Mbit/s. Also depending on the coding, the data rate may be constant (CBR) or variable (VBR);
- continuous bit stream;
- point-to-multipoint (note), multipoint-to-multipoint.

NOTE: Point-to-multipoint communication will be required, but may be realized by means other than multicasting.

#### Service requirements:

- transfer of high volume data in continuous bit streams;
- peak data rates between 64 kbit/s and 140 Mbit/s (for CBR, mean data rate equals peak data rate);
- support of point-to-multipoint and multipoint-to-multipoint communication;
- low delay and low delay variation.

### 5.4 Video in store-and-forward

Video in store-and-forward is tolerant of significant delays and delay variance by means of buffering. Video in store-and-forward encompasses video mail and video retrieval.

#### Traffic characteristics:

- video transmission;
- data rates up to 140 Mbit/s per video connection, depending on the video coding. Widely used data rates today are 64 kbit/s, 128 kbit/s, 384 kbit/s, 1,5 Mbit/s, 2 Mbit/s, 7 to 10 Mbit/s, and 45 Mbit/s. Also depending on the coding, the data rate may be constant (CBR) or variable (VBR);
- continuous bit stream;
- point-to-multipoint (note 1), multipoint-to-multipoint.

NOTE 1: Point-to-multipoint communication will be required, but may be realized by means other than multicasting.

#### Service requirements:

- transfer of high volume data in continuous bit streams;
- peak data rates between 64 kbit/s and 140 Mbit/s (For CBR, mean data rate equals peak data rate);
- support of point-to-multipoint and multipoint-to-multipoint communication;
- significant and variable delay is acceptable (note 2).

NOTE 2: Terminal buffering may be required to compensate for delay variance.

### 5.5 Multimedia communication

Multimedia communication in this context means end-to-end communication, i.e. "to the desk", involving more than one type of information, e.g. text&graphics, audio&video, voice&data&video. The different information types may be transferred via different connections. In a multipoint call there may be different combinations of information types between different combinations of participants, e.g. in a three party voice call there could also be a file transfer between two parties. When the information types are related to each other, e.g. voice and video, synchronization has to take place. The combination of information types

may change during the call, e.g. during a voice conversation the parties agree to jointly work on a document. This results in changes of data rate during the call.

**Traffic characteristics:**

Multimedia communication combines the appropriate traffic characteristics, depending on the types of information to be exchanged. For example, if text, graphics, still images and real-time video are exchanged, the traffic characteristics listed in subclauses 5.1 to 5.4 will appear in the combined data transfer. In addition to the traffic characteristics listed in subclauses 5.1 to 5.4, the traffic requirements for audio communication have to be defined in order to provide for all types of multimedia communication (see subclause 5.6).

**Service requirements:**

The multimedia service requirements will be a combination of the service requirements that are derived from the information types involved in the multimedia communication. Since the requirements for data and video communication are already summarized in the previous sections, only the requirements for voice communication are listed in subclause 5.6. In addition there is a need for synchronization of related information types. This implies that the most stringent requirement of the involved information types has to be met by all of those information types.

**5.6 Audio communication**

Although audio communication is not within the scope of this ETR, the traffic characteristics and the service requirements of audio communication are required in the context of multimedia communication.

**Traffic characteristics:**

- voice transmission;
- data rates up to 384 kbit/s (note 1);
- continuous bit stream;
- (point-to-multipoint (note 2)).

NOTE 1: Data rates less than 64 kbit/s can be achieved by using voice compression. On the other hand data rates higher than 64 kbit/s, e.g. 384 kbit/s may be used for the transmission of high quality audio.

NOTE 2: Point-to-multipoint communication may be required for conference calls.

**Service requirements:**

- transfer of data in continuous bit streams;
- data rates up to 384 kbit/s;
- (support of point-to-multipoint communication);
- very low delay and low delay variations (note 3).

NOTE 3: The delay requirements for conversational voice are more stringent than for real-time video.

**6 Network technologies**

It has been shown in clause 5 that the application scenarios which are relevant for high speed communication in private networks lead to different service requirements. These requirements can be used as a basis for the identification of suitable existing services and the selection of network technologies.

In the following, a brief overview of relevant transmission and switching/relaying technologies is given. It should be noted, that as far as functionality in terms of OSI layers is concerned, only subnetwork technologies are described. The identification of network layer protocols for the interconnection of subnetworks is outside the scope of this ETR.

## 6.1 Transmission technologies

The following transmission systems are used both as communication services on their own (leased lines) or to carry Distributed Queue Dual Bus (DQDB) and Asynchronous Transfer Mode (ATM) protocols. All other switching/relaying technologies use their own transmission systems.

### 6.1.1 Plesiochronous Digital Hierarchy (PDH)

The PDH was developed in 1965. "Plesiochronous" means "almost synchronous". Each clock is allowed a certain range of speeds. The multiplexer reads each tributary into a buffer. It reads out of the buffer at the highest allowed clock speed and, when there are no bits in the input buffer (because the bits are arriving according to a slower clock), it adds a "stuffing bit" to "stuff" the signal up to the higher clock speed. It also has a mechanism to signal to the demultiplexer that it has performed stuffing, and the demultiplexer must know which bit to throw out.

The European hierarchy of PDH systems is:

E1	2,048 Mbit/s;
E2	8,448 Mbit/s;
E3	34,368 Mbit/s;
E4	139,264 Mbit/s.

ETSI STC BTC2 is charged with the standardization for the connection characteristics and interface presentation for the following Open Network Provision (ONP) minimum set leased lines:

64 kbit/s with octet integrity;  
2 048 kbit/s unstructured and structured leased lines.

### 6.1.2 Synchronous Digital Hierarchy (SDH)

The new method of multiplexing, "SDH" in Europe, Synchronous Optical Network (SONET) in North America, was developed in the early 1980s. The basic time constant of 8 000 frames per second is preserved in SDH. What is transmitted in these 125  $\mu$ s is represented in a rectangle. All information is collected in bytes and no longer in bits. The bytes are transmitted one row at a time. The tributaries to a multiplexer each have a frame that is not aligned in time with the other tributaries, nor with the frame of the output stream. To resolve this problem, the SDH multiplexer calculates a pointer that tells where in the Synchronous Transport Module level 1 (STM-1) frame it has placed the tributary frame.

STM-1	155,520 Mbit/s;
STM-4	622,080 Mbit/s;
STM-16	2488,320 Mbit/s.

### 6.1.3 Higher order leased lines

ETSI STC BTC2 is charged with the standardization of the connection characteristics and interface presentation of the following higher order leased lines:

34 Mbit/s structured and unstructured leased lines;  
140 Mbit/s structured and unstructured leased lines.

These leased lines will use the structure developed by ETSI STC TM3 for use in an SDH environment.

## 6.2 Switching/relaying technologies

### 6.2.1 64 kbit/s ISDN

Since it can be assumed that the characteristics of 64 kbit/s ISDN are well known, only the major features will be listed for completeness sake:

- end-to-end digital connectivity;
- 2B+D (basic rate access);
- 30B+D (primary rate access);
- out of band signalling (D-channel).

**Service characteristics (isochronous service only, note 1):**

- continuous bit stream;
- isochronous (constant low delay);
- data rates 64 kbit/s, 384 kbit/s, 1 536 kbit/s, 1 920 kbit/s (B, H<sub>0</sub>, H<sub>11</sub>, H<sub>12</sub>), n×64 kbit/s (notes 2 and 3);
- connection oriented service;
- permanent and on-demand service provision;
- no broadcast or multicast capability.

NOTE 1: ISDN also offers packet- and frame-mode services.

NOTE 2: The n×64 kbit/s bearer service (n = 2 to 128) can provide a similar bandwidth as achieved by aggregating the bitstreams of a corresponding number of individual 64 kbit/s channels (see ISO/IEC DIS 13871 [45] and draft ITU-T Recommendation H.244 [13]).

NOTE 3: The name "multiple-rate bearer service" has been adopted by ETSI TC NA to describe the n×64 kbit/s bearer service.

**Relevant standards (note 4):** [19], [31], [33], [36]

NOTE 4: This list is by no means complete; only a few of the most relevant ISDN standards are listed.

**6.2.2 Ethernet, CSMA/CD - ISO/IEC 8802-3**

Carrier Sense Multiple Access with Collision Detection (CSMA/CD) controls access to the medium by means by which two or more stations share a common transmission medium. To transmit, a station waits (defers) for a quiet period on the medium (that is, no other station is transmitting) and then sends the intended message in bit-serial form. If, after initiating a transmission, the message collides with that of another station, then each transmitting station intentionally sends a few additional bytes to ensure propagation of the collision throughout the system. The station then remains silent for a random amount of time (back-off) before attempting to transmit again. The CSMA/CD LAN technology is defined for use on 50 Ω coaxial cable (10BASE5 and 10BASE2), on unshielded twisted pair (10BASE-T) and on fibre optic cable (FOIRL and 10BASE-F).

**Service characteristics:**

- transfer of small volume data in variable length data units;
- variable delay;
- transmission rates 1 Mbit/s, 10 Mbit/s and 100 Mbit/s (note);
- connectionless service;
- no guaranteed bandwidth;
- broadcast and multicast capability.

NOTE: 100 Mbit/s CSMA/CD has not yet been standardized, but it is an accepted IEEE 802 project. In addition, a project for a demand-priority protocol, using the CSMA/CD Protocol Data Unit (PDU) format over voice grade twisted pair cabling at 100 Mbit/s has been accepted as IEEE 802 project.

**Relevant standards:** [39], [44]

**6.2.3 Token ring - ISO/IEC 8802-5**

In a token ring, stations are serially connected to form a logical ring over which data and control information is transmitted and received.

Access to this ring is controlled by a signalling sequence referred to as the "token" which circulates around the ring from station to station.



A station desiring to transmit waits until it receives a token. The station changes the token to a start-of-message, transmits its message and, upon completion of the message, releases a new token for use by other stations on the ring.

Token ring is defined for operation on shielded and unshielded twisted pair medium at data rates of 4 Mbit/s and 16 Mbit/s. In addition, token ring may operate using fibre optic cable.

**Service characteristics:**

- transfer of small volume data in variable length data units;
- variable delay;
- transmission Rates 4, 16 Mbit/s (note);
- connectionless service;
- no guaranteed bandwidth;
- broadcast and multicast capability;
- priority mechanism.

NOTE: The demand-priority protocol is designed in such a way that token ring protocol data units can be transported as well as CSMA/CD PDUs at 100 Mbit/s.

**Relevant standards:** [40], [44]

**6.2.4 Fibre Distributed Data Interface (FDDI) - ISO 9314**

FDDI is a 100 Mbit/s LAN. The FDDI protocol is based on a token ring access method. The FDDI MAC uses a timed token rotation protocol to control access to the medium. Under this protocol, each station measures the time that has elapsed since a token was last received. The initialization procedures establish the target token rotation time equal to the lowest value that is bid by any of the stations. Two classes of service are defined:

- synchronous service allows use of a token whenever MAC has synchronous frames queued for transmission (note 1);
- asynchronous service allows use of a token only when the time since a token last was received has not exceeded the established target token rotation time.

NOTE 1: The meaning of "synchronous" in this context is completely different from the "synchronous" technology in subclause 6.1. "Synchronous service" in FDDI means that a station can rely on a guaranteed minimum response time.

Multiple levels of priority for asynchronous frames may be provided within a station by specifying additional (more restrictive) time thresholds for token rotation.

FDDI-II is an upward-compatible enhancement of the basic FDDI that adds a circuit-switched capability to the packet capability.

FDDI had originally been specified for use on optical fibre (single-mode and multi-mode). Recently, specifications for use of shielded and unshielded twisted pair have been added.

**Service characteristics:**

- transmission rate 100 Mbit/s;
- connectionless service:
  - variable delay;
  - transfer of small volume data in variable length data units;
  - no guaranteed bandwidth (but guaranteed minimum response time for synchronous service);
  - broadcast and multicast capability;
  - priority mechanism;
- isochronous service (only provided by FDDI-II):
  - continuous bit stream;
  - constant low delay;
  - data rates 8 kbit/s, 16 kbit/s, 32 kbit/s, 64 kbit/s, 384 kbit/s, 1,536 Mbit/s, 1,920 Mbit/s, 2,048 Mbit/s and 6,144 Mbit/s;

connection oriented service;  
permanent service provision (note);  
no broadcast or multicast capability.

NOTE 2: The use of signalling protocols, e.g. ITU-T Recommendations Q.93x, is possible, but outside the scope of ISO 9314 [42].

**Relevant standards (note 3): [42]**

NOTE 3: ISO 9314 [42] consists of several parts. Additional specifications for single mode fibre physical medium dependent, copper physical medium dependent and hybrid ring control (FDDI-II) have been added recently. However, for simplicity reasons, the standards are not listed separately.

**6.2.5 Integrated Services LAN (ISLAN) - IEEE 802.9**

ISLAN has been standardized by IEEE 802.9 [46]. It describes a time division multiplexing based interface at 4,096 Mbit/s and 20,48 Mbit/s, over unshielded twisted pair. By means of a set of different channels (B-channels, C-channel, D-channel and P-channel) it is capable of supporting voice, data as well as video-traffic. Therefore, ISLAN is suitable for the provision of multimedia services. The interface specification can be used in combination with existing PBX- and LAN-technologies.

**Service characteristics:**

- transmission rates 4,096 Mbit/s and 20,48 Mbit/s (note 1);
- connectionless service:
  - variable delay;
  - transfer of small volume data in variable length data units;
  - no guaranteed bandwidth;
  - broadcast and multicast capability;
  - priority mechanism;
- isochronous service:
  - continuous bit stream;
  - constant low delay;
  - data rates 64 kbit/s, n×64 kbit/s;
  - connection oriented service;
  - permanent and on-demand service provision (note 2);
  - no broadcast or multicast capability.

NOTE 1: An option with 16,384 Mbit/s ("IsoEnet") has been accepted as project IEEE 802.9a. A draft specification is available.

NOTE 2: The use of signalling protocols based on ITU-T Recommendations Q.93x is only recommended in IEEE 802.9 [46].

**Relevant standards: [46]**

**6.2.6 Distributed Queue Dual Bus (DQDB) - ISO/IEC 8802-6**

DQDB is defined to have the capability to work over the local area and to interoperate with the other LAN technologies.

However, DQDB is more often encountered in the metropolitan area and it introduces the concept of the MAN, where the development of a high speed technology is required to support e.g. connectionless data services. For the specification of the corresponding service, the Connectionless Broadband Data Service (CBDS), see ETS 300 211 [1] and ETS 300 217 [2]. Because of the differing environments in which the DQDB MAN will be utilized, a variety of physical layer protocols which make use of existing underlying transmission standards have been defined.

DQDB provides a high-speed shared medium access protocol for use over a dual, contra-directional (counter-flowing, unidirectional) bus subnetwork. DQDB provides three types of service:

- connectionless MAC service;
- isochronous service;
- connection oriented data service.

In order to support these services, two access methods have been defined:

- a queued arbitrated access method with three priority queues for medium arbitration and fixed-length slots for data transfer. Each priority level provides distributed queue access for the support of connectionless MAC service and connection oriented service. In addition, functions equivalent to the ATM Adaptation Layer (AAL) are provided for the support of connectionless MAC service and connection oriented service;
- a pre-arbitrated access method that uses assigned slot positions for the support of isochronous services.

#### **Service characteristics:**

- transmission rates 1,544 (T1), 2,048 (E1), 34,368 (E3), 44,736 (T3), 139,264 (E4), 155,520 (STM-1) and 622,080 Mbit/s (STM-4);
- connectionless service:
  - variable delay;
  - transfer of data in variable length data units (max. size 9 188 octets);
  - no guaranteed bandwidth;
  - broadcast and multicast capability;
  - priority mechanism (note 1).
- isochronous service:
  - constant low delay;
  - continuous bit stream;
  - variable data rates;
  - connection oriented service;
  - semi-permanent service provision (note 2);
  - multicast capability (dependent on the signalling protocol).
- connection-oriented service:
  - variable delay;
  - transfer of data in variable length data units (max. size 65 535 octets);
  - guaranteed bandwidth;
  - semi-permanent service provision (note 2);
  - multicast capability;
  - priority mechanism.

NOTE 1: In order to ensure fair sharing of bandwidth, only one priority is to be used for connectionless service.

NOTE 2: The use of signalling protocols based on ITU-T Recommendations Q.293x is possible, but currently outside the scope of ISO/IEC 8802-6 [41].

**Relevant standards:** [1], [2], [3], [7], [8], [9], [41], [47]

#### **6.2.7 Asynchronous Transfer Mode (ATM)**

ATM is the technology for B-ISDN. In ATM, information to be transferred is segmented into a set of fixed-size cells. These "cells" are equivalent to the "slots" of DQDB. Length and structure of cells and slots are identical in order to ease interworking.

Cells are identified and switched by means of a label in the header (virtual path identifier/virtual channel identifier). Cells belonging to the same connection may exhibit an irregular recurrence pattern, as cells are filled according to actual demand.

On top of the ATM layer, AAL functions have been specified for the support of different types of services (e.g. connectionless mode, constant bitrate). In particular, CBDS may be provided on top of ATM with the same characteristics as on top of DQDB.

**Service characteristics:**

- transmission rates 1,544 (T1), 2,048 (E1), 34,368 (E3), 44,736 (T3), 51,8 (OC-1), 139,264 (E4) , 155,520 (STM-1) and 622,080 Mbit/s (STM-4) (note 1).
- connectionless service (CBDS):
  - variable delay;
  - transfer of data in variable length data units (max. size 9 188 octets);
  - variable bit rate: "maximum allowed sustained information rate" is a subscription option (access class);
  - broadcast and multicast capability;
- constant bitrate service:
  - continuous bit stream;
  - constant low delay;
  - multiple data rates;
  - connection oriented service;
  - permanent and on-demand service provision (note 2);
  - multicast capability (dependent on the signalling protocol).
- variable bitrate service:
  - connection oriented service with end-to-end transport of timing information;
  - permanent and on-demand service provision (note 2);
  - multicast capability (dependent on the signalling protocol);
- connection-oriented service:
  - variable delay;
  - transfer of data in variable length data units (max. size 65 535 octets);
  - guaranteed bandwidth;
  - permanent and on-demand service provision (note 2);
  - multicast capability.

NOTE 1: Mapping standards for these data rates are available. However, their use has not yet been specified at the user-network interface.

NOTE 2: User-network interface signalling protocols based on ITU-T Recommendations Q.93x (Q.293x) are being standardized. Public network node interface signalling protocols based on ISUP (B-ISUP) are being standardized.

**Relevant standards:** [2], [4], [5], [8], [9], [10], [11], [12], [14], [15], [16], [18], [20], [22], [23], [24], [25], [26], [27], [29], [32], [34], [38]

### 6.2.8 Frame relay

Frame relay provides a connection oriented packet data service. Frame relay can be supported by different network technologies, such as ISDN, ATM, dedicated data networks.

Frame relay uses a layer 2 protocol which is derived from the ISDN Link Access Procedure on the D-channel (LAPD).

**Service characteristics:**

- connection-oriented service:
  - data rates 64 kbit/s to 2 Mbit/s (note 1);
  - variable delay;
  - transfer of data in variable length data units (max. PDU size negotiable, at least 260 octets);
  - guaranteed bandwidth;
  - semi-permanent and on-demand service provision (note 2).

NOTE 1: Provision of frame relay service on 34 Mbit/s transmission systems is under development.

NOTE 2: In the case of frame relay provision in ISDN (B-ISDN), use of signalling protocol ITU-T Recommendation Q.933 [37] (Q.293x).

**Relevant standards:** [17], [27], [28], [30], [34], [35]

## 7 Evaluation of switching/relaying technologies

Table 1 shows an attempt to classify the relevant switching/relaying technologies in terms of their suitability for the application scenarios listed in clause 5. The rationale for this attempted classification is contained in annex A. Based on this rating, interworking scenarios and requirements will be derived (see clauses 8 to 10). Additionally, geographical limitations will be taken into consideration.

Table 1

	LAN inter-connection	High speed data transfer	Real-time video	Video in store-and-forward	Multimedia communication
64 kbit/s ISDN (note 1)	+	+	+	+	+
nx64 kbit/s ISDN	++	++	++	++	++
CSMA/CD	++	++	+	+	+
Token Ring	++	++	+	++	+
FDDI	+++	+++	++	++	++
FDDI-II	++	+++	+++	+++	+++
ISLAN	n.a.	++	++	++	++
DQDB	++++ (note 2)	+++	+++	+++	+++
ATM	++++ (note 2)	++++	+++	++++	+++
Frame relay	++	++	+	+	+
Legend: + limited suitability ++ suitable +++ more suitable ++++ most suitable n.a. not applicable NOTE 1: The term 64 kbit/s ISDN is used for differentiation from B-ISDN. It encompasses both basic access and primary rate access. NOTE 2: This classification applies only for high data rate implementations (e.g. 155 Mbit/s).					

## 8 Reference configurations

### 8.1 Components of a Corporate Telecommunication Network (CTN)

A CTN consists of Customer Premises Equipment (CPE) and/or Customer Premises Networks (CPNs) which are located at geographically dispersed locations and are interconnected to provide networking services to a defined group of users.

### 8.2 General network configuration

Different types of networks will be interconnected for the provision of the transport service as basis for end-to-end communication. The general network configuration is intended to encompass all network types and specific configurations that may be used for end-to-end communication.

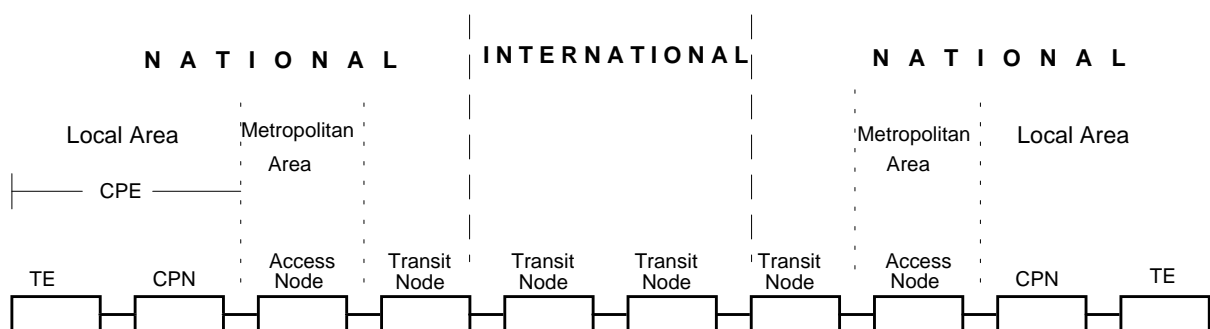


Figure 1: General network configuration

The access and transit nodes may belong to a public network or they may be part of a CTN, where customer premises networks are interconnected by virtual private networks or intervening networks.

**8.3 Specific reference configurations**

Specific reference configurations have been standardized by ITU-T, ETSI and ISO/IEC for several network types that are relevant for high speed communication. The reference configurations provide a scheme for the identification of functional groupings and interfaces which require standardization. In that respect, they may be useful in the context of high speed communication.

**8.3.1 ISDN reference configuration**

The general ISDN reference configuration as depicted in figure 2 is defined in ITU-T Recommendation I.324 [21]. The description of the functional groups is contained in ITU-T Recommendation I.411 [31].

NOTE 1: Within this ETR, the term "customer premises network" is used instead of "customer network" in order to avoid ambiguities.

NOTE 2: The general ISDN reference model shown in figure 2 is founded on 64 kbit/s B- and H-channels. It is equally applicable in the case of n×64 kbit/s services derived by channel aggregation in terminal equipment or in the customer network and also by multirate network bearer services.

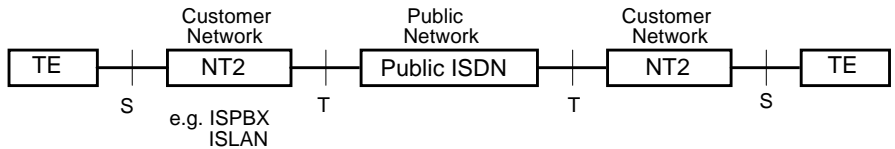


Figure 2: ISDN reference configuration

**8.3.2 B-ISDN reference configuration**

The B-ISDN reference configuration is defined in ITU-T Recommendation I.327 [22]. In addition to ITU-T Recommendation I.327 [22], descriptions of the functional groups are contained in ITU-T Recommendations I.311 [18] and I.413 [32].

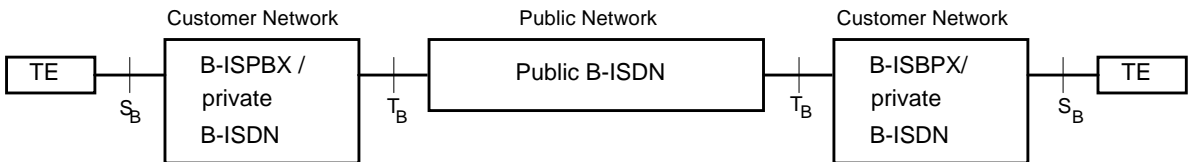
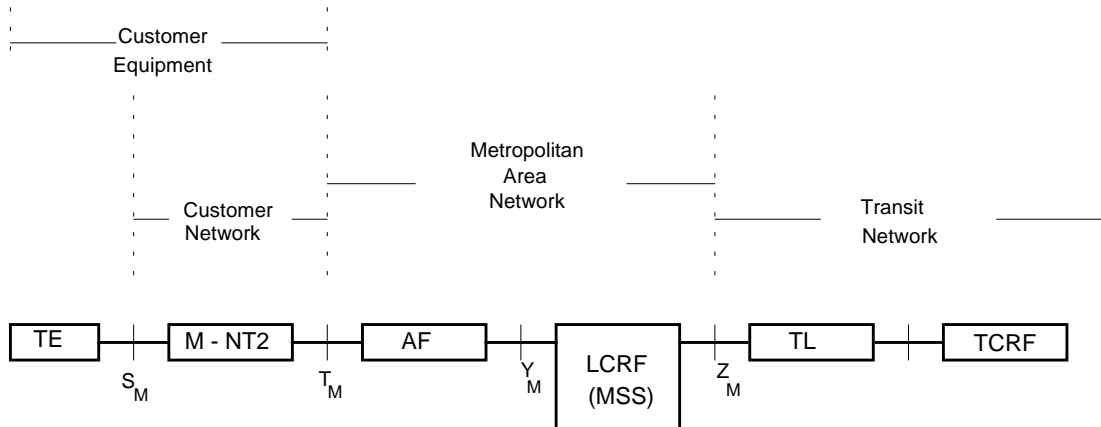


Figure 3: B-ISDN reference configuration

**8.3.3 MAN reference configuration**

The MAN reference configuration and the related functional groups are defined in ETS 300 211 [1].

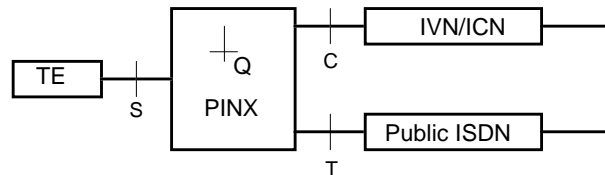


TCRF Transit Connection Related Functions  
 LCRF Local Connection Related Functions

**Figure 4: MAN reference configuration**

**8.3.4 PISN reference configuration**

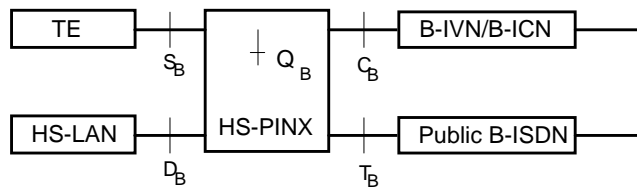
The PISN reference configuration, in particular the Private Integrated Services Network eXchange (PINX), and the related functional groupings are defined in ISO/IEC 11579-1 [43]. A simplified version is depicted in figure 5.



**Figure 5: Simplified reference configuration for PISN**

**8.3.5 HS-PISN reference configuration**

A HS-PISN reference configuration is currently under study in ISO/IEC JTC1/SC6. The results are intended to become ISO/IEC 11579-2. A simplified version of the anticipated reference configuration is given in figure 6.



**Figure 6: Simplified reference configuration for HS-PISN**

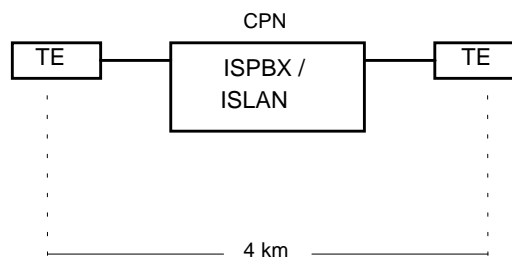
**8.4 Reference network connections**

The following set of reference network connections shall allow for the evaluation of different network technologies in terms of their suitability for high speed communication.

The calculation of QOS parameters such as end-to-end delay requires defined reference network connections with quantified distances. Therefore, the reference network extension is a prime parameter in the following reference network connections. Additional parameters may require further refinement of the reference network connections.

**8.4.1 Local connection**

A reference connection for the local area is depicted in figure 7. The distance on customer premises is taken from ISO/IEC DIS 11801 [44]. The length of access cabling is considered to be negligible (< 100 m).



**Figure 7: Local area reference connection**

**8.4.2 Metropolitan area connection**

A reference connection for the metropolitan area is depicted in figure 8.

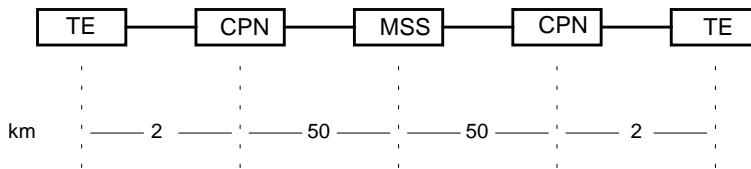


Figure 8: Metropolitan area reference connection

8.4.3 Wide-area connection (moderate size)

A reference connection for the wide area with moderate size is depicted in figure 9. The distances are taken from ITU-T Recommendation G.103 [6].

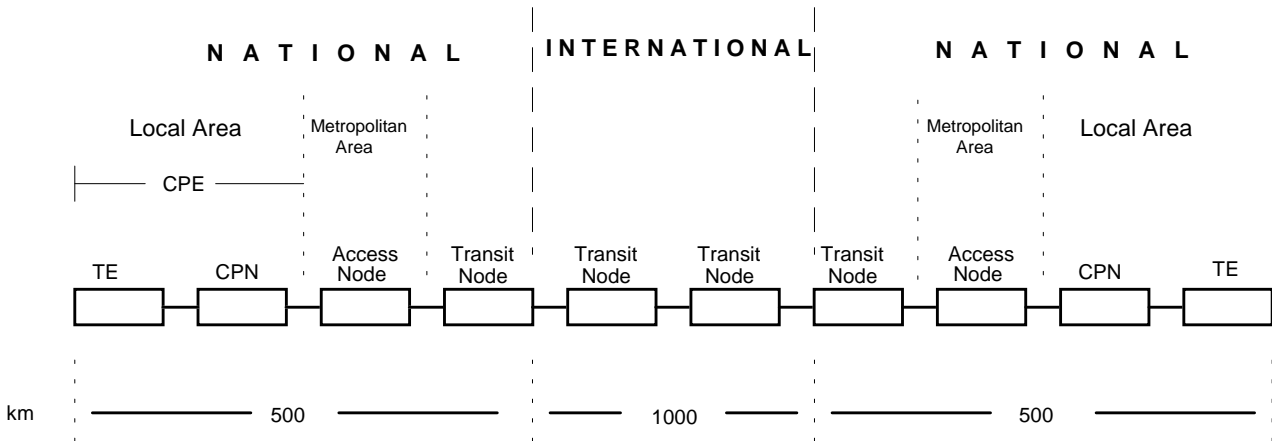


Figure 9: Wide-area reference connection (moderate size)

8.4.4 Wide-area connection (maximum size)

A reference connection for the wide area with maximum size is depicted in figure 10. According to ITU-T Recommendation G.103 [6], this is the longest international connection likely to occur in practice.

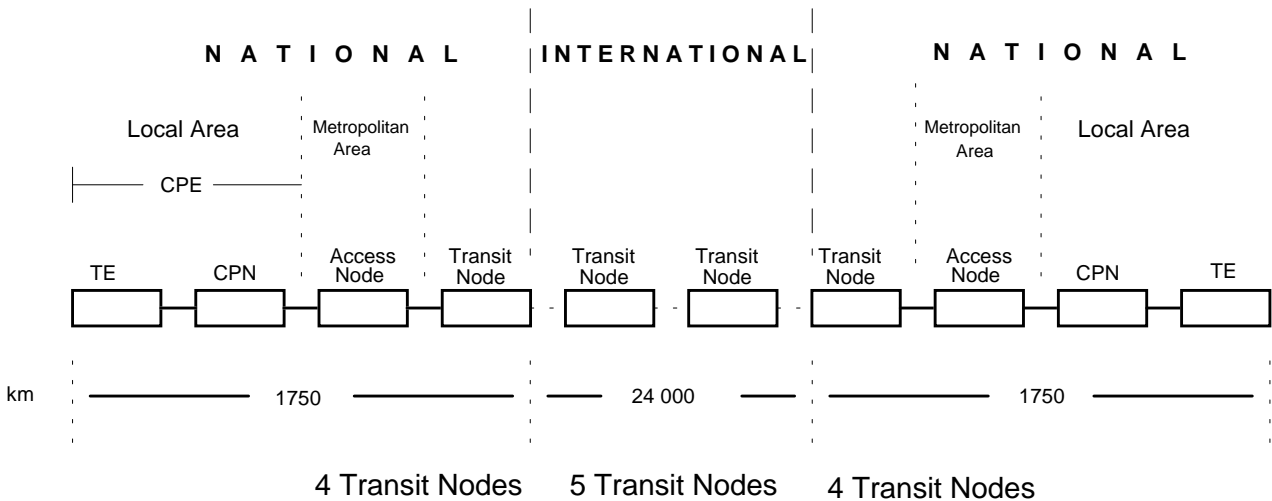


Figure 10: Wide-area reference connection (maximum size)

9 CPN functional model

The CPN functional model depicted in figure 11 describes only the simple case of a homogeneous CPN. S- and T-interfaces are used only in the context of ISDN, but should be interpreted here in a wider sense. Therefore this functional model is by no means exhaustive.

However, this functional model covers a variety of different CPN topologies. These can range from:



- a) a simple CPN where a broadband terminal is directly connected to the public network;
- b) a more complex topology with a network of terminals.

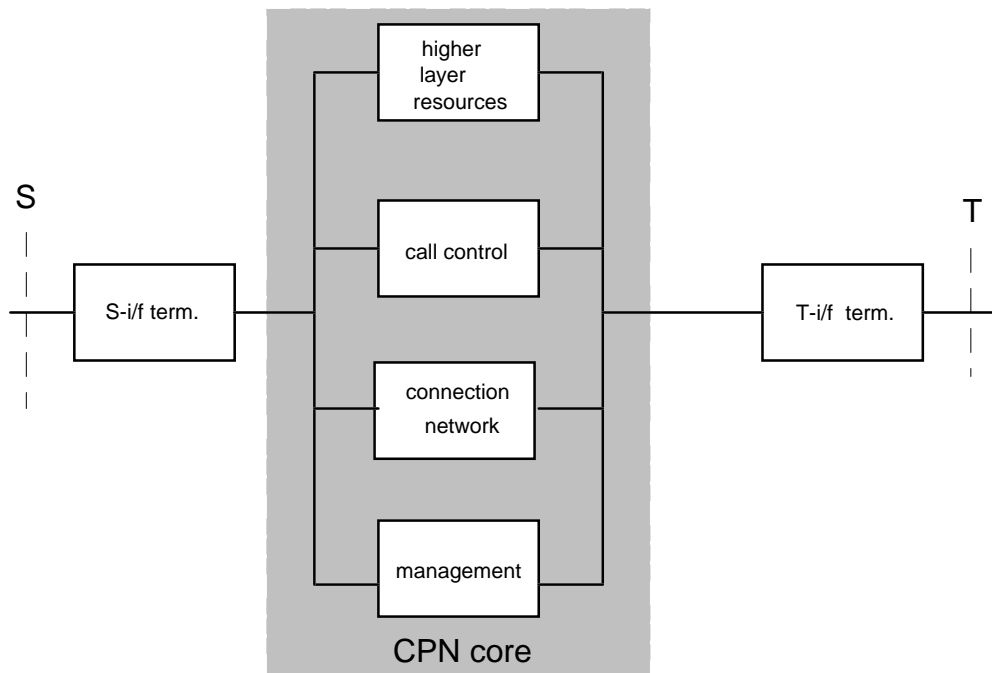


Figure 11: CPN functional model

The functional blocks shown above can be described as follows:

#### S-interface termination

The S-interface termination includes functions required for the connection of user equipment and primitives for the exchange of:

- call control information with the call control function;
- user information with the connection network function;
- management information with the management function.

#### T-interface termination

The T-interface termination includes those functions required for the connection of the CPN to the public network in accordance with the relevant T-interface protocols and primitives for the exchange of:

- call control information with the call control block;
- user information with the connection network block;
- management information with the management block.

#### Call control

This block is responsible for the interpretation of service requests and service control. It co-ordinates the activities of the other blocks in order to establish the appropriate resources that are necessary in order to satisfy a users' service requests. This block is invoked via requests received from either a user's terminal or the public network, which are carried by the network layer signalling protocol. In addition the call control block exchanges primitives with:

- S- and T-interface terminations which carry call control information;
- the CPN connection network block, which conveys network connection requests, indications etc.;
- the CPN management block, which carries requests or indications of management actions;
- the higher layer resources.

### Connection network

The connection network block is an abstraction of the physical CPN and as such is responsible for the provision and handling of the physical connections that are necessary to support a call. Requests for connections, i.e. physical resources, are received from the call control block. The connection network block exchanges primitives with:

- the S- and T-interface terminations which convey user information;
- the call control block, which conveys network connection requests, indications etc.;
- the management block, which conveys information concerning network connections (e.g. the status of connection invocations).

### Management

It is this block which is responsible for those management functions that concern operation, administration, maintenance and provision of the services provided by the CPN (possibly in conjunction with the public wide area network). The management block exchanges primitives with:

- the S- and T-interface terminations which convey management information;
- the connection network block, which conveys information such as traffic statistics, alarms, fault logging etc.;
- the call control block, which conveys, for example, current call status;
- the higher layer resources, e.g. configuration of the management database.

### Higher layer resources

This block is responsible for the termination of higher layers (of the protocol stack), provision of application and supplementary services. It could be considered as a set of servers that could be invoked by the call control block in response to a user's request. Higher layer resources model the provision of supplementary services and servers where the processing and storage of user information takes place (e.g. message handling).

The higher layer resources block exchanges primitives with:

- the call control block indicating, for example, service requests;
- the management block.

## 10 Interworking scenarios and requirements

Based on the reference configuration for HS-PISN that is depicted in figure 6, interworking scenarios for the application scenarios described in clause 5 have been derived. These recommended interworking scenarios are shown in figures 12 to 15. No recommendation is provided for the location of the interworking function.

An example configuration for LAN interconnection is contained in annex B.

### 10.1 Interworking scenario for LAN interconnection

The interworking scenario for LAN interconnection is depicted in figure 12. The selection of network technologies for the different parts of the network is based on the evaluation in clause 7.

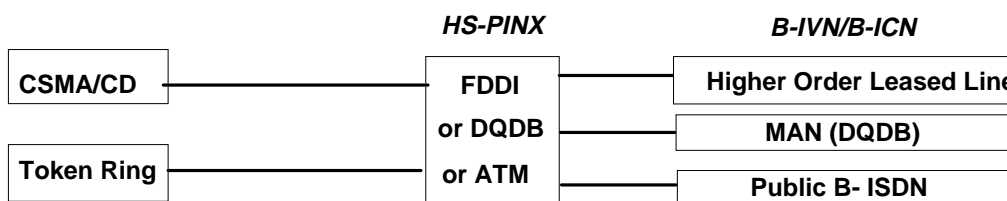


Figure 12: Interworking scenario for LAN interconnection

NOTE: DQDB technology may be used as PINX on customer premises or as MAN. Although today MANs are based on DQDB technology only, other technologies may be used in the future.

**10.2 Interworking scenario for high speed data transfer**

The interworking scenario for high speed data transfer is depicted in figure 13. The selection of network technologies for the different parts of the network is based on the evaluation in clause 7.

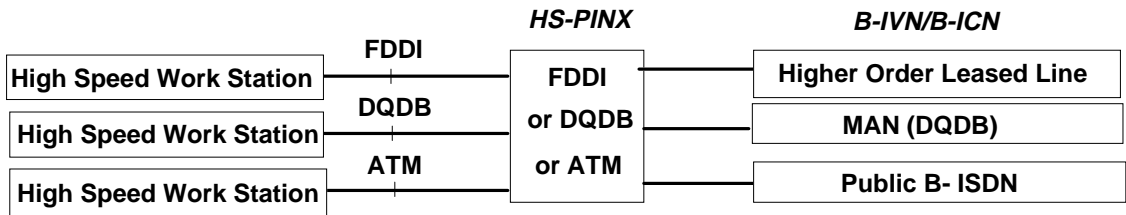


Figure 13: Interworking scenario for high speed data transfer

**10.3 Interworking scenario for video communication in real-time**

The interworking scenario for video communication in real-time is depicted in figure 14. The selection of network technologies for the different parts of the network is based on the evaluation in clause 7.

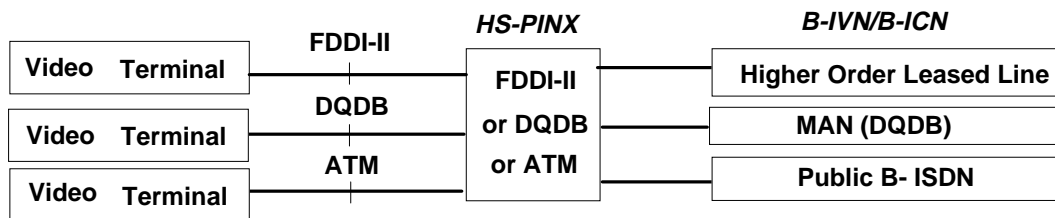


Figure 14: Interworking scenario for video communication in real-time

**10.4 Interworking scenario for multimedia communication**

The interworking scenario for multimedia communication is depicted in figure 15. The selection of network technologies for the different parts of the network is based on the evaluation in clause 7.

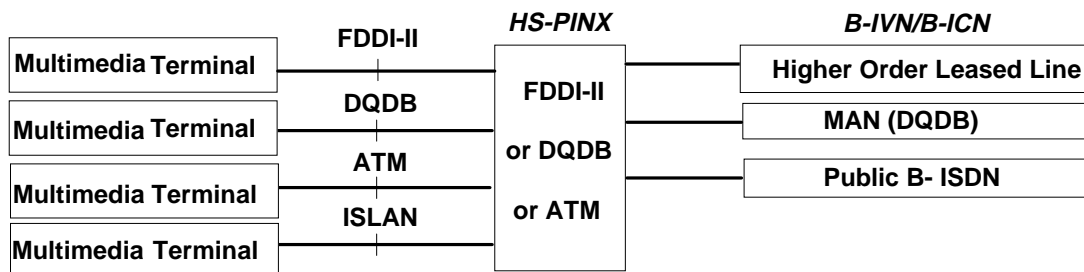


Figure 15: Interworking scenario for multimedia communication

10.5 Interworking requirements

Table 2 summarizes the interworking requirements that can be derived from the interworking scenarios in subclauses 10.1 to 10.4.

Table 2

	CSMA/CD	TR	FDDI	FDDI-II	ISLAN	DQDB	DQDB-M	ATM	B-ISDN	HO LL
CSMA/CD	—	IW	IC	*	IW	IC	IC	IC	IC	IC
TR		—	IC	*	IW	IC	IC	IC	IC	IC
FDDI			—	—	IC	IW	IW	IW	IW	IC
FDDI-II				—	IC	IW	IW	IW	IW	IC
ISLAN					—	IC	IC	IW	IW	IC
DQDB						—	IW	IW	IW	IC
DQDB-M							—	IW	IW	IC
ATM								—	IW	IC
B-ISDN									—	IC
HO LL										—

Legend:	TR	Token Ring
	DQDB-M	DQDB used as MAN
	HO LL	Higher Order Leased Line
	IW	interworking between TEs (e.g. translation)
	IC	interconnection between networks (e.g. encapsulation)
	—	not relevant
	*	not required

## **Annex A: Considerations for the evaluation of switching/relaying technologies**

Table 1 has been developed with the following considerations:

### **Suitability for LAN interconnection**

LANs have data rates in the range of 1 to 20 Mbit/s, with the majority using 10 Mbit/s. Therefore, a network is better suited for LAN interconnection than another one if its data rate is higher, because the probability of delays introduced by the interconnecting network is lower.

ISLAN being specified only as an interface for terminal access does not seem to be applicable in the context of LAN interconnection.

### **High speed data transfer**

In contrast to LAN interconnection, high speed data transfer means transfer of data with high speed for a significant amount of time. If this type of traffic has to be accommodated, a switched network like ATM is better suited than a shared medium network like FDDI or DQDB where the aggregate bandwidth is equal to the access data rate.

### **Real-time video**

Real-time video requires both relatively high data rates and isochronous capability.

Therefore, neither 64 kbit/s ISDN nor packet oriented data LANs are very well suited for real-time video transmission.

### **Multimedia communication**

The rating with respect to multimedia communication was derived as the lowest rating of the other three applications, which in essence comprise the components of multimedia communication.

### **Relationship between 64 kbit/s ISDN and nx64 kbit/s ISDN**

n×64 kbit/s ISDN offers a higher data rate to a specific application as even the primary rate access of 64 kbit/s ISDN.

### **Relationship between FDDI and FDDI-II**

According to the standardization, FDDI-II implies that FDDI as such is available as well. However, since FDDI-II means that there is an isochronous component, the bandwidth that is available for packet oriented data traffic is reduced. Therefore, FDDI-II is less suitable for packet LAN interconnection than FDDI.

### Annex B: Example configuration of LAN interconnection

Figure B.1 depicts an example configuration of LAN Interconnection.

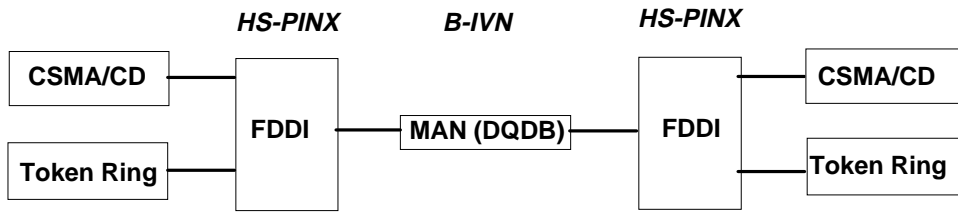


Figure B.1

**History**

<b>Document history</b>	
January 1995	First Edition
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