ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

INTERFACES BETWEEN DATA PROCESSING EQUIPMENT AND PRIVATE AUTOMATIC BRANCH EXCHANGE

Circuit Switching Application

TR/24

March 1985

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1. INTRODUCTION

This Technical Report is concerned with the standardization of interfaces between a Private Automatic Branch Exchange (PABX) and Data Processing Equipment.

The Technical Report has the following objectives :

- To state ECMA policy with regard to the application of the CCITT ISDN Recommendations in the field of data communication between Data Processing Equipment and a PABX.

- To serve as a reference document for ECMA to guide the development of a set of standards for Data Processing Equipment to PABX interfaces. It is not intended to be used as the basis for the design of such interfaces.

- To fulfill a tutorial role by providing clarification and ECMA interpretation of the ISDN recommendations.

Only circuit switching applications are considered at this time. Packet switching applications are for further study.

It is not the intention of ECMA to define completely new standards but rather to endorse, improve and complement existing international, national and industrial standards where appropriate. Of major concern is that ECMA Standards should be compatible with the CCITT Recommendations describing the user-to-ISDN interface. Where possible and appropriate, compatibility with Standards and Recommendations of other bodies such as ISO, CEPT and IEC will be maintained; if ECMA notes discrepancies between such Standards, ECMA will recommend a preferred solution.

2. REFERENCES

ECMA-TR/13 - Network Layer Principles
ECMA-TR/14 - Local Area Networks
Layers 1 to 4 Architecture and Protocols

ISO IS 3309 - Data communication. High-level Data Link control procedures. Frame structure.
ISO IS 7498 - Basic Reference Model
ISO DIS 8072 - Transport Service Definition
ISO DIS 8073 - Connection - Oriented Transport Protocol Specification
ISO DP 8208 - X.25 Packet Layer Specification for Data Terminal Equipment
ISO DIS 8348 - Network Service Definition

CCITT Recommendations:

G.703 General aspects of interfaces (of transmission systems and multiplexing equipments).
G.732 Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s.
G.734 Characteristics of 2048 kbit/s frame structure for use with digital exchange.
V.3 International alphabet N°5.
V.22 1200 bit/s duplex modem standardized for use on the general switched telephone and on leased circuits.
X.21 Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for synchronous operation on public data networks.
X.21bis Use on public data networks of Data Terminal Equipment (DTE) which is designed for interfacing to synchronous V-series modems.
X.25 Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode on public data networks.

CCITT Draft Recommendations:

I.112 Vocabulary of terms for ISDNs.
I.130 Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN.
I.210 Principles of telecommunication services supported by an ISDN.
I.211 Bearer services supported by an ISDN.
I.310 ISDN network functional principles.
I.320 ISDN protocol reference model.
I.330 ISDN numbering and addressing principles.
I.331/E.164 ISDN numbering plan.
I.411 ISDN user-network interfaces reference configurations.
I.430 Basic user-network interface -Layer 1 specification.
I.431 Primary rate user-network interface -Layer 1 specification.
I.440/Q.920 General aspects of the ISDN user-network interface Data Link layer protocol.
I.441/Q.921 Specification of the ISDN user-network interface Data Link layer protocol.
I.450/Q.930 General aspects of ISDN user-network interface layer 3 functions and protocols.
I.451/Q.931 Specification of the ISDN user-network interface layer 3 protocol.
I.460 Multiplexing rate adaption and support of existing interfaces.
I.461/X.30 Support of X.21 and X.21bis based DTEs by an ISDN.
I.463/V.110 Support of DTEs with V-series type interfaces by an ISDN.
V.25bis Automatic calling and/or answering equipment on the GSTN using the 100 series interchange circuits.

3. GLOSSARY OF TERMS

The following are definitions of terms introduced or widely used in this Technical Report. Some of them reflect the special application covered by the report and not a technical difference from the CCITT definitions. The basic vocabulary of ISDN terms can be found in CCITT Recommendation I.112.

BEARER SERVICE: A Telecommunication Service that provides the capability for the transmission of signals between user-network interfaces (CCITT Recommendation I.210).

B-CHANNEL: Is a 64 kbit/s duplex bearer channel with bit and octet timing. It is used to carry user data between TEs connected over a PCSN.

D-CHANNEL: Is a 16 kbit/s or 64 kbit/s duplex synchronous channel. It is used to carry signalling information between a TE and a PCSN.

DATA PROCESSING EQUIPMENT (DPE)
Specific type of terminal equipment exclusively or mainly used to process data (in contrast to voice only terminal equipment).

INTERWORKING UNIT (IWU)
An interworking unit provides the function needed to allow interworking between a PCSN and another network.

LAYER SERVICE: This term is defined in the ISO reference model for Open Systems Interconnection. In this layered model it defines the service that a layer provides to an upper layer.

PRIVATE CIRCUIT SWITCHING NETWORK (PCSN)
A circuit switching network with full digital transmission capabilities bounded by S interfaces.

PT: PCSN Termination at the S reference point.

R INTERFACE: The generic term for the interface provided at the R reference point to allow the connection of non-ISDN terminals using V-series or X-series interfaces.

S INTERFACE: The generic term for the interface provided at the S reference point as defined by CCITT for ISDN user-network interface.

S_0 INTERFACE: The basic access S Interface providing two B-channels and one D-Channel (2B+D) at a data rate of 192 kbit/s .

S_1 INTERFACE: The primary rate access interface providing 23 B-Channels and one D-Channel (23B+D) at a data rate of 1544 kbit/s .

S_2 INTERFACE: The primary rate access interface providing 30 B-Channels and one D-Channel (30B+D) at a data rate of 2048 kbit/s.

SERVICE: Where the term service is used without qualification it can be taken to mean Telecommunication Service. This is defined as a set of standardized protocols and functions, operational and possibly commercial features that together facilitate a specific telecommunication requirement (CCITT Recommendation I.210).

SIGNALLING: The exchange of information specifically concerned with the establishment and control of connections, the transfer of user-to-user and management information in a telecommunication network, e.g. in a PCSN.

TERMINAL ADAPTOR (TA)
A set of terminal adaptation functions. It allows Terminal Equipment with V-series or X-series interfaces to be connected to a PCSN.

TERMINAL EQUIPMENT (TE)
A general term for any terminal (voice or data processing or combination of both) connected to a PCSN at the S_0 or S_2 interface.

UNIVERSAL TA: A TA capable of supporting various user data rates including at least a recommended basic set of speeds. The TA extracts the proper information for rate adaptation from the in-band coded information and/or from the signalling messages on the D-channel when required.

4. SCOPE

The scope of this Technical Report is the application of ISDN principles to the interfaces between Data Processing Equipment and a Private Automatic Branch Exchange.

The interface of interest is the ISDN user-to-network interface, usually referred to as the S reference point. The S reference point is defined in the CCITT ISDN reference configuration (CCITT Recommendation I.411).

4.1. Functional Model

Fig. 1. shows the configuration considered in this Technical Report.

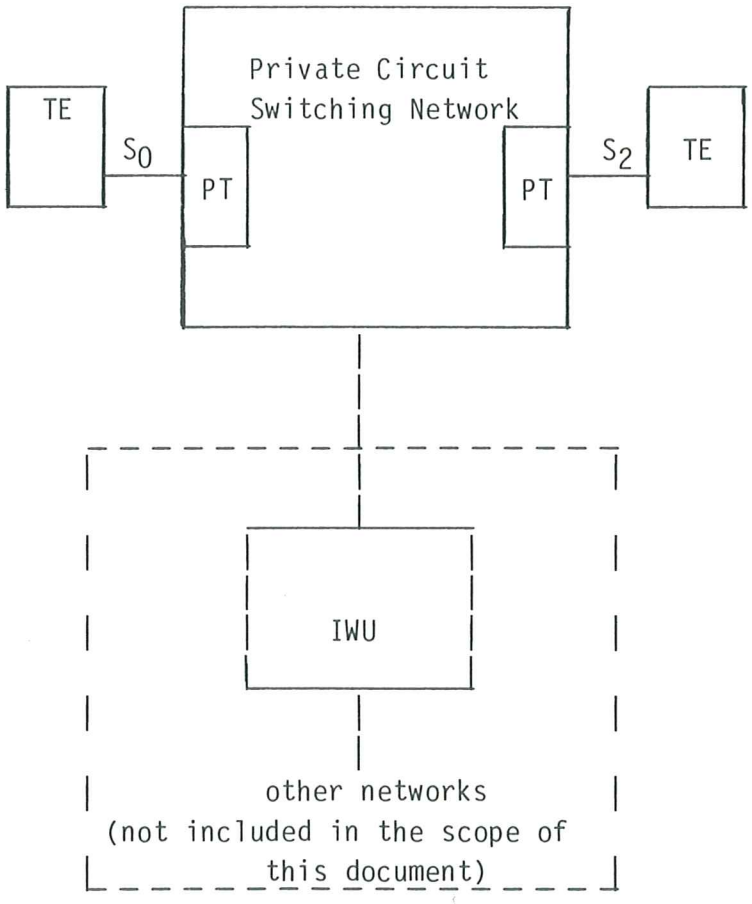


Figure 1. Functional Model

The figure shows a Private Circuit Switching Network (PCSN) which might partially include a PABX with its transmission facilities up to the user interface.

Two types of channel are provided at the S reference point:

- B-channels provide a 64 kbit/s duplex synchronous bearer service.

- D-channels provide a 16 or 64 kbit/s duplex synchronous service. The use of the D-channel is restricted to conveying signalling information.

The PCSN can provide three types of interface at the S reference point, they will be referred to as S interfaces throughout the document.

Basic access interface (S_0)

This interface offers two B-channels and one 16 kbit/s D-channel. This interface is intended for individual access to a PCSN. Typical Terminal Equipment (TE) would be telephones, printers, personal computers etc.

Primary rate access interfaces (S_1 and S_2)

S_1: The S_1 interface offers 23 B-channels and one 64 kbit/s D-channel. This interface is not used in Europe and no further reference will be made to it in this document.

S_2: The S_2 interface offers 30 B-channels and one 64 kbit/s D-channel. This interface is intended for the connection of TEs capable of servicing multiple streams of digital data. Typical TEs are minicomputers, front-end processors, mainframe computers etc .

Only 64 kbit/s data transfer is considered in the Technical Report. Transfer of data at rates greater than 64 kbit/s over a number of 64 kbit/s channels is beyond the scope of this document. Also beyond the scope of this document is the transfer of multiple subrates within a 64 kbit/s channel. These items may lead to further study.

4.2. Support of non-ISDN terminals and networks

To accomodate the connection of existing synchronous and asynchronous terminal equipment with non-ISDN interfaces Terminal Adaptation functions (TA functions) are required.

Figure 2. indicates circumstances where TA functions may be required.

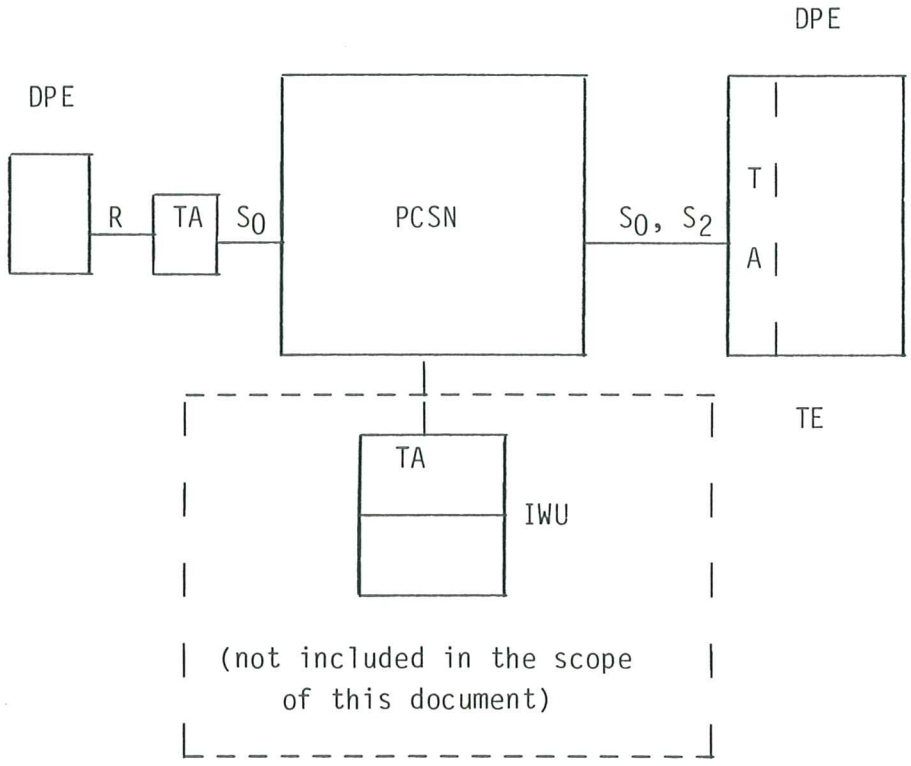


Figure 2. TA function use

A TA function is required for adapting between the S and R reference points. The R reference point refers to non-ISDN interfaces such as those of the CCITT V-series or X-series Recommendations.

The functions of a TA between the R and S reference points are :

a. to provide signalling information to the PCSN,

b. to provide rate adaptation from the terminal data rate to the 64 kbit/s B-channel, and

c. to handle terminal status information and to provide end-to-end synchronisation.

To allow for interworking between TEs connected at the R and S reference points it is necessary to incorporate the TA functions b and c above within the TE connected at the S reference point. The same applies for an IWU which is, however, beyond the scope of this document.

It is recognized that the PCSN may also be connected to other networks and that some of these connections may require functions which can be provided by an Interworking Unit (IWU). Although these connections are beyond the scope it is recognized that in some cases they will have a bearing on certain aspects of this Technical Report. For example: interworking to the ISDN.

5. SERVICES AND FACILITIES

This chapter describes the services and facilities offered by a PCSN, in particular those which are of interest to the interfacing of TEs.

5.1. Characterization of Services.

The services supported by an ISDN and network capabilities of an ISDN are described in the I.100 and I.200 series Recommendations of CCITT. CCITT Recommendation I.130 describes a method for the characterization of Telecommunication Services, which are divided into two categories:

- bearer services (e.g. digital channels, bandwidth)

- tele services (e.g. telex, telephony).

In the context of this Report, only bearer services are of interest.

Bearer services are characterized by means of attributes. An attribute is defined as a specified characteristic of an object/element whose values distinguish that object/element from others. Particular values are assigned to each attribute when a given service or network capability is described and specified.

There are three groups of attributes (see CCITT Recommendation I.210):

1. Information transfer attributes, characterizing the network capabilities for transfering information from one S reference point to one (or more) other S reference point(s). These attributes have end-to-end or global significance.

2. Access attributes, which describe the means for accessing network functions or facilities as seen at one S reference point. These attributes have only local significance.

3. General attributes, which deal with the service in general, and which cannot be allocated to one of the two other categories.

A list of attributes of bearer services and possible values is given in Annex A to this report. For full description and definition refer to CCITT I.100 and I.200 series Recommendations.

5.2. Circuit Mode Bearer Service

The only service dealt with in this Report is the circuit mode bearer service. Other types of bearer service (e.g. packet mode) are left for future study.

A circuit mode bearer service provides transfer of user information via one type of channel (B) and signalling via another type of channel (D): signalling is the means to obtain access to this circuit mode bearer service. The structure and configuration of B and D channels are described in Chapter 7.

Definition of terms describing information transfer attributes

CCITT Recommendation I.112 contains a list of definitions of most terms used in this document.

Only the most important ones for this section are listed below.

Unrestricted: Any sequence of binary information is allowed.

Demand: Communication is set up or cleared down as soon as possible after a request is received.

Reserved: Communication is set up at a time specified in the request. Release may occur at a time specified in the request or be as per demand.

Permanent: Communication is set up in response to an operationnal or administrative message. Duration is unspecified. The connection is released in response to another similar message.

Symmetric: Symmetric means that information transfers in the two directions have the same data flow characteristics.

Structural Integrity: This attribute refers to the capability of the ISDN to deliver information to the destination reference point in a structure that was presented in a corresponding signal structured at the source point or reference point.

Point-to-point: This attribute value applies when only two endpoints are provided by the connection, as used in CCITT Recommendation I.211.

5.3. Circuit 64 kbit/s Unrestricted

This document deals with a particular circuit mode bearer service: 64 kbit/s unrestricted bearer service. This transfers digital user information without any alteration. It may be used to support various user applications such as:

- Data Transmission at 64 kbit/s including digitized speech at 64 kbit/s.

- Multiple subrate data channels multiplexed into 64 kbit/s, by the user.

The values for the different attributes characterizing this 64 kbit/s unrestricted bearer service are :

Information transfer attributes:
- Mode: Circuit
- Rate: 64 kbit/s
- Information type: Unrestricted
- Structural integrity: 8 kHz octet timing
- Establishment: Demand/reserved/permanent
- Configuration: Point-to-point
- Symmetry: Duplex-symmetric

Access attributes:
- Access channel and rate: B channel for user information and a D channel (16 kbit/s or 64 kbit/s. Refer to Chapter 7) for signalling
- Access protocol: ECMA protocols for D channel (as defined in Chapter 7)

General attributes:
General attributes characterize items like:

- Supplementary services/facilities
- Quality of service
- Interworking possibilities
- Operational and commercial aspects

They are for further study.

5.4. Facilities

The mechanism to support and negotiate PCSN provided facilities is described as part of the signalling procedures, as described in Chapter 7 of this Report.

This report does not prescribe the support of any particular set of facilities. It is however expected that a PCSN will support many facilities. For reader information a list of commonly supported facilities is given in Annex B.

6. MODELS

6.1. General

This chapter does not intend to describe what place a PCSN takes inside the ISO Open Systems Interconnection architecture. This will be the subject of a further ECMA Technical Report.

In this document, the terms "layer" or "sublayer" are used in the CCITT sense and do not necessarily have the meaning defined within the ISO OSI model.

The PCSN termination presents the following characteristics to a DPE :

- It provides two or more separate paths (known as "B-channels") which may be connected through the PCSN to any other DPE attached to the PCSN. These paths support the transparent transfer of sequences of octets at 64 kbit/s.

- It provides a further path which in conjunction with suitable protocols may be used to control the B-channels. This path is known as the "D-channel".

- The channels between the PCSN and a DPE share a single physical medium.

- The protocols used on the D-channel shall be based on CCITT Recommendations I.440 and I.441 (Data Link layer) and I.450 and I.451 (Layer 3).

The protocol layering may be depicted as shown in Figure 3.

6.2. Signalling functions

The signalling functions provide to the DPE the capability to control B-channels. The functions are organized in three layers:

- layer 1 Physical connection

- layer 2 Data Link protocol

- layer 3 Signalling protocol.

These layers are conveyed via the D-channel as shown in Fig.3 and described in Chapter 7.

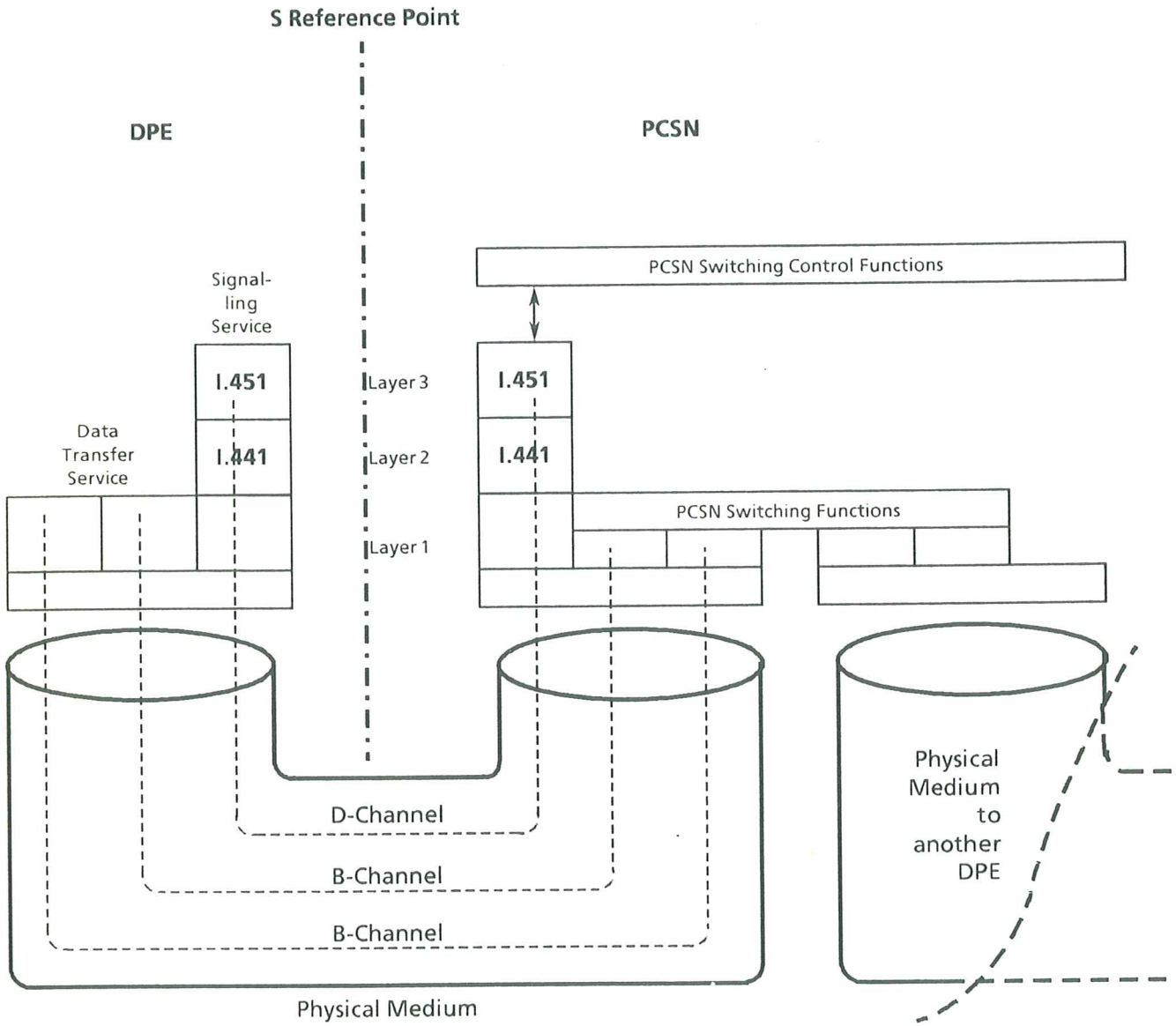


Figure 3. Model of interaction between DPE and PCSN

6.3. Data Transfer functions

The purpose of a PCSN is to allow data transfer between DPEs using B-channels. Three types of data transfer services may be provided as listed in Table 1.

Type	Service
1	64 kbit/s data transfer (basic service) with octet alignment
2	rate adapted synchronous channel
3	rate adapted asynchronous channel

Table 1.

The data transfer functions are organized in two sublayers as shown in Fig. 4.

Sublayer 1a provides the basic service. The optional sublayer 1b provides the rate adapted channel services by means of a Terminal Adaptation protocol.

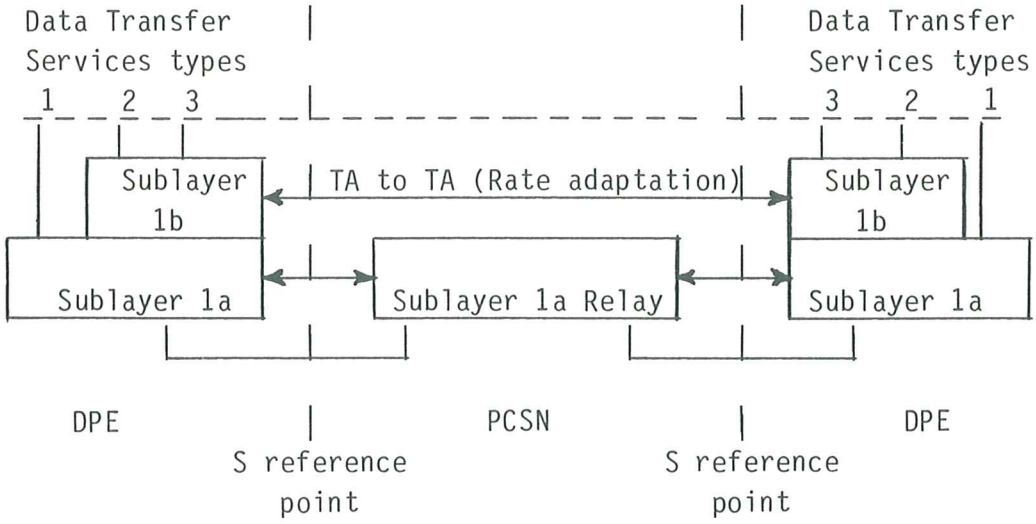


Figure 4. Data transfer sublayer structure

Note : In the future a PCSN may intervene at sublayer 1b in order to multiplex traffic within a B-channel.

The definition of protocols using the data transfer service is outside the scope of this document.

Physical connections, as defined in the ISO OSI reference model, may be provided directly over the B-channels or over the rate adapted channels. In this case the PCSN provides the relay functions shown in Fig. 5.

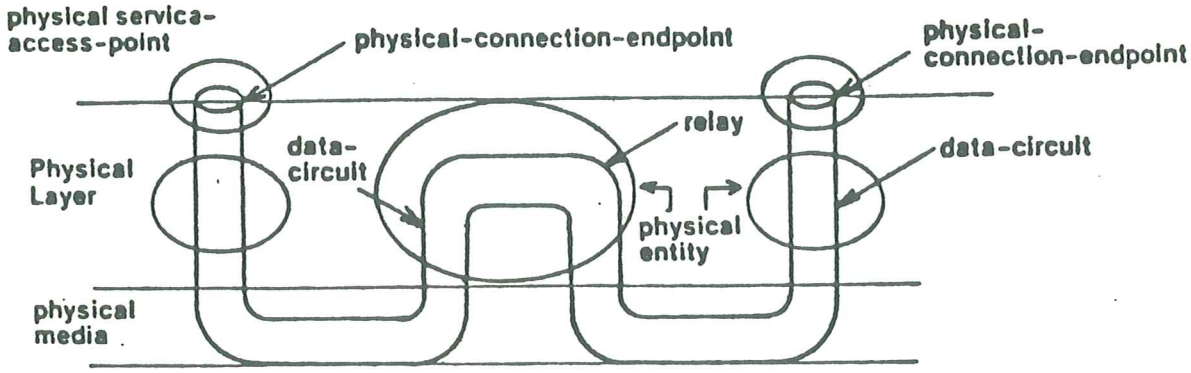


Figure 5. Interconnection of data circuits within the physical layer

6.4. Terminal Adaptor scenarios

For tutorial purposes the following examples for Terminal Adaptor scenarios are given.

6.4.1. Scenario for X.21 terminals

Figure 6. indicates one possible mapping of the X.21 signalling phase onto the PCSN signalling function. This mapping gives access to a limited set of PCSN services.

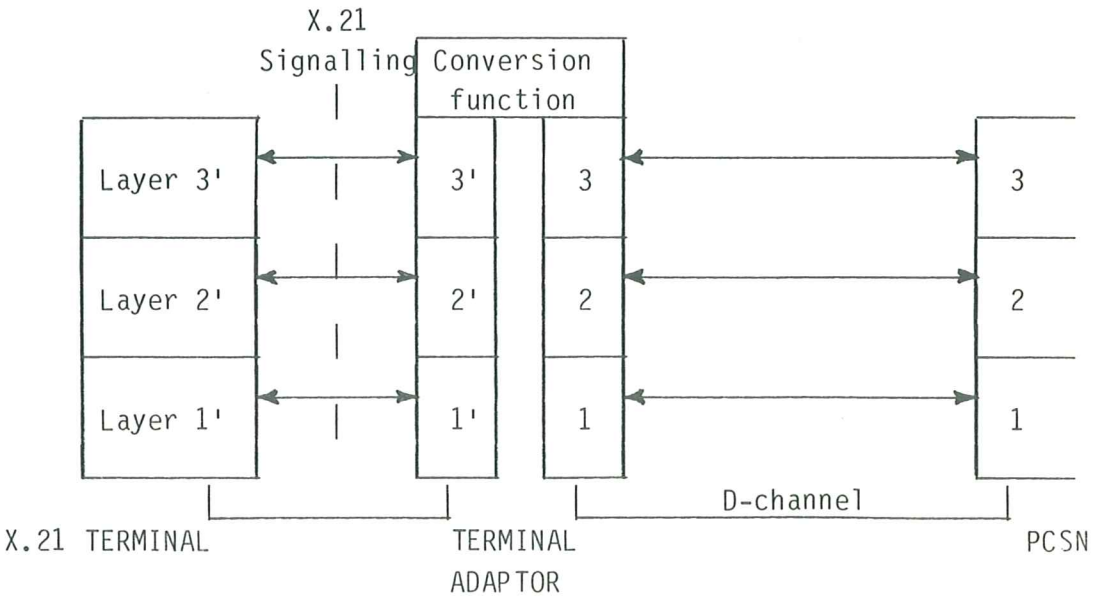


Figure 6. X.21 Signalling phase mapped onto PCSN signalling function

Figure 7. indicates a direct mapping of the data transfer service.

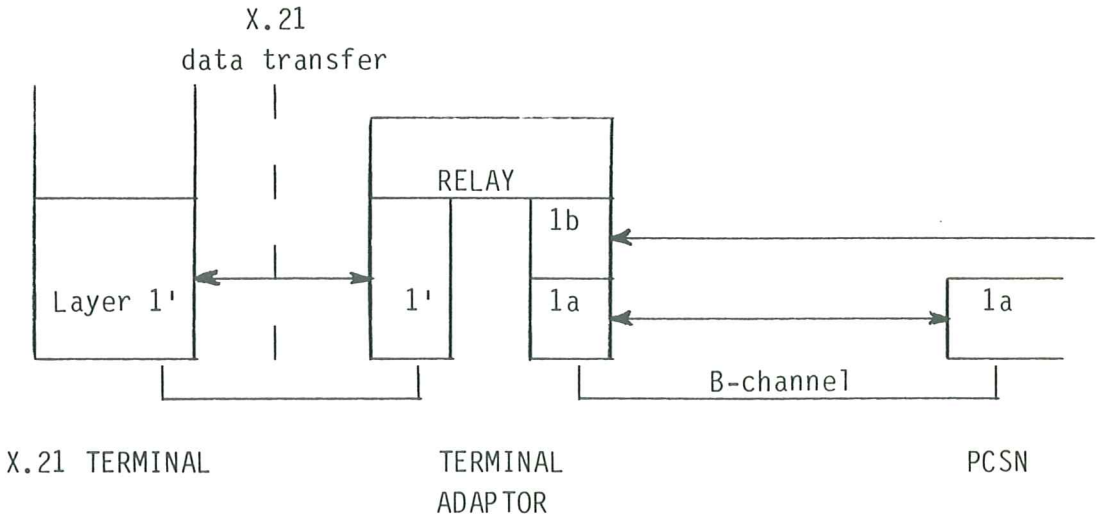


Figure 7. X.21 Data transfer phase mapped onto PCSN data transfer functions

6.4.2. Connection of V.24 and other terminals

Terminals with V.24 interfaces or other simple interfaces may be attached to a PCSN through a TA. In such cases there is no defined signalling phase on that interface and PCSN signalling functions in the TA must be invoked by some other interaction.

The support of terminals with auto-dial capabilities (e.g. V.25 or V.25bis) is for further study.

Data transfer may then proceed exactly as in the X.21 case.

6.4.3. Terminal Adaptor within DPE or IWU

DPE and IWU will be commonly connected directly to a PCSN without separate Terminal Adaptor units. However, if such equipment is to communicate with terminals connected to the PCSN through separate terminal adaptors, the sublayer 1b rate adaptation functions must be provided within the DPE or IWU. All signalling, including signalling for communication through an IWU, takes place in the D-channel and no special signalling functions are required to support terminal adaptation.

7. INTERFACES

The PCSN interfaces S_0 and S_2 support two types of channels:

- D-channel

  The D-channel is primarily intended to carry signalling information for circuit switching by the PCSN. The common signalling channel principle is applied in the sense that only one D-channel is used in one interface structure to carry the signalling information relevant to all the B-channels of that structure. D-channels use layered protocols which are subsets of the ISDN user to network interface protocols.

- B-channel

  The B-channel is a synchronous 64 kbit/s channel accompanied by bit and octet timing. It is intended to carry a wide variety of user information streams. It provides an unrestricted bearer service. The use of subrates of a B-channel (sub-channelling) or combination of several B-channels to form a single wide band channel are beyond the scope of this document. Information streams at bit rates less than 64 kbit/s need to be rate adapted to be carried on the B-channel. This is accomplished via procedures described in Chapter 8.

Use of the B-channel

B-channel protocols are user defined and are negotiated between the two users using possibly the D-channel signalling.

The D-channel protocol messages used to establish call set-up contain the appropriate bearer service identification and compatibility information. This information fully defines the purpose of the connection to be established so that the called TE is able to accept or reject the incoming call (refer to layer 3 protocol for detailed information).

The call set-up procedures over the D-channel indicate the availability of a B-channel circuit but not necessarily the instant of B-channel through-connection.

7.1. Basic Access Interface (S_0)

The basic channel structure is composed of two B-channels and one D-channel, 2B+D. The bit rate of the D-channel in this interface is 16 kbit/s.

The B-channels are independant and can be used in different circuit switched connections at the same time. These connections may be used for voice or data transfer or both.

7.1.1. Configurations

Three different configurations (see Fig. 8.) are envisaged for the basic access. The maximum range of the interfaces is limited by the specification of the electrical characteristics of transmitted and received pulses and the type of interconnecting cable. Examples of cable lengths are given in the figures for tutorial purposes.

- Point-to-point configuration

  Only one terminal (TE) is connected on one PCSN Termination (PT) at a time.
  The maximum length of the wiring between the PT and the TE is approximately 1 km.

- Short passive bus configuration

  This multipoint configuration allows more than one (up to eight) TEs to be connected to one PCSN termination. Each is connected to functionally the same S reference point, but physically to its individual S connection device (socket).
  The maximun length of the cabling over which the TEs are distributed is approximately 150 m.

- Extended bus configuration

  In this multipoint configuration the TEs are clustered at the end of the bus. Up to eight TEs are connected to one PCSN termination. Each is connected to functionally the same S reference point, but physically to its individual S connection device (socket). The TEs are clustered within a range of 35 m at the end of a cabling length of about 500 m.

The wiring (e.g. bus) between the PCSN termination providing the functional S reference point and the S physical interface (sockets) is beyond the scope of this Technical Report (see Fig. 9.).

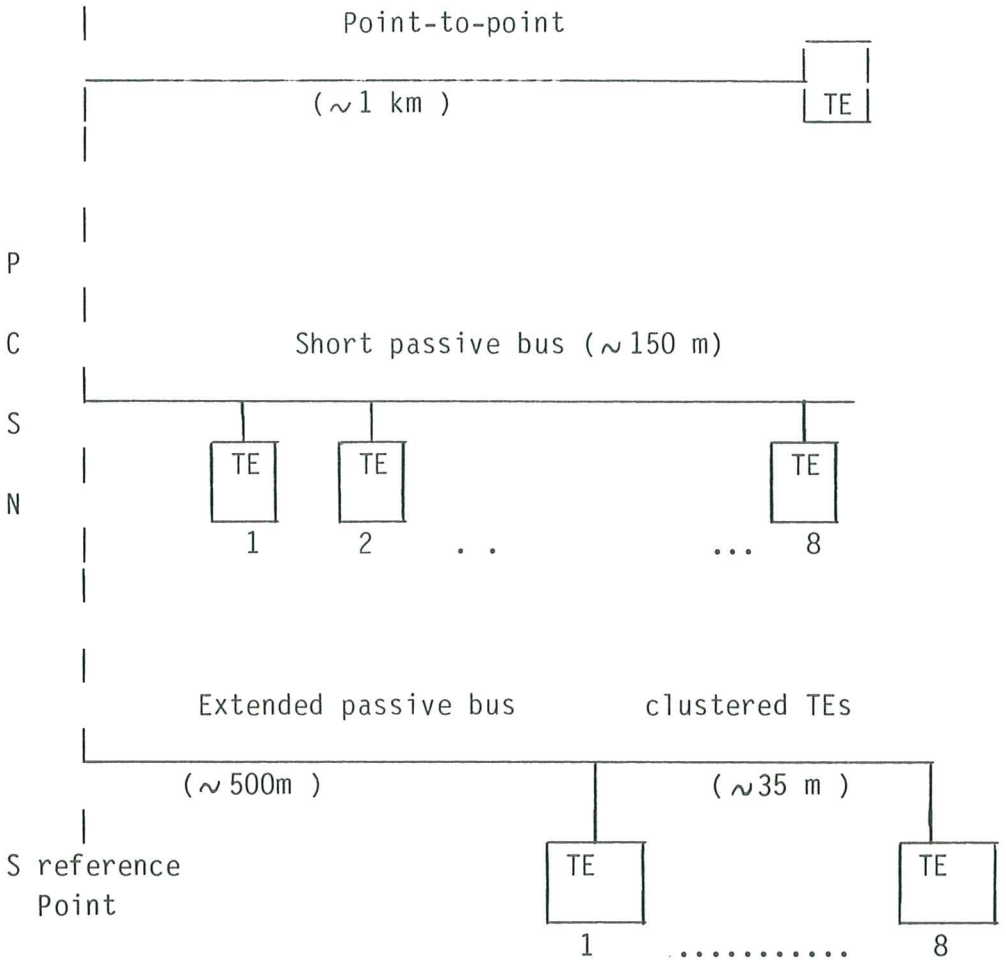


Figure 8. Physical Configurations at Basic Access

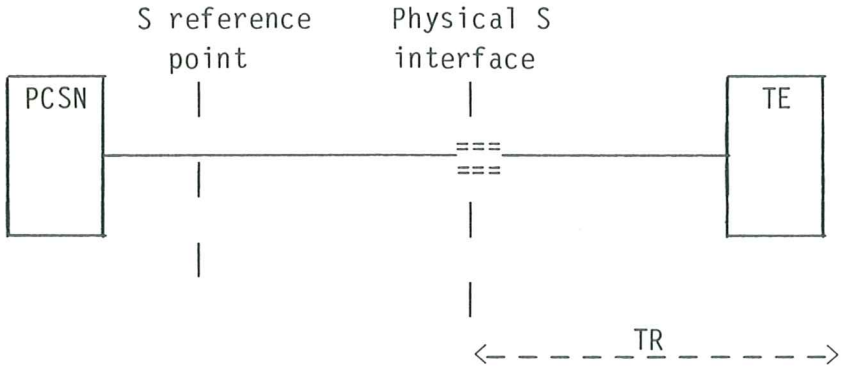


Figure 9. Wiring covered by this Technical Report

7.1.2. Physical Layer

The Physical Layer will be fully described in a separate document (refer to Chapter 11). The ECMA Physical Layer standard is based on CCITT Recommendation I.430. This Standard considers point-to-point and multipoint configurations. Whenever the necessity to differ from the CCITT Recommendation occurs, it will be explicitly indicated.

A brief description of the Physical Layer characteristics not dealt with in detail in the subsequent paragraph is given hereafter:

Services to Data Link Layer:	- transmission capability for two B-channels and one D-channel with related timing and synchronization functions - signalling capability to activate and deactivate (i.e. put into a low power consumption mode) the terminals - signalling capability to control and gain access to the D-channel - signalling capability to enable maintenance - indication to the Data Link Layer of the physical layer status.
Overall bit rate:	192 kbit/s
Frame size:	48 bits
Type of coding:	pseudo-ternary code
Contention resolution:	D-echo bits
Timing:	on bit, octet and frame level.

7.1.2.1. Wiring and Plugs

It is the idea of the ISDN to provide a universal telecommunications socket where the customer can plug in his terminal devices. In point-to-point configurations only one terminal can be associated with one basic access. In multipoint configurations several terminals (up to 8) are physically connected in parallel. However, from a functional point of view, they are treated individually.

The wiring consists of two pairs to carry the transmission in the two directions. These two pairs may also serve for power feeding between the PT and the TE(s) (see 7.1.2.2.).

Universal plugs are to be used so that there is no mechanical coding of the plugs between different types of terminal equipment (e.g. voice and non-voice terminals or service specific terminals). The plugs shall be rugged, self-locking when inserted and polarized.

Suitable IEC standardized plugs and sockets will be in the appropriate standard.

The terminating impedance (100 ohms) is part of the fixed wiring or terminating socket. This means that each TE has to present a high impedance.

7.1.2.2. Power Feeding

Physically, power feeding can be performed in two ways: either by a phantom circuit consisting of the four signal wires or via additional wires (see Fig. 11).

Power feeding in this context is the sourcing of electrical energy (DC 40 V) via the S_0 interface to supply either:

1 - the TE from the PT, or

2 - one TE from another TE (see Fig. 10.).

Two further cases will be considered:

3 - although power is sourced from the PT to the TE, the TE does not sink this power, or

4 - no power is sourced by either side.

These four cases are described below.

CASE 1

Case 1 envisages the supply of electrical energy necessary for the operation of low power consumption devices, e.g. simple telephone sets or DPEs with low power displays using power source and power sink 1 (see Fig. 11).

The total power available from the PT to all (up to 8) TEs shall be at least 400 mW.

Power feeding via the S_0 interface enables the use of a single cable connection to the TE.

If the local mains power supply is used at the TE and fails, remote feeding of the PT and one or more TEs is provided. This will result in reduced service (e.g. simple telephone service) via the basic access. The mechanism to exclude more complex terminal equipment from service consists of polarity reversal of the power voltage. Under emergency conditions, the minimum power available for the TEs from power source 1 will be 400 mW (see Fig. 11).

CASE 2

Case 2 means the supply of electrical energy from one TE to other TEs.

CASE 3

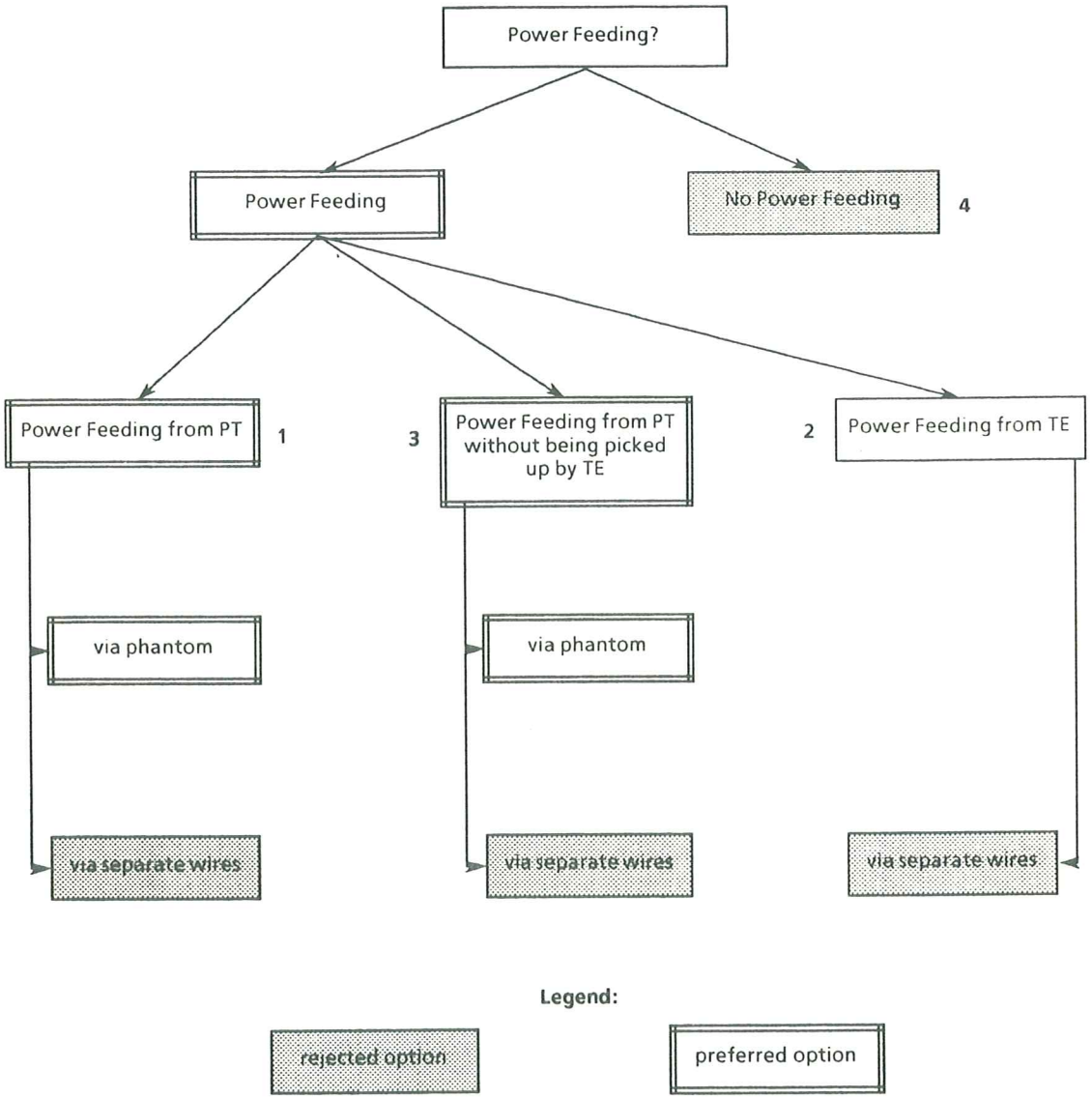
If a TE is fed directly from the mains it need not sink the power which is offered to it via the S_0 interface.

CASE 4

This case covers applications where the PT does not offer power to its counterpart(s).

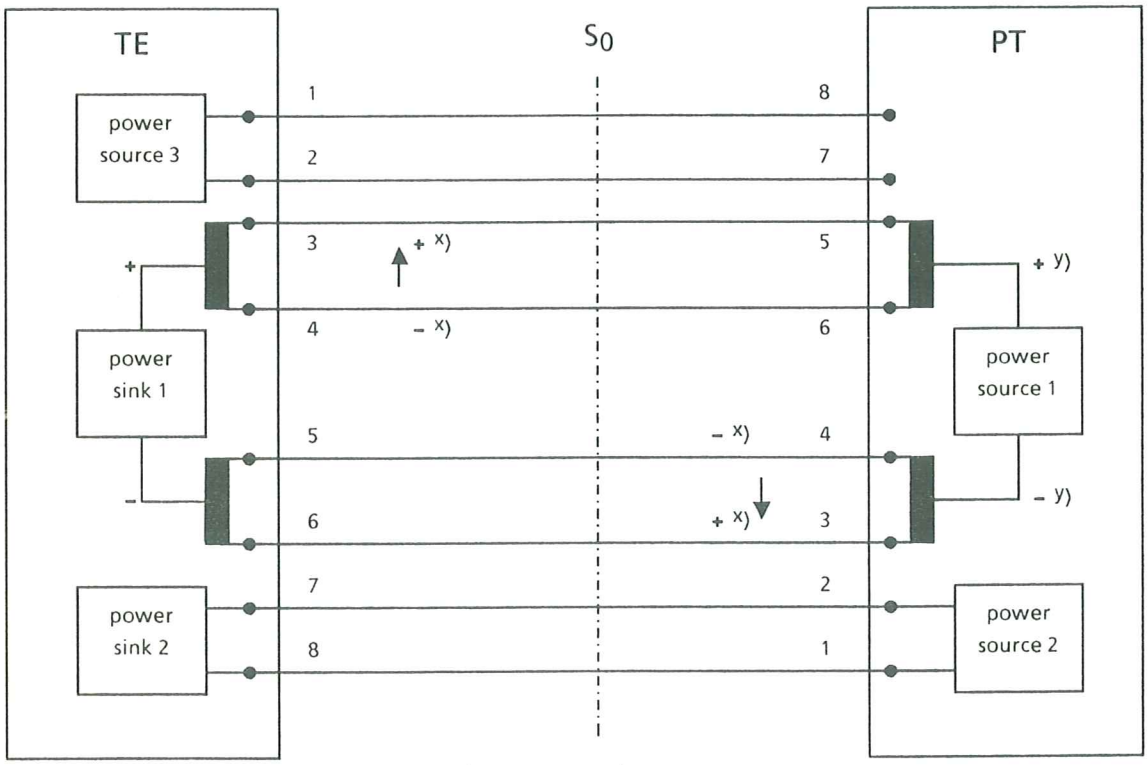
NB: The preferred and rejected solutions are indicated in Fig. 10. The preferred solution provides power feeding from the PT via the phantom, however, there is no obligation to sink this offered power.

The reference configuration for power feeding such as described in CCITT Recommendation I.430 is given for tutorial purpose.



The numbers 1, 2, 3, 4 refer to the Cases 1, 2, 3, 4 described in 7.1.2.2

Figure 10. Overview and ECMA preferred Options of Power Feeding



Note1: x) Indication of the signal polarity of the positive pulse
y) Indication of the power feeding polarity
The polarity of the voltage of power source 1 refers to the normal powering condition. Under emergency conditions the polarity is reversed.

Note 2: The use of phantom power via the leads 3/4 and 5/6 has been selected by ECMA as the preferred option.

Figure 11. Power feeding via the S interface

7.1.2.3. Interface procedures and services provided to the Data Link layer

Basic access PT and TEs can be powered down, such that only a small amount of current flows during the idle condition. The mechanism for powering up and down is part of the Activation/Deactivation procedures. The active and the inactive states are indicated to the Data Link Layer by means of appropriate primitives.

In multipoint configurations the TEs must gain access to the PT without disturbing any communication already in progress between other TEs and the PT. This is achieved by the D-channel access control. This function includes an echoed bit (D-echo bit) retransmitted in the bit stream from the PT to the TEs. Terminals attempting to gain access to the D-channel are only allowed to do so after having monitored the D-channel and found it idle. Furthermore, after having sent the first bits of their own D-channel message, they must monitor the D-echo bits. They may continue sending only if they have ensured that it is their bit being echoed, otherwise they must withdraw. This mechanism solves contention. A colliding TE which has withdrawn may reattempt later.

A priority mechanism enables different classes of priority to be considered when access to the D-channel is attempted. Within each priority class a fair chance is given to all TEs trying to get access to the D-channel. The priority mechanism allows other types of information than signalling to be conveyed in the D-channel (this subject is beyond the scope of this document).

7.1.3. Protocols on the D-channel

Signalling on the D-channel is done by a set of layered protocols such as described in the CCITT Recommendation I.320 which is based on the principles given in the X.200 series Recommendations.

These protocols cater for connection control, management requirements and some user information transfer (see 7.1.3.2.3.) and are structured into three layers:

Layer 1: The Physical Layer is described in 7.1.2.

Layer 2: The Data Link Layer is described in 7.1.3.1.

Layer 3: The term "layer 3" is used to indicate the layer above the Data Link Layer. It provides to the user the functions associated with the establishment and operation of a network connection. It is described in 7.1.3.2.

7.1.3.1. Data Link Layer

The Data Link Layer protocol is based on CCITT Recommendations I.440 and I.441 and will be the subject of an ECMA Standard.

7.1.3.1.1. General

The Data Link Layer protocol operates the Link Access Procedures on the D-channel. This HDLC type of protocol is called LAPD. The purpose of LAPD is to convey information between layer 3 entities across the S_0 interface.

LAPD is independent of the transmission bit rate. It requires a full duplex, bit transparent D-channel.
Specifically LAPD will support:

- multiple terminal installation at the S_0 interface,
- multiple layer 3 entities.

LAPD includes functions for:

- The provision of one or more Data Link connections on a D-channel. Discrimination between the Data Link connections is by means of a Data Link Connection Identifier (DLCI) contained in each frame.
- Frame delimiting, alignment and transparency, allowing recognition of a sequence of bits transmitted over a D-channel as a frame.
- Sequence control, to maintain sequential order of frames across a Data Link connection.
- Detection and recovery of transmission, format and operational errors on a Data Link connection.
- Notification to management entity or to layer 3 entity or both of unrecoverable errors.
- Flow control.

Data Link Layer functions provide the means for information transfer via point-to-point links or via broadcast links.

In the case of point-to-point information transfer, a frame is directed to a single endpoint while in the case of broadcast information transfer a frame is directed towards all (one or more) endpoints.

7.1.3.1.2. Types of operation

Two types of operation of the Data Link layer are defined for layer 3 information transfer: unacknowledged and acknowledged. They may coexist on one D-channel.

- Unacknowledged operation

With this type of operation layer 3 information is transmitted in Unnumbered Information (UI) frames.

The UI frames are not acknowledged. Transmission and format errors may be detected but no error recovery mechanism is defined. No flow control mechanism is defined.

This type of operation is applicable for point-to-point and broadcast information transfer.

The services provided in this case are:
. provision for Data Link connection between layer 3 entities for unacknowledged information transfer of layer 3 information,
. identification of Data Link connection endpoints to permit a layer 3 entity to identify another layer 3 entity.

- Acknowledged operation

With this type of operation, layer 3 information is sent in frames that are acknowledged at the Data Link Layer.

Error recovery procedures are specified. In the case of errors which cannot be corrected by the Data Link Layer, a report to the layer 3 is made. Flow control procedures are also defined.

Acknowledged operation is applicable for point-to-point information transfer.

A multiple frame mode of operation is used. This means that layer 3 information is sent in numbered Information frames (I frames). A number of I frames may be outstanding at the same time (Data Link Layer window mechanism).

Multiple frame operation is initiated by a multiple frame establishment procedure using Set Asynchronous Balanced Mode (SABM) and Unnumbered Acknowledge (UA) commands.

The services provided in this case are:

. acknowledged transfer of layer 3 information,
. identification of Data Link connection endpoints to permit a layer 3 entity to identify another layer 3 entity,
. sequence integrity of Data Link layer frames,

. detection and recovery of transmission, format and operational errors,
. notification to management entity or to layer 3 entity or to both of unrecoverable errors,
. flow control.

7.1.3.1.3. Types of frames

All Data Link Layer messages are transmitted in HDLC frames (see ISO 3309 and CCITT Recommendation I.441).

The following types of frames will be used:

- Numbered information frames: the I frames will be used to perform an information transfer between layer 3 entities,

- Unnumbered Information frames (UI),
- Supervisory frames: the S frames (RR, RNR, REJ) will be used to perform link supervisory control functions (e.g. acknowledge I frames, request retransmission of I, frames request temporary suspension of transmission),

- Unnumbered frames: these frames shall be used to provide additional link control functions (SABM, DM, DISC, UA, FRMR).

7.1.3.1.4. Data Link connection identification

A Data Link connection is identified by a Data Link Connection Identifier (DLCI).

The DLCI is associated with a connection endpoint identifier at the two ends of the link. The connection endpoint identifier is used to identify message units passed between the Data Link Layer and layer 3. The DLCI consists of two elements:

- The Service Access Point Identifier (SAPI). A Data Link Layer Service Access Point (SAP) is the means by which the Data Link Layer provides services to the layer 3.

- The Terminal Endpoint Identifier (TEI) is used to identify a specific connection endpoint within a service access point. The TEI is assigned automatically by means of a separate TEI assignment procedure.

7.1.3.2. Layer 3

The layer 3 protocol is based on CCITT Recommendations I.450 and I.451 and will be the subject of an ECMA Standard.

The primary function of layer 3 is the control of B-channel connections. This function is provided by the exchange of messages across the S_0 interface.

The procedures described are for the control of circuit switching of the B-channels. The control of packet switching connections over the D-channel is beyond the scope of this Report.

Layer 3 procedures applying to the S_0 interface use the services provided by the Data Link Layer. This includes the unacknowledged signalling information transfer service to provide broadcast operation at layer 3.

The terms "incoming" and "outgoing" are used to describe the call as viewed from the TE side of the interface.

7.1.3.2.1. Call Control Procedures

This section provides an example of call control procedures based on CCITT Recommendations I.450 and I.451. Details of the procedures and elements of procedures for inclusion in an ECMA Standard are yet to be defined.

Circuit switched calls are controlled by a sequence of messages flowing across the user-network interface.

CCITT Recommendation I.451/Q.931 allows for the use of two modes of operation, functional and stimulus. The functional mode of operation is characterized as requiring a degree of intelligent processing capability. The stimulus mode of operation is defined for use by non-intelligent TEs such as simple telephone sets. Stimulus mode is not considered to be relevant for DPEs and is not considered hereafter.

Call Establishment at the Originating End of a Connection

Before these procedures are invoked, a Data Link connection must be established between the TE and the PCSN.

Call Request

A TE initiates call establishment by transferring a SETUP message across the S_0 interface. The SETUP message will contain all address information (en-bloc sending). The SETUP message is confirmed by the PCSN by a CALL PROCEEDING message.

The CALL PROCEEDING message indicates the B-channel allocated by the PCSN which should be used by the TE (see B-channel selection).

If, on receipt of a SETUP message, the PCSN determines that the call information received from the TE is invalid (e.g. invalid facility or address), the PCSN will initiate clearing by sending a DISCONNECT or RELEASE COMPLETE message to the TE.

B-Channel Selection

In the SETUP message, the TE will indicate one of the following alternatives:

1) a preferred B-channel with no acceptable alternative,

2) a preferred B-channel, any alternative is acceptable,

3) any B-channel is acceptable.

The default is alternative 3.

When the "no channel available" condition is indicated in the SETUP ACKNOWLEDGE or CALL PROCEEDING message, the TE may either clear the call or initiate alternative procedures.

Call Confirmation Indication

Upon receiving an indication that alerting has been initiated by the TE at the called address, the PCSN transfers an ALERTING message across the S_0 interface to the calling TE.

Call Connected

Upon receiving an indication that the call has been accepted, a CONNECT message is sent across the S_0 interface to the calling TE.

Call Rejection

Upon receiving an indication that the destination TE is unable to accept the call, the PCSN will initiate clearing.

Call Establishment at the Destination End of a Connection

This procedure assumes that a Data Link connection may not exist before the first layer 3 message (SETUP) is transferred across the S_0 interface. The Data Link layer connection has to be established before any response to the SETUP message.

Incoming Call

The arrival of a call is indicated to the TE by sending a SETUP message across the interface. This message is sent if the PCSN can select an idle B-channel. If the PCSN provides facilities in the no B-channel available condition (e.g. call waiting), the message may also be sent when no B-channel is idle.

Since there might be more than one TE arranged in a multipoint configuration (see 7.1.1.), this message will be sent using a broadcast capability at the Data Link Layer. If however, the PCSN has knowledge that a single point configuration exists behind the interface, a point-to-point link may be used to carry the SETUP message.

The SETUP message may contain address information. This address information may be conveyed en-bloc or in the overlap sending mode be contained in subsequent INFO messages.

B-Channel Selection

The PCSN selects an idle B-channel which the TE must accept.

Call confirmation

An idle TE satisfying the compatibility requirements indicated in the SETUP message responds with either an ALERTING, CONNECT, CALL PROCEEDING or FACILITY/INFORMATION message (e.g. for call forwarding).

A busy TE satisfying the compatibility requirements indicated in the SETUP message responds with a RELEASE COMPLETE message including the cause.

If the compatibility requirements are not satisfied, a RELEASE COMPLETE message may be sent which contains the cause indication "call rejected".

Call Acceptance

The acceptance of a call is indicated by a CONNECT message.

Non-Selected TE Clearing

In addition to sending the CONNECT ACKNOWLEDGE message to the TE selected for the call, the PCSN sends a RELEASE message to all other TEs at the interface which had sent an ALERTING or CONNECT message in response to the SETUP message. This message notifies these TEs that the call is no longer offered to them. Each TE will return a RELEASE COMPLETE message.

Call Clearing

Clearing by the TE

At any time the TE may initiate clearing by sending a DISCONNECT message.

The PCSN may clear the call immediately. In this case it disconnects the B-channel and sends a RELEASE message to the TE. The TE will then release the B-channel and the call reference and, respond to the PCSN with a RELEASE COMPLETE message. On receipt of the RELEASE COMPLETE message the PCSN releases the call reference and the B-channel.

The RELEASE message has only local significance and does not imply any acknowledgement of clearing from the remote TE.

If the PCSN decides to retain the call reference used but give up the B-channel, it will respond to the DISCONNECT message by sending a DETACH message. Only a RELEASE message sent by the PCSN will initiate a transition to the release procedure as indicated above, i.e. all other messages which might be sent by the TE during this state will be answered by a further DETACH message.

Clearing by the PCSN

At any time the PCSN may initiate clearing by sending a DISCONNECT message. The B-channel used for that connection is disconnected but not yet released and not yet available for further calls.

To clear the call, the TE will respond by sending a RELEASE message indicating the termination of this particular call. Receiving this message the network releases the B-channel and the call reference for future use and returns a RELEASE COMPLETE message to TE.

If the TE wishes to invoke facilities and therefore retain the call reference used but allow the B-channel to be released, it shall respond to the DISCONNECT message by sending a DETACH message. The PCSN shall release the B-channel and respond with a DETACH ACKNOWLEDGE message.

In some cases the TE may receive a RELEASE message without having received a previous DISCONNECT message (e.g. due to a corrupted DISCONNECT message). In these cases the TE shall return a RELEASE COMPLETE message.

Call Rearrangements

A mechanism exists to suspend and to re-establish a call. The messages used are the SUSPEND and SUSPEND ACKNOWLEDGE. This enables portability of TEs during a call whereby the lower layers will be released while the layer 3 connection is still active.

7.1.3.2.2. Control of User Facilities

The PCSN or a TE are not required to support any particular facility. If facilities are supported there are two procedures for their control:

- Control of call related facilities, i.e. in connection with a call control procedure,

- Registration/cancellation of facilities, independently of call control procedures and of any particular call.

If the call related user facilities listed below are used, they shall be controlled by FACILITY messages specified in the ECMA Standard.

- Charging Indication,
- Closed User Group (CUG),
- Calling Line Identification,
- Called Line Identity,
- Charging Method Selection,
- Call Redirection.

Messages for the control of facilities listed in Annex B shall be considered for inclusion in an ECMA Standard.

7.1.3.2.3. Procedures for User-to-User transfer of information

Three possibilities exist to transfer data over the D-channel:

- User-to-User Signalling via a Temporary Signalling Connection

  This feature allows for communication by means of user-to-user signalling without setting up a circuit switched connection. The procedures are similar to those required for establishing a B-channel connection.

- User-to-User Signalling via a Permanent Signalling Connection

  This feature allows for communication by means of user-to-user signalling without setting up a circuit switched connection. The communication is always active. The only messages to be transferred are the USER INFO messages.

- User message inside a Call

  User-to-User transfer of information inside a call is possible in two ways: by means of a user-to-user information element or by a separate USER INFO message.

  . User-to-User Information Element

  This is an information element of variable length which may be included in the SETUP, ALERTING, CONNECT, DISCONNECT, DETACH and RELEASE messages. The content of this information element is transferred transparently across the PCSN (and possibly ISDN) to the remote TE.

  . USER INFO Message

  This message is a self-contained signalling message containing the "user-to-user" and if applicable the "more data" information elements. The "more data" information element allows segmenting and reassembling of data by the user.

  If necessary, the PCSN will flow-control the transfer of USER INFO messages by means of a CONGESTION CONTROL message which will be used to stop and to re-enable the transfer of USER INFO messages.

7.1.3.2.4. Message structure

A message is composed of a set of information elements. These are building blocks. The basic set of elements is listed hereafter.

Protocol Discriminator

To distinguish messages for user-PCSN call control from other messages.

Call Reference

To identify the call to which the particular message applies.

Message Type

To identify the function of the message.

Bearer Capability.

To indicate a requested service among those defined in CCITT Recommendations I.210 and I.211.

Call Identity

To identify a suspended call.

Call State

To describe the current status of a call.

Cause

To describe the reason for generating certain messages and to provide diagnostic information on the event of procedural errors.

CCITT Standardized Facilities

To indicate which CCITT standardized binary facilities are being invoked. Binary facilities are those which do not require parameters.

Network-specific Facilities

To indicate which network facilities are being invoked at the specified network.

Channel Identification

To identify a channel within the interface(s) controlled by these signalling procedures.

High layer and low layer compatibility

To provide means which may be used by the remote user in association with the bearer capability information element for compatibility checking. These elements are not interpreted by the PCSN but are carried transparently.

Congestion Level

To describe the congestion status of the user-to-user information flow over the D-channel.

Connected Address

To indicate which address the call is connected to. The connected address(es) may be different from the origination or destination address(es) because of changes (e.g. call redirection or transfer) during the lifetime of the call.

Destination Address

To identify one or more call destinations.

Origination Address

To identify the origin of a call.

More Data

To indicate that the user info message is being continued. The use of the More Data information element is not supervised by the PCSN.

Redirecting Address

To identify the destination address from which call redirection, diversion or transfer was invoked.

Transit Network Selection

To identify a requested transit network. This element may be repeated in a message to select a sequence of transit networks through which a call must pass.

User-to-user information

To convey information between TEs. This information is not interpreted by the PCSN but carried transparently.

7.2. Primary Rate Access Interface (S_2)

The primary rate interface structure is composed of 30 B-channels and one D-channel, corresponding to the rate of 2048 kbit/s as defined in CCITT Recommendation G.732.

The B-channels are independant and can be used in different circuit switched connections. They provide bi-directional transmission at 64 kbit/s. These channels will not be used for PCSN signalling.

The bit rate of the D-channel in this interface is 64 kbit/s.

In the case of a TE/PCSN access arrangement containing multiple interfaces, it is mandatory to provide a specific D-channel for each new set of 30 B-channels.

This interface structure will be used for point-to-point connections only.

7.2.1. Configuration

The extended access uses point-to-point configurations only. The maximum range of the point-to-point configuration is limited by the specification for the electrical characteristics of transmitted and received pulses and the type of interconnecting cable. The distance covered is estimated to be between 500m and 700m.

The wiring between the PT providing the functional S reference point and the S socket is out of the scope of this document.

7.2.2. Physical Layer

The ECMA Physical Layer Standard is based on CCITT Recommendations I.431, G.703, G.732, G.734.

In particular the CRC mechanism being introduced in CCITT Recommendations G.732 shall be considered for inclusion in the ECMA Standard.

A brief description of the Physical Layer characteristics not dealt with in detail in the subsequent paragraphs is given hereafter:

Overall bit rate:	2048 kbit/s
Frame size:	256 bits
Type of coding:	pseudo-ternary code (HDB3)
Contention resolution:	not applicable
Timing:	on bit, octet and frame level
D-channel:	in time slot 16

7.2.2.1. Wiring and Plugs

The wiring consists of two circuits to carry the bit stream in the two directions of transmission.
Suitable IEC standardized plugs and sockets will be indicated in the ECMA Standard.
The input and output impedances of the TE shall be in accordance with CCITT Recommendation G.703.

7.2.2.2. Power Feeding

The S_2 interface does not provide power feeding.

7.2.2.3. Interface Procedures and Services provided to higher Layers

The interface procedures and services provided to higher layers shall be specified. They shall follow the rules for the procedures and services provided by layer 1 of the basic access. Consideration will be given to operational and maintenance aspects of CCITT Recommendation G.732.

7.2.3. Protocols on the D-channel

The D-channel is used as a common signalling channel for the 30 B-channels. Signalling on the D-channel is done by a set of layered protocols such as described in CCITT Recommendation I.320 which is based on the principles given in the CCITT X.200 series Recommendations.

These protocols cater for Signalling.

Layer 1: The Physical Layer is described in 7.2.2.

Layer 2: The Data Link Layer is used to establish a point-to-point type of connection. It is described in 7.2.3.1.

Layer 3: The term "layer 3" is used to indicate the layer above the Data Link Layer. It provides the functions associated with the establishment and operation of a TE-to-TE connection as well as the B-channel management. It is described in 7.2.3.2.

Many aspects of the Data Link Layer and layer 3 protocol specifications for the primary rate access are identical to those of the basic access. In such circumstances reference to the basic access texts will be made.

7.2.3.1. Data Link Layer

The Data Link Layer protocol is based on CCITT Recommendation I.441 and shall be the subject of an ECMA Standard.

The Data Link Layer protocol operates the Link Access Procedures on the D-channel. This HDLC type of protocol is called LAPD. The purpose of LAPD is to convey information between layer 3 entities across the S_2 interface. The definition of the Data Link Layer protocol is similar to the one recommended for the basic access (see 7.1.3.1.) with the following differences:

- Only point-to-point links are considered. The use of more than one Service Access Point (SAP) shall be considered.

- The default value of certain Data Link layer parameters is different from the values proposed for the basic access interface.

7.2.3.2. Layer 3

The layer 3 protocol is based on CCITT Recommendations I.450 and I.451 and shall be specified in an ECMA Standard.

The procedures as described for the point-to-point mode of operation for the S_0 interface apply (see 7.1.3.2.).

B-Channel Negotiation at the Destination End

Negotiation between the PCSN and the TE is permitted for the selection of a B-channel.

8. TERMINAL ADAPTOR: TA

The PCSN shall support the connection of DPE's with non-ISDN interfaces because it is considered that:

- For many years to come the quantity of DPEs with R interfaces will represent a large percentage of all available DPEs.

- Users with existing DPEs with interfaces conforming to CCITT X-series and V-series Recommendations will want to connect such terminals to the PCSN.

- Users will need to be able to establish connections between different types of terminal as well as to establish connections to external networks via suitable IWUs.

To satisfy these needs ECMA will develop standards for Terminal Adaptors which support the connection of DPEs with X-series and V-series interfaces to the S_0 interface. The configurations of interest have been described in the scope.

In this Technical Report no assumptions are made concerning the realisation of a TA and consequently all references are made to the functions of a Terminal Adaptor. The main functions of a TA between the R and S reference points are described in 8.1.

The following TA types are described :

- Section 8.2. describes a TA for a DPE with X.21 and X.21bis interfaces, and

- Section 8.3. describes a TA for a DPE with V.24 interfaces for both synchronous and asynchronous modes of operation.

The configurations described in 4.2. are those of interworking between DPEs connected at the R reference points or R and S reference points. In the latter case,the TE connected at the S reference point must contain some of the functions of the TA.

The same applies for an IWU. Although the function of the IWU is outside of the scope of this document, it is recognized that some provision must be made for signalling of DPE-TA interface circuit states on the B-channel.

8.1. Functions of a Terminal Adaptor

The following functions may be performed by a TA:

- Mapping between signalling on the D-channel and the R and/or user interface,

- Rate adaptation during data transfer from user data rates to the 64 kbit/s B-channel rate,

- Handling of terminal status information and provision of end-to-end synchronization.

It should be noted that the subfunctions of the different TA types are similar. In particular, the rate adaptation method is basically the same for both X.21 and V.24 TA types. Also the allocation of the various status bits has been made in order to simplify the different interworking configurations.

8.1.1. Signalling

The D-channel protocol is used for signalling. This function can be handled in one of the following ways:

- A separate terminal with an S_0 interface is used,

- The TA contains functions for D-channel handling and for an operator interface,

- The TA supports an R interface protocol which is mapped to the D-channel signalling.

The TA shall use D-channel signalling for peer-to-peer parameter exchange concerning e.g. user rates, character formats, operating modes and protocol identification on the B-channel.

8.1.2. Data Transfer

The Terminal Adaptor is responsible for the conversion of different user rates to the 64 kbit/s rate in the B-channel. This conversion is based on the CCITT two-step rate adaptation scheme (I.460 series).

The first step adapts user rates of 4800 bit/s and below to an intermediate rate of 8 kbit/s. User rates of 7200 bit/s and 9600 bit/s are adapted to an intermediate rate of 16 kbit/s. User rates between 12 kbit/s and 19,2 kbit/s are adapted to an intermediate rate of 32 kbit/s. User rates of higher than 19,2 kbit/s are converted directly to 64 kbit/s in one step.

The second step of rate adaptation converts the intermediate rate (8, 16 or 32 kbit/s) to 64 kbit/s. This is described in CCITT Recommendation I.460.

The first step of rate adaptation is performed by using an 80 bit frame as shown in Table 2.

Octet Number	Bit Number							
	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0	0
1	1	D1	D2	D3	D4	D5	D6	S1
2	1	D7	D8	D9	D10	D11	D12	X
3	1	D13	D14	D15	D16	D17	D18	S3
4	1	D19	D20	D21	D22	D23	D24	S4
5	1	E1	E2	E3	E4	E5	E6	E7
6	1	D25	D26	D27	D28	D29	D30	S6
7	1	D31	D32	D33	D34	D35	D36	X
8	1	D37	D38	D39	D40	D41	D42	S8
9	1	D43	D44	D45	D46	D47	D48	S9

Table 2.

The functional division within this frame is described below:

- Octet 0 contains all ZEROs and the first bit of octets 1 to 9 contain ONEs. These 17 bits are used to establish frame alignment,

- 48 of the bits (bits 2 to 7 in octets 1 to 4 and octets 6 to 9) are used to carry user data. This means that for an intermediate rate of 8000 bit/s a user rate of 4800 bit/s can be supported. Lower user rates, for example 2400 bit/s or 1200 bit/s, are handled by repeating user data bits,

- Bits S and X are used to convey channel and modem control information associated with the data bits, and flow control,

- Bits E1 to E3 are used to carry bit repetition information, and bits E4 to E7 are used for a number of different purposes such as network independent clock information and multiframe alignment.

8.1.3. Terminal Status Information and End-to-end Synchronization

Terminal status information is conveyed by the rate adaptation scheme by using the S and X bits in the 80 bit frame. The exact use of the S and X bits depends upon the type of R interface supported.

End-to-end synchronization is used by the TA function to achieve a clean transition between the signalling phase and the data transfer phase. This is to ensure that the DPE at either end will only start transmitting data when a data path exists.

8.2. Terminal Adaptor for X.21 and X.21bis DPEs

The Terminal Adaptor for an X.21 or an X.21bis DPE shall comply with CCITT Recommendation I.461/X.30.

The bit rate adaption scheme described in 8.1.2 is used. The X bit is not used and is set to ZERO. Bits E4-E6 are not used and are set to ONE. For the X.21 interface the status of the "C" circuit is conveyed by the S bits and the "I" circuit status is derived from the received S bits. X.21 byte timing is not guaranteed to be passed from end-to-end. For the X.21bis interface the S bits carry the state of circuit 105, which allows half-duplex operation.

All X.21 connection or disconnection commands and responses are mapped onto corresponding messages in the D-channel.

8.3. TA for support of V.24 type terminals

There is a CCITT Recommendation I.463/V.110 for the support of synchronous V.24 terminals.

There is no such CCITT Recommendation available for a TA supporting start-stop V.24 terminals. This support is required and the rate adaptation mechanism described in 8.3.3. is recommended.

The functional differences between the asynchronous and synchronous cases are described in 8.3.3.

8.3.1. TA Features

The rate adaptation technique used in the Terminal Adaptor for support of V.24 based terminals shall fulfill the following basic requirements:

Data rates

Table 3. shows combinations of data rate tolerance, number of stop bits and number of data bits which may be supported in the asynchronous case. The supported synchronous speeds are also indicated, although the information in the table is irrelevant for these cases.

Data rate	Data rate tolerance(Note)	Number of data bits	Number of stop bits	Remark
50	+2,5% -2,5%	5	1. 5	
75	"	5 ; 7 ; 8	1 ; 1,5 or 2	
110	"	7, 8	1 or 2	
150	"	"	"	
200	"	"	"	
300	"	"	"	m
600	+1 % -2,5%	"	1 or 2	m,s
1200	"	"	"	m,s
2400	"	"	"	m,s
4800	"	"	"	m,s
7200	"	"	"	s
9600	"	"	"	m,s
12000	"	"	"	
14400	"	"	"	s
19200	"	"	"	m,s
48000	-	-	-	s
56000	-	-	-	s

m: mandatory means the rate is supported by a Universal TA function.
s: supported synchronous speeds.

Note: The figures indicated apply to receiving data from the TE. Tolerances for sending to the TE shall be considered.

Table 3.

Note: A preferred subset of the speeds given in Table 3. will be agreed upon later. Speeds not indicated in Table 3. are for further study.

Split speed

This is supported for asynchronous terminals only e.g. 1200/75 bit/s as used in videotex applications.

Duplex / half duplex / simplex modes

The transmission through the PCSN is full duplex but half duplex or simplex procedure may be supported at the R interface.

Interface circuits to be supported

For the start-stop mode of operation the essential and optional interchange circuits are listed in Table 4. For further details refer to CCITT Recommendation I.463/V.110.

Number	Description	Essential
103	Transmitted data	Yes
104	Received data	Yes
105	Request to send	Yes
106	Ready for sending	Yes
107	Data set ready	Yes
108/1	Connect data set to line	Yes
108/2	Data terminal ready	Yes
109	Data channel received line signal detector	Yes
111	Data signalling rate selector (DTE source)	No
112	Data signalling rate selector (DCE source)	No
113	Transmitter signal element timing (DTE source)	Note 4,5
114	Transmitter signal element timing (DCE source)	Note 5
115	Receiver signal element timing (DCE source)	Note 5
125	Calling indicator	Yes
140	Loopback/maintenance test	Note 6
141	Local loopback	Yes
142	Test indicator	Yes

Note 4: This circuit is needed in those cases where a TA function in an IWU has to support synchronous data signals from voice-band modems with PCSN-independent bit timing.
Note 5: For synchronous operation only.
Note 6: For further study.

Table 4.

Flow control for asynchronous terminals

The rate adaptation scheme shall provide the possibility for flow control. This function may be used for interworking between terminals and/or computers operating at different speeds in the asynchronous mode. Its use is optional.

Synchronous modems with network independent clocks

Although not described in this document, the TA Standard shall specify an extension to the rate adaptation scheme to cover the case of interworking with a modem (via an IWU function) operating in the synchronous mode with a network independent clock.

Secondary (backward) channel
No support provided.

Break signal for asynchronous terminals
Supported.

Wrong stop-bit polarity for asynchronous terminals

The TA shall transfer asynchronous start-stop characters and the break condition.
Correct transfer of characters with wrong stop-bit polarity will not be guaranteed.

Frame synchronisation time
Refer to CCITT Recommendation I.463/V.110.

8.3.2. Signalling

The D-channel is used to transport the following parameters between TA functions:

- Speed
- Number of stop bits (Note)
- Parity (Note)
- Character length (Note)
- Terminal type (whether X.21; V-series; synchronous or asynchronous)
- Ability to use flow control (Note)
- Ability to use network independent clocks

Note: Asynchronous terminals only.

It is expected that this parameter information will be exchanged at the beginning of the call, as it is envisaged that some terminal equipment will be unable to support end-to-end signalling protocols.

8.3.3. Frame Use

The frame structure used for both asynchronous and synchronous is basically as defined in 8.1.2. Byte boundaries will not exist in the case of bit repetition, repeated user bits may lie across a frame boundary. In the case of asynchronous terminals an asynchronous to synchronous conversion stage is described in 8.3.3.2.

Briefly, for both the asynchronous and synchronous cases, the S bits may be used to convey the status of interchange circuits 105, 107, 108 and 109.

Interworking between terminals of different interface types is considered in 8.4.

Network independent clocks may be catered for by the use of E bits to carry stuffing information.

8.3.3.1. Asynchronous Frame Use

Use is made of an asynchronous to synchronous conversion technique to fill the user data segment of the frame. This technique, which appears in the CCITT Recommendation V.22 alternative B (for a 1200 bit/s modem), is described in 8.3.3.2.

The use of S and E bits in the asynchronous case is fully compatible with their use in the synchronous case.

8.3.3.2. Asynchronous to Synchronous Conversion

The principle for this method is first to convert the asynchronous characters including start and stop bits to a synchronous bit stream with the same nominal data rate. The synchronous bit stream is then converted to 64 kbit/s as defined in this Chapter.

The asynchronous to synchronous conversion can best be represented by a four stage process, although in practice some stages are unused, at certain user data rates. See Fig. 12. for the general case.

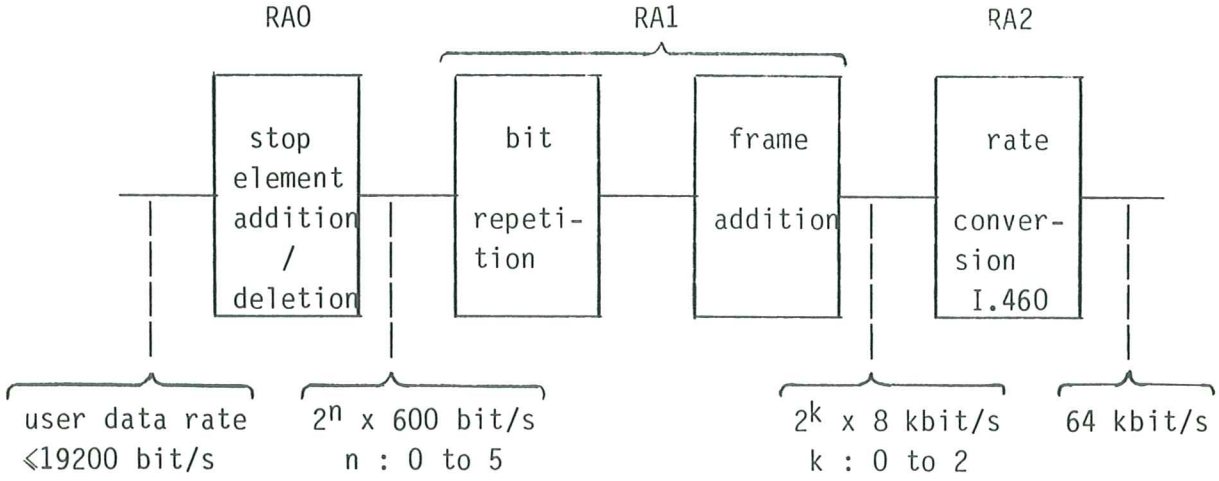


Figure 12.

Incoming asynchronous data is padded by the addition of extra stop elements to fit the nearest available channel multiple of 600 bit/s. This function, designated as RA0 preceeds the synchronous RA1 and RA2 functions. It takes the resultant bit stream, repeats each bit depending upon the incoming rate, and further rate adapts to a 64 kbit/s stream.

8.3.3.3. Overspeed/Underspeed

If the terminal is transmitting characters continuously with an overspeed of up to +1% (or +2,5% in the case of speeds less than 600 bit/s), the asynchronous to synchronous converter deletes stop elements as often as necessary (maximum one every 8 characters for 1% overspeed) so as not to cause loss of data. Gaps between characters are represented by additional stop elements.

8.3.3.4. Break Signal

The rate adaptation scheme will carry the break signal defined as follows.

- If the converter detects M to 2M+3 bits, all of start polarity, where M is the number of bits per character in the selected format including start and stop bits, the converter shall transmit 2M+3 bits of start polarity.

- If the converter detects more than 2M+3 bits all of start polarity the converter shall transmit all these bits as start polarity.

- The 2M+3 or more bits of start polarity received from the transmitting side shall be output to the receiving terminal.

- The terminal must transmit on circuit 103 at least 2M bits of stop polarity after the start polarity break signal before sending further data characters. The converter shall then regain character synchronization from the following stop to start transition.

8.3.3.5. Receiver

The bearer rate and character format must be the same for both the transmitter at one end of the connection and the receiver at the other end. On the receive side, the synchronous to asynchronous converter may reduce the length of the stop bit to allow for overspeed in the transmitting terminal.

8.3.4. Examples

In the following examples D, S, X and E bits are used as defined in 8.1.2.

Fig. 13. gives an example of rate adaptation of 4800 bit/s asynchronous characters with 8 data bits and one stop bit to the 8 kbit/s intermediate rate.

Fig. 14. shows the same case as Fig. 13. with the exception that the transmitting terminal is transmitting with overspeed which has caused one stop element to be deleted in the 8 kbit/s intermediate rate.

Fig. 15. shows an example of rate adaptation of 2400 bit/s asynchronous characters with 8 data bits and one stop bit to the 8 kbit/s intermediate rate,

Fig. 16. shows an example of rate adaptation of 300 bit/s asynchronous characters using the rate adaptation for 600 bit/s synchronous user rate.

Fig. 17. shows an example of rate adaptation of 600 bit/s asynchronous characters with 8 data bits and one stop bit to the 8 kbit/s intermediate rate.

Fig. 18. shows the same case as Fig. 17. with the exception that the transmitting terminal is transmitting with overspeed which has caused one stop element to be deleted.

0	0	0	0	0	0	0	0
1	1	0	D1	D2	D3	D4	S1
1	D5	D6	D7	D8	1	0	X
1	D1	D2	D3	D4	D5	D6	S3
1	D7	D8	1	0	D1	D2	S4
1	0	1	1	E4	E5	E6	E7
1	D3	D4	D5	D6	D7	D8	S6
1	1	0	D1	D2	D3	D4	X
1	D5	D6	D7	D8	1	0	S8
1	D1	D2	D3	D4	D5	D6	S9

Fig 13. 4800 bit/s without stop bits removed

0	0	0	0	0	0	0	0
1	1	0	D1	D2	D3	D4	S1
1	D5	D6	D7	D8	1	0	X
1	D1	D2	D3	D4	D5	D6	S3
1	D7	D8	1	0	D1	D2	S4
1	0	1	1	E4	E5	E6	E7
1	D3	D4	D5	D6	D7	D8	S6
1	0	D1	D2	D3	D4	D5	X
1	D6	D7	D8	1	0	D1	S8
1	D2	D3	D4	D5	D6	D7	S9

Fig 14. 4800 bit/s with one top bit removed

0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	S1
1	D1	D1	D2	D2	D3	D3	X
1	D4	D4	D5	D5	D6	D6	S3
1	D7	D7	D8	D8	1	1	S4
1	1	1	0	E4	E5	E6	E7
1	0	0	D1	D1	D2	D2	S6
1	D3	D3	D4	D4	D5	D5	X
1	D6	D6	D7	D7	D8	D8	S8
1	1	1	0	0	D1	D1	S9

Fig 15. 2400 bit/s without stop bits removed

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	S1
1	1	1	1	1	1	1	X
1	1	1	1	1	0	0	S3
1	0	0	0	0	0	0	S4
1	1	0	0	E4	E5	E6	E7
1	D1	D1	D1	D1	D1	D1	S6
1	D1	D1	D2	D2	D2	D2	X
1	D2	D2	D2	D2	D3	D3	S8
1	D3	D3	D3	D3	D3	D3	S9
0	0	0	0	0	0	0	0
1	D4	D4	D4	D4	D4	D4	S1
1	D4	D4	D5	D5	D5	D5	X
1	D5	D5	D5	D5	D6	D6	S3
1	D6	D6	D6	D6	D6	D6	S4
1	1	0	0	E4	E5	E6	E7
1	D7	D7	D7	D7	D7	D7	S6
1	D7	D7	D8	D8	D8	D8	X
1	D8	D8	D8	D8	1	1	S8
1	1	1	1	1	1	1	S9
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	S1
1	1	1	1	1	1	1	X
1	1	1	1	1	1	1	S3
1	1	1	1	1	1	1	S4
1	1	0	0	E4	E5	E6	E7
1	1	1	1	1	1	1	S6
1	1	1	1	1	1	1	X
1	1	1	1	1	1	1	S8
1	1	1	1	1	1	1	S9
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	S1
1	1	1	1	1	1	1	X
1	1	1	1	1	1	1	S3
1	1	1	1	1	1	1	S4
1	1	0	0	E4	E5	E6	E7
1	1	1	1	1	1	1	S6
1	1	1	0	0	0	0	X
1	0	0	0	0	D1	D1	S8
1	D1	D1	D1	D1	D1	D1	S9

Fig 16. 300 bit/s mapped into 600 bit/s channel

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	S1
1	1	1	0	0	0	0	X
1	0	0	0	0	D1	D1	S3
1	D1	D1	D1	D1	D1	D1	S4
1	1	0	0	E4	E5	E6	E7
1	D2	D2	D2	D2	D2	D2	S6
1	D2	D2	D3	D3	D3	D3	X
1	D3	D3	D3	D3	D4	D4	S8
1	D4	D4	D4	D4	D4	D4	S9
0	0	0	0	0	0	0	0
1	D5	D5	D5	D5	D5	D5	S1
1	D5	D5	D6	D6	D6	D6	X
1	D6	D6	D6	D6	D7	D7	S3
1	D7	D7	D7	D7	D7	D7	S4
1	1	0	0	E4	E5	E6	E7
1	D8	D8	D8	D8	D8	D8	S6
1	D8	D8	1	1	1	1	X
1	1	1	1	1	0	0	S8
1	0	0	0	0	0	0	S9
0	0	0	0	0	0	0	0
1	D1	D1	D1	D1	D1	D1	S1
1	D1	D1	D2	D2	D2	D2	X
1	D2	D2	D2	D2	D3	D3	S3
1	D3	D3	D3	D3	D3	D3	S4
1	1	0	0	E4	E5	E6	E7
1	D4	D4	D4	D4	D4	D4	S6
1	D4	D4	D5	D5	D5	D5	X
1	D5	D5	D5	D5	D6	D6	S8
1	D6	D6	D6	D6	D6	D6	S9
0	0	0	0	0	0	0	0
1	D7	D7	D7	D7	D7	D7	S1
1	D7	D7	D8	D8	D8	D8	X
1	D8	D8	D8	D8	1	1	S3
1	1	1	1	1	1	1	S4
1	1	0	0	E4	E5	E6	E7
1	0	0	0	0	0	0	S6
1	0	0	D1	D1	D1	D1	X
1	D1	D1	D1	D1	D2	D2	S8
1	D2	D2	D2	D2	D2	D2	S9

Fig 17. 600 bit/s without stop bits removed

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	S1
1	1	1	0	0	0	0	X
1	0	0	0	0	D1	D1	S3
1	D1	D1	D1	D1	D1	D1	S4
1	1	0	0	E4	E5	E6	E7
1	D2	D2	D2	D2	D2	D2	S6
1	D2	D2	D3	D3	D3	D3	X
1	D3	D3	D3	D3	D4	D4	S8
1	D4	D4	D4	D4	D4	D4	S9
0	0	0	0	0	0	0	0
1	D5	D5	D5	D5	D5	D5	S1
1	D5	D5	D6	D6	D6	D6	X
1	D6	D6	D6	D6	D7	D7	S3
1	D7	D7	D7	D7	D7	D7	S4
1	1	0	0	E4	E5	E6	E7
1	D8	D8	D8	D8	D8	D8	S6
1	D8	D8	1	1	1	1	X
1	1	1	1	1	0	0	S8
1	0	0	0	0	0	0	S9
0	0	0	0	0	0	0	0
1	D1	D1	D1	D1	D1	D1	S1
1	D1	D1	D2	D2	D2	D2	X
1	D2	D2	D2	D2	D3	D3	S3
1	D3	D3	D3	D3	D3	D3	S4
1	1	0	0	E4	E5	E6	E7
1	D4	D4	D4	D4	D4	D4	S6
1	D4	D4	D5	D5	D5	D5	X
1	D5	D5	D5	D5	D6	D6	S8
1	D6	D6	D6	D6	D6	D6	S9
0	0	0	0	0	0	0	0
1	D7	D7	D7	D7	D7	D7	S1
1	D7	D7	D8	D8	D8	D8	X
1	D8	D8	D8	D8	0	0	S3
1	0	0	0	0	0	0	S4
1	1	0	0	E4	E5	E6	E7
1	D1	D1	D1	D1	D1	D1	S6
1	D1	D1	D2	D2	D2	D2	X
1	D2	D2	D2	D2	D3	D3	S8
1	D3	D3	D3	D3	D3	D3	S9

Fig 18. 600 bit/s with one stop bit removed

8.4. Interworking

8.4.1. X.21 - X.21bis Interworking

X.21 - X.21bis interworking is covered in CCITT Recommendation I.461/X.30.

8.4.2. X.21/X.21bis - V.24 Interworking

Consideration is given to X.21 - V.24 interworking in CCITT Recommendation I.463/V.110.

8.4.3. IWU with Modems

For interworking between a PCSN and the existing analogue telephony network an interworking unit with a modem is required.

The following functions are required in the IWU:

- rate adaptation from the modem data rate to the 64 kbit/s B-channel,
- mapping of modem interchange circuits to the S and X bits as described in CCITT Recommendation I.463/V.110,
- handling of D-channel protocol for call set-up and call release,
- conveyance of the modem clock through the PCSN to the terminal in the case of synchronous modems. (It should be noted that with the CCITT rate adaptation method no mechanism is described for the transport of modem clock information.)

9. ADDRESSING

9.1. PCSN Address

The establishment of a connection across the PCSN requires the use of addresses. The addressing and numbering principles are defined in CCITT Recommendations I.330 and I.331.

A single PCSN address is sufficient to identify an interface at an S reference point (S_0 or S_2). This does not preclude the assignment of several addresses to the same S interface (e.g. interface accessed as single address and as member of a group). The assignment of the same address to several interfaces is also possible (e.g. group hunting).

The PCSN address does not identify a particular B-channel.

A PCSN address may be an ISDN address (conforming to CCITT Recommendations I.330 and I.331 principles) or a local address, in which case it may be a string of IA5 alphanumeric characters.(CCITT Recommendation V.3)

9.2. Subaddressing

The use of subaddresses is optional. When a subaddress is provided by the calling user, it will be transparently conveyed by the PCSN as an element that is separate from both the PCSN number and the user-to-user information (CCITT Recommendation I.330). The maximum length shall be 32 digits.

Subaddresses can be used to access a particular application; this may lead to the negotiation of a suitable B-channel within the S_2 interface.

10. OPERATION AND MAINTENANCE

10.1. Operation

Operation is considered to cover such fields as operation, administration, charging...

The basic mechanisms are provided by the D-channel layer 3 protocol. A detailed specification on how they should be used for the various functions will be produced.

10.2. Maintenance

Maintenance issues are listed as a subject for further study at CCITT. It will be considered the same in this document.

However, the ECMA Standards indicated in chapter 11 shall make provisions for later introduction of statements on maintenance.

11. SUBJECTS FOR STANDARDIZATION BY ECMA COVERED BY THIS REPORT

Physical Layer of the S Interfaces between DPE and PCSN

Electrical characteristics of the TE input and output at the Basic Access Interface (S_0).

Electrical characteristics of TE connection at the Basic Access Interface (S_0).

Electrical characteristics of the TE input and output at the Primary Rate Access Interface (S_2).

Electrical characteristics of TE connection at the Primary Rate Access Interface (S_2).

Connectors.

TE/PCSN Interface Data Link Layer Protocol for D-channel

Specification of the TE/PCSN interface Data Link layer protocol.

TE/PCSN Interface Layer 3 Protocol for D-channel

Specification of the TE/PCSN interface layer 3 protocol.

Rate Adaptation for the Support of Synchronous and Asynchronous Equipment using V-series interfaces

TA function for asynchronous terminals.
TA function for synchronous terminals.
End-to-end synchronization.

A N N E X A

EXAMPLES OF BEARER SERVICE ATTRIBUTES AND THEIR VALUES

This table is an abstract derived from CCITT Recommendation I.211

Attribute	Example of values
1. Information transfer attributes	
1. Information transfer mode	circuit packet
2. Information transfer rate	bit rate (kbit/s) 64 384 1536 1920
3. Information transfer capability	unrestricted digital information speech 3,1 kHz audio 7 kHz audio 15 kHz audio video
4. Structural integrity	8 kHz (octet timing) service data unit integrity unstructured
5. Establishment of communication	demand reserved permanent
6. Communication configuration	point-to-point multipoint broadcast
7. Symmetry	simplex duplex symmetric duplex asymmetric
2. Access attributes	
8. Access channel and rate	D 16 kbit/s D 64 kbit/s B
9.1 Signalling access protocol	I.440 I.450
9.2 Information access protocol	G.711 I.460 I.450 X.25

A N N E X B

EXAMPLE OF PABX FACILITIES

This is a list of facilities that can be provided in a PABX.

The facilities that a user can expect to find could be provided either by the terminal or by the PABX.

- Abbreviated dialling
- Dial by name
- Auto redialling
- Hot-line
- Call waiting
- Call hold
- Call transfer
- Automatic call back
- Broadcast
- Group hunting
- Permanent circuit
- Call pick up
- Call diversion
- Priority break in
- Line booking
- Time and Date
- Local mode

A N N E X C

EXAMPLE OF THE PROCEDURE FOR A SIMPLE CIRCUIT SWITCHED CALL