INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

X.81

PUBLIC DATA NETWORKS

TRANSMISSION, SIGNALLING AND SWITCHING

INTERWORKING BETWEEN AN ISDN CIRCUIT - SWITCHED AND A CIRCUIT-SWITCHED PUBLIC DATA NETWORK (CSPDN)

ITU-T Recommendation X.81

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation X.81 was published in Fascicle VIII.3 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation X.81

INTERWORKING BETWEEN AN ISDN CIRCUIT-SWITCHED AND A CIRCUIT-SWITCHED PUBLIC DATA NETWORK (CSPDN)

(Melbourne, 1988)

The CCITT,

considering

(a) that I-Series Recommendations describe the integrated services digital network (ISDN);

(b) that interface characteristics, line multiplexing and inter-exchange signalling for use in CSPDNs are described by Recommendations such as X.26/X.27/X.50/X.51/Q.761 to Q.766/X.60/X.61/X.71/X.80;

(c) that Recommendation X.200 describes the reference model for Open System Interconnection;

(d) that Recommendation X.213 describes the Network Service Definition for Open Systems Interconnection for CCITT applications;

(e) that Recommendation X.300 defines the general principles for interworking between public networks, and between public networks and other networks for the provision of data transmission services;

(f) that Recommendation X.301 defines the general arrangements for call control within a subnetwork and between subnetworks for the provision of data transmission services;

(g) that Recommendation X.302 defines the general arrangements for internal network utilities within a subnetwork and between subnetworks for the provision of data transmission services;

(h) that Recommendation X.305 describes functionalities of subnetworks relating to the support of the OSI Network Service;

(i) that Recommendation X.10 describes categories of access to PSPDNs and ISDNs for the provision of data transmission services;

(j) that the I.230 Series Recommendations describe the bearer services supported by an ISDN;

(k) that Recommendation X.30 describes the support of X.21, X.21 *bis* and X.20 *bis* based DTEs on the ISDN;

(l) the need for arrangements when interworking between ISDN circuit switched and CSPDNs for the provision of data transmission services.

unanimously declares the view

that the scope of this Recommendation is intended to cover interworking between an ISDN using circuit-switched connection types and a CSPDN.

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0 Introduction

This Recommendation is one of a set of Recommendations produced to facilitate considerations of interworking between networks. It is based on Recommendation X.300, which defines the general principles for interworking between public networks, and between public networks and other networks for the provision of data transmission services. Recommendation X.300 indicates in particular how collections of physical equipment can be represented as "Subnetworks" for consideration in interworking situations.

This Recommendation describes the interworking arrangements between ISDNs (circuit switched bearer) and CSPDNs for the provision of data transmission services.

1 Scope and field of application

The purpose of this Recommendation is to describe the detailed arrangements for the interworking between CSPDNs and ISDNs (CS) for the provision of data transmission services. These arrangements are applicable only to the interworking involving transmission capabilities, and not to interworking involving communication capabilities as described in Recommendation X.300.

a) within the scope of interworking between an ISDN using circuit-switched connection types and a CSPDN the following cases of network interworking can be identified:

   i) where the terminals connected to the interworking networks use identical data transmission services and have identical high layer capabilities. The identity of data transmission services in both networks assumes that both terminals involved in a communication belong to the same user class of service;
   ii) where the terminals connected to the interworking networks use non-identical data transmission services but have identical high layer capabilities. In this case two terminals involved in a communication may belong to different user classes of service, e.g. user classes of service 4 and 30.

b) Not within the scope of this Recommendation is asynchronous mode of operation at the network-to-network interface (ISDN-to-CSPDN interface). In the case, that the ISDN supports the connection of asynchronous mode terminals via an appropriate terminal adaptor (TA) (see Recommendation X.30) and that interworking has to be provided to asynchronous terminals connected to a CSPDN, then the interworking arrangements as for synchronous mode operation will be used. Asynchronous to synchronous conversion may be provided within the TA for ISDN-connected terminals and at the terminal or at the CSPDN for CSPDN-connected terminals.

   Note - The typing of subnetworks in this Recommendation is based on the support for the OSI connection-mode Network Service and is therefore only valid in this context.

2 References

[1] Recommendation X.1
[2] Recommendation X.2
[3] Recommendation X.10
[4] Recommendation X.20
[5] Recommendation X.21
[6] Recommendation X.21 *bis*
[7] Recommendation X.25
[8] Recommendation X.27
[9] Recommendation X.30
[10] Recommendation X.50
[11] Recommendation X.51
[12] Recommendation X.60
[13] Recommendation X.61
[14] Recommendation X.71
[15] Recommendation X.300
[16] Recommendation X.321
[17] I.230 and I.250 Series Recommendations
[18] Recommendation G.703
[19] Recommendation G.708
[20] Recommendation G.811
[21] Recommendation Q.761-Q.766

3 Definitions

This Recommendation makes use of the following terms defined in the Recommendation as indicated:

Terms	Defined in Recommendation
Bearer service	I.230 Series
Data transmission service	X.10; X.300
OSI network layer service	X.213
User class of service	X.1
Supplementary services	I.250 Series; X.2

4 Abbreviations

DTE	Data terminal equipment
DCE	Data circuit-terminating equipment
SS No. 7	Common channel signalling system number 7
CSPDN	Circuit switched public data network
ISDN	Integrated services digital network
IWF	Interworking functions
LAPB	Link access protocol, balanced
OSI-NLS	Open system interconnection - Network layer service
HDLC	High level data link control
TA	Terminal adaptor
TE	Terminal equipment
UC	User class of service

Abbreviations of SS No. 7 messages and X.71 signals

SS No. 7 messages:

ACM	Address complete
ANS	Answer
IAM	Initial address
INF	Information
INR	information message
REL	Release
RLC	Release complete
RLSD	Released

X.71 signals:

CC	Call connected
CCF	Call confirmation
CDI	Called line identification
CLI	Calling line identification
CLEAR	Clearing signal
CLEAR C.	Clear confirmation
SEL	Selection signals
TTC	Transit through connect

Additional information contained in SS No. 7 messages and X.71 signals

CDI	Called line identification
CDIR	Called line identification request
CLI	Calling line identification
CLIR	Calling line identification request

5 General aspects

This Recommendation, in describing interworking arrangements between two subnetworks for the provision of data transmission services, adheres to the general principles of Recommendation X.300. The environments of these two subnetworks are described in the following sections.

5.1 *CSPDN*

The CSPDN provides circuit switched data transmission services as defined in Recommendations X.1 and X.2 for the provision of data transmission services, the CSPDN may be accessed by DTEs by the categories of access B as defined in Recommendation X.10. Other possibilities of access, which are not relevant to this Recommendation are described in Recommendation X.321.

5.2 *ISDN*

The ISDN provides circuit switched data transmission services/bearer services/supplementary services as defined in Recommendation X.1, the I.230 Series and I.250 Series. For the provision of data transmission services the ISDN may be accessed by TE2s by the categories of access S as defined in Recommendation X.10 and by TEs as defined in the I.230 Series. (circuit-mode 64 kbit/s unrestricted, unstructured). Other possibilities of access which are not relevant to this Recommendation are described in Recommendation X.321.

5.3 *Call control between the CSPDN and ISDN*

The general arrangements for call control between the CSPDN and ISDN circuit switched are as defined in Recommendation X.301. Network utilities used between the CSPDN and ISDN circuit switched are as defined in Recommendation X.302 (not visible for users).

6 Specification of interworking functions

The interworking functions specified hereafter have been grouped in accordance with their assignment to OSI-model-layers 1 to 3.

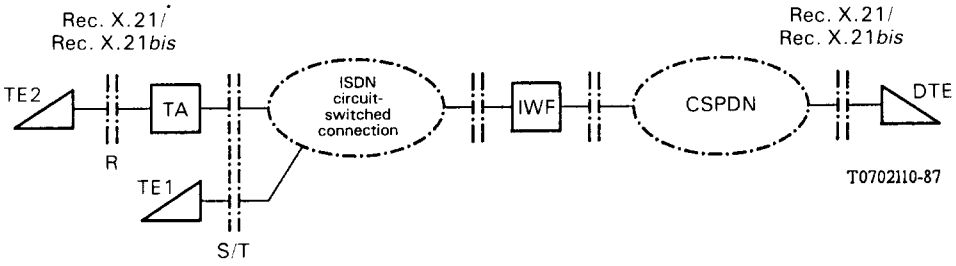
6.1 *Interworking functions for identical data transmission services*

Reference configuration of the interworking between a circuit switched ISDN and a CSPDN using identical bearer services.

As can be seen from Figure 1/X.81, the following terminal to terminal interworking cases may arise for which network interworking capabilities are necessary for user classes 3-7/categories S and B of Recommendation X.10.

ISDN	CSPDN
(Categories S1-S5)	(Categories B1-B5)
TE2 + TA X.21	DTE X.21
TE2 + TA X.21	DTE X.21 *bis*
TE2 + TA X.21 *bis*	DTE X.21
TE2 + TA X.21 *bis*	DTE X.21 *bis*
TE1 (see Note in Figure 1/X.81)	

TE2 and DTE involved in an end-to-end communication must be of the same user class. In this case a CSPDN Gateway must also support the same user class of service.



TE1 ISDN Terminal Equipment Type 1 (Note)
TE2 ISDN Terminal Equipment Type 2
TE2 and DTE Belonging to the same user class (in user classes of service 3-7)

Note – In cases where a TE1-type terminal is used, the bit stream at the S/T-interface has to comply to the X.30 frame structure.

FIGURE 1/X.81

Reference configuration

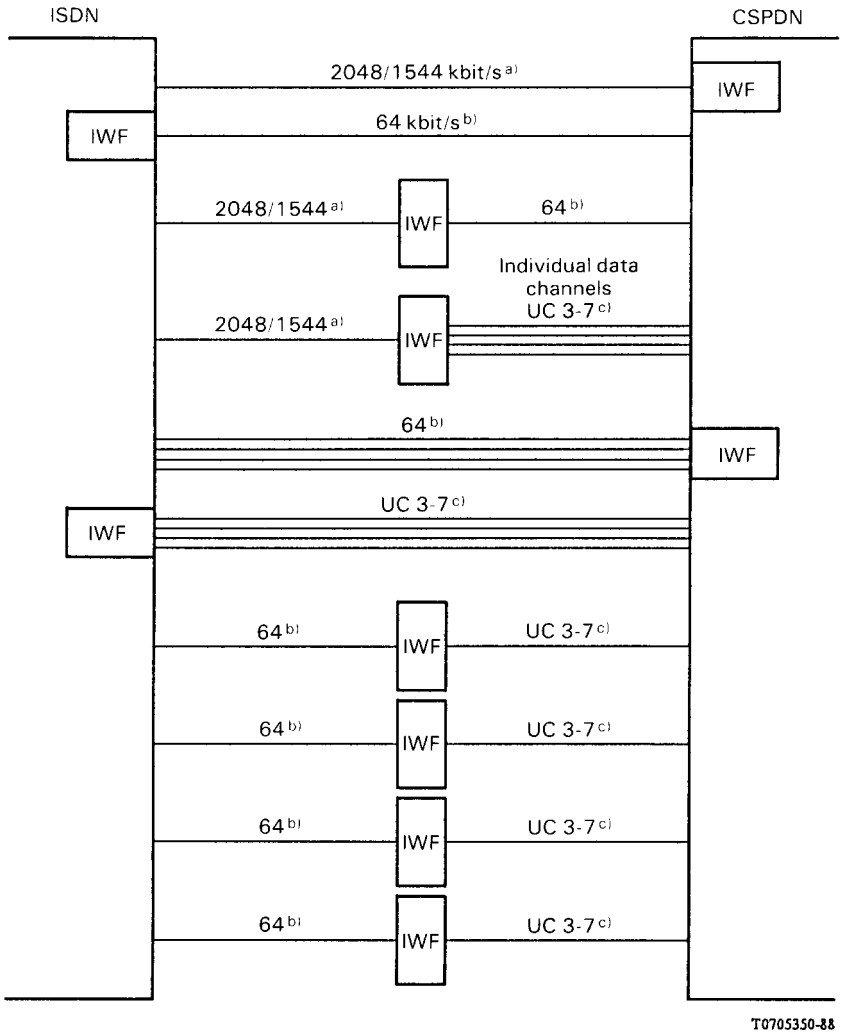
6.1.1 *Physical link characteristics and interworking functions assigned to layer 1*

6.1.1.1 *Location of the interworking functions*

The interworking functions may be provided by the ISDN, or by the CSPDN or separately between the interworking networks.

The interworking links may be provided as multiplexed lines offering a multiplicity of channels at the conversion point, or as individual channels. Consequently, the conversion facility has to provide layer 1 multiplexing/demultiplexing functions in the case where multiplexed lines are connected to it. Multiplexing may take place only on the ISDN side or only on the CSPDN side or on both sides of the location, where the interworking functions are provided. The question as to whether the interconnection lines will be multiplexed or not will depend on the location of the IWF, i.e. on whether the conversion facilities are installed at the data switching exchange or at the ISDN exchange. In either case the location of the IWF should be considered from an economic viewpoint regardless of

whether the conversion facilities are designed as separate hardware and software-based modules or as integrated parts of either an ISDN exchange or a data switching exchange (see also Figure 2/X.81).



IWF Interworking Functions
UC User class

a) See § 6.1.1.1 a).
b) See § 6.1.1.1 b).
c) See § 6.1.1.1 c).

FIGURE 2/X.81

Alternative IWF location and interfaces

Depending on the location of the IWF (see Figure 2/X.81), the electrical characteristics on one or both sides of the IWF shall comply with the current Recommendations on interface characteristics as follows:

a) Recommendation G.703/G.708 when offering the 2048/1544 kbit/s interface for 32/24 ☒ 64 kbit/s channels on the ISDN side;

b) Recommendation G.703/X.27 when offering the 64 kbit/s interface for data channels multiplexed in accordance with the X.50 or the X.51 or the X.51 multiplex scheme on the CSPDN side;

c) any interface recommendation applicable to individual data channels offered on the CSPDN side at speeds specified for user classes of service 3-7 and their associated 6 + 2 and 8 + 2 envelope bit rates.

6.1.1.2 *Timing requirements*

Since interworking takes place between two networks, the ISDN and the CSPDN, phase and/or clock adjustment must take place. The timing requirements of the IWF are the same, as specified in Recommendation G.811 for the interconnection of digital link.

6.1.1.3 *Bit rate adaption*

Since switching in the ISDN is provided only for 64 kbit/s channels and no standards are currently available for switching of subchannels, the bit rates of user classes of service 3-7 have to be adapted to 64 kbit/s.

The bit rate adaption mechanism shall be in accordance with Recommendation X.30, §§ 2.1.1 and 2.2.1. On the CSPDN side of the IWF there will be the need to allocate the information which is contained within 40 bit frames received from the ISDN on a 64 kbit/s bearer into either 6 + 2 or 8 + 2 envelopes.

The same applies to an incoming envelope stream received from a data network. The bit positions within the envelopes have to be allocated to the relevant positions in an outgoing 40 bit frame to be sent to the ISDN.

Concerning the layer 1 relay functions of an IWF for rate adaption, the following two configurations, presented by Figure 3/X.81, have been identified.

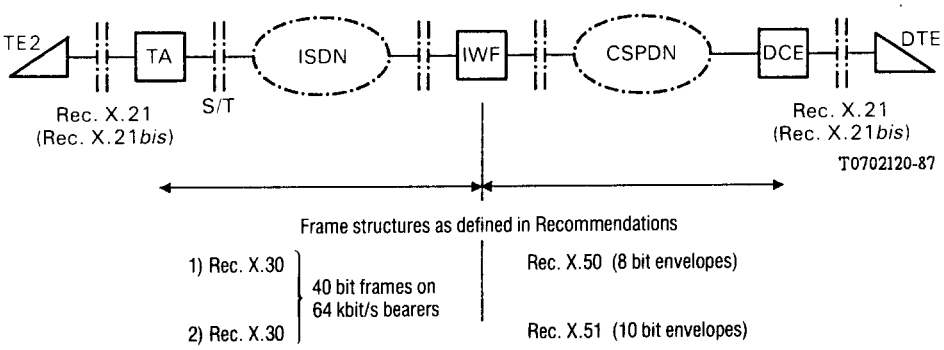


FIGURE 3/X.81

Rate adaption configurations

The bit rate adaption for both directions is restricted to the transfer of information and status. Framing bits, housekeeping bits and any other bits will not be transferred by the IWF. Mapping of housekeeping functions is a subject of further study.

(1) Interworking with an X.50-structured CSPDN

(8 bit envelope structure)

For interworking with a CSPDN utilizing the 8 bit envelope structure as identified in Recommendation X.50, § 1.1 a). This implies the suppression of each fourth status bit on transition from CSPDN to ISDN and replication of each third status bit on transition from ISDN to CSPDN is necessary.

(2) Interworking with an X.51-structured CSPDN

(10 bit envelope structure)

For interworking with a CSPDN utilising the 10 bit envelope structure as identified in Recommendation X.51, the data and status bits are mutually assembled for retransmission in the coordination defined in X.51 respectively X.30. An example is shown in Figure 4/X.81.

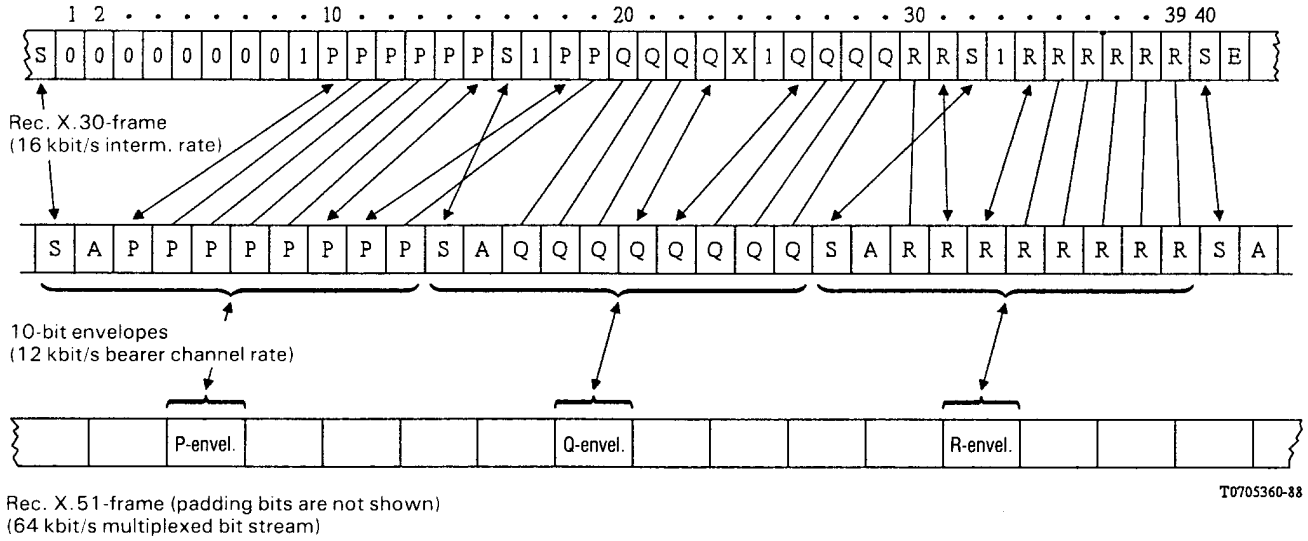


FIGURE 4/X.81

Exemple of Recs X.30/X.51 rate adoption
(shown is the 9.6 kbit/s case)

6.1.2 *Support of the OSI-network layer service (OSI-NLS)*

The support of the OSI-NLS provided by the interworking networks is shown in Figure 5/X.81 which is in accordance with Recommendation X.321.

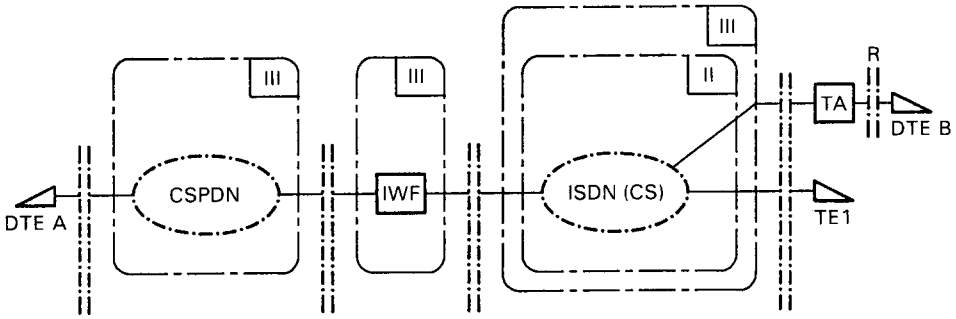
Mapping of OSI-NLS - signals by the IWF for the call establishment phase is for further study.

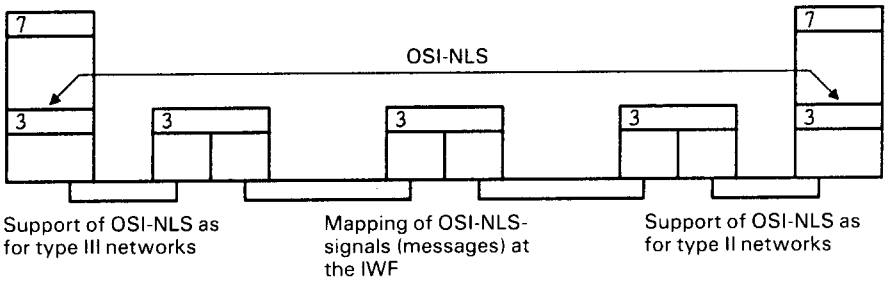
Note - Since the CSPDN is not capable of giving full support to the OSI-NLS during the call establishment phase, the IWF have to react on requests, which may arise at the ISDN-side and which cannot be handled successfully within the CSPDN.

6.1.3 *Signalling conversion (protocol mapping)*

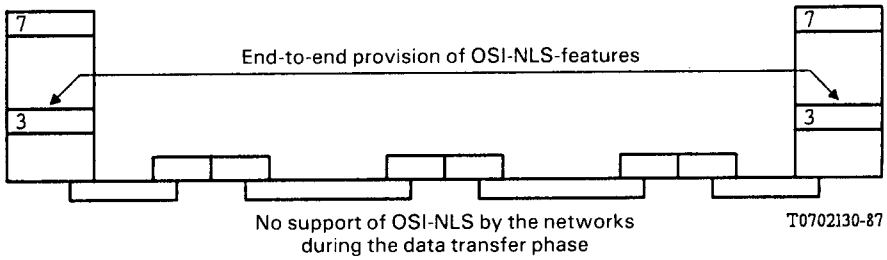
While on the ISDN side of the IWF common channel signalling with the SS No. 7 ISDN USER PART can always be assumed, signalling on the data network side can be either channel associated utilizing the X.71 signalling scheme or SS No. 7 based on X.60 and X.61 or Q.761 to Q.766.

The logical representation of the mapping functions in the case of signalling conversion from SS No. 7 to X.71 is shown in Figure 6/X.81 and § 6.1.3.1 to 6.1.3.3. A typical configuration of an end-to-end data connection including several signalling conversion points is shown in Figure 7/X.81.





Call establishment phase

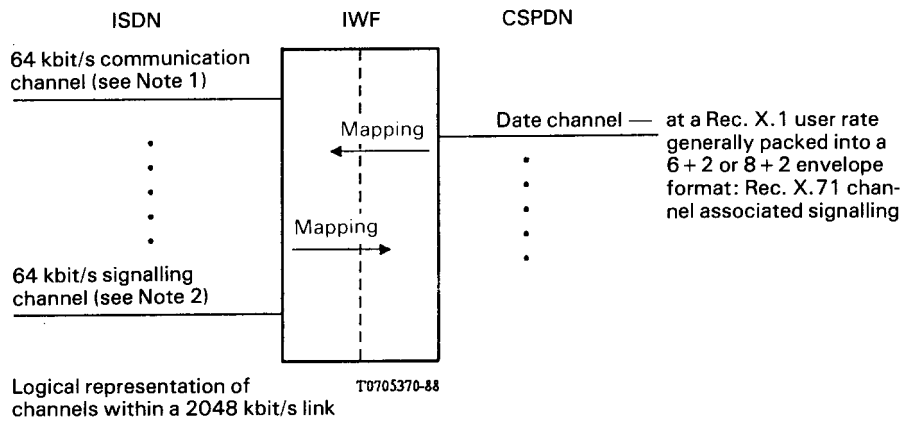


Data transfer phase

Note – Categorization of type II and III networks see Rec. X.300.

FIGURE 5/X.81

Support of the OSI-Network Layer Service



Note 1 – 64 kbit/s communication channel bearing a data channel at a Rec. X.1 user rate (non-transparent ISDN connection).

Note 2 – Common channel signalling SS No. 7, ISDN USER PART.

FIGURE 6/X.81

Signalling conversion

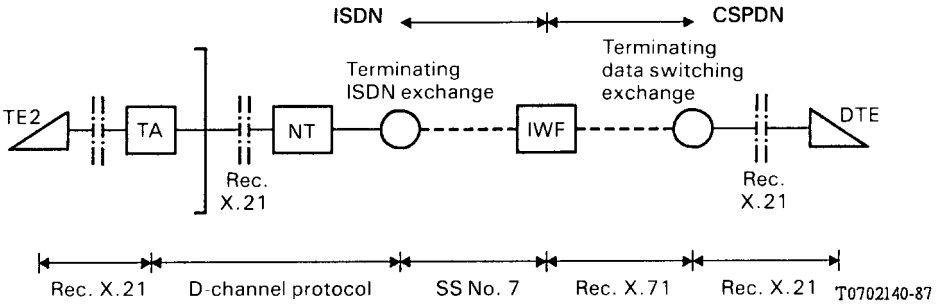
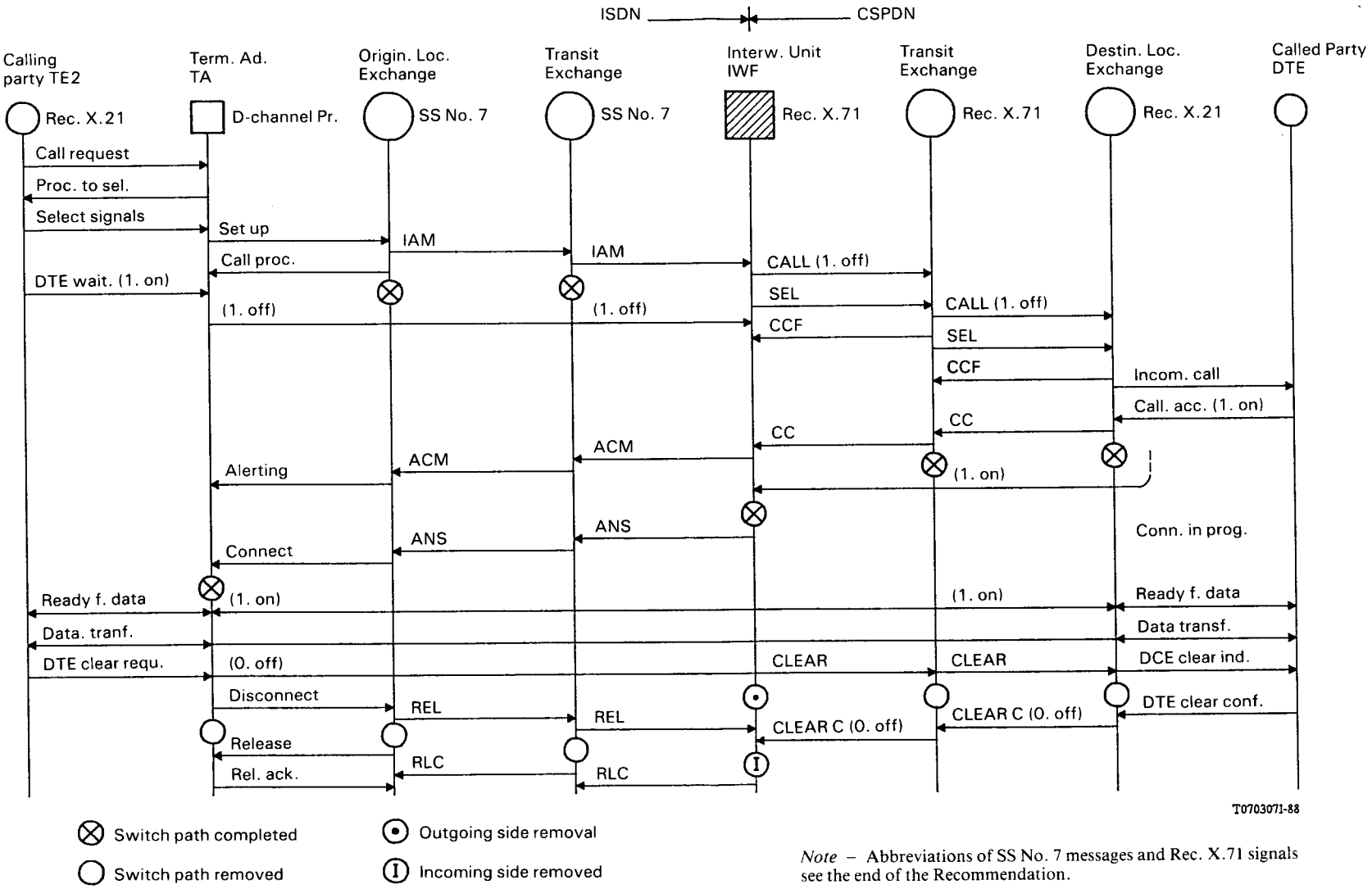


FIGURE 7/X.81

Signalling conversion points

6.1.3.1 *Signalling conversion for a basic call from ISDN to CSPDN*

Figure 8/X.81 illustrates the signalling conversion procedure in the IWF referring to the simple case of a basic call which originates in an ISDN and terminates in an X.71 network, and which does not invoke any additional facilities. The call is assumed to be successful and the clear down is initiated by the user of the ISDN. Besides of the signalling conversion functions in the IWF Figure 8/X.81 also shows the relevant signalling events of the D-channel protocol and of Recommendation X.21.



Note – Abbreviations of SS No. 7 messages and Rec. X.71 signals see the end of the Recommendation.

FIGURE 8/X.81

Signalling conversion of a basic call from ISDN to CSPDN

The call set-up sequence begins in the IWF at the moment when the SS No. 7 initial address message (IAM)[1)] is received from the adjacent ISDN exchange. At this point of time the 64 kbit/s communication channel is already through-connected within the ISDN. In the following the X.71 call signal and selection signals (SEL) are sent to the adjacent CSPDN exchange, which confirms the call with the call confirmation signal (CCF). The call is forwarded link by link to the destination exchange of the CSPDN which calls according to Recommendation X.21 the DTE. After the DTE has accepted the call the destination exchange of the CSPDN sends back the X.71 call connected signal (CC). The CC signal is transmitted link by link towards the IWF. Parallel with the link by link transmission of the CC signal the data channel is switched through within the CSPDN. The reception of the CC signal and of the terminating throughconnection signal (1, ON) which is sent across the throughconnected data channel by the called DTE defines the instant of connect through in the IWF.

The IWF sends instead of the CC signal the SS No. 7 address complete message (ACM). After the data channel through-connection within the IWF the SS No. 7 answer message (ANS) is sent to the adjacent ISDN exchange. Both messages are transmitted link by link towards the originating exchange of the ISDN. The originating exchange of the ISDN sends after reception of ANS the CONNECT message (according to Recommendation Q.931) to the terminal adaptor (TA) of the calling TE2, and as a consequence throughconnection of the data channel in the TA can be performed according to Recommendation X.30. Now ready for data alignment followed by data transfer can take place between TE2 and DTE according to Recommendation X.21.

Clearing is initiated for example at the TE2 by DTE clear request (0, OFF), which is transmitted transparently via the data channel to the DTE. Accompanying this inslot signal the TA sends the DISCONNECT message (according to Recommendation Q.931) to the originating ISDN exchange. From there the No. 7 RELEASE message is transmitted link by link towards the IWF and as a consequence the 64 kbit/s communication channel is cleared down. The clearing down of the data channel within the CSPDN is initiated by the reception of the clearing signal (0, OFF).

6.1.3.2 *Signalling conversion for a basic call from CSPDN to ISDN*

Figure 9/X.81 illustrates the signalling conversion procedure in the IWF referring to the simple case of a basic call which originates in a CSPDN and terminates in an ISDN, and which does not invoke any additional facilities. The call is assumed to be successful and the clear down is initiated by the customer of the CSPDN. After throughconnection of the 64 kbit/s communication channel in the ISDN exchanges the SS No. 7 ANS message is received in the IWF. As a consequence the IWF sends the X.71 CC signal to the adjacent CSPDN exchange. The CC signal is transmitted link by link towards the originating exchange of the CSPDN. By this way the data channel is switched through within the CSPDN.

After the data channel finally is switched through in the originating exchange of the CSPDN and in the terminal adaptor ready for data alignment between DTE and TE2 can be performed.

6.1.3.3 *Signalling conversion for a complex call set-up between ISDN and CSPDN*

If the call involves additional facilities in comparison with the basic call additional procedures are necessary in Recommendation Q.761 to 765 and in Recommendation X.71.

Figures 10/X.81 and 11/X.81 illustrate examples involving these additional procedures for call set-up,requiring both calling and called line identification.

6.1.3.3.1*Call set-up from ISDN to CSPDN* (Figure 10/X.81)

In this case the called line identification (CDI) is requested by means of an additional information (CDIR) within the X.71 selection signals (SEL). The request of calling line identification (CLIR) is contained in the X.71 Transit through connect signal (TTC) and in the SS No. 7 information message (INR).

The called line identification (CDI) is transmitted via the CSPDN as a separate X.71 signal and via the ISDN as an additional information of the address complete message (ACM).

The calling line identification (CLI) is transmitted via the ISDN by means of the information message (INF) and via the CSPDN as a separate X.71 signal.

If the calling line identification (CLI) is already contained in the SS No. 7 IAM independently if it is requested or not, the SS No. 7 messages INR and INF may be omitted.

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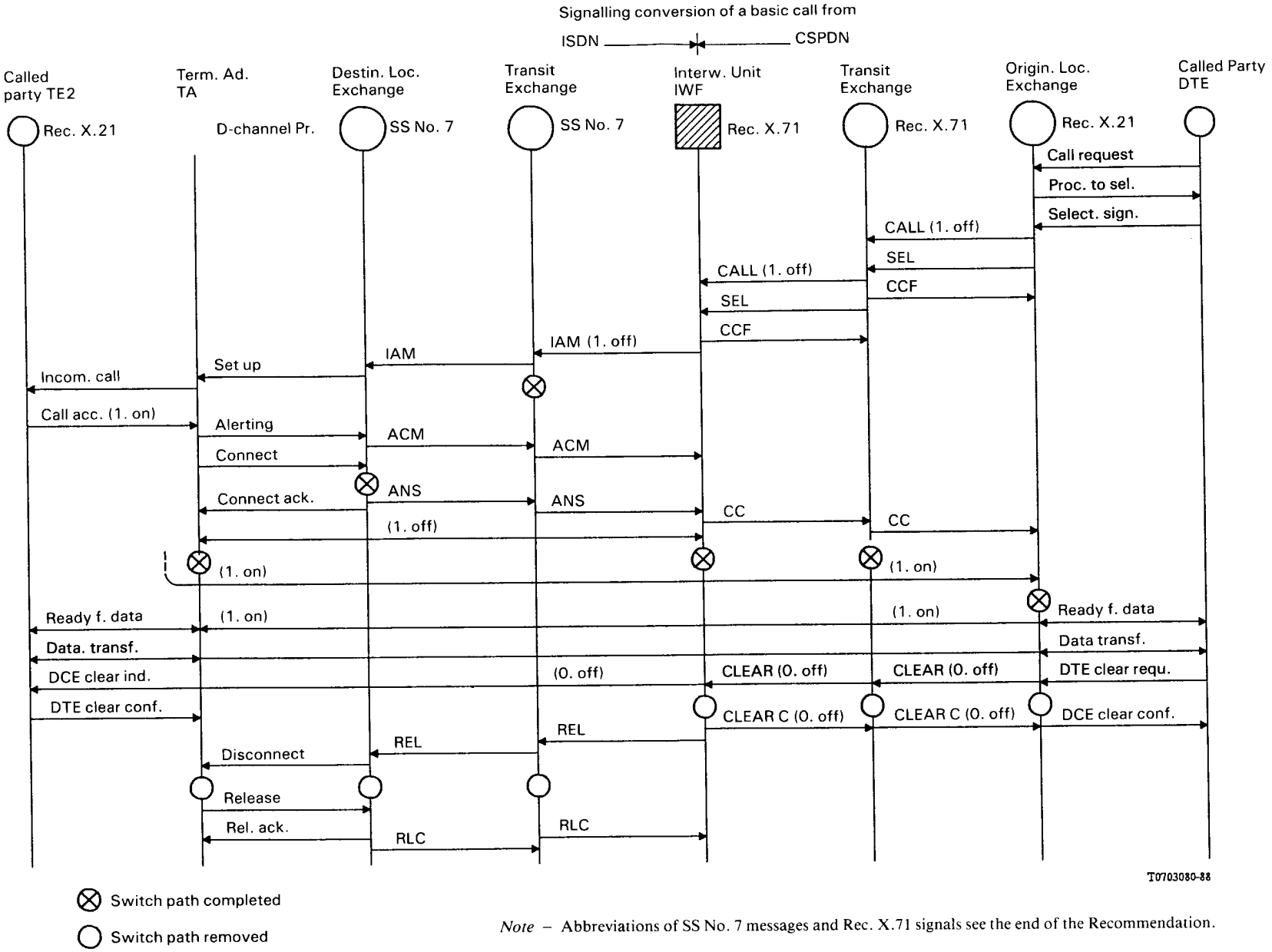
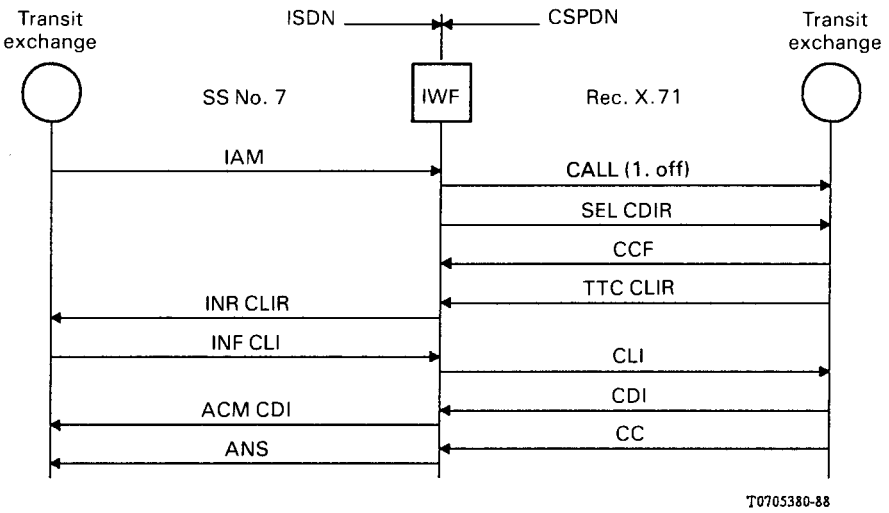
1) Containing all information for call set-up.



Note – Abbreviations of SS No. 7 messages and Rec. X.71 signals see the end of the Recommendation.

FIGURE 9/X.81

Signalling conversion of a basic call from CSPDN to ISDN



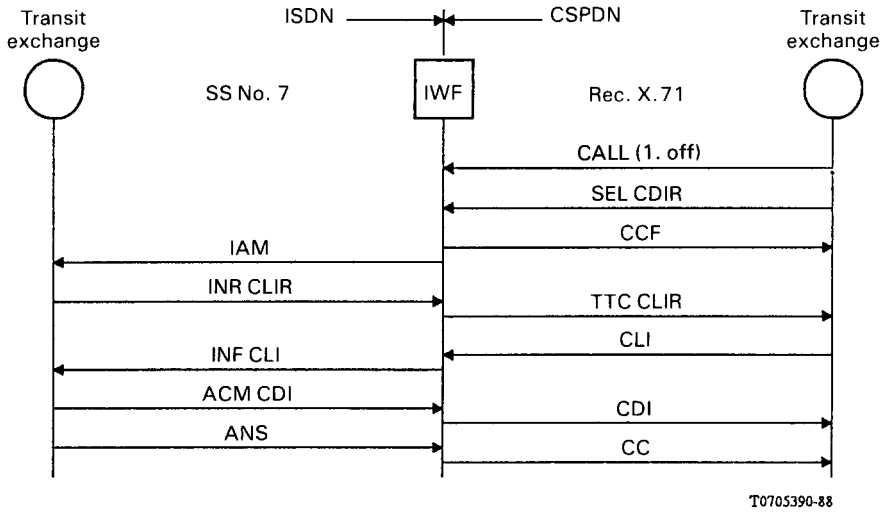
Note – Abbreviations of SS No. 7 messages and Rec. X.71 sign. see the end of the Recommendation.

FIGURE 10/X.81

Call set up with calling/called line identification from ISDN to CSPDN

6.1.3.3.2*Call set-up from CSPDN to ISDN* (Figure 11 /X.81)

Calling and called line identification and their requests are carried within the same SS No. 7 message and X.71 signals as described under § 6.1.3.3.1.



Note – Abbreviations of SS No. 7 messages and Rec. X.71 sign. see the end of the Recommendation.

FIGURE 11/X.81

Call set up with calling/called line identification from CSPDN to ISDN

6.1.3.4 *Ready for data alignment*

For user classes 3-7 a ready for data alignment procedure is executed after end-to-end connection has been established. The purpose of the ready for data alignment procedure is to indicate to the communicating terminals the exact point in time of the entry into the data transfer phase. The ready for data alignment signal is defined by the reception of a 1/ON-signal at the user/network interfaces at both ends. The 1/ON-signal is transmitted:

- in the ISDN by setting the data bits of the X.30-frames to one and the associated status bits to ON,
- in the CSPDN by setting the data bits of the envelopes to one and the associated status bits to ON.

For the ready for data alignment signal the IWF are transparent.

6.1.4 *Protocol mapping for supplementary services*

The IWF shall map the protocols which are necessary to support supplementary services. Bearing in mind, that for each network, the ISDN as well as for the CSPDN an individual set of supplementary services is defined, three different situations of interworking will arise:

a) A specific supplementary service is supported by both networks equivalently. In this case a one to one mapping by the IWF is possible.

b) A specific supplementary service is supported by the ISDN but not supported equivalently by the CSPDN. In this case;

   - either the request for this service coming from the ISDN has to be refused by the IWF, or
   - the request for this service coming from the ISDN may be mapped to the CSPDN but with reduced functionality.

c) A specific supplementary service is supported by the CSPDN but not supported equivalently by the ISDN. In this case;

   - either the request for this service coming from the CSPDN has to be refused by the IWF, or
   - the request for this service coming from the CSPDN may be mapped to the ISDN but with reduced functionality.

A table containing the supplementary services supported by CSPDN as specified in Recommendation X.2 is given in Table 1/X.81. The supplementary services for data transmission supported by ISDN circuit switched are specified in the I.250 Series Recommendations.

6.1.5 *Mapping of service signals and causes*

The IWF shall map signals and causes used in each of the interworking networks. Bearing in mind, that the list of causes used in the ISDN and list of service signals used in the CSPDN are not fully identical, a complete one to one mapping of all signals is not possible.

A table containing the service signals of the CSPDN and the causes of the ISDN and their mapping is for further study.

6.2 *Interworking functions for non-identical data transmission services*

Reference configuration of the interworking between a circuit-switched ISDN and a CSPDN using different data transmission services:

In Figure 12/X.81 end-to-end communication between terminals to different user classes of service is assumed. As an example, TE1 may belong to user class of service 30 at a data signalling rate of 64 kbit/s and the DTE may belong to user class of service 4 at a data signalling rate of 2400 bit/s category B2. The interworking functions in Figure 12/X.81 are partly different from those in Figure 1/X.81.

6.2.1 *Physical link characteristics and interworking functions assigned to layer 1*

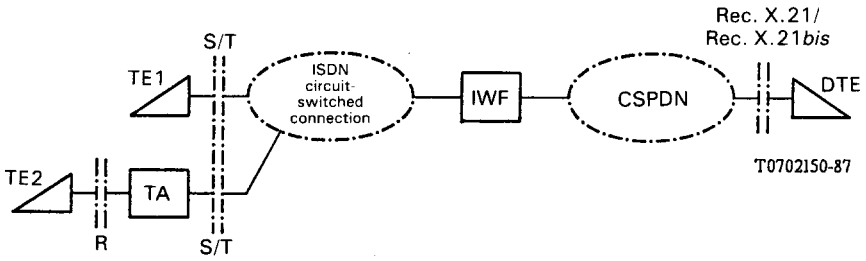
6.2.1.1 *Location of the interworking functions*

Location and features of the interworking functions are the same as described in § 6.1.1.1 for the cases where the data transmission services are identical.

TABLE 1/X.81

Supplementary services supported by CSPDN

1	Optional user facilities assigned for an agreed contractual period
1.1	Direct call
1.2	Closed user group
1.3	Closed user group with outgoing access
1.4	Closed user group with incoming access
1.5	Incoming calls barred within a closed user group
1.6	Outgoing calls barred within a closed user group
1.7	Calling line identification
1.8	Called line identification
1.9	Bilateral closed user group
1.10	Bilateral closed user group with outgoing access
1.11	Incoming calls barred
1.12	Reverse charging acceptance
1.13	Connect when free
1.14	Waiting allowed
1.15	Redirection of calls
1.16	On-line facility parameter registration/cancellation
1.17	DTE inactive registration/cancellation
1.18	Data and time indication
1.19	Hunt group
2	Optional user facilities requested by the DTE on a per-call basis
2.1	Direct call
2.2	Abbreviated address calling
2.3	Multi-address calling
2.4	Reverse charging
2.5	RPOA selection
2.6	Charging information
2.7	Called line identification



Note – In cases where a TE1-type terminal is used, the bit stream at the S/T-interface complies with the Rec. X.30 frame structure.

FIGURE 12/X.81

6.2.1.2 *Timing requirements*

Phase and clock adjustment regulations are not applicable in the case of non-identical data transmission rates.

6.2.1.3 *Bit rate conversion*

For bit rate conversion between the two non-identical data transmission services, a flow control is needed, since the effective mean data transfer rate must be decreased to the rate of the slower terminal.

The flow control method required must be derived from the protocols applied in both terminals.

6.2.1.3.1 *Protocol compatible terminals*

Assuming a HDLC-based terminal to terminal protocol rate conversion can be provided by the IWF by flag insertion/extraction and use of intermediate buffer capacity:

In an existing connection, both the ISDN-section and the CSPDN-section are bit-transparent, but differing data signalling rates are used. It is assumed that both terminals are protocol-compatible above the physical layer of the reference model. Complying examples may be teletex-terminals, but also multi-mode terminals, as long as they are in the same mode, e.g. in the teletex mode. A further assumption is that the terminal-to-terminal protocol includes a flow control facility, based on HDLC. The data transfer is then decreased to the capability of the slower terminal by injection of interframe time fill flags into the ISDN section. The only functions related to rate conversion to be effected by the IWF are to extract interframe time fill from the ISDN/CSPDN directed data stream, to inject the necessary interframe time fill into the CSPDN/ISDN directed data stream, and intermediate buffering.

The IWF-functions needed during the data transfer phase can be restricted then to:

1) provision of the physical layer adaptation functions by use of suitable interface modules to access both networks, and

2) support of the rate conversion provided by the terminals' flow control facility by provision of an intermediate buffer capacity and flag extraction/insertion.

The buffer capacity must be related to the maximum frame length and window size. In this respect, all link channel states and also exception conditions have to be considered, including their description in X.25.

Figures 13/X.81 and 14/X.81 below are examples for frame sequences on both interfaces of the IWF.

6.2.1.3.2 *Terminals with different protocols*

This case requires further study.

6.2.2 *Support of the OSI-network layer service (OSI-NLS)*

Is as described in § 6.1.2.

6.2.3 *Signalling conversion (protocol mapping)*

Is for further study, considering also § 6.1.3.

6.2.4 *Protocol mapping for supplementary services*

Is as described in § 6.1.4.

6.2.5 *Mapping of service signals and causes*

Is as described in § 6.1.5.

7 Operation and maintenance

Is for further study.

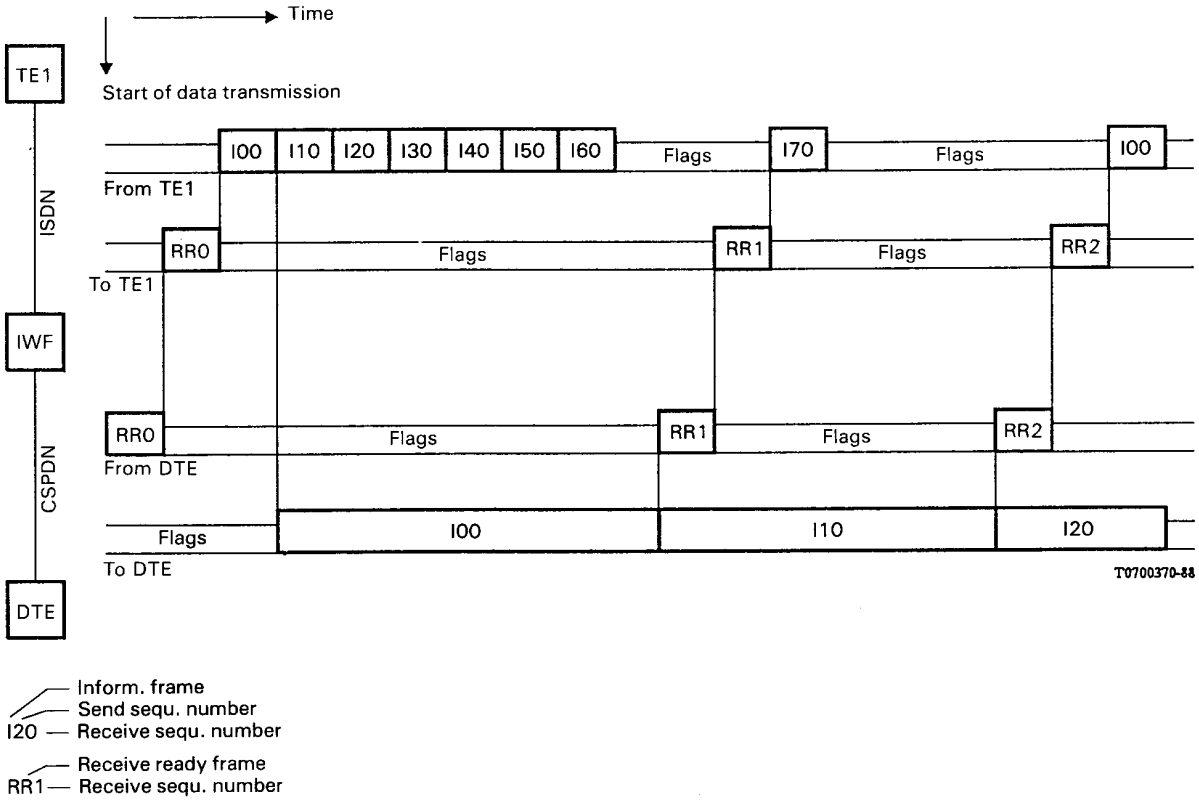


FIGURE 13/X.81

Transmission ISDN to CSPDN example

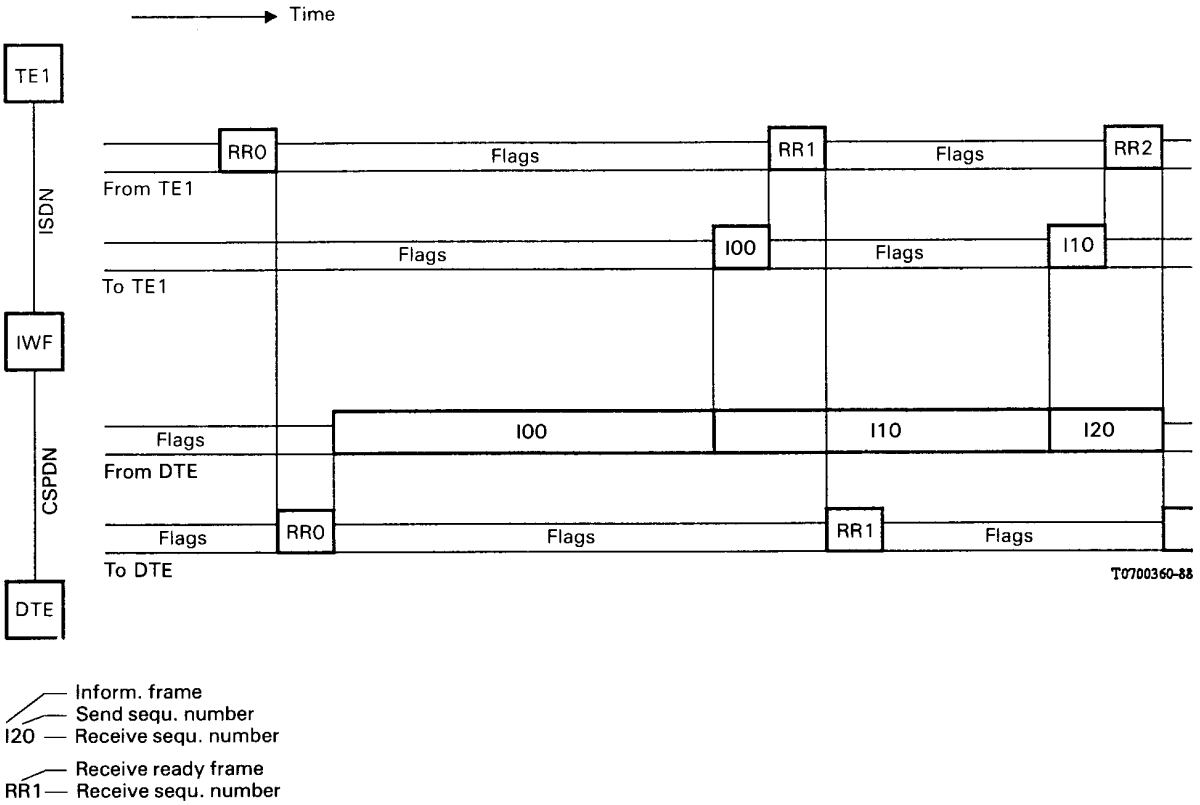


FIGURE 14/X.81

Transmission CSPDN to ISDN example