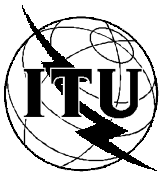

INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.530

(03/93)

INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

INTERNETWORK INTERFACES

NETWORK INTERWORKING BETWEEN AN ISDN AND A PUBLIC SWITCHED TELEPHONE NETWORK (PSTN)

ITU-T Recommendation I.530

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation I.530 was revised by the ITU-T Study Group XVIII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

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CONTENTS

Page

1 General 1

2 Scope 1

3 Abbreviations 1

4 Interworking configuration and network characteristics 1
- 4.1 Interworking configurations 1
- 4.2 Key ISDN and PSTN characteristics and related interworking functions 2

5 ISDN bearer services suitable for ISDN-PSTN interworking 2
- 5.1 ISDN bearer services suitable for ISDN to PSTN interworking (circuit) 3
- 5.2 ISDN bearer services suitable for PSTN to ISDN interworking (circuit) 4
- 5.3 ISDN bearer services suitable for ISDN to PSTN interworking (packet) 4
- 5.4 ISDN bearer services suitable for PSTN to ISDN interworking (packet) 4

6 Connection type suitable for ISDN-PSTN interworking 4

7 Functional requirements for ISDN-PSTN interworking 5
- 7.1 Interworking between signalling systems 5
- 7.2 Provision of interworking indications 6
- 7.3 Generation of in-band tones and announcements 7
- 7.4 Handling of non-voice calls between ISDN and PSTN subscribers 8
- 7.5 Control of speech processing and echo control devices 9
- 7.6 A/m law encoding 9

8 Handling of packet mode calls between ISDN and PSTN subscribers 9

NETWORK INTERWORKING BETWEEN AN ISDN AND A PUBLIC SWITCHED TELEPHONE NETWORK (PSTN)

(Melbourne, 1988; ammended at Helsinki, 1993)

1 General

In many countries, digitization of the existing PSTN has been ongoing over a number of years through the implementation of digital switching and transmission facilities. Furthermore, common channel signalling systems (e.g. Signalling System No. 6, Signalling System No. 7) have been introduced or will soon be introduced in these networks.

The digitization of the user network access is one of the steps by which an IDN becomes an ISDN. However, it is foreseen that this will be a long transition period for some networks.

Thus, the purpose of this Recommendation is to identify the interworking functions and requirements to support interworking between an ISDN and a PSTN.

2 Scope

The purpose of this Recommendation is to describe the general arrangements for interworking between ISDN and PSTN. Both the provision of ISDN voice transmission and data transmission services are within the scope of this Recommendation.

3 Abbreviations

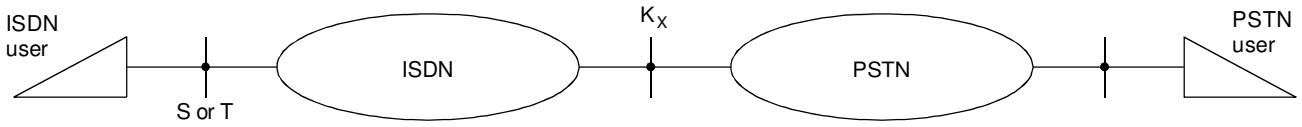
For the purpose of this Recommendation, the following abbreviations are used:

DTE	Data terminal equipment
DTMF	Dual-tone multiple frequency
IDN	Integrated digital network
ISDN	Integrated Services Digital Network
ISUP	ISDN user part
LE	Local exchange
NT	Network termination
PABX	Private Automatic Branch Exchange
PSTN	Public switched telephone network
SS No. 7	Signalling System No. 7
TE	Terminal equipment
TA	Terminal adaptor
TUP	Telephone user part.

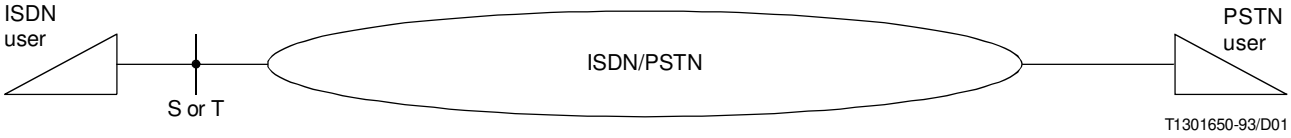
4 Interworking configuration and network characteristics

4.1 Interworking configurations

See Figure 1



a) Interexchange scenario



b) Intra-exchange scenario

NOTES

1 In part a) refer to Recommendation I.324 for the definition of K_x reference point.

2 Part b) illustrates the case where no clear division exists between ISDN and PSTN network components.

FIGURE 1/I.530

4.2 Key ISDN and PSTN characteristics and related interworking functions

Table 1 identifies the key characteristics of an ISDN and a PSTN, indicating possible interworking functions to accommodate dissimilar characteristics.

4.2.1 Location of interworking functions

Given that the transition period from a PSTN to an ISDN may occur over a long period of time, there will be an ongoing requirement for ISDN-PSTN interworking. In such a situation, it is likely that interworking functions will be required at not just one but several locations. As the transition to ISDN continues, interworking points will come into existence and later may not be required.

Points where interworking may exist are

- within the local exchange;
- at transit exchange;
- at international gateway offices.

NOTE – The optimum location of each interworking function may be specific per interworking function and dependent on the usage of the service, network topology, etc.

5 ISDN bearer services suitable for ISDN-PSTN interworking

This clause considers the subject of ISDN services suitable for ISDN-PSTN interworking. The discussions dealing with the ISDN to/from PSTN direction are addressed in individual subclauses, as is the subject of circuit mode and packet mode.

TABLE 1/I.530

Key ISDN and PSTN characteristics

	ISDN	PSTN	Interworking funcions
Subscriber interface	Digital	Analogue	a
User network signalling	Out-band (Rec. I.441, I.451)	Mainly in-band (e.g. DTMF)	b, e
User terminal equipment supported	Digital TE (ISDN NT, TE1 or TE2 + TA)	Analogue TE(e.g. dial pulse telephones, PABXs, modem-equipment DTEs)	c
Interexchange signalling	SS No. 7 ISDN user part (ISUP)	In-band (e.g. R1, R2 or; No. 4, No. 5) or out-band (e.g. SS No. 6, SS No. 7 TUP)	d, e
Transmission facilities	Digital	Analogue/digital	a
Information transfer mode	Circuit/packet	Circuit	f
Information transfer capability	Speech, digital unrestricted, 3.1 kHz audio, multi-use, etc.	3.1 kHz audio (voice/voice-band data)	f

Interworking functions

a Analogue-to-digital and digital-to-analogue conversion on transmission facilites.

b Mapping between PSTN signals in the subscriber access and Recommendation I.451 message for intra-exchange calls.

c Support of communication between modem-equipped PSTN DTEs and ISDN terminals.

d Conversion between the PSTN signalling system and Signalling System No. 7 ISDN user part.

e Mapping between signals in the ISDN subscriber (Recommendations I.441, I.451) access and PSTN in-band interexchange signallling (e.g. R1).

f Further study required.

5.1 ISDN bearer services suitable for ISDN to PSTN interworking (circuit)

Currently, there are four identified bearer services that could be used within the ISDN for ISDN to PSTN interworking. These are (refer to Recommendation I.231)

i) circuit mode 64 kbit/s, 8 kHz structured bearer services, usable for speech information transfer (Note 1);

ii) circuit-mode 64 kbit/s, 8 kHz structured bearer services, usable for 3.1 kHz audio information transfer (Note 2);

iii) circuit-mode 64 kbit/s unrestricted, 8 kHz structured bearer service (Note 3).

iv) circuit-mode 64 kbit/s, 8 kHz structured bearer service, usable for multi-use information transfer (Note 4).

It is recognized that the communication characteristics obtained for each of these three bearer services on an ISDN to PSTN basis may not be the same as that obtained for ISDN to ISDN configurations.

NOTES

1 This bearer service is used for the ISDN to PSTN-interworking for the purpose of speech information transfer.

2 This bearer service is used for the ISDN to PSTN interworking for the purpose of 3.1 kHz audio information transfer. For PSTN to ISDN interworking, this bearer service will be selected at the boundary of the PSTN to the ISDN for the purpose of speech information transfer *and* for 3.1 kHz audio information transfer.

3 This bearer service may be required for ISDN-PSTN interworking. Refer to Recommendation I.231 for the 64 kbit/s interworking service requirements.

4 When this bearer service is used for ISDN to PSTN interworking, special echo control procedures may be necessary (see 7.5).

5 ISDN-PSTN interworking means interworking both ways between ISDN and PSTN, while ISDN to PSTN refers to a call initiated in the ISDN and terminated in the PSTN, and PSTN to ISDN refers to a call initiated in the PSTN and terminated in ISDN.

5.2 ISDN bearer services suitable for PSTN to ISDN interworking (circuit)

Currently, there is no internationally recognized method of service differentiation between voice and non-voice calls originating in the PSTN. However, the "circuit-mode 64 kbit/s, 8 kHz structured bearer service for 3.1 kHz audio information transfer" provides for the capability equivalent to PSTN. (see Recommendation I.231.) Therefore, PSTN calls may interwork to this service in ISDN.

The call progress indicator within ISUP will identify when interworking between ISDN and PSTN occurs. This indicator will enable the ISDN to select a connection that would support 3.1 kHz audio. A V-Series terminal connected to the ISDN via a terminal adaptor and using the 64 kbit/s unrestricted bearer service requires the use of an IWF (including a modem) for calls from PSTN users. To effect the connection, a 64 kbit/s connection to the IWF would need to be used.

5.3 ISDN bearer services suitable for ISDN to PSTN interworking (packet)

Currently, there are two identified bearer services that could be used within the ISDN, for ISDN (packet mode calls) to PSTN interworking:

i) B-channel: packet-mode, unrestricted digital information, service data unit integrity, X.25 link level, X.25 packet level bearer service;

ii) D-channel: packet mode, unrestricted digital information, service data unit integrity, I.441 link level, X.25 packet level bearer service.

NOTE – Mechanisms are for interworking based on X.31 Case A and X.32 are covered in 8.

5.4 ISDN bearer services suitable for PSTN to ISDN interworking (packet)

For further study.

6 Connection type suitable for ISDN-PSTN interworking

This clause identifies the mapping of ISDN bearer services and possible connection types for ISDN-PSTN interworking. Depending on the specific ISDN bearer service being considered, more than one ISDN connection type may be applicable. However, in some cases the connection type may not be fully compatible with the requested bearer service, thereby leading to downgrading of service.

The ISDN bearer services and possible connection types that may be used are summarized in Table 2, under the four possible interworking cases. Refer to Recommendation I.335 for more details regarding the mapping between ISDN bearer services and ISDN connection types.

TABLE 2/I.530

ISDN bearer services and connection types suitable for ISDN-PSTN interworking

Interworking	ISDN bearer services categories	ISDN connection types			
		64 kbit/s unrestricted	Speech	3.1 kHz audio	Packet
ISDN to PSTN (circuit)	64 kbit/s unrestricted	Y	N	N	N
	Speech	R(1)	Y	Y	N
	3.1 kHz audio	R(1)	N	Y	N
	multi-use	R(2)	N	N	N
PSTN to ISDN (circuit)	64 kbit/s unrestricted	Y	N	N	N
	3.1 kHz audio	R(1)	N	Y	N
ISDN to PSTN (packet)	Virtual call and permanent virtual circuit	Y	N	N	Y
PSTN to ISDN (packet)	Virtual call and permanent virtual circuit	Y	N	N	Y

Y: Yes Can be used (some interworking scenarios may require further study).

N: NO Cannot be used.

R(1) Can be used except when A/μ-law conversion and/or echo control may be required.

R(2) Upon encounting interworking with the PSTN, appropriate echo control and A/μ-law conversion capabilities may need to be provided on the connection.

NOTES

1 It is recognized that existing PSTN services must be supported by ISDN using currently defined ISDN bearer services.

2 It is possible that the service obtained on each of the bearer services for ISDN to PSTN interworking may not be the same as that obtained for ISDN to ISDN configurations.

3 Refer to Recommendation I.231 for the service requirements for 64 kbit/s interworking. Various mechanisms for ISDN-PSTN interworking supporting V-Series terminals connected to the ISDN using the 64 kbit/s unrestricted bearer service are contained in Recommendation I.515. Procedures require further study.

4 Other ISDN bearer services and connection types that may be applicable for ISDN-PSTN interworking are for further study.

7 Functional requirements for ISDN-PSTN interworking

7.1 Interworking between signalling systems

Interworking between signalling systems, specifically for interexchange calls between the PSTN signalling system (which may be in-band) and Signalling System No. 7 (ISDN UP) on an ISDN, may be required. The interworking procedures are specified in Recommendation Q.699.

For intra-exchange calls between the ISDN and PSTN subscriber, interworking between I.451 messages and signals in the PSTN subscriber access may also be required.

7.2 Provision of interworking indications

An interworking indication is required for the ISDN local exchange (LE) to know that ISDN-PSTN interworking has occurred. ISUP Q.761-Q.764 and I.451/Q.931 protocols have the ability to identify this interworking situation to the ISDN LE and the ISDN terminal (call progress indicator).

The ISDN terminal would be informed in every case that ISDN-PSTN interworking has occurred. This information is required to satisfy as a minimum the requirement to:

- tell the terminal to connect the B-channel so that in-band tones and announcements can be received when ISDN-to-PSTN calls are originated;
- tell the ISDN terminal that some or all of service selection information and address may be unavailable - the terminal may then be required to accept the call without out-band compatibility checking;
- tell data terminal equipment to anticipate in-band handshaking signals for ISDN-PSTN calls.

The following interworking scenarios have been recognized:

a) an ISDN-PSTN call which uses a Signalling System No. 7 ISUP connection between the originating and terminating local exchanges;

b) an ISDN-PSTN call which uses a non-Signalling System No. 7 ISUP connection (e.g. R1, Signalling System No. 7 TUP) between the originating and terminating local exchanges;

c) an ISDN-PSTN call which involves a combination of Signalling System No. 7 ISUP and non-Signalling System No. 7 ISUP interexchange signalling connections between the originating and terminating local exchanges;

d) an ISDN-PSTN call within the same local exchange (i.e. no interexchange signalling).

7.2.1 Network indication of modification of communication characteristics

The network will always provide an indication to the user of modification of communication characteristics. The modification of communication characteristics may be due to the following reasons:

- interworking with another network;
- resource constraints in the network.

In addition to providing an indication, the network may solicit user acceptance of the modification of communication characteristics in certain cases. Examples are:

- downgrading of service;
- upgrading of service.

For most interworking cases, user acceptance is not applicable.

There may be a requirement for the resolution of information transfer capability requests other than speech and 3.1 kHz audio on ISDN-to-PSTN calls. The choices of rejection (with a suitable cause indication) or negotiation (involving parameter exchange) are possible (Recommendation I.515).

There may also be a requirement for the rejection of supplementary service requests available on an ISDN, but not supported on the PSTN. However, negotiation for supplementary services may be possible as well.

The principles for call negotiation in an ISDN-PSTN interworking situation are for further study.

7.2.2 Failure indication

Failure indication, when carried by the I.451 and ISUP signalling messages, should be meaningful and give a clear indication of the reason.

The network failure indication should be able to identify the network where congestion occurred. This may be of use in networks allowing ROA selection.

7.3 Generation of in-band tones and announcements

In-band tones and announcements are provided for all speech and 3.1 kHz audio bearer service calls between an ISDN and a PSTN (reference Recommendation E.180). Within ISDN, in-band tones and announcements, with the exception of ring-back tone, should be provided at a point as close as possible to the calling user (i.e. network, PABX, or terminal). Whenever possible, out-band messages should also be used within the ISDN and the local access.

The network (ISDN or PSTN) must be capable of generating in-band tones and announcements. However, for ISDN-to-PSTN interworking cases, the ISDN terminals will receive the in-band tones and announcements whenever the tones are generated within the PSTN, i.e. beyond the interworking point. Nevertheless, this does not preclude the terminal from providing its own tones and announcements.

In-band ring-back tone should be generated by the terminating exchange (or terminating PABX).

Furthermore, two call scenarios exist:

a) the call is unsuccessful (user busy, network congestion, etc.);

b) the call is delivered successfully.

Regardless of the call type, the same in-band tones and announcements (depending on the call scenario) should be provided to the callling user.

7.3.1 Call type 1: PSTN-to-ISDN

7.3.1.1 Unsuccessful call delivery

When the point of call failure (i.e. the point at which the call cannot proceed further) is within the PSTN or at the PSTN user, normal PSTN procedures apply.

When the point of call failure is within the ISDN or at the ISDN user, the ISDN should send the appropriate out-band clearing message as far back towards the gateway exchange as possible.

- If the out-band message can be sent all the way through to the gateway exchange, then the gateway exchange should pass the information to the PSTN using the PSTN's normal procedures (i.e. out-band if the PSTN supports the out-band message, otherwise in-band).
- If the message cannot be sent out-band all the way to the gateway exchange, then the appropriate in-band tone or announcement should be provided by the ISDN at the point where out-band signalling is no longer capable of handling the message.

For the above cases, the clearing message should not be sent prior to the completion of the announcement.

7.3.1.2 Successful call delivery

If the call is delivered successfully to the ISDN user, then the terminating ISDN exchange should generate in-band ring-back tone towards the PSTN user.

7.3.2 Call type 2: ISDN-to-PSTN

7.3.2.1 Unsuccessful call delivery

When the point of call failure is within the ISDN, the call should be handled as an ISDN-to-ISDN call (see Recommendation I.520).

When the point of call failure is within the PSTN, the PSTN's procedures apply. For instance, if the PSTN supports out-band signalling to the gateway exchange, then the gateway exchange should map the message to the appropriate out-band ISDN clearing message (i.e. the gateway exchange handles the call as an ISDN-to-ISDN call). If the PSTN does not support out-band signalling, then it will generate the appropriate in-band tone or announcement.

The ISDN terminal should be alerted to the fact that interworking has occurred so that the user can be prepared to receive the appropriate in-band tone or announcement. The intermediate interworking point will provide the interworking message which will suppress, when necessary, tone generation in the ISDN terminal, and pass through any in-band tones.

For the above cases, the clearing message should not be sent prior to the completion of the announcement.

7.3.2.2 Successful call delivery

If the call is delivered successfully to the PSTN user, then the terminating PSTN exchange will provide in-band ring-back tone. The ISDN terminal should be alerted to the fact that interworking has occurred so the user can be prepared to receive the in-band ring-back tone.

7.4 Handling of non-voice calls between ISDN and PSTN subscribers

There may be an interworking requirement for the capability to interconnect modem-equipped terminals on the PSTN and compatible terminals on an ISDN access. This may in the future include a means for compatibility checking and the provision of a modem pool to perform A/D conversion and rate adaption (Recommendation I.515).

There are in principle two alternative approaches to provide data communication between an ISDN customer and a PSTN customer:

i) The data terminal of the ISDN customer is connected to a modem which in turn is connected to an A/D converter (PCM). A call will be handled as for telephony. Further study is required to determine what interworking functions are required in this case.

ii) The data terminal of the ISDN customer is connected to a terminal adaptor according to, e.g. Recommendation I.463, i.e. the data flow is rate adapted to 64 kbit/s. At a suitable interworking point, the original data flow (e.g. 1.2 kbit/s) is extracted and converted to "analogue" form by a modem for further transfer to the remote data terminal (i.e. the usage of modem pools). Mechanisms for modem interworking are contained in Recommendation I.515.

To handle non-voice calls in an ISDN-PSTN interworking situation, the following interworking functions may be required.

a) capability to distinguish a data call and its relevant parameters when the call is coming from a PSTN;

b) capability to distinguish a data call and its relevant parameters when the call is going to a PSTN;

c) special routing algorithms for inclusion of proper IWFs as detected in a) and b);

d) IWFs for protocol conversion as detected in a) and b).

For interworking between ISDN and PSTN, the need for in-band parameter exchange is recognized as necessary, with the understanding that out-band parameter exchange should be used whenever possible (refer to Recommendation I.515).

NOTE – When ISDN-PSTN interworking, using a modem pool in conjunction with the 64 kbit/s unrestricted bearer service, it may not be possible to extend PSTN supervisory tones to the ISDN user. The interworking implications of this in the ISDN are for further study.

7.5 Control of speech processing and echo control devices

Connections provided for ISDN/PSTN interworking may use speech processing techniques as long as these do not restrict the required information transfer. Restrictive devices should be functionally modified or removed using, for example, the 2.1 kHz in-band [ECD (echo control device) disabling] tone.

Digital circuit multiplication equipment (DCME) for example is designed to be compatible with the 3.1 kHz audio transfer capability. Echo control devices and their use in the PSTN are recommended in Recommendation G.131.

In the case of the multi-use bearer service, different procedures may be required at international gateway and other exchanges. As the multi-use call progresses through the international (or other) exchanges, it may be necessary to associate an echo control device(s) with the circuit, but in a disabled state. If subsequently, interworking with the PSTN occurs, the device(s) can then be enabled by a backward Signalling System No. 7 message.

Similar Recommendations should apply to the ISDN/PSTN interworking case. In particular, both echo suppressors and echo cancellers must be located within a range limitation of the four-wire/two-wire interface. These limits are mentioned in 2.2/G.131, 1.1.3/G.164 and 3.2/G.165. If echo control devices are included in the ISDN connection, they will need to have the capability of being disabled by the 2.1 kHz echo control disabling tone generated by modems as is the current practice in the PSTN. While echo suppressors should respond to a 2100 Hz tone (Recommendation G.164), echo cancellers should only respond if the tone includes phase reversals as specified in Recommendation G.165. It is recommended that the 2.1 kHz tone should not be converted into an ISDN signalling message and vice-versa.

7.6 A/μ law encoding

The treatment of A/μ law encoding and translation in ISDN/PSTN interworking can be based on the continuation of existing procedures whereby appropriate A/μ law translation is performed by the μ-law network when crossing international boundaries, except in the case of a terminal that uses the multi-use bearer service (e.g. a 7 kHz terminal which uses G.725 procedures[1)]). Terminals would encode speech and 3.1 kHz audio using the G.711 law appropriate to the resident network. Unrestricted 64 kbit/s services bit streams would not be manipulated in any way by the ISDN: terminals would be free to use any encoding (including G.711 or G.721) as deemed appropriate between themselves when unrestricted 64 kbit/s capability is requested.

8 Handling of packet mode calls between ISDN and PSTN subscribers

There may be an interworking requirement for the capability to interconnect synchronous modem equipped data terminals on the PSTN and X.25 terminals on an ISDN access using “virtual circuit service” on the ISDN. The scenario under consideration is indicated in Figure 2.

The procedures required at the AU/PH (e.g. the modem functionality) and at the user-network interface on the PSTN side are based on Recommendations X.32 an X.31 Case A. The virtual circuit bearer service is provided by the ISDN (as per Recommendation X.31 Case B) and the service characteristics for this configuration are based on those defined in 3/X.32.

Recommendation X.32 recognizes the following three types of services based on the PSTN terminal identification options and associated billing/charging restrictions:

a) non-identified;

b) identified; and

c) customized.

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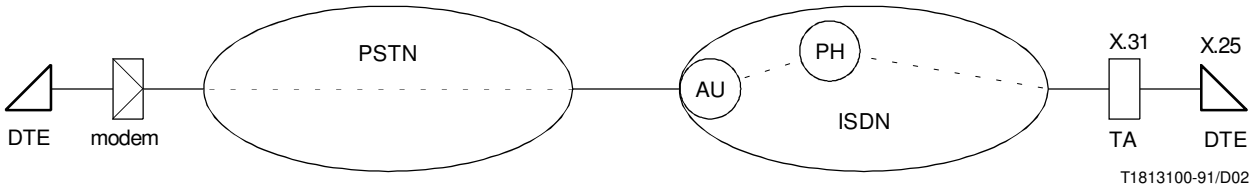
1) G.725 requires 7 kHz terminals to handle G.711 (PCM) encoding to both A-and μ-laws, and to be able to detect and switch if necessary.



AU Access unit
PH Packet handler

FIGURE 2/I.530

ISDN-PSTN interworking for packet mode calls –
Access to virtual circuit service of an ISDN through a PSTN