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DATA COMMUNICATION OVER
THE TELEPHONE NETWORK

ISDN TERMINAL ADAPTOR FRAMEWORK

ITU-T Recommendation V.130

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). 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, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation V.130 was prepared by ITU-T Study Group 14 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 29th of August 1995.

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NOTES

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

2.   The status of annexes and appendices attached to the Series V Recommendations should be interpreted as follows:

–   an *annex* to a Recommendation forms an integral part of the Recommendation;

–   an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

CONTENTS

SUMMARY

This Recommendation provides information on the functions of a terminal adaptor from both the conceptual and practical points of view. The expression "Terminal Adaptor" is commonly used to refer to a stand-alone item of equipment (or alternatively a printed circuit card plugged into a terminal) that allows a non-ISDN terminal to be connected to an ISDN user-network interface. Formally though, Terminal Adaptor (TA) is the name of one of the (conceptual) Functional Groups defined in Recommendation I.411. The TA Functional Group contains functions that allow a TE2 (non-ISDN) terminal to use the services provided by an ISDN. The popular understanding of the term TA is thus well aligned with the theoretical definition. This Recommendation coordinates information from other Recommendations, expands on topics only briefly discussed elsewhere, describes the relationship between Terminal Adaptors and Modems, and provides tutorial material, and guidance on future enhancements and applications.

Recommendation V.130

ISDN TERMINAL ADAPTOR FRAMEWORK

(Geneva, 1995)

1   Scope and introduction

1.1   Scope

The purpose of this ISDN Terminal Adaptor Framework Recommendation is to:

a)   coordinate information from other Recommendations;

b)   expand on topics only briefly discussed elsewhere;

c)   describe the relationship between Terminal Adaptors and Modems;

d)   provide tutorial material;

e)   provide guidance on future enhancements and applications.

1.2   Introduction

Formally, the expression "Terminal Adaptor" (TA) refers to one of the (conceptual) Functional Groups defined in Recommendation I.411. The TA is described in 3.4.4/I.411 and contains functions that allow a TE2 (non-ISDN) terminal to use the services provided by an ISDN.

However, the expression "Terminal Adaptor" is also used to refer to a stand-alone item of equipment (or alternatively a printed circuit card plugged into a terminal) that allows a non-ISDN terminal to be connected to an ISDN user-network interface.

Also, there already exist a number of Recommendations which describe terminal adaptors and terminal adaptation protocols that allow terminals conforming to V- or X-Series Recommendations to be connected to the ISDN. Certain material in these Recommendations is of more general application and is referred to in this Recommendation.

This Recommendation examines in detail the functions of a terminal adaptor from both the conceptual and practical points of view.

Clause 10 describes a particular type of TA which is a combination of TA and modem functions. It allows a V-Series DTE to be connected to the ISDN and use the 3.1 kHz audio bearer service to communicate with another V-Series DTE attached via a modem to the GSTN. This means that no network-provided interworking function (modem pool) is required, only the digital-to-analogue conversion and signalling facilities that are already provided for telephony.

2   References

The following Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

–   CCITT Recommendation G.711 (1988), *Pulse code modulation (PCM) of voice frequencies*.

–   ITU-T Recommendation H.244 (1995), *Synchronized aggregation of ISDN B-channels*.

–   ITU-T Recommendation I.231.9 (1993), *Circuit mode 64 kbit/s and 8 kHz structured multi-use bearer service category*.

–   ITU-T Recommendation I.320 (1993), *ISDN protocol reference model*.

–   ITU-T Recommendation I.333 (1993), *Terminal selection in ISDN*.

- ITU-T Recommendation I.411 (1993), *ISDN user-network interfaces – Reference configurations*.
- ITU-T Recommendation I.430 (1993), *Basic user-network interface – Layer 1 specification*.
- ITU-T Recommendation I.431 (1993), *Primary rate user-network interface – Layer 1 specification*.
- ITU-T Recommendation I.501 (1993), *Service interworking*.
- ITU-T Recommendation I.515 (1993), *Parameter exchange for ISDN interworking*.
- ITU-T Recommendation I.530 (1993) *Network interworking between an ISDN and a Public Switched Telephone Network (PSTN)*.
- ITU-T Recommendation Q.931 (1993), *Digital Subscriber Signalling System No. 1 (DSS 1) – ISDN user-network interface layer 3 specification for basic call control*.
- ITU-T Recommendations T.200-Series[1], *Programming communication interface for terminal equipment connected to ISDN*.
- ITU-T Recommendation V.8 (1994), *Procedures for starting sessions of data transmission over the general switched telephone network*.
- ITU-T Recommendation V.10 (1993), *Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s*.
- ITU-T Recommendation V.11 (1993), *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*.
- ITU-T Recommendation V.14 1993), *Transmission of start-stop characters over synchronous bearer channels*.
- ITU-T Recommendation V.24 (1993) *List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE)*.
- CCITT Recommendation V.25 *bis* (1988), *Automatic calling and/or answering equipment on the General Switched Telephone Network (GSTN) using the 100-series interchange circuits*.
- ITU-T Recommendation V.25 *ter* (1995), *Serial asynchronous automatic dialling and control*.
- ITU-T Recommendation V.28 (1993), *Electrical characteristics for unbalanced double-current interchange circuits*.
- ITU-T Recommendation V.12 (1995), *Electrical characteristics for balanced double-current interchange circuits for interfaces with data signalling rates up to 52 Mbit/s*.
- CCITT Recommendation V.42 *bis* (1988) *Data compression procedures for Data Circuit-Terminating Equipment (DCE) using error correcting procedures*.
- ITU-T Recommendation V.58 (1994), *Management information model for V-Series DCEs*.
- CCITT Recommendation V.110 (I.463) (1992), *Support of data terminal equipment with V-Series type interfaces by an integrated services digital network*.
- CCITT Recommendation V.120 (I.465) (1992), *Support by an ISDN of data terminal equipment with V-Series type interfaces with provision for statistical multiplexing*.
- CCITT Recommendation X.24 (1988), *List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) on public data networks*.
- ITU-T Recommendation X.25 (1993), *Interface between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit*.

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[1] Presently at the stage of draft.

–   ITU-T Recommendation X.30 (I.461) (1993), *Support of X.21, X.21 bis and X.20 bis based data terminal equipments DTEs by an Integrated Services Digital Network (ISDN).*

–   ITU-T Recommendation X.31 (I.462) (1993), *Support of packet mode terminal equipment by an ISDN*.

–   ISO/IEC 2110:1989, *Information technology – Data communication – 25-pole DTE/DCE interface connector and contact number assignments*.

–   ISO/IEC 13871, *Information technology – Telecommunications and information exchange between systems – Private telecommunications networks – Digital channel aggregation*.

3   Definitions

For the purposes of this Recommendation, the following definition applies:

3.1   modec: The term modec is used to refer to a functional block (sometimes called a digital modem) whose overall functionality is equivalent to that of a modem connected to a codec. A modec has no internal analogue components and only digital interfaces.

4   Abbreviations

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

BC	Bearer Capability
CLI	Calling Line Identification
DTE	Data Terminal Equipment
HLC	High Layer Compatibility
IPE	In-band Parameter Exchange
IWF	Interworking Function
LLC	Low Layer Compatibility
MIB	Management Information Base
MSN	Multiple Subscriber Number
MTA	Multi-protocol Terminal Adaptor
NT	Network Termination
PID	Protocol Identification
SUB	Sub-addressing
TA	Terminal Adaptor
TE1	ISDN data terminal
TE2	DTE with a non-ISDN interface
UDI-TA	Unrestricted Digital Information with Tones and Announcements

5   Reference models

According to clause 3/I.411, the Terminal Adaptor (TA) functional group lies between the R and S reference points and contains functions that allow a TE2 (non-ISDN) terminal to use the services provided by an ISDN.
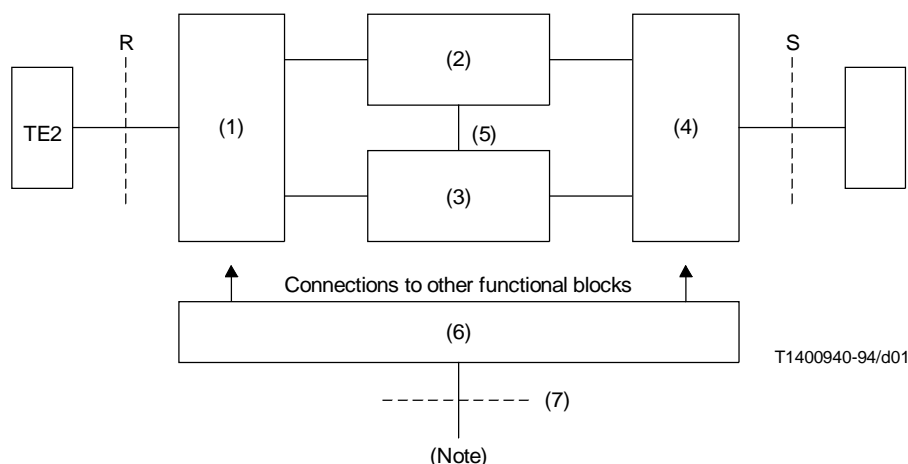
Clause 4/I.411 describes various physical configurations involving the TA functional group and the simplest one has interfaces at both the R and S reference points. However, other arrangements are possible and actual items of equipment containing the TA functional group may also contain other functional groups, resulting in the interface on the network side not being at the S reference point.

In general though, for simplicity, the configuration with interfaces at the R and S reference points is used throughout this Recommendation. Also, for clarity, the expression "interface at the R (or S) reference point" is abbreviated to "R (or S) interface".

Alternative arrangements on the network side are discussed in the subclause describing the network interface functions (5.1.4).

5.1 Functional reference model

The Functional Reference Model in Figure 1 is derived from Figure A.1/V.110. Figure 1 shows the main functional blocks that make up a terminal adaptor. These functions are described below.


```
NT    Network termination
TE2   Data terminal equipment (DTE) with a non-ISDN interface
(1)   Terminal interface functions
(2)   User (U) plane functions
(3)   Control (C) plane functions
(4)   Network interface functions
(5)   Synchronization between User and Control functions
(6)   Management and maintenance control
(7)   Local control and management interface
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NOTE – This interface is optional. It is needed if the TA cannot be adequately controlled from the R interface.

FIGURE 1/V.130

Terminal adaptor functional reference model

5.1.1 Terminal interface functions

This block provides physical layer functions at the R interface according to applicable Recommendations or International or National Standards. (These are listed in 8.1.) Alternatively this interface may be internal to a piece of equipment and therefore not subject to standardization.

5.1.2 User (U) plane functions

The main U plane function is the adaptation of the user's information signalling rate and format at the R interface to that of the ISDN B- or other channel(s) being used at the S interface.

Additional U plane functions include:

– end-to-end mapping of the states of R interface control signals;

– in-band notification/checking/negotiation of adaptation protocol (for multi-protocol TAs);

– in-band notification/checking/negotiation of adaptation protocol parameters;

– handling error conditions detected at the R interface;

– recovery of timing information (network independent clock);

– end-to-end flow control between TAs (methods are described in both Recommendations V.110 and V.120);

– multiplexing of several user connections into one ISDN call;

– aggregation of several ISDN calls to provide one user connection. Protocols for this purpose are described in Recommendation H.244 and the complementary International Standard, ISO/IEC 13871;

– detection and optional correction of errors that occur between the TAs;

– compression of the user information stream to increase the effective throughput;

– encryption of the user information stream for security purposes;

– modec function (see 10.3).

NOTE – Recommendations may not yet exist to provide all the functions described above.

5.1.3 Control (C) plane functions

The main C plane function is the mapping function needed to convert between the automatic calling and/or answering procedures used at the R interface and the ISDN D-channel signalling protocol. For R interfaces with little or no automatic calling and/or answering capability, the deficiency must be made up by a local management function.

Additional C plane functions include:

– out-of-band notification/checking/negotiation of adaptation protocol (for multi-protocol TAs);

– out-of-band notification/checking/negotiation of adaptation protocol parameters;

– security checking of incoming calls using the Calling Line Identification (CLI) supplementary service;

– identification of a particular TA on a shared ISDN access using, for example, the Multiple Subscriber Number (MSN) or Sub-addressing (SUB) supplementary services. The terminal selection process is discussed in detail in Recommendation I.333.

5.1.4 Network interface functions

This block provides physical layer functions at the interface on the ISDN side. For the S interface, T interface or coincident S and T interface, these functions are specified in Recommendation I.430 or I.431. Alternatively this interface may be internal to a piece of equipment and therefore not subject to standardization, for example, the functions of TA and NT2 may be combined. Also, for connection to some ISDNs, provision of the NT1 function is the responsibility of the subscriber, not the network-provider. In this case the NT1 and TA functions may be combined into one piece of equipment, which is commonly called a "Terminal Adaptor".

5.1.5 Synchronization between User and Control plane functions

This block synchronizes signalling (in the C plane) with user information flow (in the U plane). An example is:

– starting the rate adaptation protocol when the call has been connected.

5.1.6　Management and maintenance control

This block provides overall control of the TA and may in addition provide maintenance functions. Examples are:

–　storage of ISDN numbers for Calling Line Identification (CLI) checking of incoming calls;

–　control of maintenance loops.

5.1.7　Local control and management interface

This optional interface is required if the TA cannot be adequately controlled from the R interface. An example is:

–　a keypad to provide manual call control;

–　indicator lights or an alphanumeric display to show the status of the TA.

5.2　Protocol reference model

A terminal adaptor performs protocol conversion in both the control and user planes. The concept of planes is discussed in 2.2/I.320.

5.2.1　Control plane

The TA performs conversion in the control plane between the signalling procedures at the R and S interfaces. This requires a pair of protocol stacks linked by a signalling conversion function (Figure 2A). At the S interface all three protocol layers must be present (ISDN D-channel signalling protocol). The structure of the R-signalling layer varies from one R interface to another and will depend on the nature of the protocol at the R interface. The signalling conversion function provides a mapping between the primitive operations of the two signalling protocols. Examples of primitive operations are the commands to setup and clear a call. Auto-calling procedures are described in 6.1.

For some R interfaces, it may not be possible to perform certain management functions via the R interface. This deficiency must be made up by a local management function. It may involve manual intervention, either at the time the operation takes place (e.g. to place a call) or at some time in advance (e.g. to store a called party number).

Example of R-signalling layers:

–　For an X.25 interface it is X.25 layer 2 and the call control part of layer 3.

–　For a V-Series interface one possibility is V.25 *bis*.

The ISDN D-channel signalling protocol may also be used to carry out the additional functions described in 5.1.3. The ability to perform these functions depends on the availability of certain features in the ISDN to which the TA is attached.
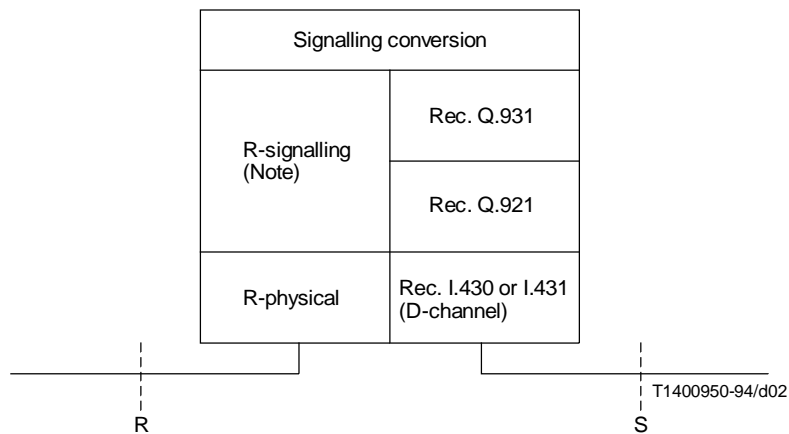
5.2.2　User plane

The TA serves as a relay for user information between the R and S interfaces. This requires a pair of protocol stacks linked by a relay function (Figure 2B). At the S interface the adaptation protocol is used to allow the user's information to be carried in a B, D, H or other channel using an appropriate ISDN bearer service. If required, a higher bit-rate channel may be formed by aggregating two or more of these channels.

The choice of adaptation protocol is determined by the combination of channel type and bearer service used over that channel. For example, V.110 is designed for use over the 64 kbit/s unrestricted (or restricted) circuit mode bearer service, carried in a B channel. V.120 is more flexible in its usage and can operate using an unrestricted (or restricted) circuit mode bearer service carried in a B or H channel or, alternatively, a frame mode bearer service carried in a B, H or D channel.

The adaptation protocol may, in addition, support the functions described in 5.1.2.
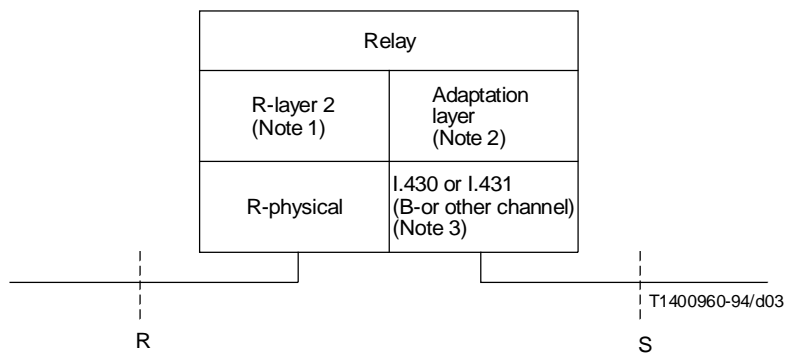
A particular TA implementation is not limited to the use of a single adaptation protocol. Choice of protocol can be by configuration or by negotiation on a call by call basis. Clause 9 describes such a Multi-protocol Terminal Adaptor (MTA).

NOTE – The structure of the R-signalling layer varies from one R interface to another.

FIGURE 2A/V.130

Terminal adaptor protocol reference model – Control (C) plane

NOTES

1   Layer 2 at the R interface may be null.
2   The structure of the Adaptation layer varies from one type of TA to another.
3   Any channel provided for user information may be used at the S interface.

FIGURE 2B/V.130

Terminal adaptor protocol reference model – User (U) plane

5.3 Interworking model

The Interworking Model in Figure 3 shows possible interworking scenarios for a terminal adaptor. It is a simplified version of the diagram in Figure 1/I.515. The general requirements for successful interworking are:

5.3.1 TE2 + TA to TE2 + TA (scenario a)

The two TE2 + TA combinations must have a minimum common functionality for communication to be successful, for example both TAs must support the same rate adaptation protocol operating at the same bit rate.

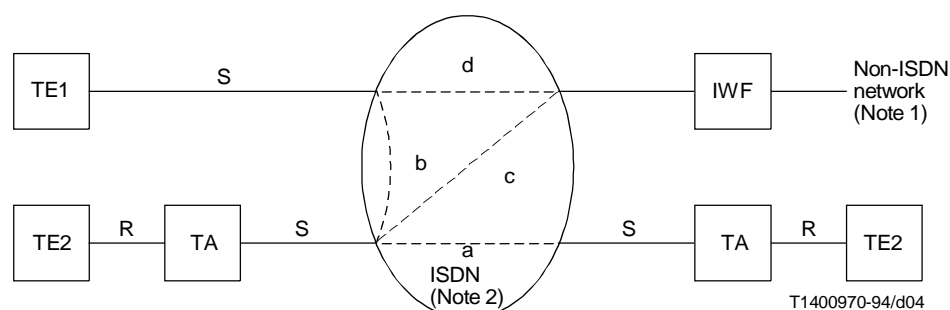### 5.3.2 TE2 + TA to TE1 (scenario b)

The TE1 must contain functionality such that it is compatible with the TE2 + TA. Thus, a TE1 which is ended to be able to interwork with an adapted TE2 will need to contain some of the functions described within this Recommendation. These functions are in addition to those required for communication between directly connected terminals (TE1 to TE1).

5.3.3 TE2 + TA to non-ISDN network via IWF (scenario c)

The requirements for the TA in this scenario depend very much on the type of non-ISDN network concerned and the functionality of the IWF. In many cases the IWF will need to contain some of the functions described in this Recommendation, for example, it may need to terminate the rate adaptation protocol used over the ISDN. It may also need a further adaptation function to the non-ISDN network. In the case of the GSTN this would be a modem. Alternatively, as described in clause 10, the modem function could be placed in the TA and the 3.1 kHz audio bearer service be used to interwork with the GSTN.

5.3.4 TE1 to non-ISDN network via IWF (scenario d)

In this scenario the TE1 must have equivalent functionality to the TE2 + TA in scenario (c). It will therefore need to contain some of the functions described in this Recommendation.

TE1 ISDN data terminal
TE2 Data terminal equipment (DTE) with a
    non-ISDN interface
TA   Terminal Adaptor
IWF Interworking Function

Interworking scenarios:
a   TE2 + TA to TE2 + TA
b   TE2 + TA to TE1
c   TE2 + TA to non-ISDN network
d   TE1 to non-ISDN network

NOTES

1   Examples of non-ISDN networks are Circuit and Packet Switched Public Data Networks and the GSTN.
2   For the purposes of this figure, NT1 and NT2 functions are considered to be within the ISDN.

FIGURE 3/V.130

Interworking model

5.4 Call mapping model

Because a TA can provide multiplexing or channel aggregation there is not always a one-to-one mapping between calls as seen by the TE2(s) and calls over the ISDN.

In the diagrams below, each rectangle represents a call. Those above the dotted line (which represents the time dimension) are as seen at the TE2 side of the TA and those below the line, the ISDN side.

In Figure 4 three cases are shown where the durations of the calls on both sides of the TA are the same. The first is for a simple TA where there is a 1:1 mapping between the calls at the TE2 and ISDN sides. An example is the V.110 TA described in Appendix I.

The second is for a TA which multiplexes several (in this case three) TE2 calls into one ISDN call. An example would be a TA using the statistical multiplexing feature of Recommendation V.120.

The third case is for a TA using channel aggregation to synthesize a 128 kbit/s channel out of two ISDN 64 kbit/s circuit mode calls.
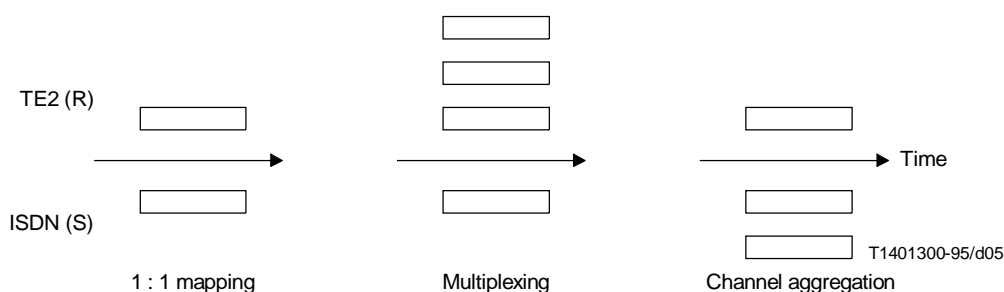

FIGURE 4/V.130

Call mapping for three different types of TA

Figure 5 illustrates a more complex situation. It shows a possible sequence of TE2 and ISDN calls for an X.25 DTE connected to an X.31 TA. When the first X.25 call request appears from the TE2 (on the left) an ISDN call is set up. As time proceeds (moving to the right) the first X.25 call is disconnected, but other calls have been set up and so the ISDN call remains in progress. Only when the last X.25 call has been disconnected can the ISDN call be cleared. The continuation of the ISDN call for a short time beyond the end of the last X.25 call is a timeout period to reduce the risk of clearing an ISDN call, only to find that another needs to be set up almost immediately. The duration of this timeout period is determined by performance and cost factors.

6 Connection establishment (Call control)

6.1 Auto-calling procedures

In order to maximize the ease of use of a TA it is desirable that an existing TE2 (DTE) should be able to use an auto-calling procedure in the same way that it would when connected to a modem or a dedicated public data network (PSPDN or CSPDN).
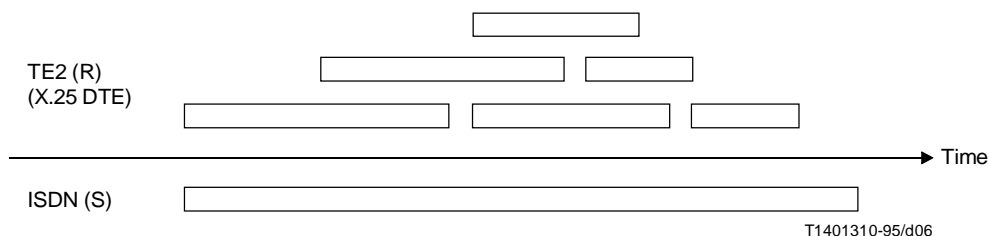
FIGURE 5/V.130

Call mapping for an X.31 TA

Mappings between auto-calling procedures at the R interface and the signalling protocol at the S interface are already described in the following Recommendations:

–   Recommendation X.30 (I.461):   for X.21 based DTEs;

–   Recommendation X.31 (I.462):   for X.25 based DTEs;

–   Recommendation V.110 (I.463):   for DTEs supporting V.25 *bis* procedures (Appendix II/V.110).

The V.25 *bis* procedures described in Appendix II/V.110 could be applied to other types of terminal adaptors for V-Series DTEs. Examples are TAs containing a modem function or using V.120 rate adaptation.

Recommendation V.25 *ter* contains a description of alternative auto-calling procedures for asynchronous V-Series DTEs. The mapping of these on to the Q.931 signalling protocol is for further study. As well as containing call control commands, Recommendation V.25 *ter* also has commands for configuration and status monitoring. A proposal has been made to use a Management Information Base (MIB) to provide the mapping between V.25 *ter* and Q.931 primitive operations. An example of such a MIB (for V-Series DCEs) is to be found in Recommendation V.58.

6.2   Multi-Use bearer service applications

The Multi-Use bearer service is defined in Recommendation I.231.9. It provides a Bearer Capability (BC) of 64 kbit/s Unrestricted Digital Information with Tones and Announcements (UDI-TA). As a network option it can provide automatic fallback to the 3.1 kHz audio or speech BC to allow interworking with ISDN 3.1 kHz audio or speech terminals or terminals on the GSTN.

A multi-protocol terminal adaptor (MTA – as described in clause 9) containing an adaptation function conforming to either Recommendation V.110 or V.120 and a MODEC function (see Appendix I) could use the Multi-Use bearer service with the fallback option to simplify the selection of its operating mode.

The operation of terminals which use the "bearer capability selection option" of the Multi-Use bearer service is described in 3.3/I.501 and is summarized below.

6.2.1   Outgoing calls

For an outgoing call the MTA's SETUP message contains UDI-TA (Unrestricted Digital Information with Tones and Announcements) as the preferred BC with 3.1 kHz as the fallback. Subsequent operation depends on any BC contained in the CONNECT message received from the ISDN:

6.2.1.1   BC = UDI-TA

The TA operates in the 64 kbit/s unrestricted mode. Optionally, in-band procedures may then be used by the MTA to select a rate adaptation scheme, for example, V.110 or V.120.

6.2.1.2 BC = 3.1 kHz audio or no BC specified (possibly with GSTN interworking indicated)

The TA operates in the 3.1 kHz audio mode. Optionally, the MODEC can then commence (in-band) modem identification procedures.

6.2.2 Incoming calls

For an incoming call the MTA's response depends on the BC(s) contained in the SETUP message:

6.2.2.1 BC = both UDI-TA and 3.1 kHz

Providing the TA is otherwise compatible (e.g. the rate adaptation specified in the LLC information element is acceptable) then it responds with a CONNECT message containing the UDI-TA BC and operates in 64 kbit/s unrestricted mode. Otherwise it responds with the 3.1 kHz BC and operates in the 3.1 kHz audio (modec) mode. This allows 3.1 kHz (modec) interworking with other terminal adaptors which support the Multi-Use bearer service but use incompatible rate adaptation protocols in 64 kbit/s unrestricted mode.

6.2.2.2 BC = UDI-TA or 64 kbit/s unrestricted digital

The TA responds with a CONNECT message containing the BC copied from the SETUP message and operates in the 64 kbit/s unrestricted mode.

6.2.2.3 BC = 3.1 kHz only (possibly with GSTN interworking indicated)

The TA responds with a CONNECT message containing the BC copied from the SETUP message and operates in the 3.1 kHz audio (modec) mode.

7 Rate adaptation protocol and parameter negotiation

For many applications, both calling and called terminals can be preconfigured and no negotiation is required. Recommendation I.515 identifies a number of circumstances in which parameter exchange might be required. One of these is the selection of the rate adaptation protocol to be used. Further negotiation may then be required to select the values of parameters for a particular protocol. There are two possible ways of negotiating protocols and parameters. Out-of-band procedures using D channel signalling (Recommendation Q.931) can be used before and possibly after call establishment. In-band procedures can be used only once the call has been established. Figure 6 shows a taxonomy of the negotiation processes that can be used.
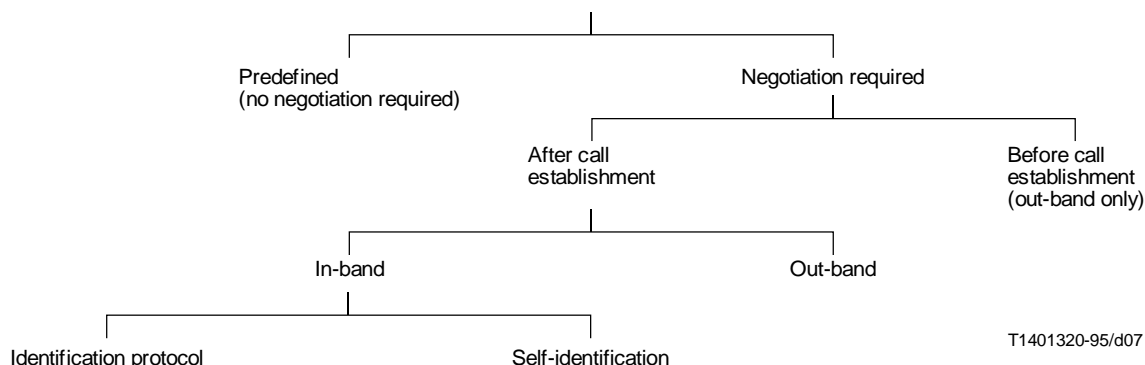

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FIGURE 6/V.130

Ataxonomy of negotiation processes

7.1 Out-of-band (Q.931) procedures

Recommendation Q.931 provides three information elements for call negotiation:

     i)   Bearer Capability (BC);

     ii)   Low Layer Compatibility (LLC);

     iii) High Layer Compatibility (HLC).

Some networks may allow only the forwarding of these parameters to the destination without the destination being able to return alternative values. Thus they may be used to select alternative features at the destination but not be used for negotiation. In addition, some networks may allow a further exchange of information (using Recommendation Q.931) during the call.

However, certain networks and gateways between networks may not allow the transparent passage of the BC, LLC and HLC information elements, thus limiting the features that may be specified. Thus, whilst out-of-band procedures have the advantage of allowing a decision to be made on compatibility before the call is connected, their use may be limited.

7.2 In-band negotiation procedures

In-band procedures can, in principle, be used both for rate adaptation protocol negotiation and for subsequent parameter selection. Since the bearer channel is used there is no network-imposed restriction on what information can be exchanged. A disadvantage to the user is that a charge will be made for the call even if it has to be cleared immediately because the terminals are found to be incompatible.

7.2.1 Protocol Identification (PID)

This procedure is used by the TAs to determine which adaptation protocol is to be used. Two methods have been described, one involving the use of an Identification protocol and the other relying on the TA being able to identify the adaptation protocol from what is received from the other TA.

7.2.1.1 Identification protocol

Appendix I/I.515 proposes a protocol which allows in-band negotiation of the adaptation protocol. This protocol consists of three phases. The first is one of end-to-end synchronization, in which the two TAs establish that they both support the identification protocol. A timer is provided to accommodate the situation when only one of the TAs supports PID. Secondly, the answering TA sends a message indicating which adaptation protocol(s) it supports. Finally, the originating TA responds with a message indicating which one of the proposed protocols it has selected. If none is acceptable then it sends a null reply and disconnects the call.

7.2.1.2 Self-identification

Appendix II/I.515 discusses guidelines for self-identification procedures that may be used by multi-protocol terminal adaptors (MTAs – see clause 9). This relies on the TA being able to recognize the protocol being received. For example, Recommendation V.120 uses HDLC framing (identified by flags) whilst Recommendation V.110 uses a fixed length frame (identified by a frame synchronization pattern). It is necessary for the available protocols to be placed into a priority order and for the MTA to start with the one having the highest priority. If it does not receive an appropriate response then it tries the protocol with the next highest priority. If compatibility is not achieved then the TA initiates a disconnect.

7.2.2 In-band Parameter Exchange (IPE) for a particular protocol

This is part of the adaptation protocol and is used to negotiate the values of certain parameters in the protocol. An example is given in Appendix I/V.110. The procedure described there is similar to that described in 7.2.1.1 for adaptation protocol negotiation. There is an initial synchronization stage during which the TAs agree on a V.110 intermediate rate using a self-identification procedure. This is followed by an exchange of parameter information during which the values are agreed.

8 TE2 – TA interface considerations

The interface at the R reference point between the TA and the TE2 functional blocks may be a physical interface or may be embedded within a piece of equipment.

8.1 Physical interfaces

Recommendations X.30, X.31, V.110 and V.120 describe TAs for terminals with interfaces conforming to V- and X-Series Recommendations at rates up to 56 kbit/s. However, the use in TAs of techniques such as data compression and channel aggregation will result in a need for interfaces at significantly higher bit rates.

Applicable Recommendations and International Standards are:

- Interchange circuits – Recommendation V.24, Recommendation X.24;

- Electrical characteristics – Recommendation V.10, Recommendation V.11, Recommendation V.12, Recommendation V.28;

- Interface connectors and pin assignments – ISO/IEC 2110.

8.2 Flow control and buffering

No flow control or buffering is needed for the simple situation in which two TE2s are connected using V.110 TAs and the bit rates of both TE2s are the same as that of the V.110 protocol. The same is true when Recommendation V.120 is used in a similar situation without error correction.

In more complex circumstances the effective rate across the ISDN will not be the same as the bit rate of one or other of the TE2s. Possible circumstances are:

- the TE2s (using V.110 or V.120 TAs) have different interface bit rates;

- Recommendation V.120 is being used with error correction and retransmissions are reducing the effective throughput;

- Recommendation V.120 is being used with a data compression protocol, e.g. V.42 *bis*, which is resulting in a variable effective throughput;

- Recommendation V.120 is being used with statistical multiplexing of a number of data streams.

In such cases it is necessary to decouple the terminal from the ISDN by providing buffering and flow control. In the data compression and statistical multiplexing cases, it is desirable to operate the TE2 interface at a rate comparable to the maximum possible rate over the ISDN (subject to the terminal being able to accept this) and to use flow control to reduce the rate as necessary. End-to-end flow control between the TAs is a U-plane function (5.1.2). In addition, local flow control will be needed at the TE2-TA interface. Techniques for local flow control during asynchronous operation are described in 2.4.1/V.110.

8.3 Embedded interfaces

A common form of construction for an ISDN interface for some terminals is that of a plug-in printed circuit card. Depending on the nature of the interface between this card and the rest of the terminal the complete unit may form either a TE1 or a TE2 + TA. In particular, in some cases the interface behaves like the DTE interface of a modem although it does not necessarily have the same physical characteristics. In this case the card can reasonably be described as a TA. In other cases the card functions are much more closely integrated into the terminal and it is not reasonable to separate them, the whole terminal being described as a TE1.

The T.200-Series Recommendations describe a "Programme communication interface for terminal equipment connected to ISDN". This is a software interface between application software and the ISDN interface software and hardware. It is through this interface that the application transfers data and management information. This includes information required to control any terminal adaptation functions that are present.

9 Multi-protocol terminal adaptor

A Multi-Protocol Terminal Adaptor (MTA) supports more than one adaptation protocol in the user plane. The actual protocol used is chosen on a per call basis. Figure 7 shows such a TA which supports three different adaptation functions (shown as U plane functions 1, 2 and 3). These could be, for example, rate adaptation conforming to Recommendations V.110 and V.120 using the 64 kbit/s unrestricted BC, adn a modec function (clause 10) using the 3.1 kHz audio BC.

The selection of the appropriate U plane function could be made by the user or automatically during or immediately after call set-up. The following is a possible automatic procedure.

If the type of network (ISDN or GSTN) to which the called terminal is attached is known, then the MTA can originate a call specifying the appropriate bearer service and, optionally, for the ISDN only, LLC and/or HLC information.

If the type of network is unknown then the following procedure can be adopted:

1) Originate the call with a 64 kbit/s bearer specified and, optionally, LLC and/or HLC information. If the destination is on the ISDN and the call succeeds then an in-band protocol (e.g. Appendix I/I.515) can be used to select a rate adaptation protocol. Otherwise proceed to step 2.

2) If the call cannot be completed because the called terminal was incompatible (i.e. on the GSTN or a 3.1 kHz terminal on the ISDN) then the call is reoriginated with a 3.1 kHz bearer specified. When the call has been connected then modem facility negotiation can proceed using, for example, the procedure specified in Recommendation V.8.

The need to have to make a second call attempt in some cases is undesirable as it increases both the effective call set-up time and the signalling load on the network.

A better approach (if the network supports it) is for the originating terminal to use the Multi-Use bearer service with the 3.1 kHz audio interworking option. This allows a single call set-up to be used (see 6.2).
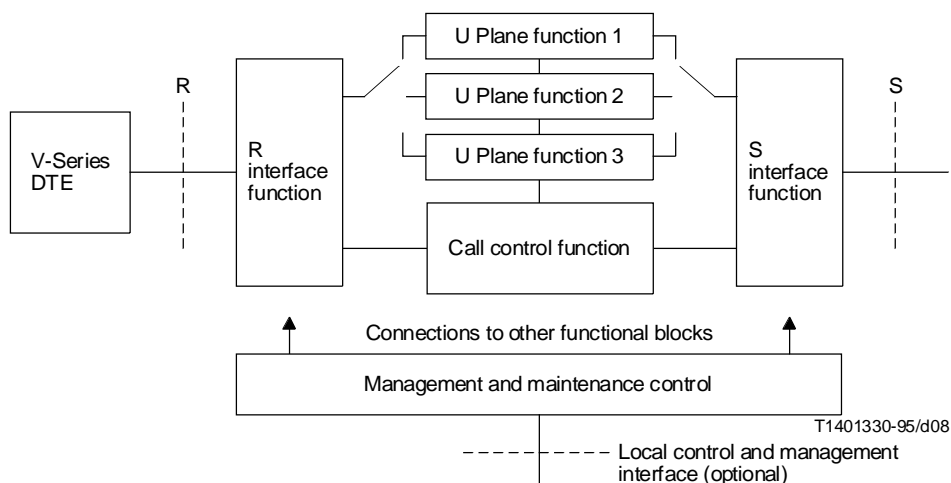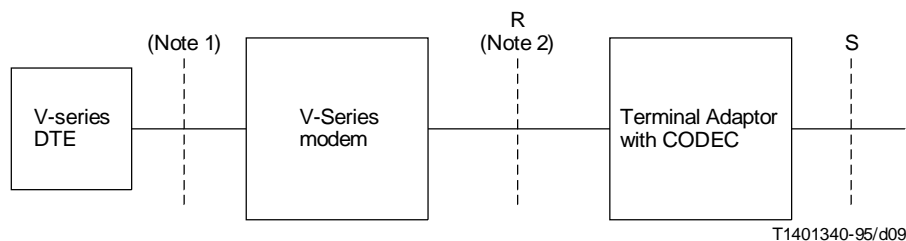

FIGURE 7/V.130

Multi-protocol terminal adaptor

10 Adaptation to 3.1 kHz audio bearer (GSTN interworking)

10.1 Introduction

Recommendation I.530 identifies two alternative ways of providing data communications between ISDN and GSTN subscribers.

i) The DTE (TE2) of the ISDN subscriber is connected to a TA which rate adapts the information flow to 64 kbit/s according to, for example, Recommendation I.463 (V.110). At a suitable interworking point within the network, the original information flow is extracted and converted to an "analogue" form by a modem for transfer over the GSTN to the remote terminal (i.e. the usage of modem pools). This mechanism is described in Recommendation I.515.

ii) The DTE (TE2) of the ISDN subscriber is connected to a modem which in turn is connected to a TA incorporating a codec. Interworking between the ISDN and GSTN is handled as for telephony. This second case, "Terminal Adaptor with CODEC", is shown in Figure 8.

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NOTES

1   This is the normal interface between a V-Series DTE and a Modem.
2   This R interface is the same as an interface between a modem and the GSTN. It is the subject of national standardization.

FIGURE 8/V.130

V-Series DTE connect to the ISDN via Modem and a TA with a CODEC

10.2 Terminal adaptor with codec

The "Terminal Adaptor with codec" can be described by reference to Figure 1 (Functional Reference Model). It has an R interface which is the same as that presented to a Modem by the GSTN. The "R interface functions" block (1) emulates the line card at a local exchange, performing such functions as power feeding, ringing current generation, hook switch and DTMF or pulse dialling detection and 2-4 wire conversion (hybrid). This interface is subject to national standardization.
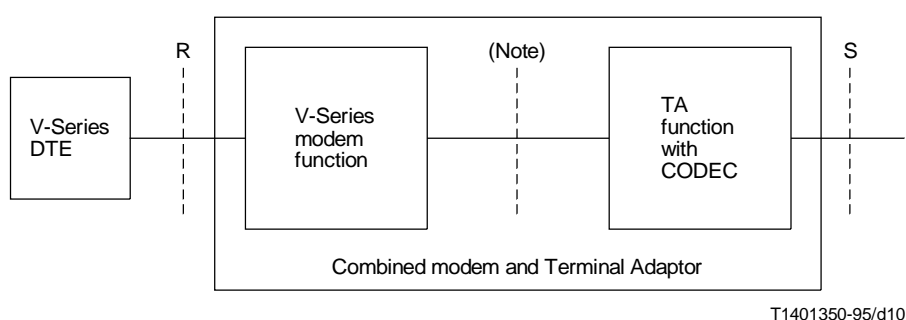
The "User plane functions" block (2) consists of a codec which conforms to Recommendation G.711. A-law or μ-law coding is chosen to suit national requirements. In addition this functional block is required to generate dial-tone in response to the off-hook condition being detected at the R interface.

The "Control plane functions" block converts between the signalling at the R and S interfaces. This TA uses the 3.1 kHz audio bearer service.

10.3   Combined modem and terminal adaptor

A modem and a terminal adaptor can be combined into a single piece of equipment (Figure 9). This causes the R reference point to move to the interface with the DTE. The analogue interface between the modem function and the TA with codec function becomes internal and therefore not subject to standardization. It is then possible to remove from the TA and the modem the analogue line interface components that were associated with their being physically separate items of equipment.
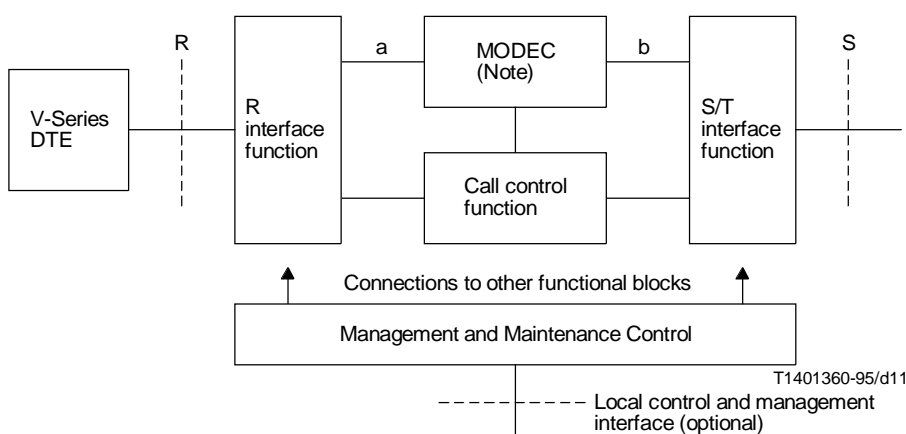
Figure 10 shows how the process of integrating a modem into a terminal adaptor can be taken a stage further by defining a new functional block, a modec (sometimes called a digital modem), which has no internal analogue functions and only digital interfaces. Interface (a) is the DTE's bit or character stream. Interface (b) is an octet stream which is the same as the PCM coding (according to Recommendation G.711) of the voiceband signal at the analogue (GSTN) interface of an equivalent modem. This TA uses the 3.1 kHz audio bearer service.

T1401350-95/d10

NOTE – This is an internal analogue interface and is not subject to standardization.

FIGURE 9/V.130

V-Series DTE connected to the ISDN via a combined Modem and TA

T1401360-95/d11

NOTE – A modec eliminates the analogue functions of a modem and a codec.

FIGURE 10/V.130

Functional model of a TA incorporating a MODEC

11   Management

For further study.

Appendix I

Protocol model for a V.110 TA (asynchronous mode)

This appendix contains an example showing how the Protocol Reference Model (see 5.2) can be used. Figures I.1 and I.2, respectively, show the protocol models for the C and U planes of a TA intended to connect an asynchronous (start-stop) terminal to an ISDN Basic Access. It uses V.110 rate adaptation and V.25 *bis* or V.25 *ter* auto-calling.
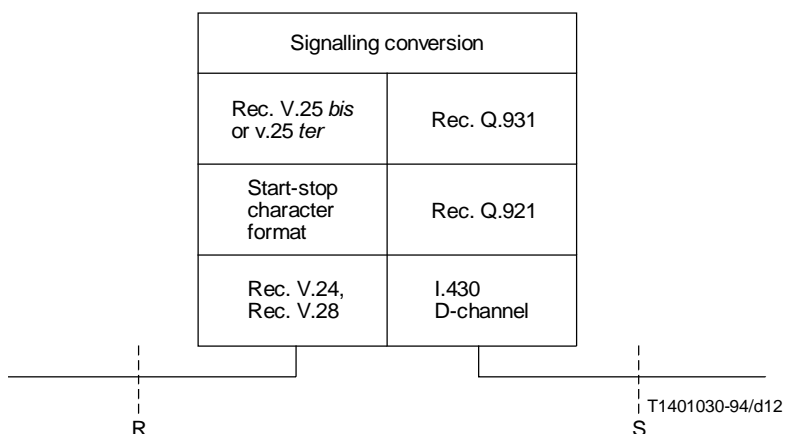
Signalling conversion	
Rec. V.25 *bis* or v.25 *ter*	Rec. Q.931
Start-stop character format	Rec. Q.921
Rec. V.24, Rec. V.28	I.430 D-channel

T1401030-94/d12

R   S

FIGURE I.1/V.130

V.110 Terminal adaptor protocol model – Control (C) plane

Relay	
	V.110 RA0 (V.14)
	V.110 RA1
Start-stop character format	V.110 RA2
Rec. V.24, Rec. V.28	I.430 B-channel

T1401370-95/d13
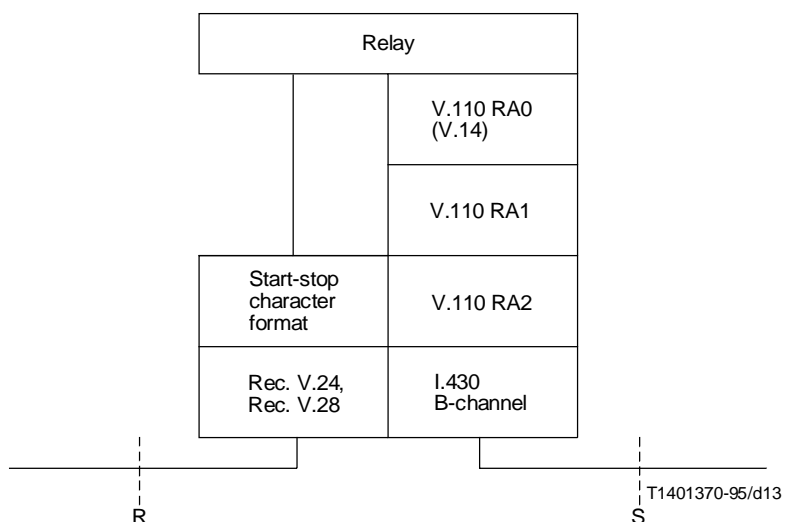
R   S

FIGURE I.2/V.130

V.110 Terminal adaptor protocol model – User (U) plane

In the control plane (Figure I.1), on the terminal side, signalling is performed using the V.25 *bis* or V.25 *ter* protocol which is carried by an asynchronous (start-stop) character stream over a physical interface with V.24 signal definitions and V.28 electrical characteristics. The signalling conversion function maps between the V.25 *bis* or V.25 *ter* commands and responses and the Q.931 messages on the network side.

In the user plane (Figure I.2), on the terminal side, the user's information is carried in the start-stop character format. This character stream is then subjected to the three stages of rate adaptation in the V.110 protocol stack. The RA0 function uses the method described in Recommendation V.14 to generate a synchronous bit stream. This is then subjected to first and second stage rate adaptation by the RA1 and RA2 functions to produce a 64 kbit/s stream that is carried over the ISDN B-channel. The process is reversed for the information stream received from the network.