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SERIES I: INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

General structure – Description of ISDNs

FRAMEWORK FOR PROVIDING ADDITIONAL PACKET MODE BEARER SERVICES

Reedition of CCITT Recommendation I.122 published in the Blue Book, Fascicle III.7 (1988)

NOTES

1 CCITT Recommendation I.122 was published in Fascicle III.7 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 I.122

FRAMEWORK FOR PROVIDING ADDITIONAL PACKET MODE BEARER SERVICES

(Melbourne, 1988)

1 Introduction

Packet mode bearer services supported by an ISDN are given in Recommendation I.232. Recommendation I.462 (X.31) specifies the procedures for two such bearer services, virtual call and permanent virtual circuit bearer services, for the support of X.25 packet mode terminals in ISDN.

This Recommendation establishes an architectural framework within which additional packet mode bearer services are described.

1.1 *Scope*

The architectural framework and service descriptions given in this Recommendation provide the basis for further work to be done by CCITT during the 1989-1992 Study Period. This method of work involves first the description of services and then the development of protocols to support them.

During the course of this work the first ISDN principle given in Recommendation I.120 should be followed. That is, a wide range of applications should be supported by the same network using a limited set of connection types and multipurpose user-network interface arrangements. From considerations in this Recommendation it is also desirable to limit the number of bearer services. It is recognized, however, that at this time it is premature to exclude any potential bearer services. The criteria on the basis of which the number of these bearer services could be reduced requires further study.

The Recommendation also provides a general description on interworking requirements between I.122 based services and I.462 (X.31) based services or PSPDNs.

1.2 *Objectives*

The principle of separation of the user and control planes for all telecommunication services has been established as a fundamental concept of the ISDN protocol reference model (Rec. I.320). This principle has been applied, however, only to circuit mode services. Packet mode services in ISDN are based on Recommendation I.462 (X.31). Recommendation I.462 (X.31) is a pragmatic approach that minimizes deployment and interworking difficulties, while at the same time providing access to packet services through an integrated physical interface.

The evolution of packet mode services in ISDN has been investigated, and an architectural framework for providing additional packet mode services has been established in this Recommendation. In undertaking this investigation the main objective was to establish a framework based on the ISDN protocol reference models described in Recommendation I.320. More specifically, this framework was aimed at achieving:

a) full integration of C-plane (control plane) procedures for all services, i.e. one set of protocols for call control; supplementary services and operational, administrative and maintenance messages (OAM) across all telecommunication services;

b) the decoupling of user information transfer requirements from C-plane transfer requirements. This allows the possibility of defining telecommunication services whose U-plane (user plane) characteristics are tailor-made only to the transfer needs of user information and not to those of C-plane information.

The bearer services supported within this architectural framework are in the virtual call and permanent virtual circuit bearer service category. All bearer services defined within this framework if and when included in Rec. I.232 will have recommended overall provision A (Additional).

1.3 *Definitions of terms*

In the context of this Recommendation, the following definitions apply:

Note – This list is not complete. For example, some of these definitions apply to terms relevant to only some of the bearer services discussed in this Recommendation.

1.3.1 **delivered duplicate frames**

A frame D received by a particular destination user is defined to be a duplicated frame if both of the following conditions are true:

a) D was not generated by the source user;

b) D is exactly the same as a frame that was previously delivered to that destination.

1.3.2 **delivered errored frames**

A delivered frame is defined to be an errored frame when the value of one or more bits in the frame is in error, or when some, but not all, bits in the frame are lost bits or extra bits (i.e. bits that were not present in the original signal). (See Rec. X.140).

1.3.3 **delivered out-of-sequence frames**

Consider a sequence of frames F_1, F_2, f_3, . . ., F_n. Assume that F_1 is transmitted first, F_2 second, . . . F_n last.

A delivered frame F_i is defined to be out-of-sequence if it arrives at the destination user after any of the frames $F_{(i+1)}$, $F_{(i+2)}$, . . ., F_n.

1.3.4 **dynamic window control**

The term dynamic window control refers to a set of procedures based on which the transmitter's transmit window is modified, according to a user-perceived congestion condition in the network.

1.3.5 **end-to-end communication**

End-to-end communication is a direct peer-to-peer communication of TE to TE, or TE to a network interworking function (IWF) supporting, for example, PSPDN interworking.

1.3.6 **explicit congestion message**

Explicit congestion message is a message generated by the network and sent to a user terminal to indicate a congestion condition.

1.3.7 **implicit congestion control**

Implicit congestion control is a scheme under which user terminals first detct a possible congestion condition by means other than explicit congestion messages, and then take appropriate action to reduce their throughput.

1.3.8 **information integrity**

Information integrity is a network providing frame-relaying bearer service defines that all frames carried by the network shall satisfy the FCS check.

1.3.9 **logically separate (C-plane information)**

Logically separate means that C-plane information is sent separately from U-plane information in one of the following ways:

1) on a physically separate interface;

2) on another channel (time slot) within the same interface; or

3) on a separate logical link within the same channel (e.g., D-channel).

1.3.10 **lost frames**

A transmitted frame is declared to be a lost frame when the frame is not delivered to the intended destination user within a specified timeout period, and the network is responsible. (See Rec. X.140).

1.3.11 **misdelivered frames**

A misdelivered frame is a frame transferred from a source user to a destination user other than the intended destination user. It is considered inconsequential whether the information is correct or incorrect in content. (See Rec. X.140).

1.3.12 **quality of service (QOS)-parameter set** (See Rec. X.213)

For each QOS-parameter, a set of “subparameters” is defined from among the following possibilities:

a) a *target* value which is the QOS value desired by the calling user;

b) the *lower quality acceptable* value which is the lowest QOS value agreeable to the calling user. (When the lowest quality acceptable refers to throughput, the term "minimum" may be used, while when it refers to transit delay, the term "maximum" may be used.);

c) an *available* value which is the QOS that the network is willing to provide;

d) a *selected* value which is the QOS value to which the called user agrees.

1.3.13 **real time call establishment**

The term real time call establishment refers to a set of procedures based on which the communication can be started in a relatively short time (i.e. in the order of a few seconds) after the request is made. (See definition for demand communication establishment in Rec. I.130).

1.3.14 **residual error rate**

Residual error rate is defined for both the additional packet-mode bearer services and the corresponding layer services.

The layer services corresponding to the additional packet-mode bearer services are characterized by the exchange of service data units (SDUs). For frame relaying 1, SDUs are exchanged at the functional boundary between the core functions of Recommendation[1] and the end-to-end protocol implemented above them. For frame relaying 2 and frame switching, SDUs are exchanged at the functional boundary between the complete I.441* and the end-to-end functions implemented above I.441*. For the X.25-based additional packet mode service (APMS), SDUs are exchanged at the functional boundary of X.25 PLP-DTP (packet layer protocol-data transfer part) and the end-to-end functions implemented above.

The network participates in this exchange by means of protocol data units (PDUs). In frame relaying 1 and 2, PDUs are frames as defined in the core functions of I.441*. In frame switching, PDUs are frames as defined in I.441*, while in X.25-based APMS, they are packets as defined in X.25 PLP.

The residual error rate for the corresponding layer service of APMS is defined as:

$$R = 1 - \frac{\text{Total correct SDUs delivered}}{\text{Total offered SDUs}}$$

The residual error rate for the APMS is defined as the ratio:

$$R = 1 - \frac{\text{Total correct PDUs delivered}}{\text{Total offered PDUs}}$$

1.3.15 **throughput**

Throughput for a virtual connection section[2] in a network providing the frame relaying bearer service, is the number of data bits contained between the address field and the FCS field of the frames successfully transferred in one direction across that section per unit time. Successful transfer means that the FCS check for each frame is satisfied.

1.3.16 **transit delay**

Transit delay is defined only between pairs of section boundaries[3]. Transit delay of a frame protocol data unit (FPDU)[4] starts at the time t_1 at which the first bit of the FPDU crosses the first boundary, and ends at the time t_2 at which the last bit of the FPDU crosses the second boundary.

Transit delay = t_2-t_1.

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[1] I.441* is I.441 with appropriate extensions. The use of the extensions may depend on each bearer service and is for further study.

[2] Virtual connection section is defined in Rec. X.134.

[3] The definition of section boundaries is given in Rec. X.134.

[4] The definition of FPDU is given above in residual error rate.

2 Service aspects

2.1 *General service characteristics*

This Recommendation describes a set of potential packet mode bearer services that have the following characteristics in common:

1) All C-plane procedures, if needed, are performed in a logically separate manner using protocol procedures that are integrated across all telecommunications services (i.e. I.451 with appropriate extensions).

2) The U-plane procedures share the same layer 1 functions based on Rec. I.430/I.431. Moreover, they share the same core procedures, defined in § 3.1, that among other functions allow for statistical multiplexing of user information flows immediately above the layer 1 functions.

The basic bearer service provided by the network is the order preserving bidirectional transfer (see § 2.3.1) of service data units (i.e. frames or packets) from one S/T reference point to another. The data units are routed through the network on the basis of an attached label (e.g. the data link connection identifier (DLCI) value of the frame). This label is a logical identifier with local significance. In the virtual call case, the value of the logical identifier and the other associated parameters are negotiated during the call set-up by means of C-plane procedures. Depending on the bearer service and parameters, the network may accept or reject the user requested service. In the permanent virtual circuit case, the logical identifier and the other associated parameters are defined by means of administrative procedures. The network treatment of the data units, (e.g. unacknowledged transfer, acknowledged transfer, error recovery) in addition to simple transfer, depends on the specific bearer service requested.

The user network interface structure at the S/T reference point allows for the establishment of multiple virtual calls and/or permanent virtual circuits to many destinations.

2.2 *Quality of Service parameters*

Each potential bearer service described in this Recommendation provides service quality that is characterized by the values of the following parameters:

1) throughput;

2) transit delay;

3) information integrity;

4) residual error rate;

5) delivered errored frames;

6) delivered duplicated frames;

7) delivered out-of-sequence frames;

8) lost frames;

9) misdelivered frames;

10) others for further study.

Note – The applicability and values of these parameters for different bearer services are for further study.

2.3 *Individual bearer service descriptions*

This section contains descriptions of four specific potential bearer services proposed for standardization:

a) frame relaying 1,

b) frame relaying 2,

c) frame switching, and

d) X.25-based additional packet mode.

2.3.1 *Frame relaying 1 service description*

Frame relaying 1 shares with the other services the general service characteristics and quality of service parameters described in §§ 2.1 and 2.2, respectively.

The frame relaying 1 data units are frames as defined in Rec. I.441. The basic bearer service provided is the unacknowledged transfer of frames from S/T to S/T reference point. More specifically, in the U-plane:

1) it preserves their order as given at one S/T reference point if and when they are delivered at the other end.

Note – Since the network does not terminate the upper part of I.441, sequence numbers are not kept by the network. Networks should be implemented in a way that, in principle, frame order is preserved;

2) it detects transmission, format and operational errors (e.g. frames of unknown DLCI);

3) frames are transported transparently (in the network), only the address and FCS field may be modified;

4) it does not acknowledge frames (within the network).

All of the above functions are based on Rec. I.441. Appropriate extensions to the core functions of Rec. I.441 may be needed, e.g. for congestion control. In the C-plane all signalling capabilities for call control, parameter negotiation, etc. are based on a common set of protocols (e.g. Rec. I.451 extended), as for all ISDN telecommunication services. In the case of permanent virtual circuits (PVC) no real time call establishment is necessary and parameters are agreed upon at subscription time.

However, additional functions are needed:

– to monitor throughput and to enforce it,

– to control congestion.

The mechanisms to achieve these functions are still under investigation.

Appropriate protocol capabilities should be available so that the network may discard erroneous frames if it elects to do so. Note that if networks elect to forward erroneous frames to the user, fraud and misdelivery of frames may occur.

From the service perspective, frame relaying 1 provides service quality characteristics with the following parameter values:

(Parameter values are for further study).

2.3.2 *Frame relaying 2 service description*

Frame relaying 2 shares with the other services the general service characteristics and Quality of Service parameters described in §§ 2.1 and 2.2, respectively.

The frame relaying data units are frames as defined in Rec. I.441. The basic bearer service provided is an unacknowledged transfer of frames from S/T to S/T reference point. More specifically, in the U-plane:

1) it preserves their order as given at one S/T reference point if and when they are delivered at the other end.

Note – Since the network does not terminate th upper part of I.441, sequence numbers are not kept by the network. Networks should be implemented in a way that, in principle, frame order is preserved;

2) it detects transmission, format and operational errors (e.g. frames of unknown DLCI);

3) frames are transported transparently in the network, only the address and FCS field may be modified;

4) it does not acknowledge frames (within the network);

5) normally the only frames received by a user are those sent by the distant user. (Currently, implicit congestion control is preferred in which the network does not generate any congestion control messages toward the user. The generation of explicit congestion control messages by the network is for further study.)

All of the above functions are based on Rec. I.441. Appropriate extensions to Rec. I.441 may be needed, e.g. in relation to congestion control.

In the C-plane all signalling capabilities for call control, parameter negotiation, etc. are based on a common set of protocols (e.g. Rec. I.451 extended), as for all ISDN telecommunication services. In the case of permanent virtual circuits (PVC) no real time call establishment is necessary and any parameters are agreed upon at subscription time.

However, additional network functions are needed:

– to monitor throughput and to enforce it,

– to control congestion.

The mechanisms to achieve these functions are still under investigation.

Appropriate protocol capabilities should be available so that the network may discard erroneous frames if it elects to do so. Note that if networks elect to forward erroneous frames to the user, fraud and misdelivery of frames may occur.

The difference between the two types of frame relaying is that in frame relaying 2 the end points always implement, above the core functions, the upper part of Rec. I.441 extended. Consequently, in frame relaying 2 the network may take advantage of the knowledge of the layer 2 parameters in order to facilitate network operations such as charging and resource allocation. In frame relaying 1 the functions implemented end-to-end above the core functions are user selectable and may not be the upper part of Rec. I.441. Consequently, in frame relaying 1 the network in principle has no knowledge of the protocol used end-to-end.

From the service perspective, frame relaying 2 provides service quality characteristics with the following parameter values:

(Parameter values are for further study).

The terminal operates with an extended I.441 protocol. As a result the user perspective is the transparent transport of data end-to-end, with a quality influenced by the statistical multiplexing of data streams in the network. Acknowledgement of data is end-to-end as well as error detection and recovery.

2.3.3 *Frame switching service description*

Frame switching has general service characteristics and Quality of Service parameters as given in §§ 2.1 and 2.2, respectively.

In addition, in the U-plane, frame switching:

1) provides for the acknowledged transport of frames;

2) detects and recovers from transmission, format, and operational error;

3) detects and recovers from lost or duplicated frames;

4) provides flow control.

All of the above functions are based on Recommendation I.441. Appropriate extensions to Recommendation I.441 may be needed.

In the C-plane all signalling capabilities for all call control, parameter negotiation, etc. are based on a common set of protocols (e.g. Rec. I.451 extended), as for all ISDN telecommunication services. In the case of permanent virtual circuits no real time call establishment is necessary and any parameters are agreed upon at subscription time.

From the service perspective, frame switching provides service quality characteristics with the following parameter values:

(Parameter values are for further study).

2.3.4 *X.25-based additional packet mode service description*

X.25-based additional packet mode has general service characteristics and Quality of Service parameters similar to the packet mode services described in X.31.

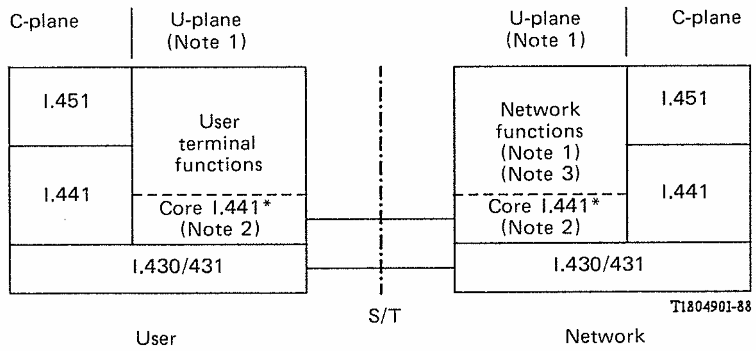
The U-plane capabilities are the same as in X.25 PLP Data Transfer Part (DTP)

In the C-plane all signalling capabilities for call control, parameter negotiation, etc. are based on a common set of protocols (e.g. Rec. I.451 extended), as for all ISDN telecommunication services. In the case of permanent virtual circuits (PVC) no real time call establishment is necessary and any parameters are agreed upon at subscription time.

3 User-network interface protocol reference model

Figure 1/I.122 is a direct application of the ISDN protocol reference model to the packet mode communications discussed in this Recommendation. It shows the user-network interface protocol architecture. Only those functions on the network side that are visible on the user side of the S/T reference point are shown.

On the user side, Recommendations I.430 or I.431 provide the layer 1 protocol for the U- (user) C- (control) planes. The C-plane uses the D-channel with Recommendations I.441 extended and I.451 extended as the layer 2 and 3 protocols, respectively. In the case of permanent virtual circuits (PVC) no real time call establishment is necessary and any parameters are agreed upon at subscription time. The U-plane may use any channel (D, B, H_0 and H_1) on which the user implements at least the lower part (the core functions) of Recommendation I.441.



Note 1 – The U-plane functions applicable to each bearer service are given in Table 1/I.122.

Note 2 – The core functions of Recommendation I.441 are described in § 3.1.

Note 3 – The U-plane functions provided by the network at the S/T reference point are determined by the network after negotiation with the user, based on the requested bearer service and associated parameters. These functions are user selectable for each call. A network may choose not to implement the full set of options. These functions may not be available one by one. So far only three groupings have been identified:

a) the null set,

b) the upper part of Rec. I.441, and

c) the upper part of Rec. I.441 and the data transfer part of X.25 PLP.

FIGURE 1/I.122

User/network interface protocol architecture

TABLE 1/I.122

U-plane functions applicable to each bearer service

Bearer service	User terminal (Note 1)	Network
Frame relaying 1	I.441* Core (Note 2)	I.441* Core
Frame relaying 2	I.441*	I.441* Core
Frame switching	I.441*	I.441*
X.25-based additional packet mode	I.441* X.25 DTP	I.441* X.25 DTP

Note 1 – Additional user selectable functions may be implemented.

Note 2 – I.441* is I.441 with appropriate extensions. The use of the extensions may depend on each bearer service and is for further study.

3.1 *Core functions of Rec. I.441*

The core functions are:

– frame delimiting, alignment, and transparency,

– frame multiplexing/demultiplexing using the address field,

– inspection of the frame to ensure that it consists of an integer number of octets prior to zero bit insertion or following zero bit extraction,

– inspection of the frame to ensure that it is neither too long nor too short (see Note),

– detection of transmission errors.

Note – The maximum and minimum frame lengths that apply to the Additional packet mode bearer services are for further study.

3.2 *Other user terminal functions*

If not already prescribed by the selected packet mode bearer service, the user may also implement functions such as, for example, recovery from detected transmission, format, and operational errors above the core functions using the full procedures of Recommendation I.441. Additional functions such as flow control may also be implemented. For example, X.25 data transfer functions may also be implemented above the preceding stack.

3.3 *Network functions*

On the network side, Recommendations I.430 or I.431 provide the layer 1 protocol for both C- and U-planes. The C-plane is handled just as on the user side, i.e. the network fully terminates the protocols of Recommendations I.441 and I.451. In the U-plane, at least the core functions of Recommendation I.441 protocol are terminated. The network may terminate additional protocol functions only as requested by the user and negotiated and agreed to by the user and the network. The U-plane protocols to be terminated by the network are determined by the specific bearer service requested by the user, and negotiated and agreed to by the user and network.

Interactions between the U- and C-planes of the terminal, and between the U- and C-planes of the network are independent. As a result, coordination between the U- and C-planes at the users equipment is not the responsibility of the network.

During the three phases of a call (call establishment, data transfer, and call clearing), C- and U-plane synchronization is achieved in a similar way as for all ISDN telecommunications services. That is, after the C-plane has established the connection, the U-plane may commence data transfer with or without an initialization procedure in the U-plane. In the case of permanent virtual circuit the establishment and call clearing is accomplished by administrative procedures.

3.4 *Further service requirements at the user-network interface*

Procedures at the user-network interface should be also applicable when two users are connected via a circuit mode bearer service (permanent or demand). Mechanisms that can be used to achieve this objective include, for example, the symmetrization of the procedure involved, or the use of additional procedures for the determination of the asymmetric relationships. The selection of such a mechanism is for further study.

3.5 *Potential bearer services*

Four potential bearer services are identified as part of this architectural framework. The first potential bearer service, frame relaying 1, is provided when no functions above the core functions are terminated by the network: if needed, such functions are terminated only end-to-end.

The second potential bearer service, frame relaying 2, is provided when no functions above the core functions are terminated by the network; I.441 upper functions are terminated only at the end points.

The third potential bearer service, frame switching, is provided when the full Recommendation I.441 protocol is terminated by the network.

The fourth potential bearer service, X.25-based additional packet mode, is provided when the full Recommendation I.441 protocol and the data transfer part (DTP) of Recommendation X.25 PLP (packet layer protocol) are terminated by the network.

Further information on the service characteristics of these four potential bearer services is given in Annex A.

4 Interworking requirements

4.1 *Interworking between packet mode services*

To interconnect different packet mode bearer services, it is necessary to provide interworking between an ISDN offering any of the bearer services described in this Recommendation, and:

1) an ISDN offering any of these additional packet mode bearer services,

2) an X.25-based service offered either by an ISDN or a PSPDN.

For interworking configuration 1), procedures for both the C-plane and the U-plane at an internetwork reference point which includes international gateway reference points, have to be standardized. In addition it would be desirable that these procedures be developed in such a way that they also could be used at an inter-exchange reference point within an ISDN offering any of the bearer services described in this Recommendation. Examples of such procedures may include: routing, address translation, security and accounting tasks.

For interworking configuration 2), interworking based on either call control mapping or port access is possible. A high level description of interworking arrangements is contained in Annex B.

4.2 *Support of existing terminals*

Additionally, terminal adapter functions should be provided that allow existing terminals (e.g. asynchronous, start/stop DTEs, X.25 packet mode DTEs and V-Series interface terminals) to access from an ISDN one or more of the bearer services described in this Recommendation.

4.3 *Interworking with circuit mode services*

Other service interworking configurations (e.g. with a CSPDN, or between different bearer services within an ISDN) may also need to be considered.

5 Support of OSI connection-oriented network layer service

In the interworking between an ISDN offering any of the bearer services described in this Recommendation and X.25-based service offered either by an ISDN or a PSPDN, an interworking function (IWF) is required.

To support network layer service (Rec. X.213) when the bearer service used is one of the bearer services described in this Recommendation, the use of additional end system functionality may be required and end-to-end (i.e. TE-to-TE or TE-to-IWF) compatibility must be ensured.

Annex C contains requirements for the support of network layer service (Rec. X.213).

6 Applications

Packet mode bearer services described in this Recommendation aim at data services up to 2 Mbit/s. Within this broad category, some specific applications are as follows:

1) *Block interactive data applications*

   An example of a block interactive application would be high resolution graphics (e.g. high resolution videotex, CAD/CAM). The main characteristics of this type of application are low delays [e.g. approximately less than . . . ms (the exact value is for further study)] and throughput approximately in the range of 500 kbit/s to 2048 kbit/s.

2) *File transfer*

   The file transfer application is intended to cater for large file transfer requirements. Transit delay is not as critical for this application as it is for example in the first application. Higher throughput (e.g. 16 kbit/s to 2048 kbit/s) might be necessary in order to produce reasonable transfer times for large files.

3) *Multiplexed low bit rate*

   The multiplexed low bit rate application exploits the multiplexing capabilities of the layer 2 protocol in order to provide an economical access arrangement for a large group of low bit rate applications. The low bit rate sources should be multiplexed onto any ISDN-channel by an NT function which could take the form of a LAN, PABX, or Centrex. The delay requirements are in the area of . . . ms (the exact value is for further study) and the throughput within the range of 16 kbit/s to 2048 kbit/s.

4) Character-interactive traffic

   An example of a character-interactive traffic is text editing. The main characteristics of this type of applications are short frames, low delays and low throughput.

Identification of additional applications and their characteristics (e.g. delay, throughput, etc.) for bearer services described in this Recommendation are desirable for the complete definition of the service requirements.

ANNEX A

(to Recommendation I.122)

Further service-related information

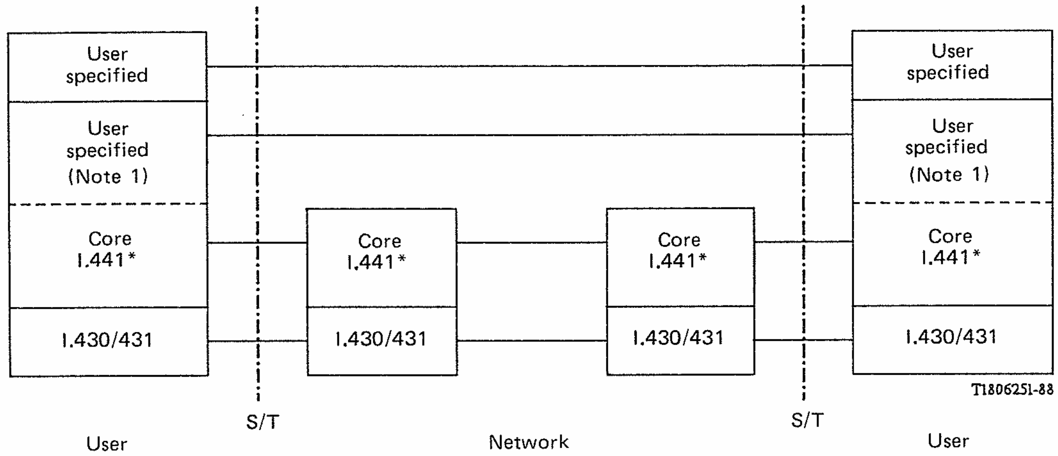
A.1 *Introduction*

This Annex contains further service related information on the I.122 based bearer services. The intent of this Annex is to clarify and supplement the service descriptions given in the main body of this Recommendation. Note that the information given in this Annex should not be interpreted as material that completes the service descriptions of the bearer services given in this Recommendation.

A.2 *Service related information*

A.2.1 *Frame relaying 1*

The U-plane configuration for this service is shown in Figure A-1/I.122.



Note – I.441* (upper) is one protocol. Other standard or proprietary protocols may also be used. Additional requirements may be placed on terminals depending on the congestion control and throughput enforcement used.

FIGURE A-1/I.122

Frame relaying 1 service U-plane

Figure A-1/I.122 shows the network in a generic way and illustrates all U-plane functions up to and including layer 3. In a specific network, frame relaying 1 may be implemented in one or more nodes, all other nodes in the network providing only circuit-mode functions.

Frame relaying 1 can be offered on both, basic and primary rate interfaces and on any ISDN channel (D, B, and H). Some restrictions (e.g. frame length) apply when in an end-to-end connection at least one of the access channels is the D-channel (16 kbit/s).

The bearer service provided by the network at the S/T reference point supports only the core functions defined in § 3.1. A frame received by such a point is discarded if the frame does not meet the I.441 core format requirements (for example, if the frame is too long, has an unknown label, etc.). Moreover, frames may be discarded due to internal network conditions, or other reasons such as throughput enforcement.

In all other cases, the frame is relayed to one of the adjacent nodes according to the routing plan established at call set-up time, or at subscription time (if the network is providing a permanent virtual circuit service).

No additional U-plane functions (see Note) visible to the users are performed by the network. If needed by the application, additional functions are performed end-to-end by layer(s) above the core functions.

Note – Some additional auxiliary U-plane functions such as reset or explicit congestion control may be defined if needed from the service perspective.

A.2.2 *Frame relaying 2*

The U-plane configuration for this service is shown in Figure A-2/I.122.

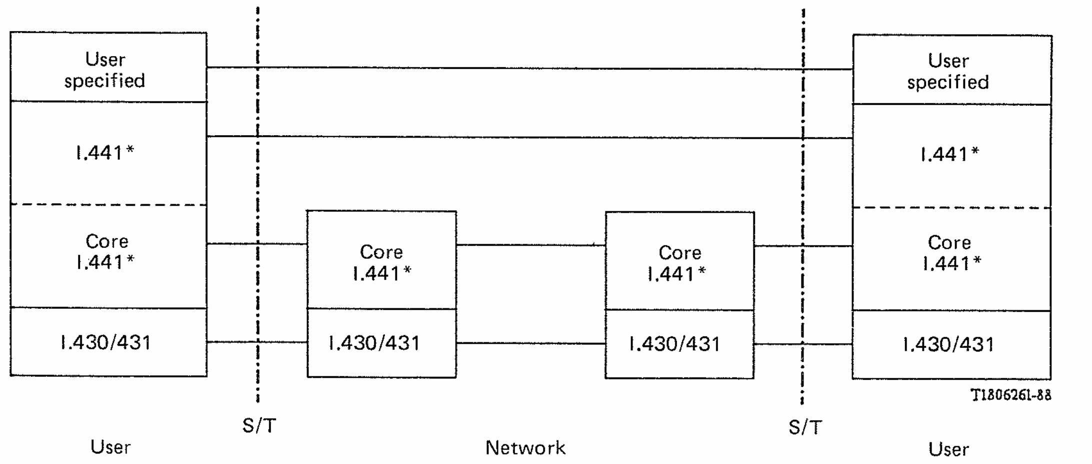


FIGURE A-2/I.122

Frame relaying 2 service, U-plane

Figure A-2/I.122 shows the network in a generic way and illustrates all U-plane functions up to and including layer 3. In a specific network, frame relaying 2 may be implemented in one or more nodes, all other nodes in the network providing only circuit-mode functions.

Frame relaying 2 can be offered on both, basic and primary rate interfaces and on any ISDN channel (D, B, and H). Some restrictions (e.g. frame length) apply when in an end-to-end connection at least one of the access channels is the D-channel (16 kbit/s).

The bearer service provided by the network at the S/T reference point supports only the core functions defined in § 3.1. A frame received by such a point is discarded if the frame does not meet the I.441 core format requirements (for example, if the frame is too long, has an unknown label, etc.). Moreover, frames may be discarded due to internal network conditions, or other possible reasons such as throughput enforcement.

The terminals operate end-to-end with the complete I.441* protocol. In all other cases, the frame is relayed to one of the adjacent nodes according to the routing plan established at call set-up time, or at subscription time (if the network is providing a permanent virtual circuit service).

No additional U-plane functions (see Note) visible to the users are performed by the network. If needed by the application, additional functions are performed end-to-end by layer(s) above the core functions.

Note – Some additional auxiliary U-plane functions such as reset or explicit congestion control may be defined if needed from the service perspective.

A.2.3 *Frame switching*

The U-plane configuration for this service is shown in Figure A-3/I.122.

Figure A-3/I.122 shows the network in a generic way and illustrates all functions up to and including layer 3. In a specific network, frame switching must be implemented in at least one node in the network.

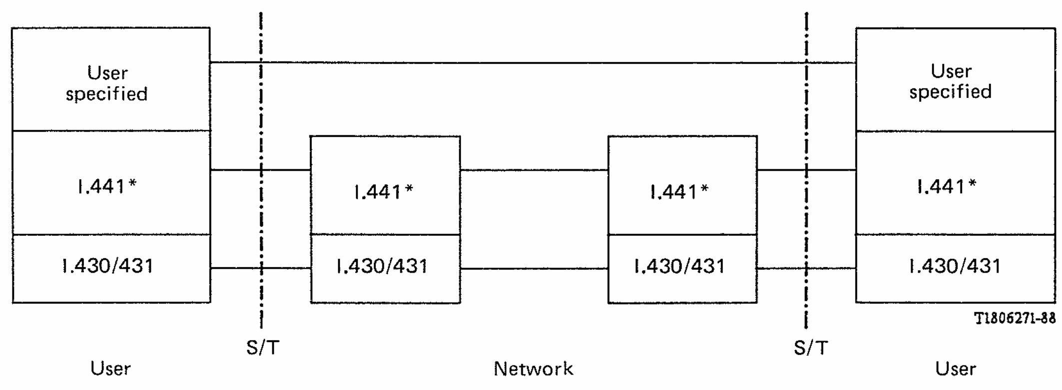


FIGURE A-3/I.122

Frame switching service, U-plane

Frame switching can be offered on both basic and primary rate interfaces and on any ISDN channel (D, B, and H). Some restrictions (e.g. frame length) apply when in an end-to-end connection at least one of the access channels is the D-channel (16 kbit/s).

The bearer service provided by the network at the S/T reference point supports the full Recommendation I.441 function. Received frames that satisfy the Recommendation I.441 procedure are passed on to an adjacent node according to a routine plan established at call set-up time, or at subscription time.

No additional U-plane functions visible to the users are performed in the network. If needed by the application, additional functions are performed end-to-end by layer(s) above layer 2.

A.2.4 *X.25-based additional packet mode*

The U-plane configuration can comprise several nodes having layer 1, layer 2, and layer 3 functions as is shown in Figure A-4/I.122. Figure A-4/I.122 shows the network in a generic way and illustrates all functions up to and including layer 3. Other configurations with nodes making use only of the core aspects of Recommendation I.441 as defined in § 3.1 of Recommendation I.122 are possible.

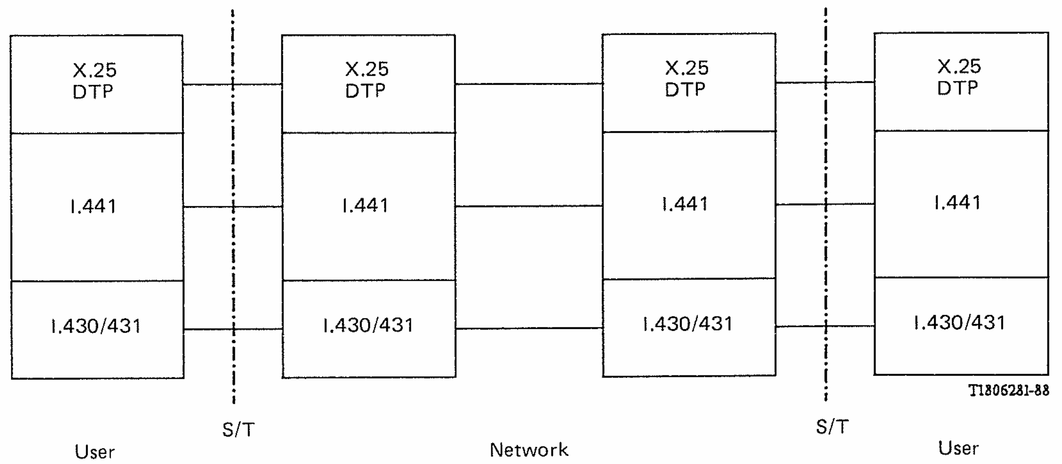


FIGURE A-4/I.122

X.25 based packet mode service, U-plane

X-25-based additional packet mode service can be offered on both the basic and primary rate ISDN access interfaces and on any ISDN channel (D, B, and H). Some restrictions (e.g. packet length) apply when in an end-to-end connection at least one of the access channels is the D-channel (16 kbit/s).

The bearer service provided by the network at the S/T reference point supports the full Recommendation I.441 and the data transfer part of Recommendation X.25 PLP functions.

The U-plane contains X.25-based layer 3 functions and the C-plane procedures use Recommendation I.451 extended to transfer the parameters necessary for the establishment and release of virtual circuits (e.g. throughput class, window size, etc.). The capability to negotiate some parameters must also be provided. Whether or not X.25 multiplexing is provided is for further study.

X.25 PLP-DTP consists of all X.25 PLP functions with the exception of the connection establishment and release functions, including user facilities (supplementary services). The exclusion of other X.25 PLP functions is for further study.

ANNEX B

(to Recommendation I.122)

General arrangement for interworking between an ISDN where I.122 bearer services are requested and an ISDN or a PSPDN providing service based on Recommendation X.25

B.1 *Possible scenarios*

Figure B-1/I.122 shows the interworking arrangements considered. When the interworking function IWF logically belongs to the ISDN (Recommendation I.122), interworking based on call control mapping takes place. In the case where the IWF logically belongs to the PSPDN (Recommendation X.25) or ISDN (Recommendation X.31), interworking based on either call control mapping or port access is possible. As shown in the figure, different interfaces can be specified for the different reference points, depending on whether the IWF logically belongs to the ISDN (Recommendation I.122), or to the PSPDN (Recommendation X.25) or ISDN (Recommendation X.31).

B.2 *IWF logically belonging to ISDN (Recommendation I.122)*

To enable interworking, the I.122 bearer services, in conjunction with an IWF, should provide full support of the X.213 network layer services. The association of an ISDN (Recommendation I.122) with an IWF in such a manner could therefore be considered globally as a Type I subnetwork, in the sense defined in Recommendation X.300.

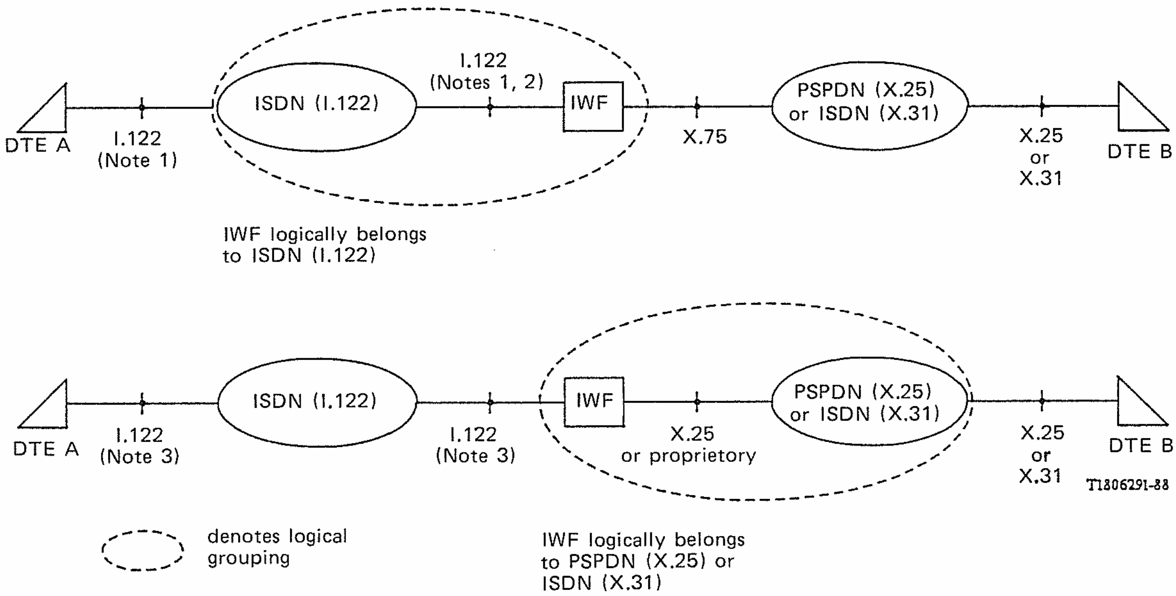
A PSPDN (Recommendation X.25) or an ISDN (Recommendation X.31) could also be considered as a Type I subnetwork.

As specified in Recommendation X.300, the interworking arrangement between two Type I subnetworks should be based on Recommendation X.75.

B.3 *IWF logically belonging to the PSPDN (Recommendation X.25)/ISDN (Recommendation X.31)*

The association of a PSPDN (Recommendation X.25)/ISDN (Recommendation X.31) with an IWF together behaves like a user terminal requesting I.122 service from an ISDN (Recommendation I.122). Therefore, the interworking arrangement can be based on Recommendation I.122.

In this arrangement, interworking based on either call control mapping or port access is possible. When port access method is used, existing call control procedures in Recommendation X.25 are used for the control of virtual circuits.



Note 1 – To achieve functional compatibility, additional procedures may be required in the U-plane. These procedures terminate at the IWF, and are mapped into X.75 procedures.

Note 2 – In the C-plane, Signalling System No. 7 or Rec. I.451 with appropriate extensions, or proprietary protocols with equivalent functions, may be used.

Note 3 – To achieve functional compatibility, additional procedures are required in the U-plane in the case of interworking based on port access. These procedures terminate at the IWF, and are mapped into Rec. X.25 procedures.

FIGURE B-1/I.122

Interworking between ISDN (Rec. I.122) and PSPDN (Rec. X.25) or ISDN (Rec. X.31)

ANNEX C

(to Recommendation I.122)

Support of network layer service (X.213) in an ISDN offering additional packet mode bearer services

C.1 Network layer service can be provided by using the X.25-based additional packet mode bearer service. In this case the mapping concerns enhanced Recommendations I.451 and X.25 data transfer functions. In the case of frame switching and frame relaying, the network layer service can be provided through the use of enhanced Recommendation I.451, with, in addition:

a) additional end system functionality, or

b) enhanced I.441 functions.

C.2 *C-plane enhancements*

Recommendation I.451 should be enhanced so that the OSI network service parameters can be paired with Recommendation I.451 messages and information elements for all bearer services. Several enhancements to Recommendation I.451 are needed to convey all connection establishment and release primitives and parameters in relevant I.451 protocol elements.

C.3 *U-plane enhancements*

For frame switching and frame relaying, there are two different approaches for the mapping of data transfer primitives into protocol elements:

1) layer 3 protocol elements supported by a DTE specific protocol which is transparent for the network (preferably X.25 PLP), and

2) I.441 protocol elements enhanced to map directly into the OSI network service data transfer primitives.

Further study is required for the selection and detailed definition of one of the two options.

ANNEX D

(to Recommendation I.122)

Congestion control in frame relaying service

Note – This Annex does not cover congestion control in frame switching and X.25-based additional packet mode bearer services. This is because in these services, there is termination of user data transfer protocol in the network and so existing mechanisms for congestion control can be used.

D.1 *General objectives of congestion control*

The term "congestion control" as used here refers to a set of mechanisms incorporated to attain certain network performance objectives, particularly in the peak periods, while optimizing or improving the network resource requirements.

1) The network should, with high probability, meet the Quality of Service in terms of throughput, delay and availability negotiated with the user. Therefore, the number of occurrences of user perceived congestion should be minimized.

2) Under heavy load, the network should not allow user interference to the extent where one user can monopolize network resource usage at the expense of other users.

Specific congestion control mechanisms to achieve these objectives are for further study. One possible approach of congestion control is presented below.

D.2 *User reaction to network congestion*

The network has no other direct control on the data flow of a user other than dropping frames. It does so without sending explicit congestion control messages to the user. Frame discard by a network may have charging implications. This requires further study.

Users should reduce their information transfer rate when they perceive the impact of network congestion. Reduction of throughput by a user may well result in an increase of the effective throughput available to the user during congestion.

It is suggested that a user of frame relaying 1 service implement some form of congestion-sensitive adaptation function that has the following characteristics:

i) no blocking of data flow under normal conditions,

ii) reduction to a lower throughput upon detection of network congestion,

iii) progressive increase to the maximum negotiated throughput upon congestion abatement.

For frame relaying 2 service, the user is required to implement the above congestion-sensitive adaptation function through the use of the windowing mechanism in Recommendation I.441. In this case, the user will base the detection of congestion on events available in the I.441 elements of procedure (e.g. receipt of a REJECT frame, detection of frame loss, etc.). The user dynamically adjusts its window size in accordance with network congestion condition.

D.3 *Control action by the network congestion*

Users of frame relaying services should reduce their information transfer rate when they perceive the impact of network congestion (see § 2). But the network cannot rely solely on the user's behaviour to control network congestion. This is the case for both frame relaying 1 and frame relaying 2 services.

The network should monitor the throughput of each call/interface and exercise a frame discard strategy under congestion conditions, for those calls/interfaces that exceed their negotiated throughput. However, because congestion can occur even when the calls do not exceed their negotiated throughput (e.g. network failures), the network should discard frames in a way that assures some fairness among users.

The selection of mechanism(s) which may be used by the network for this purpose are for further study.

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