ETSI TECHNICAL REPORT

ETR 016

April 1991

Source: ETSI TC-BT

Reference: DTR/BT-02002

ICS: 33.060.20

Key words: PTN, performance

Business Telecommunications (BT); Serveability performance objectives for Private Telecommunications Networks (PTN)

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Foreword

ETSI Technical Reports (ETRs) are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim - European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or I-ETS.

This ETR has been produced by the Business Telecommunications (BT) Technical Committee of the European Telecommunications Standards Institute (ETSI).

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Chapter I: General

1 Scope and field of application

This technical report deals with serveability performance objectives for Private Telecommunication Networks (PTN). It contains 5 chapters:

Chapter I is the general introduction.

Chapter II specifies portion boundaries, reference connections and reference events to be used in the definition of performance parameters for Private Telecommunication networks.

As the performance of a Private Telecommunication Network in some implementations is dependent on the performance of an intervening public ISDN, the defined portion boundaries, reference connections and reference events also take the public ISDN into consideration.

Chapter III specifies speed of service performance objectives. Four parameters are defined : overall connection set-up delay, overall alerting delay, disconnect delay and release delay.

Chapter IV specifies the accuracy and dependability performance objectives. Four parameters are defined : call set-up error probability, call set-up failure probability, premature disconnect probability and call clear failure probability.

Chapter V specifies availability parameters and values to be used in planning and operation of these networks. Two parameters are defined and specified; service availability and mean time between service outages.

The serveability performance objectives relate to ISDN bearer service circuit switched 64 Kbit/s unrestricted basic connections established on demand.

The objectives specified take into account physical bearers, switching and transmission equipment between interfaces at the S reference points. Extension terminal equipment and failures due to incorrect use are not considered.

NOTE: Annex A contains a list of abbreviations used in this Technical Report.

2 Planning guidelines

This technical report provides guidelines to be used when planning a private telecommunication network (PTN), which may contain public network portions.

The apportionment boundaries, reference connections and reference events defined in this report can be used as a base for apportioning the network performance. In the case where the performance of a PTN is dependent on an intermediate public ISDN, the apportionment boundaries, reference connections and reference events specified shall be used as base also for apportioning the network performance of the intermediate public ISDN.

The performance values specified in this report should be taken as worst-case limits under the conditions specified herein. The term "worst-case" means that these values should be met during normal busy hour in the worst performing portion. The performance of a connection may be better than the worst case values specified in this report.

In the hybrid (private/public) case, when the expected connection may operate near to the worst case performance, negotiation should take place with the public network provider when installing the connection.

3 Normative references

This European Technical Report (ETR) incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] CCITT Recommendation I.350: "General aspects of quality of service and network performance in digital networks, including ISDNs".

[2] CCITT Recommendation I.351: "Recommendations in other services including network performance objectives that apply at T reference point of an ISDN".

[3] CCITT Recommendation I.352: "Network performance objectives for connection processing delays in an ISDN".

[4] CCITT Recommendation Q.709: "Hypothetical Signalling Reference Connection".

[5] CCITT Recommendation X.130: "Call processing delays in public networks when providing international synchronous circuit-switched date services".

[6] CCITT Recommendation X.131: "Call blocking in public data networks when providing international synchronous circuit-switched data services".

[7] CCITT Recommendation X.134: "Portion boundaries and packet layer reference events; basis for defining packet switched performance parameters".

[8] CCITT Recommendation X.135: "Delay aspects of grade of service for public data networks when providing international packet-switched data services".

[9] CCITT Recommendation X.136: "Accuracy and dependability performance values for public data networks when providing international packet-switched services".

[10] CCITT Recommendation X.137: "Availability performance values for public data networks when providing international packet-switched service".

[11] CCITT Recommendation X.140: "General quality of service parameters for communication via public data networks".

[12] CCITT Recommendation E.800: "Quality of service and dependability vocabulary".

[13] prENV 41 007-1: "Definition of terms in private telecommunication networks".

[14] prENV 41 004: "Reference configurations for calls through exchanges of private telecommunication networks".

[15] prENV 41 006: "Scenarios for interconnections between exchanges of private telecommunication networks".

[16] CCITT Recommendation E.850: "Connection retainability objective for the international telephone service".

NOTE: The CCITT documents above are approved Recommendations. Further work is in progress aiming at CCITT Recommendations on General Aspects (I.350R, I.351R, I.35E), Connection processing (I.352R), Service Availability (I.35A) and Circuit Mode Transfer (I.35C).

4 Definitions

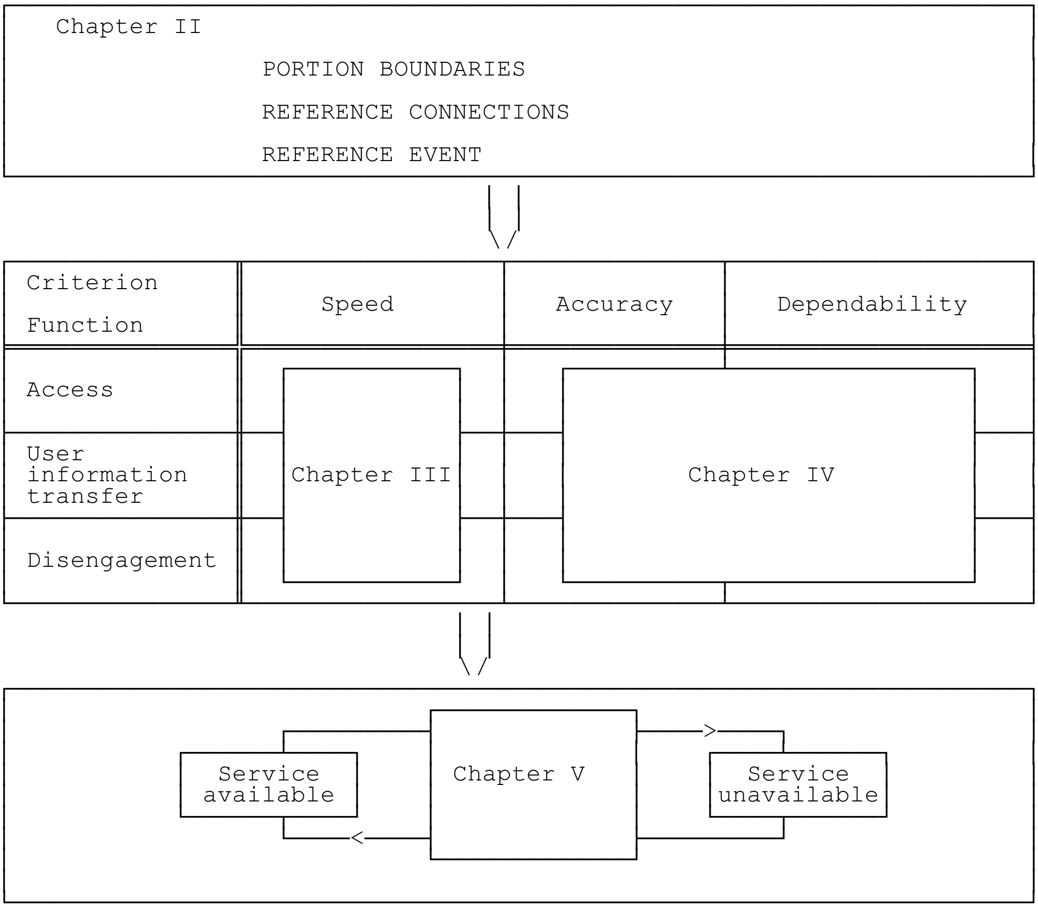


Figure 1: Approach to serveability performance objectives standardisation

The approach used in this Technical Report is based upon the models described in CCITT Recommendation X.134 [7] X.137 [10] and CCITT Recommendation I.350 [1].

Figure 1 gives an overview of this approach and the relation between chapters concerned. The approach consists of four basic steps:

[1] A set of boundaries is defined to delimit an end-to-end connection into concentrated sub-elements or portions. Communication across each boundary are characterized by a set of reference events, each of which corresponds to a particular protocol state transition.

[2] Primary performance parameters are defined on the basis of the reference events. The primary parameters describe the speed, accuracy and dependability of a connection element in performing three primary communication functions; access (or call set up), user information transfer and disengagement (or call clearing).

[3] Service outages are defined by comparing the observed values for certain primary parameters (the "decision parameters") with corresponding outage thresholds. This provides a basis for classifying the service, at any time, as being "available" (no service outage) or unavailable (service outage).

[4] Specific availability parameters are defined to characterize the resulting binary random process. Statistical procedures are defined to enable the availability parameters to be estimated on the basis of intermittent observations.

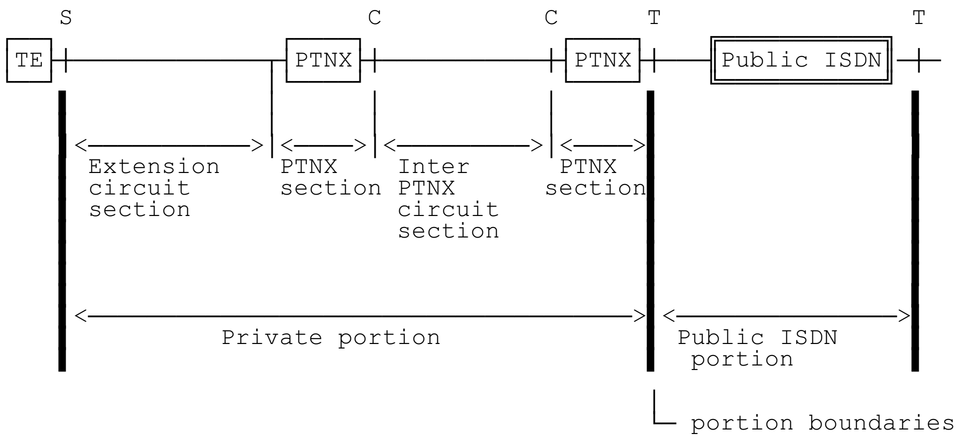


Figure 2: Definition of sections and portions

For definition of general terms used, reference is made to documents listed above. For the special application of these models to private networks, i.e. for the context of this technical report, the following definitions apply (see figure 2):

An **extension circuit section** is the physical circuit or set of circuits connecting a TE (at the interface at the S reference point) to a PTNX (at the physical implementation of the Private Network Termination (PT) functional grouping). It does not include any parts of the TE or the PTNX (the PT is regarded as a part of the PTNX). Terminal adapters (TAs) are considered part of the TE. It is assumed that protocols defined at the S reference point are used on this section.

An **inter PTNX circuit section** is the physical circuit or set of circuits connecting (between the interfaces at the C reference points) two adjacent PTNXs (Reference is made to prENV 41 006 [15], item 7.1). It does not include any parts of the PTNX. It is assumed that protocols defined at the Q reference point are used at this section.

A **PTNX section** is a physical implementation of a PTNX between interfaces at C reference points, between (and including) the physical implementation of the Private Network Termination functional grouping and the interface at the C reference point or between the interfaces at the C and T reference points.

A **section boundary** (or **boundary**) separates a circuit section from the adjacent PTNX section, terminal or public ISDN portion (see chapter II).

Chapter II: Portion boundaries, reference connections and reference events

1 Portion boundaries

A **private portion** of an end to end connection, including an intervening public ISDN, consists of one extension circuit section and the collection of adjacent alternating PTNX sections and inter PTNX circuit sections.

A **public ISDN** portion of an end to end connection consists of the public ISDN between two interfaces at T reference points as defined in CCITT Recommendation I.325.

A **portion boundary** is a section boundary delimiting a private or a public ISDN portion.

For illustration of sections, portions and boundaries, see chapter I, figure 2.

2 Reference connections

2.1 General

Two general reference connections will be used in this technical report:

A **private reference connection** consisting of two extension circuit sections and the collection of adjacent alternating PTNX sections and inter PTNX circuit sections (figure 3).

A **hybrid reference connection** consisting of two private portions and one intermediate public ISDN portion (figure 4)

For the hybrid reference connection, end-to-end performance values will be dependent on the performance values of the private portions and the intermediate public ISDN portion. As these may have different network operators, network performance parameters and values will have to be defined end-to-end as well as for these portions alone.

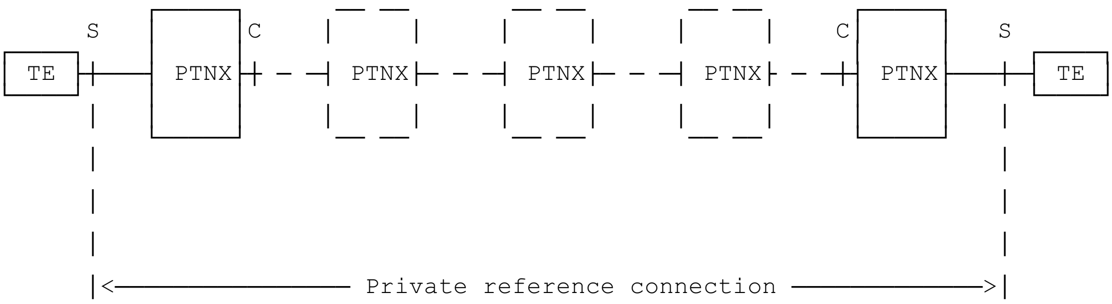


Figure 3: Private reference connection

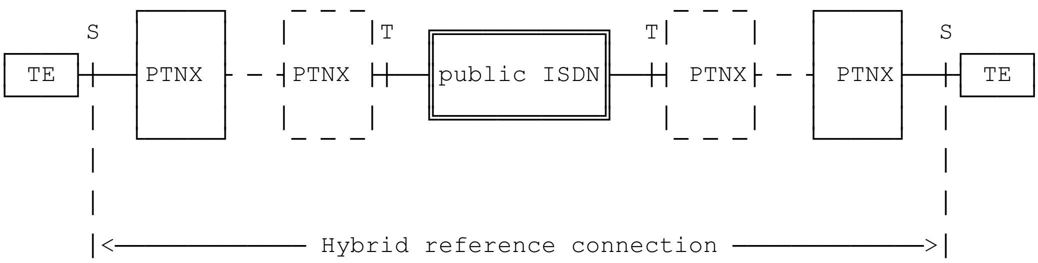


Figure 4: Hybrid reference connection

2.2 PTNX implementation dependent reference connections

In the case where performance parameters or values are dependent on type of PTNX implementation, four PTNX implementation dependent reference connections will be used:

I1 a private reference connection, where the PTNXs are implemented as ISPBXs

I2 a hybrid reference connection where the PTNXs are implemented as ISPBXs

I3 a hybrid reference connection where the PTNXs are implemented as ISCTXs (in the sense that there is no interface at the T reference point)

I4 a hybrid reference connection where the originating/terminating PTNX is implemented as an ISPBX and the terminating/originating PTNX is implemented as an ISCTX.

NOTE: In the case when an ISCTX is implemented with an interface at the T reference point, it should from a serveability performance objectives point of view be regarded as an ISPBX.

3 Reference events

All parameter values in the context of this Technical Report are specified at portion boundaries and are measured using the relevant call processing message transfer events (MTEs).

Figures 5 to 10 give examples of relevant MTEs. They show the message sequences across the PTN when a call is initiated or cleared between TE A (the calling number in the examples is 12345) and TE B (called number is 14345 in the examples).

Performance-significant reference events are specified in chapters III to V respectively.

Some specific abbreviations are used in the examples:

cr1 to 4 : call references in the different sections.
cse : cause elements eg for not being successful.
CPN : Called Party Number.

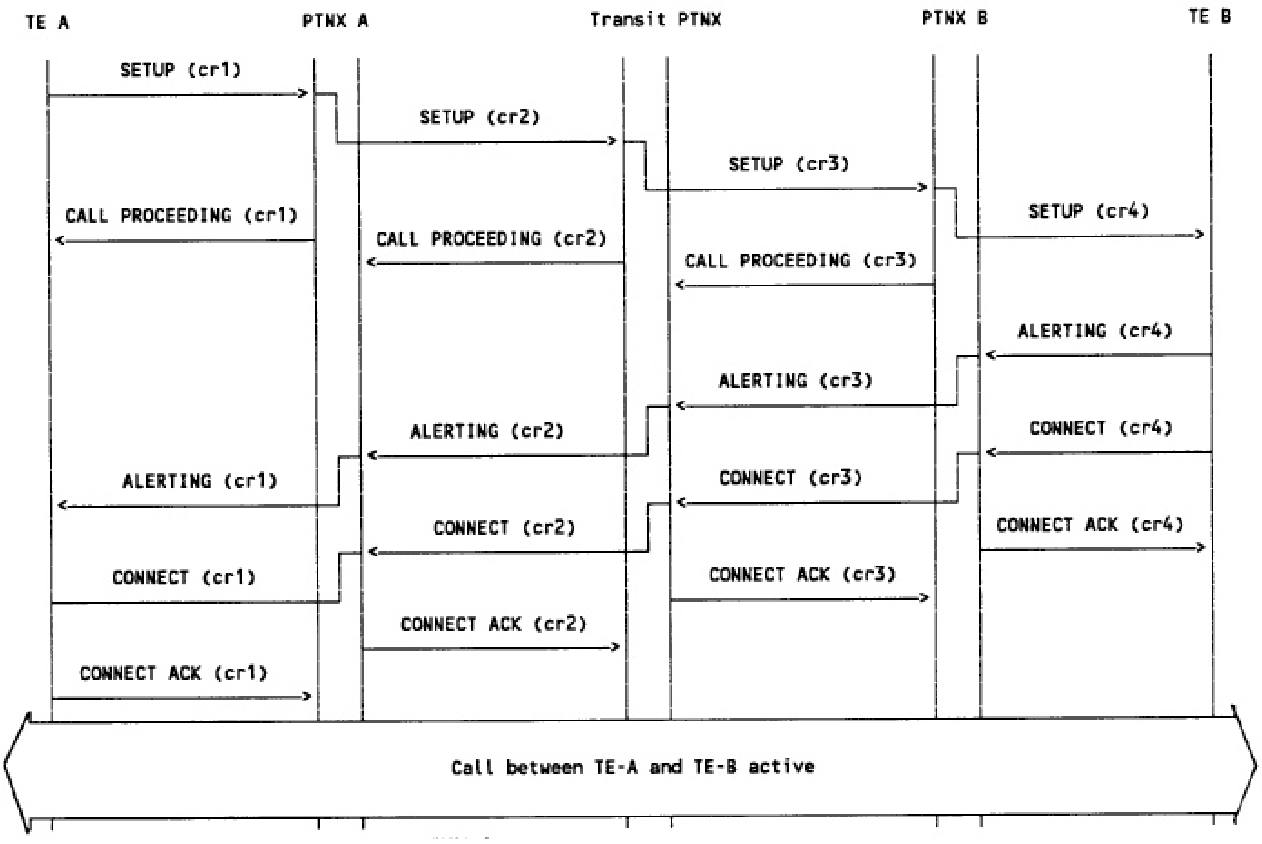


Figure 5: Enbloc setup, successful call

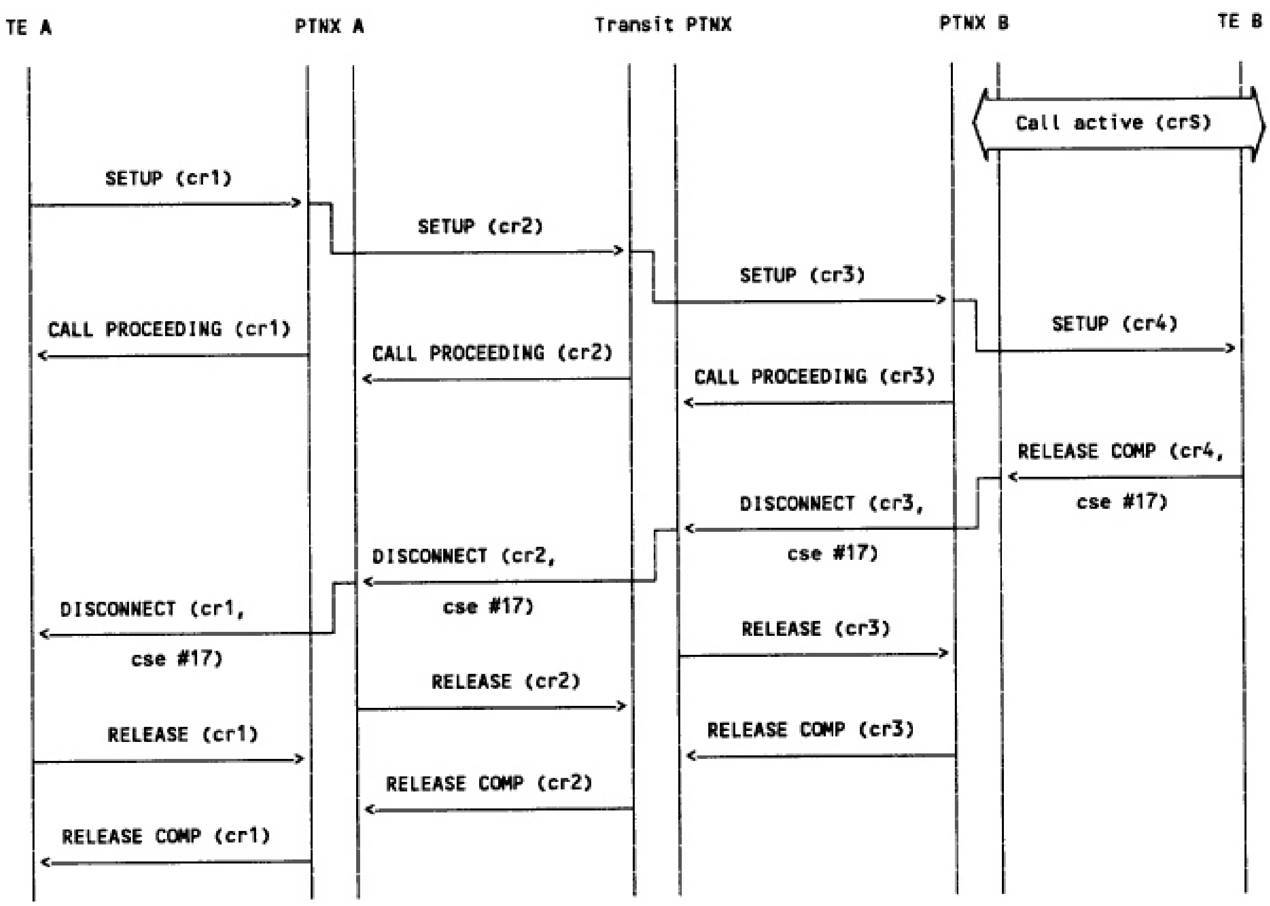


Figure 6: Enbloc setup, unsuccessful call

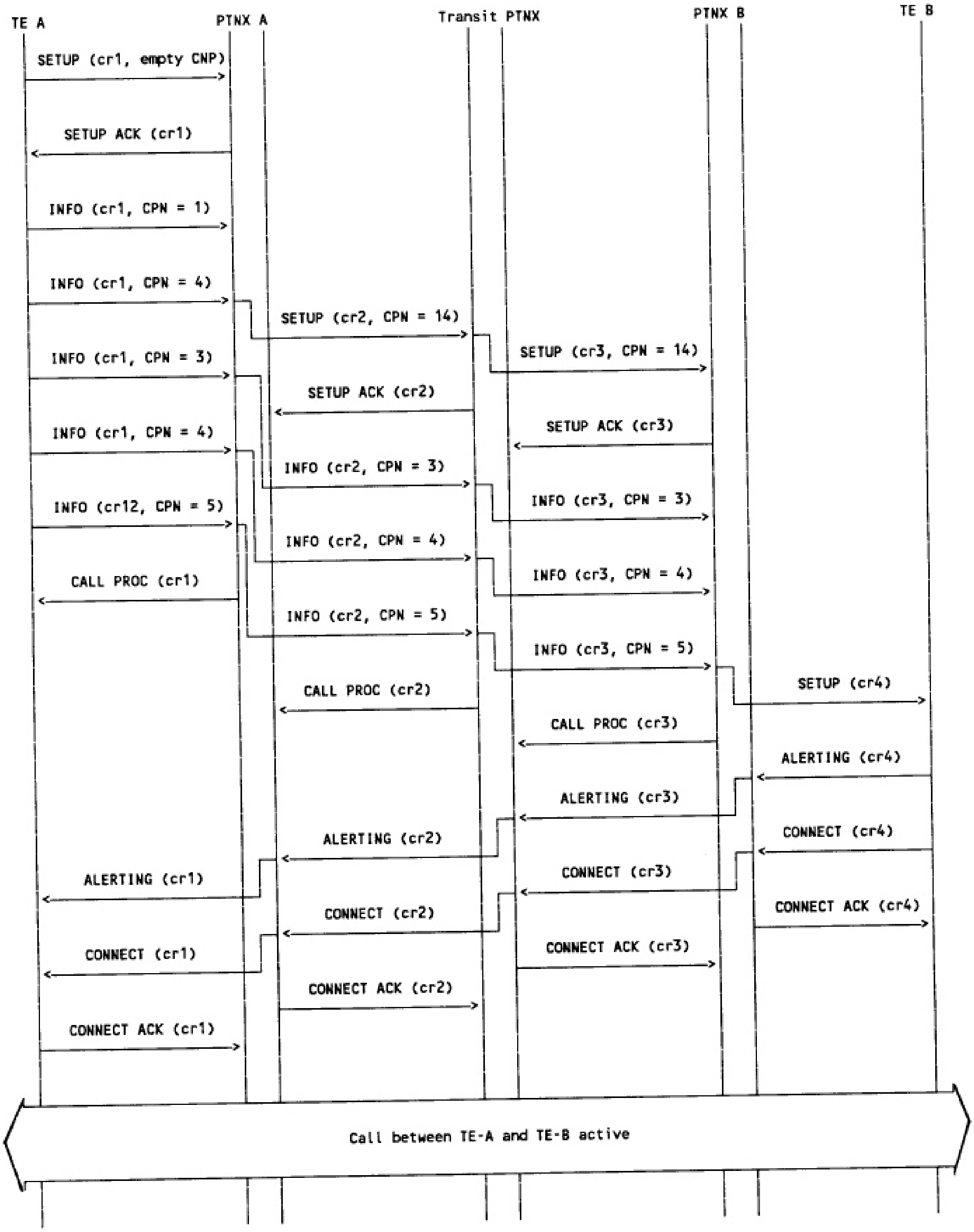


Figure 7: Overlap setup, successful call

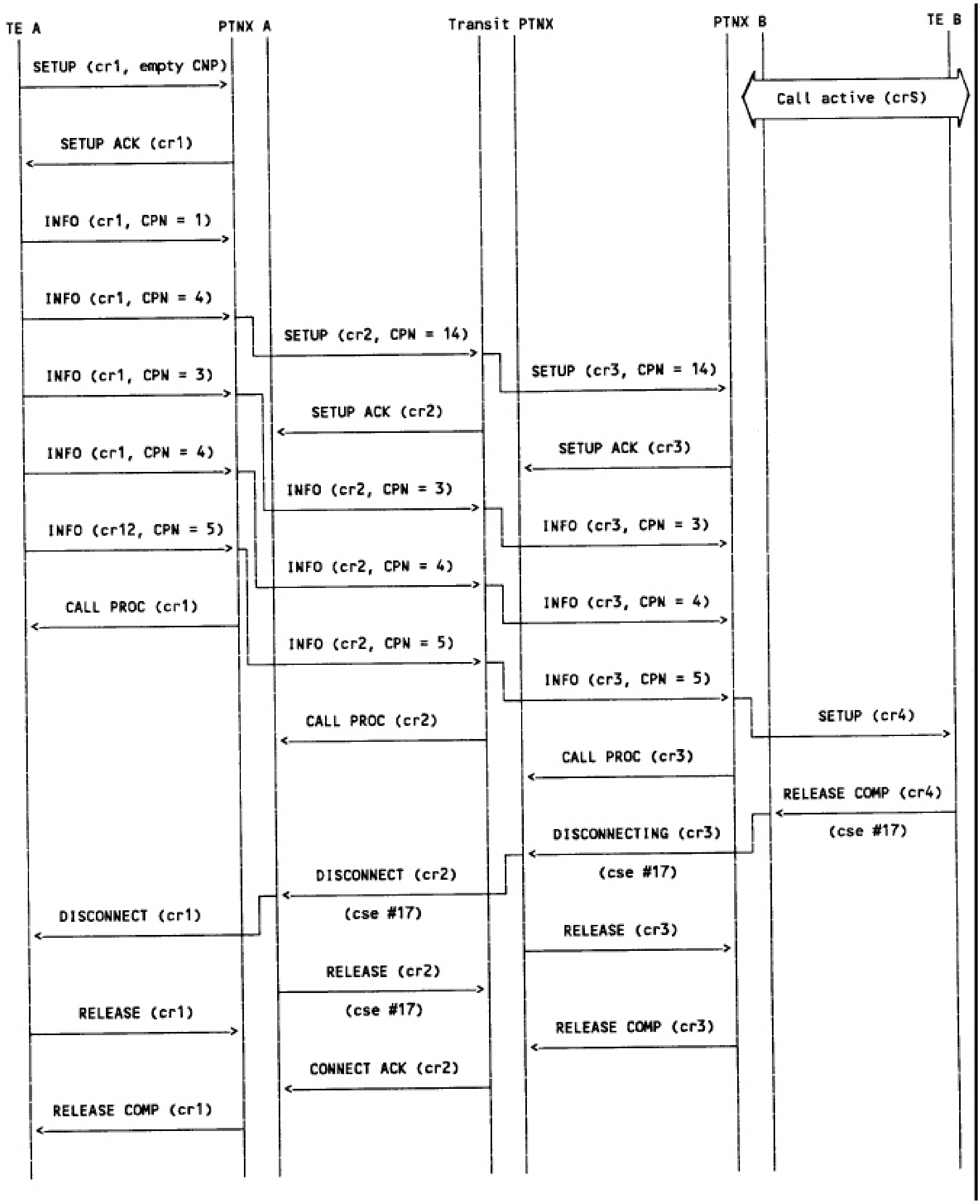


Figure 8: Overlap setup, unsuccessful call

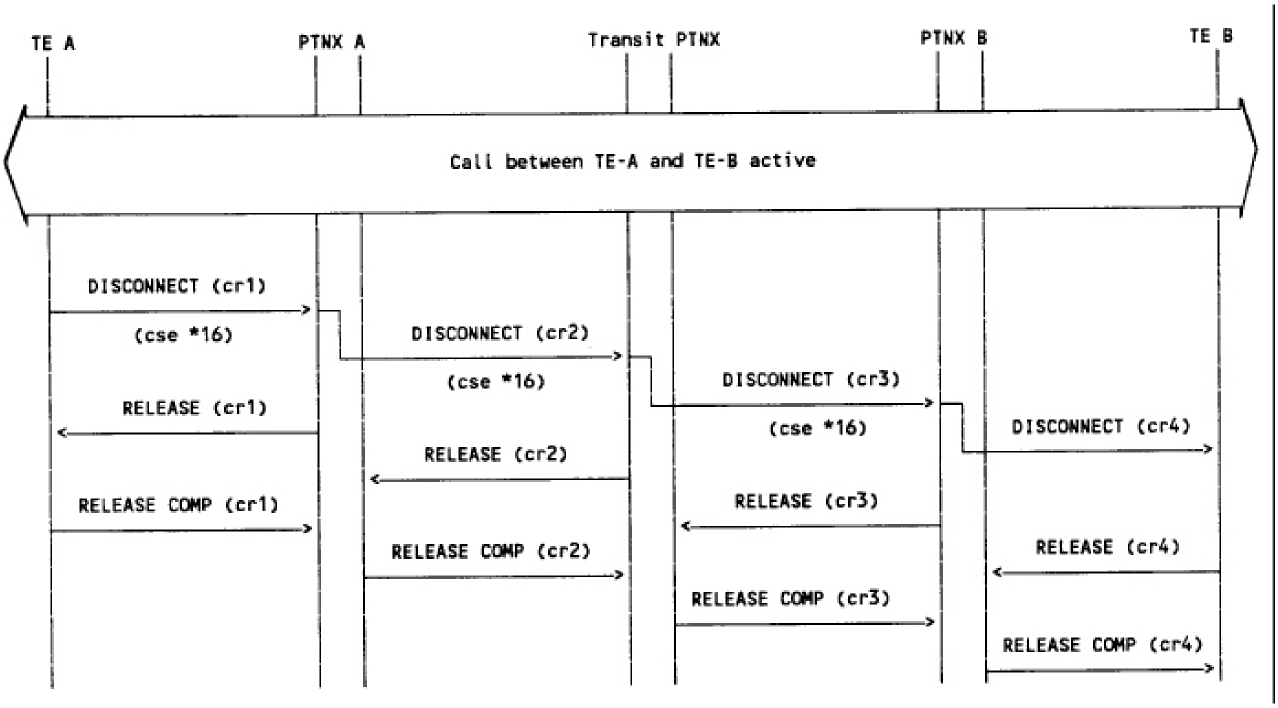


Figure 9: Normal call clearing by originator

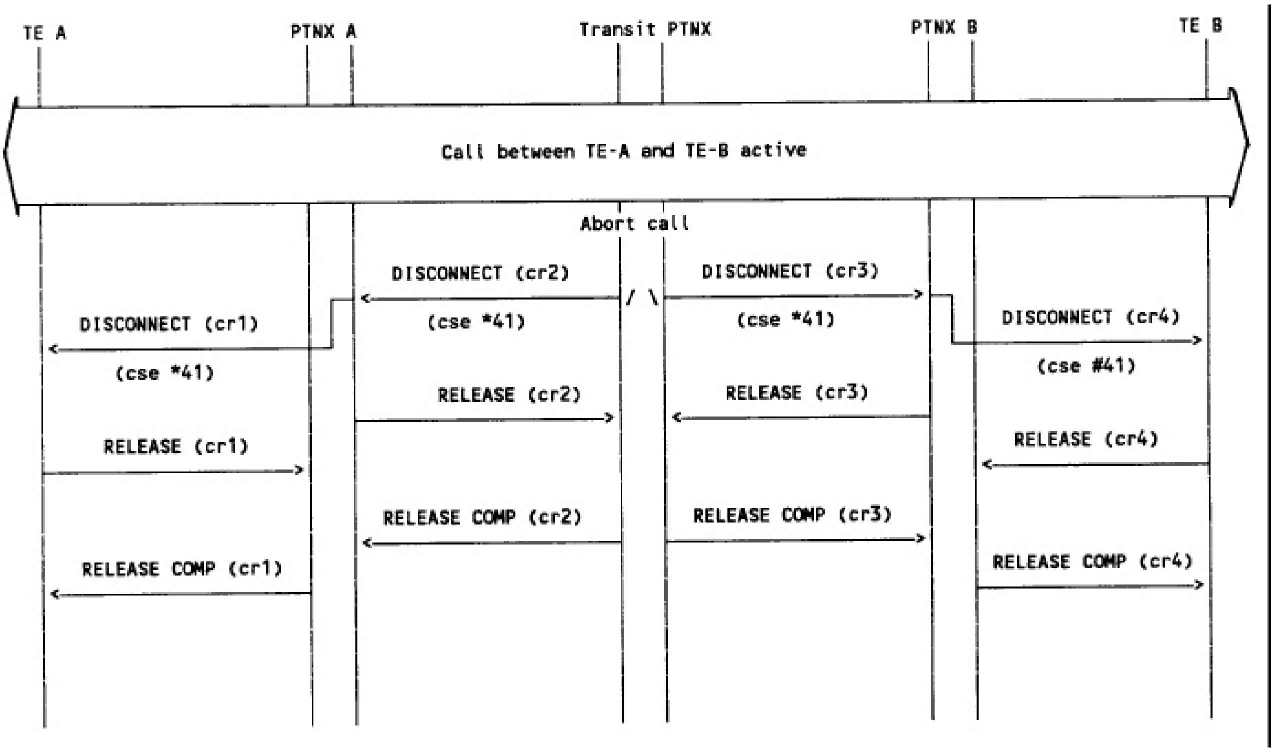


Figure 10: Call abort by Transit PTNX

Chapter III: Speed of service performance

1 General

1.1 Defined parameters

Four speed of service parameters are defined in this chapter:

- access parameter - connection processing delays:
  - overall connection set-up delay
  - overall alerting delay
- disengagement parameter:
  - disconnect delay
  - release delay

Each parameter can be applied to any basic section or portion of a PTN. This generality makes the parameters useful in performance allocation and concatenation.

1.2 Sections of the PTN

The PTN normally contains terrestrial sections but may also contain satellite sections. Furthermore these sections may be pure private, using leased circuits or can be hybrid using the public ISDN as intervening network.
This report specifies end to end delay values.
The delay values for public ISDN portions have to be taken into account for the overall values of the delays. These can be found in the relevant European Telecommunication Standards - ETSs.

1.3 Interpretation of the values

Mean and 95 % probability values for the worst case overall connection set-up delay, overall alerting delay, disconnect delay and release delay are specified for each network portion type (further study is required). The term worst case means that these value should be met during the normal busy hour in worst performing PTN portions used by the provided services. The performance of a private network portion will normally be better than the worst-case values specified in this Standard.

Numerical methods for dividing end-to-end performance to estimate individual portion performances are also included in this report (see Annex B).

2 Connection processing delays in circuit-switched PTN connections

The values for the connection processing delay parameters should be determined taking into account that delays are caused in:

- the calling and called extension circuit section;
- the connection processing at the originating and destination PTNX;
- The transit PTNXs;
- the intervening networks (see NOTE)

NOTE: The intervening network may consist of: (see chapter II)

- a dedicated transmission system;
- a public ISDN portion connected at the T reference point.

The end to end connection is then called hybrid reference connection.

The delays, caused in the public ISDN portion, are defined in the relevant European Telecommunication Standards (ETS).

Connection processing delay values are only defined for a basic connection and therefore do not provide for any effects that might be introduced by supplementary services.

2.1 Overall connection set-up delay

2.1.1 Observations and measurements

The private reference configuration of figure 11 is a simplified example of figure 3 and is used to provide a baseline reference configuration for defining the overall connection set-up delay.

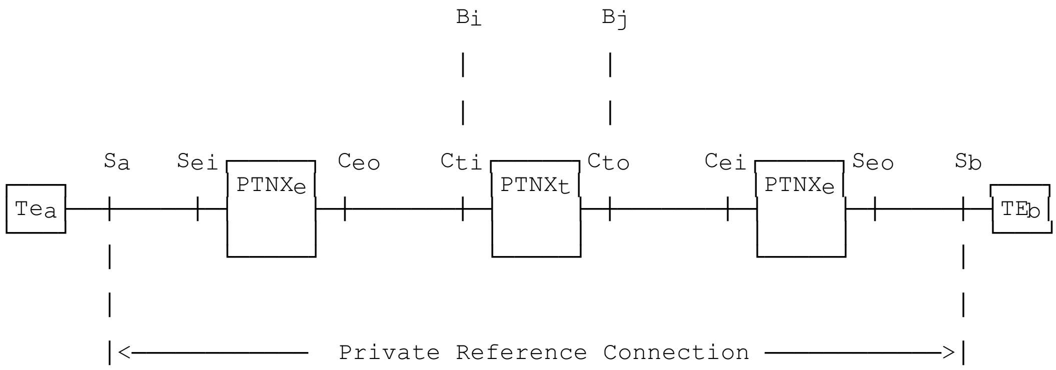


Figure 11: Private reference connection

NOTE: e and t refer to end (PTNX) and transit (PTNX)

i and o refer to incoming and outgoing.

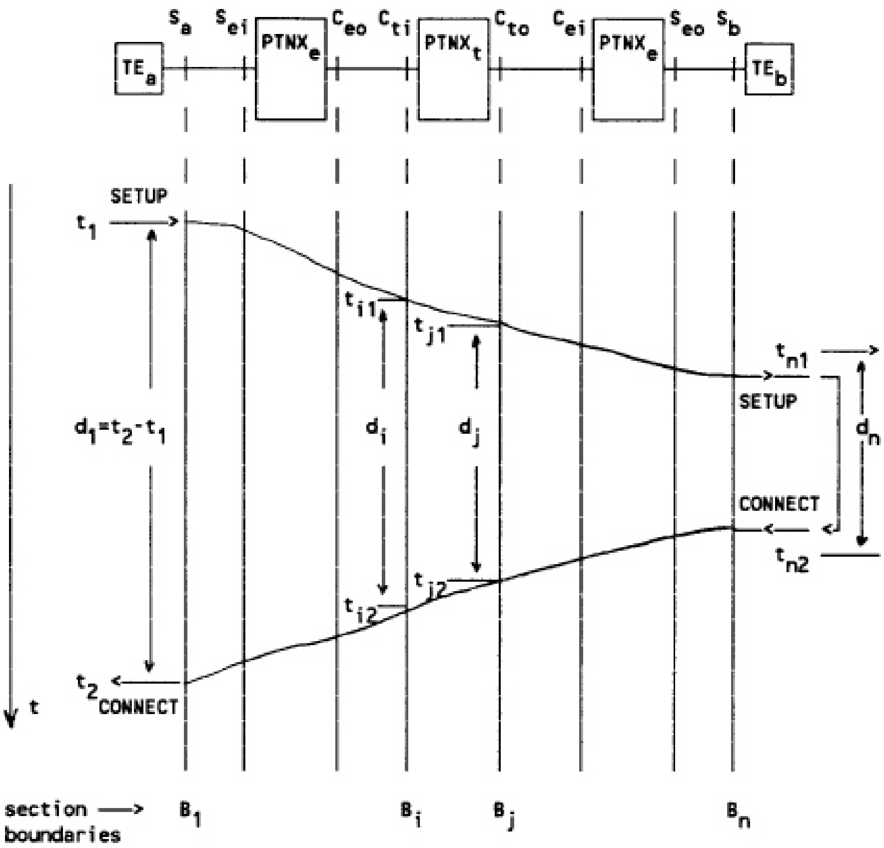
All paramete values will be specified at section boundaries. As defined in chapter II, these boundaries are: the Private Network Termination (PT) and the S, T or C reference points of the PTN. The examples of Figures 5 to 8 of chapter II, showing call processing message transfer events (MTEs), are used.

Connection set-up delays can be defined based on observations and measurements at a single section boundary, B_i as shown in figure 12, and also between two section boundaries (B_i,B_j). In the former case, the connection set-up delay includes the delay for all sections on the called side of Bi and the terminal device. In the latter case, the connection set-up delay includes only the delay between B_i and B_j.

2.1.2 Definition of connection set-up delay

The transfer of messages is shown in figure 12 along with section boundaries.

(A table showing the specific message transfer events used in measuring the connection set-up delay is for further study).



$d_i = t_{i2} - t_{i1}$; $d_j = t_{j2} - t_{j1}$; $d_n = t_{n2} - t_{n1}$

Figure 12: Connection set-up delay events (example)

2.1.2.1 Connection set-up delay at a section boundary Bi

Connection set-up delay at a section boundary Bi is the length of time that starts when a SETUP or the last address information message creates a message transfer event at Bi and ends when the corresponding CONNECT message returns and creates its message transfer event at B_i.

In figure 12, this is = $d_i = t_{i2} - t_{i1}$

where:

t_{i1} = time of occurrence of the starting message transfer event

t_{i2} = time of occurrence for the ending message transfer event

2.1.2.2 Connection set-up delay between two section boundaries

The connection set-up delay can be measured at one section boundary, Bi, and then measured at another boundary Bj, farther from the calling S interface. The difference in the values obtained is the connection set-up delay contributed by the section between two boundaries.

The connection set-up delay between the two boundaries = (di - dj)

where:

d_i = connection set-up delay measured at B_i.

d_j = connection set-up delay measured at B_j.

The connection set-up delay for a section is the connection set-up delay between the boundaries delimiting that section.

2.1.2.3 Overall connection set-up delay

The overall connection set-up delay is the connection set-up delay between the two S interfaces B_1 and B_n in figure 12. This overall connection delay excludes the called user response time or any delay that might be introduced by users or user equipment.

The overall connection set-up delay = d_1 - d_n

The overall connection set-up delay should not exceed the values given in table 1.

Table 1: Overall connection setup delay for private telecommunication networks.

PTN Connection Type	Statistic	Connection setup delay
64 kbit/s unrestricted	Mean	4500 ms (NOTE)
	95 %	8350 ms (NOTE)

NOTE: Provisional values; the target values, statistical reference distribution and measuring methods are for further study.

The target worst case values for a PTN should be the same as for the public ISDN.

Notes to table 1.

NOTE 1: The values take into account worst case situations. The specification of worst case situations is for further study. e.g. The values observed will be dominated by the number of PTNXs in a connection and also the length of the connection will be an important factor.

NOTE 2: Delays should be specified for a nominal busy hour.

NOTE 3: Connection set-up attempts which exceed a specified timeout value should be excluded in computing these statistics and should be counted separately as connection setup denials. This timeout is provisionally set to 60 seconds, further study is however required.

NOTE 4: When transmitting a signal message, like in figure 11, before the message actually passes across the S reference point, it may have to wait in the PTNX or signalling system while another message (signal or user packet) is being transmitted to the extension user. Since this waiting time depend on the volume of user packet (message) traffic over the D-channel, the resulting delay is beyond the responsibility of the PTN provider.

NOTE 5: The delay objectives should primarily be applicable to a private reference connection with only PTNXs as switching centres.

NOTE 6: The connection setup and disconnect procedures for circuit mode voice and data are essentially the same. Therefore, the delay definitions should be applicable for circuit mode voice and circuit mode data.

NOTE 7: It is assumed that the time difference between the connect message on the D-channel and the actual cut-through of the B-channel can be neglected.

NOTE 8: The PTN normally contains terrestrial sections but may also contain satellite sections. These sections may be pure private, using leased circuits or can be hybrid using the public ISDN as intervening network. It is proposed that the above values apply to a terrestrial network. for satellite links used in the private or public intervening networks the above limits should be allowed to be exceeded.

It is proposed that only one satellite link be allowed for in either the private or the public portion of the intervening network in order to meet the 400 ms one-way delay as required in CCITT Recommendation G.114.

The above reasons would allow to an additional overall propagation delay of up to 520 ms to the values given in table 1.

2.1.3 Allocation of connection setup delay

Allocation of connection setup delay among the sections of the connection and requirements for the overall connection set up delay of the intervening public ISDN. (Further study is required)

2.1.3.1 The hybrid case

In Chapter II (subclause 2.2) four PTNX implementation dependent reference connections are proposed. The example for calculation hereafter is based on implementation I_1, of a private reference connection where the PTNXs are implemented as ISPBXs (see figure 13).

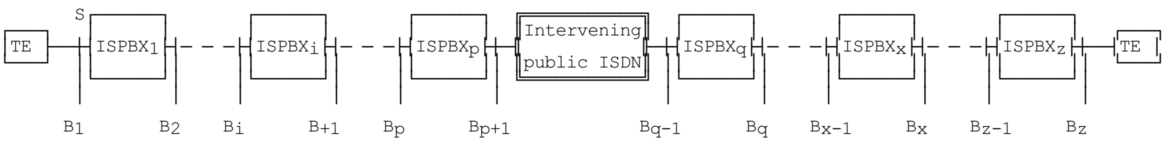


Figure 13: Private reference configuration (Implementation I1 as in Chapter II, subclause 2.2)

It is supposed that the overall connection setup delay of a PTN should neither be better nor worse than the public ISDN. This means that for the mean value of the connection setup delay:

$$x = \frac{\sum x_i}{1-z} + x_p \quad or \quad x_p = x - \frac{\sum x_i}{1-z} \qquad [1]$$

Where:

x = the mean value of the overall connection setup delay as defined in table 1. The provisional end-to-end value is 4500 ms.

x_i = the mean value of the connection setup delay between the section boundaries B_i and B_{i+1}.

x_p = the connection setup delay mean value to be negotiated for the intervening ISDN.

z = total number of PTN sections.

2.1.3.2 Connection setup delay between two section boundaries

The measuring method of the connection setup delay between section boundaries B_i and B_{i+1} (x_i) is described in subclause 2.1.2.2.

The value of x_i depends on different factors:

f_1: the nature of the PTN section, e.g:
- the calling and called extension circuit section;
- the inter ISPBX circuit section;

- the ISPBX section;

f_2: the message transfer event delays (see subclause 2.1.2);

f_3: the nature of the circuits, e.g. satellite links, radio links, terrestrial links, etc.

f_4: the length of the circuits.

f_5: the signalling options e.g. en bloc or overlap sending.

f_n: etc. further study is required.

x_i can be expressed as a function of these factors.

2.1.3.3 Requirements of the intervening public ISDN (further study is required)

When implementing a PTN, the formula under subclause 2.1.3.1 defines an overall connection setup delay of the intervening ISDN (x_p). These requirements are to be negotiated with the public ISDN provider.

A possible method is described in Annex B.

2.2 Alerting delay

2.2.1 Observations and measurements

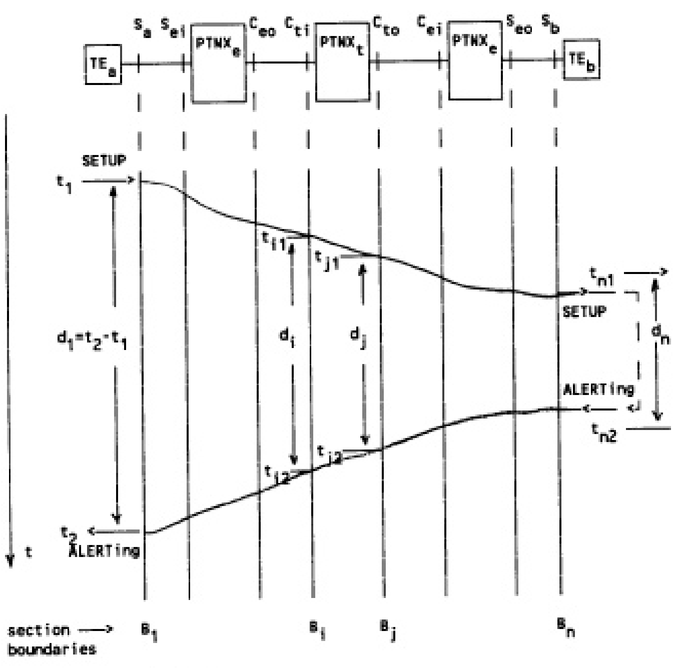
Alerting delay is defined using an approach similar to that described in subclause 2.1.1 for connection set-up delay.

The Standard is applicable in case of manual answering terminals and some automatic answering terminals.

2.2.2 Definition of alerting delay

The transfer of messages is shown in figure 14 along with connection element boundaries.

(A table showing the specific message transfer events used in measuring the alerting delay is for further study).



$d_i = t_{i2} - t_{i1}$; $d_j = t_{j2} - t_{j1}$; $d_n = t_{n2} - t_{n1}$

Figure 14: Alerting delay events (example)

2.2.2.1 Connection set-up delay at a section boundary Bi

Alerting delay at a section boundary Bi is the length of time that starts when a SETUP or the last address information message creates a message transfer event at Bi and ends when the corresponding ALERTing message returns and creates its message transfer event at B_i.

In figure 14, this is = $d_i = t_{i2} - t_{i1}$

where t_{i1} = time of occurrence of the starting message transfer event

where t_{i2} = time of occurrence for the ending message transfer event

2.2.2.2 Alerting delay between two section boundaries

The alerting delay can be measured at one section boundary, Bi, and then measured at another boundary Bj, farther from the calling S interface. The difference in the values obtained is the alerting delay contributed by the sections between two boundaries.

The alerting delay between the two boundaries = (di - dj):

where d_i = alerting delay measured at B_i.

where d_j = alerting delay measured at B_j.

The alerting delay for a section is the alerting delay between the boundaries delimiting that section.

2.2.2.3 Overall alerting delay.

The overall alerting delay is the alerting delay between the two S interfaces B_1 and B_n in figure 14. This overall alerting delay excludes the called user response time or any delay that might be introduced by users or user equipment.

The overall alerting delay = $d_1 - d_n$

The overall connection set-up delay should not exceed the values given in table 2.

Table 2: Overall alerting delay for private telecommunication networks

PTN Connection Type	Statistic	Alerting delay
64 kbit/s unrestricted switched	Mean	4500 ms (NOTE)
	95 %	8350 ms (NOTE)

NOTE: Professional values; the target values, statistical reference distribution and measuring methods are for further study.

The target worst case values for a PTN should be the same as for the public ISDN.
Notes to table 2.
The same notes apply for this table as for table 1, subclause 2.1.2.3.

2.2.3 Allocation of alerting delay

Allocation of alerting delay among the sections of the connection and requirements for the overall alerting delay of the intervening public ISDN. (further study is required)

2.2.3.1 The hybrid case

In Chapter II (subclause 2.2) four PTNX implementation dependent reference connections are proposed. The example for calculation hereafter is based on implementation I_1, of a private reference connection where the PTNXs are implemented as ISPBXs (see figure 15).

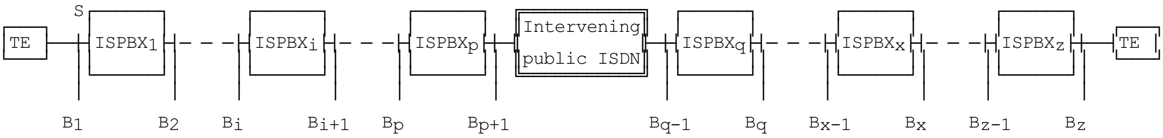


Figure 15: Private reference configuration. (Implementation I1 as in Chapter II, subclause 2.2)

It is supposed that the overall alerting delay of a PTN should neither be better nor worse than the public ISDN. This means that for the mean value of the alerting delay:

$$y = \frac{\sum y_i}{1-z} + y_p \qquad or \qquad y_p = y - \frac{\sum y_i}{1-z} \qquad [1]$$

y = the mean value of the overall alerting delay as define

d in table ETR BT-2002/2. The provisional end-to-end value is 4500 ms.

y_i = the mean value of the alerting delay between the section boundaries B_i and B_{i+1}.

y_p = the alerting delay mean value to be negotiated for the intervening ISDN.

z = total number of PTN sections.

2.2.3.2 Alerting delay between two section boundaries

The measuring method of the alerting delay between section boundaries B_i and B_{i+1} (y_i) is described in subclause 2.2.2.2.

The value of y_i depends on different factors:

f_1: the nature of the PTN section, e.g:

- the calling and called extension circuit section;
- the inter ISPBX circuit section;
- the ISPBX section;

f_2: the message transfer event delays (see subclause 2.2.2);

f_3: the nature of the circuits, e.g. satellite links, radio links, terrestrial links, etc.

f_4: the length of the circuits.

f_5: the signalling options e.g. en bloc or overlap sending.

f_n: etc. further study is required.

y_i can be expressed as a function of these factors.

2.2.3.3 Requirements of the intervening public ISDN (further study is required)

When implementing a PTN, the formula under subclause 2.2.3.1 defines an overall alerting delay of the intervening ISDN (y_p). These requirements are to be negotiated with the public ISDN provider.

A possible method is described in Annex B.

2.3 Disconnect delay

2.3.1 Observations and measurements

Disconnect definition is based only on a one-way message transport from the clearing party to the cleared party. Therefore, this parameter requires observations at two section boundaries.

The examples of figures 9 and 10 in chapter II, showing call processing message events (MTEs) for call clearing, are used.

2.3.2 Definition of disconnect delay between two section boundaries

The transfer of messages is shown in figure 16 along with section boundaries.

(A table showing the specific message transfer events used in measuring the disconnect delay is for further study).

Disconnect delay between two section boundaries B_i and B_j is defined as the length of time that starts when a DISConnect message creates a message transfer event at B_j and ends when the that DISConnect message creates a message transfer event at B_i, father from the clearing party.

The disconnect delay between two section boundaries = ti - tj (see figure 16).

where:

t_i = Time of occurrence for the message transfer event at B_i.

t_j = Time of occurrence for the massage transfer event $_a$t B_j.

The disconnect delay for a section is the disconnect delay between the boundaries delimiting that section.

2.3.2.1 Overall disconnect delay

The overall disconnect delay is the disconnect delay between the two S interfaces B_1 and B_n in figure 16.

The overall disconnect delay = $t_1 - t_n$

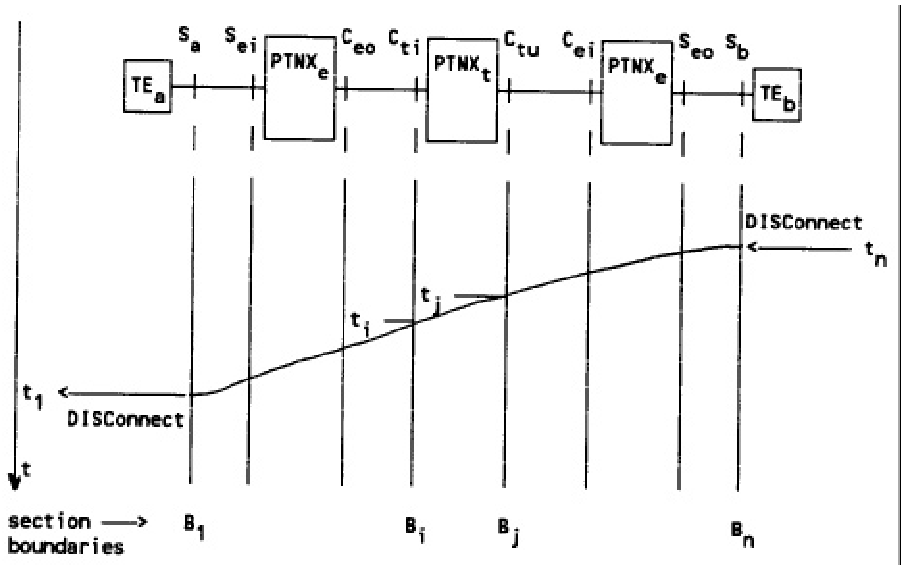


Figure 16: Disconnect delay events (example)

The overall disconnect delay should not exceed the values given in table 2.

Table 3: Disconnect delay for private telecommunication networks.

PTN Connection Type	Statistic	Disconnect delay
64 kbit/s unrestricted switched	Mean	2700 ms (NOTE)
	95 %	4700 ms (NOTE)

NOTE: Provisional values; the target values, statistical reference distribution and measuring methods are for further study.

The target worst case values for a PTN should be the same as for the public ISDN.

Notes to table 3

The notes 1, 2, 5, 6 and 8 to table 1 in subclause 2.1.2.3 also apply for this table.

2.3.3 Allocation of disconnect delay among the sections of the connection and requirements for the overall disconnect delay of the intervening public ISDN. (further study is required)

2.3.3.1 The hybrid case

In Chapter II (subclause 2.2) four PTNX implementation dependent reference connections are proposed. The example for calculation hereafter is based on implementation I_1, of a private reference connection where the PTNXs are implemented as ISPBXs (see figure 17).

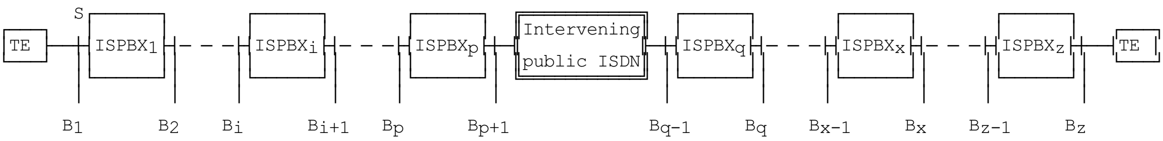


Figure 17: Private reference configuration

(Implementation I_1 as in Chapter II, subclause 2.2)

It is supposed that the overall disconnect delay of a PTN should neither be better nor worse than the public ISDN. This means that for the mean value of the disconnect delay:

$$w = \sum_{1-z} w_i + w_p \qquad or \qquad w_p = w - \sum_{1-z} w_i \qquad [1]$$

w = the mean value of the overall alerting delay as defined in table 3. The provisional end-to- end value is 4500 ms.

w_i = the mean value of the connection setup delay between the section boundaries B_i and B_{i+1}.

w_p = the connection setup delay mean value to be negotiated for the intervening ISDN.

z = total number of PTN sections.

2.3.3.2 Disconnect delay between two section boundaries

The measuring method of the disconnect delay between section boundaries B_i and B_{i+1} (w_i) is described in subclause 2.3.2.2.
The value of w_i depends on different factors:

f_1: the nature of the PTN section, e.g:

- the calling and called extension circuit section;
- the inter ISPBX circuit section;
- the ISPBX section;

f_2: the message transfer event delays (see subclause 2.3.2);

f_3: the nature of the circuits, e.g. satellite links, radio links, terrestrial links, etc.

f_4: the length of the circuits.

f_5: the signalling options e.g. en bloc or overlap sending.

f_n: etc. further study is required.

w_i can be expressed as a function of these factors.

2.3.3.3 Requirements of the intervening public ISDN (further study is required)

When implementing a PTN, the formula under subclause 2.3.3.1 defines an overall disconnect delay of the intervening ISDN (w_p). These requirements are to be negotiated with the public ISDN provider.

A possible method is described in Annex B.

2.4 Release delay

2.4.1 Observations and measurements.Release delay is defined only at the clearing party S interface

2.4.2 Definition of release delay.

The transfer of messages is shown in figure 18 along with section boundaries.

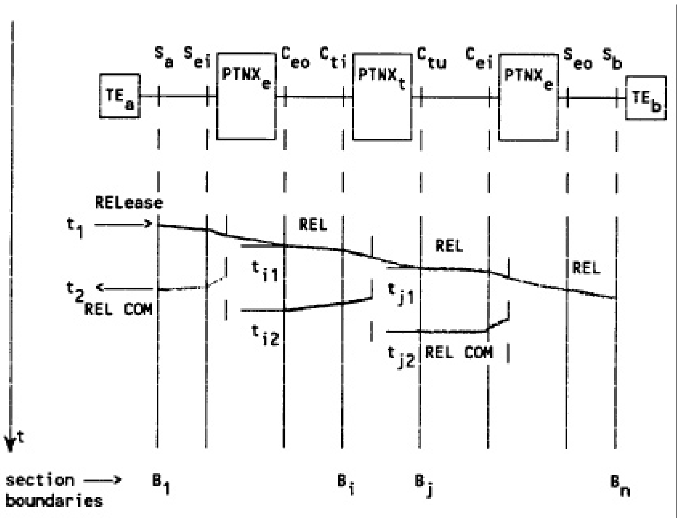


Figure 18: Release delay events (example)

Release delay is defined as the length of time that starts when a RELease message from the clearing party creates a message transfer event at the clearing party S interface and ends when the RELease COMplete message creates a message transfer event at the same interface.

The release delay at the clearing party S interface = t2 - t1

where:

t_1 = time of occurrence for the starting message transfer event

t_2 = Time of occurrence for the ending message transfer event.

Since the release message sent by the PTNX at the clearing end is only transported over the access section at that end, the distinction between overall delay and section delay is not relevant. The specific message transfer events used in measuring release delay will be drafted later.

The release delay for a section is the release delay between the boundaries delimiting that section.

The release delay should not exceed the values given in table 4.

Table 4: Release Delay for private telecommunication networks

PTN Connection Type	Statistic	Release delay
64 kbit/s unrestricted switched	Mean	300 ms (NOTE)
	95 %	850 ms (NOTE)

NOTE: Provisional values; the target values, statistical reference distribution and measure are for further study.

The target worst case values for a PTN may differ from the values of the public ISDN when other release options are used.

Notes to table 4.

NOTE 6 of table 1 in subclause 2.1.2.3 also applies for this table.

Chapter IV: Accuracy and dependability performance

1 General

1.1 Defined parameters

In this Chapter four accuracy and dependability parameters are defined:

- access parameters:

  * call set-up error probability

  * call set-up failure probability

- user information transfer parameter:

  * premature disconnect probability

- disengagement parameter:

  * call clear failure probability

Each of these parameters can be applied to any basic section or portion of a PTN. This generality makes the parameters useful in performance allocation and concatenation.

1.2 Sections of the PTN

The PTN normally contain terrestrial sections but may also contain satellite sections. Furthermore these sections may be pure private, using leased circuits or can be hybrid using the public ISDN as intervening network.

1.3 Interpretation of values

Mean and 95 % probability values for worst case call set-up error probability, call set-up failure probability, premature disconnect probability and call clear failure probability are specified for each network portion type identified in table NP zzz/1 (further study is required). The term worst case means that these value should be met during the normal busy hour in worst performing PTN portions used by the provided services. The performance of a private network portion will normally be better than the worst-case values specified in this Standard.
Numerical methods for combining individual portion performance values to estimate end-to-end performance are also included in this report . See the example for delay values in Annex B.

2 Accuracy and dependability performance parameters for circuit switched PTN connections

This standard specifies accuracy and dependability performance values for specific portions of the PTN. These portions are:

- the calling and called extension circuit section;

- the connection processing at the originating and destination PTNX;

- the intervening network (see NOTE);

NOTE: The intervening network may consist of: (see Chapter II)

- a collection of adjacent alternating PTNXs and inter PTNX circuit sections connected at the C reference point. The end to end connection is then called private reference connection

- a public ISDN portion connected at the T reference point. The end to end connection is then called hybrid reference connection.

2.1 Access parameters

This section specifies worst-case values for two access parameters: call set-up error and call set-up failure probability. They define the accuracy to obtain the wanted destination. Examples are:

- no alerting and no connection;
- all circuits busy signal;
- announcement;
- misrouting (wrong number);
- double connection;
- etc.

2.1.1 Observations and measuring methods

The private reference configuration of figure 19 is a simplified example of figure 3 and is used to provide a baseline reference configuration for defining the call set-up error and call set-up failure probability.

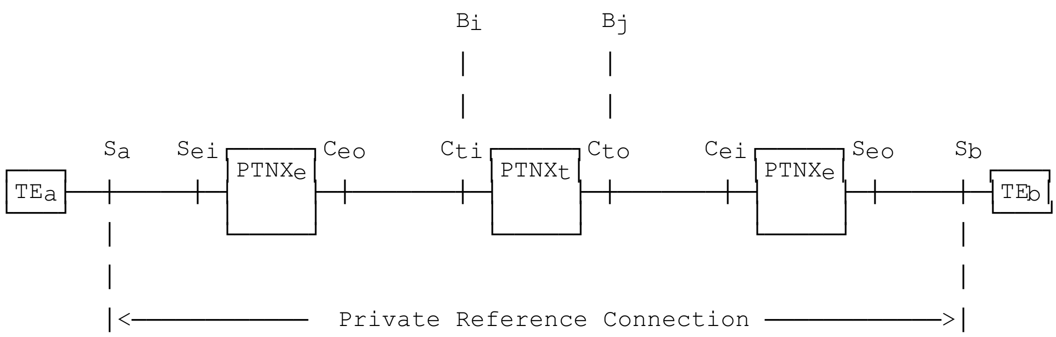


Figure 19: Private reference connection

NOTE: e and t refer to end (PTNX) and transit (PRNX)

i and o refer to incoming and outgoing.

The call set-up error and call set-up failure performance values will be specified between pairs of section boundaries (eg. B_i, B_j). In Chapter II, the following boundaries are identified: the Private Network Termination (PT) and the S, T or C reference points of the PTN.

B_j is one of the set of boundaries to which the call attempt can properly be routed. Figure 20 identifies the sequence of four particular events that occur between two of those boundaries during a successful call set-up. A call set-up attempt over this section is an occurrence of event (a). A successful call set-up attempt over this section is a sequential occurrence of the corresponding events (a, b, c and d) when these are sent within the timeout period, which is defined by timer T3O3 [1).]

The receipt of a set-up ACKnowledge, RELease or RELease COMplete from the remote boundary B_j or the receipt of a clear request primitive from call control stops timer T303.

[1)] The timeout value for timer T303 is not yet defined for the PTN.

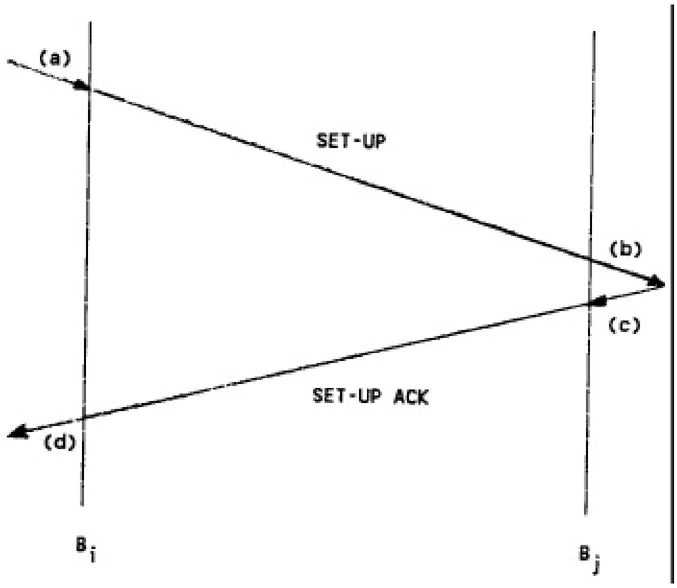


Figure 20: Reference events occurring during successful call.

2.1.2 Call set-up error probability

a) Definition.

The parameter "call set-up error probability" is used to measure the accuracy of the access to the PTN.

Call set-up error probability is the ratio of total call attempts that result in call set-up error to the total call attempts in a population of interest.
It can be estimated by using the following formula:

$$CSE = \frac{E_N}{N}$$

Where:

CSE = Call Set-up Error Probability

E_N = The number of call set-up errors in the measured period

N = The total number of attempts in the measured period.

With the reference to figure 20, a call set-up error is defined to occur on any call attempt in which event (d) occurs, but event (c) does not occur within the time period of the timeout of timer T303.

Call set-up error is essentially the case of a "wrong number". It occurs when the network responds to a valid call request by erroneously establishing a call to a destination terminal other than the one designated in the call request. It may be caused, for example, by network operator administrative or maintenance actions.

Call set-up error is distinguished from successful call set-up by the fact that the intended called user is not contacted during the call set-up attempt.

The specific RTEs (Reference Transfer Events) used in measuring call set-up error probability at each section boundary are those given in figures 5 to 8.

Call set-up values are only defined for a basic connection and therefore do not provide for any effect that might be introduced by supplementary services.

b) Values.

The contribution from each network portion to the overall call set-up error probability under the conditions described in this Standard shall not exceed the values specified in table 5.

Table 5: Worst case call set-up error probability values for ISDN circuit mode 64 kbit/srestricted basic onnections in a Private Telecommunication Network (PTN)

PTN Connection Type	Statistic	Call Set-up Error probability
64kbit/s unrestricted	Mean	1.5×10^{-4} (NOTE 1)
	95 %	2.5×10^{-4} (NOTE 1)

NOTE 1: Provisional values; the target values, statistical reference distribution and measuring methods are for further study. The target worst case values for a PTN should be the same as for the public ISDN.

NOTE 2 It is not yet defined if the values also cover the hybrid (Public - Private) case.

2.1.3 Call set-up failure probability

a) Definition.

The parameter "call set-up failure probability" is used to measure the dependability of the access to the PTN.

Call set-up failure probability is the ratio of total call attempts that result in call set-up failure to the total call attempts in a population of interest.

It can be estimated by using the following formula:

$$CSF = \frac{F_N}{N}$$

Where:

CSF = Call Set-up Failure Probability

F_N = The number of call set-up failures in the measured period

N = The total number of attempts in the measured period.

With the reference to figure ETR BT-2002/20, a call set-up error is defined to occur on any call attempt in which either one of the following outcomes is observed within the timeout period of time T303:

1) Events (b) or (d) do not occur;

2) Events (b) and (c) occur, but event (d) does not.

Call attempts that are cleared by the section as a result of incorrect performance or non-performance on the part of an entity outside the section are excluded.

The specific RTEs (Reference Transfer Events) used in measuring call set-up error probability at each section boundary are those given in figures 5 to 8.

Call set-up values are only defined for a basic connection and therefore do not provide for any effect that might be introduced by supplementary services.

b) Values.

The contribution from each network portion to the overall call set-up failure probability under the conditions described in this Technical Report shall not exceed the values specified in table 6.

Table 6: Worst case call set-up failure probability values for ISDN circuit mode 64 kbit/s unrestricted basic connections in a Private Telecommunication Network (PTN)

PTN Connection Type	Statistic	Call Set-up Failure probability
64 kbit/s unrestricted	Mean	1.5×10^{-2} (NOTE)
	95 %	2.5×10^{-2} (NOTE)

NOTE: Provisional values; the target values, statistical reference distribution and measuring methods are for further study. The target worst case values for a PTN should be the same as for the public ISDN.

2.1.4 Excluded call attempts

A call set-up attempt can also fail as a result of user blocking. Such failures are excluded from serveability performance measurements. Examples of user blocking include the following:

1) Either the originating or the called user issues a clear request to reject the call set-up attempt.

2) The called user delays excessively in generating the ALERting or CONNect message, with the result that the connection is not established before the timeout.

3) All channels at the called termination are in use.

2.2 User information transfer parameters

This section specifies worst-case values for the premature disconnect (cut-off) probability. It is one measure for the accuracy of the information transfer capability of a connection.

2.2.1 Observations and measurements

The private reference configuration of figure 19 is a simplified example of figure 3 and is again used to provide a baseline reference configuration for defining the premature disconnect probability.

A premature disconnect event is measured on a both-way end-to-end basis. For planning purposes however it is desirable to allocate the overall measure between a pair of section boundaries.

2.2.2 Definitions of premature disconnect

Premature disconnect is an interruption of the service. An "**interruption**" is defined in CCITT Recommendation E.800 as the temporary inability of a service to be provided persisting for more than a given time duration, characterised by a change beyond given limits in at least one parameter essential for the service.

Premature release is defined in CCITT Recommendation E.800 as the event that an established connection will be released for a reason other than intentionally by any of the parties involved in the call.

Premature disconnect is the extreme case of premature release when the connection is completely interrupted or:

1) when a single interruption occurs lasting longer than t* seconds which causes the transmission quality of the connection to be unsuitable for further information transfer.

2) when a succession of interruptions occur lasting for less than t* seconds where the product of the average duration of each interruption and the frequency of occurrence (i.e., average number of interruptions/second) exceeds p*.

* The values for t and p depend on the service used within the ISDN. For the telephone service: t = 10 seconds and p = 0.005. They have to be defined for the other ISDN services.

NOTE: Parameters and objectives for transmission interruptions (not giving rise to premature disconnect) are standardised in the relevant ETS.

The measure to be used is defined in CCITT Recommendation E.850 as the probability of a prematurely disconnected connection when normalised to a call holding time of one minute (P_r). The estimator of the premature disconnect probability (P_{re}) is:

$$P_{re} = \frac{1 - \frac{R_N}{N}}{T}$$

Where:

N = number of telephone calls successfully established in some period of time
T = the mean holding time in minutes
R_N = the number of telephone call successfully completed out of N calls.

The relationship between the premature disconnect probability and its estimator and the method to estimate the premature disconnect probability are defined in Annexes A and B of CCITT Recommendation E.850 [16].

2.2.3 Value for premature disconnect.

The contribution from each network portion to the overall premature disconnect probability under the conditions described in this Technical Report shall not exceed the values specified in table 7.

Table 7: Worst case premature disconnect probability values for ISDN circuit mode 64 kbit/s unrestricted basic connections in a Private Telecommunication Network (PTN).

PTN Connection Type	Statistic	Normalised Premature Release probability (P_r)
64 kbit/s unrestricted	Mean	3×10^{-4} (NOTE)
	95 %	5×10^{-4} (NOTE)

$$P_r = 1 - \frac{R_N}{N}$$

NOTE: Provisional values; the target values, statistical reference distribution and measuring methods are for further study. The target worst case values for a PTN should be the same as for the public ISDN.

2.3 Disengagement performance - call clear failure probability.

This section specifies worst case values for call clear failure probability.

2.3.1 Observations and measurements.

The private reference configuration of figure 19 is a simplified example of figure 3 and is again used to provide a baseline reference configuration for defining the call clear failure probability.
The relevant MTEs are given in figures 5 to 8.
Call clear failure is defined with reference to events at the boundaries of a section (B_i,B_j in figure 19).

A call clear attempt occurs when a clear request enters the section creating a reference event (see figure 19) at B_i.
A call clear failure occurs when no corresponding clear indication reference event occurs at Bj within the timeout of the relevant timer.

2.3.2 Call clear failure probability definition.

This parameter is used to measure the accuracy and dependability of the general function of disengagement in an ISDN circuit mode 64 kbit/s unrestricted basic connection established on demand.

Call clear failure probability is the ratio of total call attempts that result in call clear failure to the total call attempts in a population of interest.

It can be estimated by using the following formula:

$$CCF = \frac{C_N}{N}$$

Where:

CCF = Call Clear Failure Probability

C_N = The number of call set-up errors in the measured period

N = The total number of attempts in the measured period.

2.3.3 Values of call clear failure probability.

The contribution from each network portion to the overall call clear failure probability under the conditions described in this Technical Report shall not exceed the values specified in table 8.

Table 8: Worst case call clear failure probability values for ISDN circuit mode 64 kbit/s unrestricted basic connections in a Private Telecommunication Network (PTN)

PTN Connection Type	Statistic	Call Clear Failure probability
64 kbit/s unrestricted	Mean	2 x 10^{-5} (NOTE)
	95 %	3.5 x 10^{-5} (NOTE)

NOTE: Provisional values; the target values, statistical reference distribution and measuring methods are for further study. The target worst case values for a PTN should be the same as for the public ISDN.

Chapter V: Availability performance

1 Availability function

The following performance parameters from Chapter III and IV are used in computing the availability of a connection connection set-up delay, alerting delay, disconnected delay, release delay (Chapter III), call set-up error probability, call set-up failure probability, premature disconnect probability and call clear probability (Chapter IV).

Linear combinations of these parameters are called the availability decision parameters. Each decision parameter is associated with an outage threshold. Decision parameters and their outage thresholds are listed in table 9.

Availability Decision Parameter	Outage Criteria
call set-up failure probability (cfb) call set-up error probability (cep)	(cfp + cep) > 0.9
premature disconnect probability (pdp) call clear failure probability (ccfp)	(pdp + ccfp) > to be defined
connection set-up delay	> to be defined
alerting delay	> to be defined
disconnect delay	> to be defined
release delay	> to be defined
user info transfer parameters	to be defined

Table 9: Outage criteria for the availability decision parameters

NOTE: Availability decision parameters and outage criteria are provisional and require further study.

Performance is considered independently with respect to each availability decision parameter. If the value of the parameter is equal to or better than the defined outage threshold, performance related to that parameter is defined to be acceptable. If the value of the parameter is worse than the threshold, performance relative to that parameter is defined to be unacceptable.

The reference events used in defining the decision parameters do not occur if the link at a section boundary is unavailable. During a continuous time interval the link associated with the circuit section is available for service if and only if :

1) The is in the information transfer phase for at least x % of the time interval.

2) All continuous periods when the is not in the information transfer phase are less than y seconds in length and

3) All continuous busy conditions are less than Z seconds in length

NOTE: x, y and z to be defined.

Otherwise the link is considered unavailable for providing service.

The link associated with a circuit section can be unavailable for the following reasons :

1) A nonfunctional physical circuit or

2) A control system unable or unwilling to establish the information transfer phase

3) A control system unable or unwilling to clear a busy condition.

A connection associated with a circuit section is defined to be available (or to be in the available state) if:

1) The performance is acceptable relative to all decision parameters and

2) Both links at the boundaries of the section are available.

A connection associated with a circuit section is defined to the unavailable (or in the unavailable state) if:

1) The performance of one or more of the five decision parameters is unacceptable or

2) One or both links at the boundaries of the section are unavailable due to causes inside the section. (link unavailability due to causes outside the section are excluded, i.e. failures of data link controllers or physical circuits outside the section in question.)

The intervals during which a connection section is unavailable are identified by superimposing the unacceptable performance periods for all decision parameters as illustrated in figure 21.

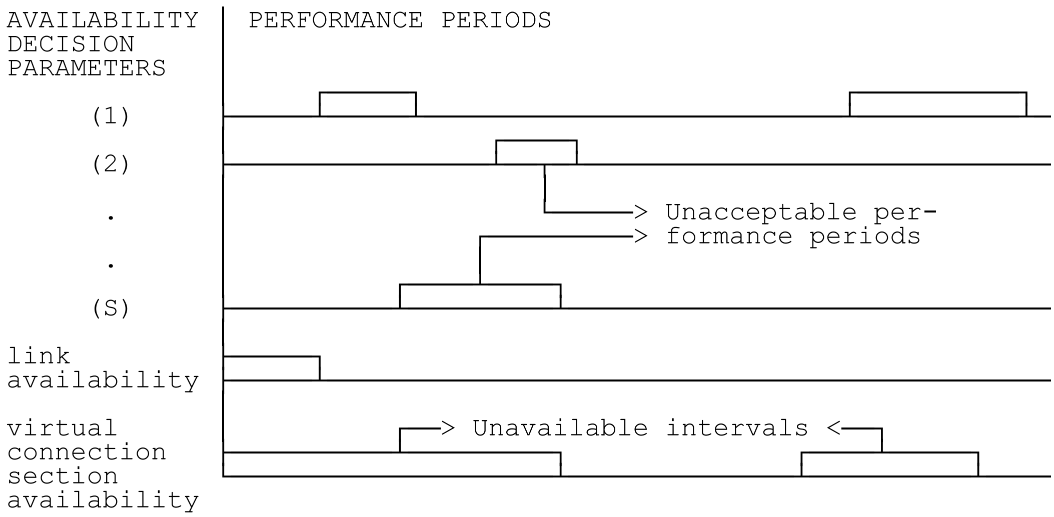


Figure 21: Determination of availability states

In order to exclude transient impairments from being considered as periods of unavailability, a single test of the availability state must exceed 5 minutes. In order to reduce the probability of state transitions during a test of the current availability state, that test should be less than 20 minutes. A minimal availability test meeting these restrictions is defined in CCITT Recommendation X.137 [10] Annex A.

NOTE: the text of the test in Annex A of CCITT Recommendation X.137 [10] can be adapted to PTNs when the availability parameters and outage criteria have been agreed.

2 Availability parameters

This section specifies worst-case values for two availability parameters, service availability and mean time between service outages.

2.1 Service availability definition

The service availability for a connection portion is the long term percentage of scheduled service time in which that portion is available.
Scheduled service time for a connection portion is the time during which the network operator has agreed to make that section available for service. The normal objective would be xx hours per day and yy days per week.

NOTE: xx and yy have to be defined.

A procedure for estimating the end-to-end availability from the individual portion performance values is described in CCITT Recommendation X.137 [10] Annex B.

2.2 Definition of mean time between service outages

Mean time between service outages (MTBSO) for a connection section is the average duration of any continuous interval during which the connection is available. Consecutive intervals of scheduled service time are concatenated. Annex A describes a procedure for estimating the mean time between the service outages of a section.

2.3 Values

The contribution from each network portion to overall service availability and the mean time between service outages under the conditions described in this standard shall not be worse than the values specified in table 10.

NOTE: Values have to be defined and agreed upon

Availability Parameter	Value
service availability (%)	
Mean time between service outage (hours)	
Mean time to service restoral MTTSR (hours)	

Table 10: Worst-case service availability and mean time between service outage values. The MTTSR values represent the mean time to service restoral that would result if the service availability and the mean time between service outage values are achieved as stated in the table (for definition see below)

2.4 Related parameters

Four other parameters are commonly used in describing availability performance. These are defined as follows :

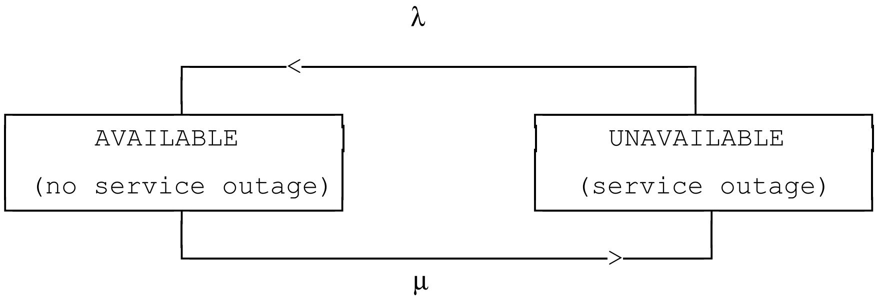
- Mean time to service restoral (MTTSR) is the average duration unavailable service time intervals.

- Failure rate ("lambda") is the average number of transitions from the available state to the unavailable state per unit available time.

- Restoral rate ("mu") is the average number of transitions from the unavailable state to the available state per unit available time.

- Unavailability (U) is the long term ratio of unavailable service time, expressed as a percentage.

Under the exponential distribution assumption of failure and restoration, the mathematical values for any of these parameters may be estimated from the values for service availability (A) and mean time between service outages as summarized in figure 22.



a) State diagram

$$MTBSO = \frac{1}{\mu} \qquad MTTSR = \frac{1}{\lambda}$$

$$A = 100\left[\frac{MTBSO}{MTBSO + MTTSR}\right] = 100\left[\frac{\lambda}{\mu + \lambda}\right]$$

$$U = 100 - A = 100\left[\frac{MTTSR}{MTBSO + MTTSR}\right] = 100\left[\frac{\mu}{\mu + \lambda}\right]$$

b) Parameter relationship

Figure 22: Basic availability model and parameters.

Annex A: Abbreviations

ISCTX	Integrated services centrex
ISDN	Integrated services digital network
ISPBX	Integrated services private branch exchange
PT	Private network termination
PTN	Private telecommunication network
PTNX	Private telecommunication network exchange
TE	Terminal equipment
PTNX	Private Telecommunication Network Exchange
$PTNX_e$	End PTNX
$PTNX_t$	Transit or intervening PTNX
S_a	Interface at the originating S reference point
S_b	Interface at the destination S reference point
S_{ei}, S_{eo}	Interface at the S reference point, at the incoming or outgoing side of the end PTNX
TE_a	Originating Extension Terminal
TE_b	Destination Extension Terminal
C_{ei}	Interface at the C reference point of incoming side of the end PTNX
C_{eo}	Interface at the C reference point of outgoing side of the end PTNX
C_{ti}	Interface at the C reference point of the incoming side of the intervening $PTNX_t$
C_{to}	Interface at the C reference point of the outgoing side of the intervening $PTNX_t$
$B_1..B_i..B_n$	Connection Element Boundaries

Annex B: Negotiation with the public network provider concerning the performance of the intervening public network

Example for delay values (Further study is required)

Negotiation will not take place by the network on a per call basis but when installing the interconnection of two private networks via the public (ISDN) network.

It is only necessary to negotiate when the expected connection is long and the possibility exists that the worst case can be reached.

In order to be able to negotiate with the public network provider it is necessary that the delay values for the private part(s) can be defined.

Therefore provisional values for a network section (see figure B.1) are proposed as follows :

- Connection Setup or Alerting delay (worst case values) :

  - mean value : 450 ms per connection section.

  - 95% value : 835 ms per connection section.

- Disconnect delay :

  - mean value : 270 ms per connection section.

  - 95% value : 470 ms per connection section.

  - Maximum number of private sections in the connection : 8.

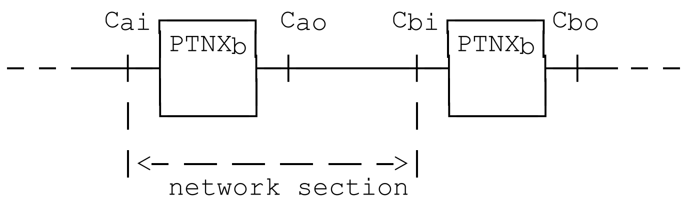


Figure B.1

Referring to the formulas [1] in subclauses 2.1.3.1; 2.2.3.1 and 2.3.3.1 of Chapter III, the required set-up delay values (x_p) the alerting delay values (y_p) and the disconnect delay values (w_p) should be lower than the worst case values within a public ISDN.

Those values for the intervening ISDN have to be negotiated with the public network provider on installation time.

If the intervening network is long and the worst case performance may be reached, the public network provider should be asked to guarantee better performance of the intervening network.

Better performance means lower delays. This can be reached by :

- providing higher quality networks;

- reducing the number of public network sections in the connection.

For the latter case examples are given in the figure B.2.

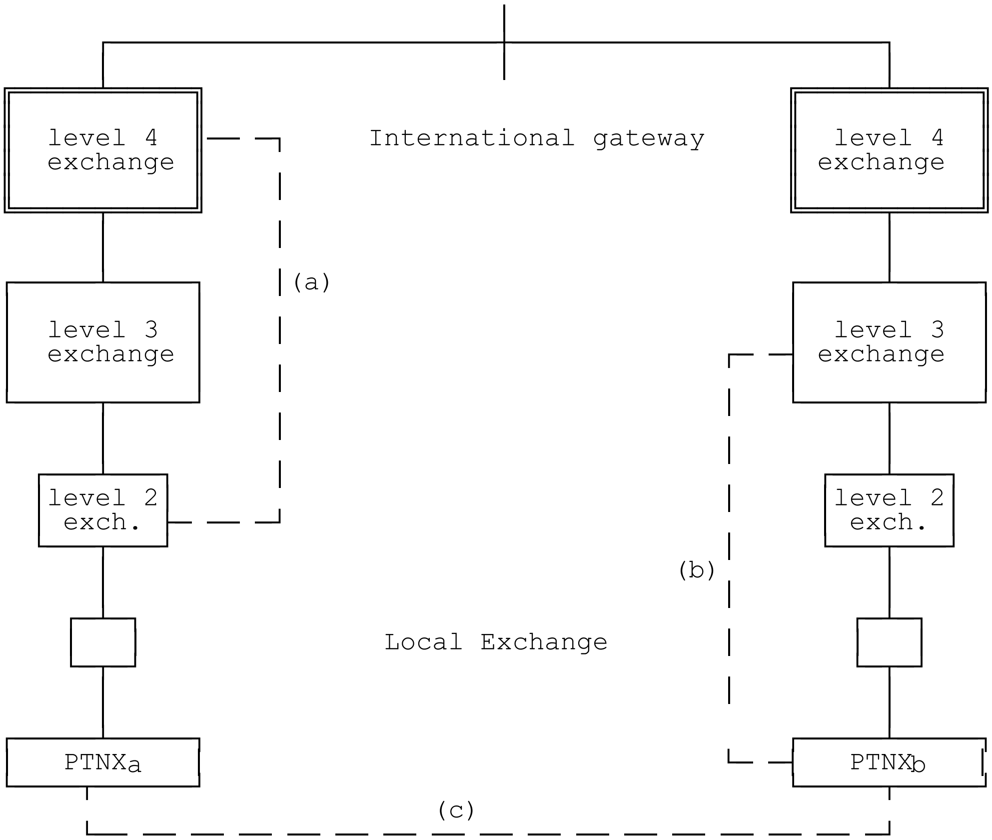


Figure B.2

The number of public network sections can be reduced by :

a) making direct connections between switching centres of eg level 2 and 4; 1 and 3 etc... in the public intervening ISDN;

b) connecting the PTN to a switching center of figure order eg. directly to a level 2, 3 or even 4 switching center;

c) even interconnecting the PTN parts by a direct connection (dedicated leased line).

It can be supposed that the cost for the use of the intervening public (ISDN) network depends on the performance of this network. eg. It should be logical that a dedicated leased line, which give the best performance (lowest delays) should cost most.

History

Document history	
April 1991	First Edition
January 1996	Converted into Adobe Acrobat Portable Document Format (PDF)