INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

E.439

(03/2000)

SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Quality of service, network management and traffic engineering – Network management – Checking the quality of the international telephone service

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Test call measurement to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation

ITU-T Recommendation E.439

(Formerly CCITT Recommendation)

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ITU-T RECOMMENDATION E.439

TEST CALL MEASUREMENT TO ASSESS N-ISDN 64 kbit/s CIRCUIT-SWITCHED BEARER SERVICE UDI IN OPERATION

Summary

This Recommendation presents an overview of the operational measurements, defined in Recommendation E.438, that can be performed by test calls and used to assess the performance of N-ISDN 64 kbit/s circuit-switched UDI bearer services. Correspondent measurements (excluding transmission quality measures), performed by exchanges on live traffic, are specified in Recommendation M.3650. These Recommendations should be used by administrations and by ROAs for monitoring and improvement analysis of ISDN services and networks in operations. The measured values can be used both to set guaranteed performance levels in Service Level Agreement with the customers and Service Quality Agreements with other administrations, and to verify, analyse and improve the performance level currently achieved.

Source

ITU-T Recommendation E.439 was prepared by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 13 March 2000.

FOREWORD

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

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

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Introduction

ISDN traffic is growing, particularly for access to Internet and to broadband networks, and for videocommunication services. Standard measurements, as close as possible to those used for PSTN, are needed to monitor the level of performance achieved.

This Recommendation describes practical definitions and methods to be used in operation for measuring the performance of ISDN CSCT 64 kbit/s UDI bearer service on a per-call basis through test call generation. The standard NP/QOS measures and the related definitions and considerations are described in ITU-T Recommendation E.438. Similar measures taken in operation for real traffic are described in ITU-T Recommendation M.3650.

The list of operational measures and the NP/QOS parameters enabling assessment, by the three performance serveability criteria, of the three communication functions of an ISDN call, are described in clause 7. Remarks on performance of multiple channel calls for ISDN are made in 7.2. Specific considerations on ISDN calls using primary rate interface accesses are made in clause 8. Calculation methods and procedures to derive the NP/QOS statistical parameters from the NP measures obtained on a per-call basis are provided in Annex A. In Annex B, data collection principles and statistical calculation procedures for the same parameters are described. Annex C references statistical procedures to estimate the confidence interval for the performance parameters and compliance testing to verify their acceptability level.

Recommendation E.439

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1 Introduction

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This Recommendation describes practical definitions and methods to be used in operation for measuring the performance of ISDN CSCT 64 kbit/s UDI bearer service on a per-call basis through test call generation. The standard NP/QOS measures and the related definitions and considerations are described in ITU-T Recommendation E.438. Similar measures taken in operation for real traffic are described in ITU-T Recommendation M.3650.

The list of operational measures and the NP/QOS parameters enabling assessment, by the three performance serveability criteria, of the three communication functions of an ISDN call, are described in clause 7. Remarks on performance of multiple channel calls for ISDN are made in 7.2. Specific considerations on ISDN calls using primary rate interface accesses are made in clause 8. Calculation methods and procedures to derive the NP/QOS statistical parameters from the NP measures obtained on a per-call basis are provided in Annex A. In Annex B, data collection principles and statistical calculation procedures for the same parameters are described. Annex C references statistical procedures to estimate the confidence interval for the performance parameters and compliance testing to verify their acceptability level.

2 Scope

This Recommendation describes methods for assessing in operation the serveability performance of setup, information transfer and disengagement phases of 64 kbit/s circuit-switched ISDN connections and networks by means of test calls. Methods are given for determining the values of derived performance parameters from the primary measurements. The parameters themselves are, for the most part, defined in other Recommendations in the E-, G-, I-, M- and O-series.

The methods described in this Recommendation are applicable only to the unrestricted digital bearer service accessed via basic rate and primary rate ISDN[1,2,3,4]. QOS estimation of teleservices using 64 kbit/s UDI requires the definition of appropriate performance parameters that take account of the effects of terminal equipment on QOS: this is for future study. In some cases, a compromise is necessary between the formal definition of a parameter and the means of measuring it. Where such compromises are required, this Recommendation takes the pragmatic view that a performance parameter is of little value if it cannot be operationally measured and its formal definition has been

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1 This includes both 64 kbit/s services and n × 64 kbits/s services.

2 The inclusion of parameters for assessing the information transfer phase of 3.1 kHz audio and the speech bearer services are for further study. Therefore, the performance of mixed connections ISDN ↔ PSTN are not presently considered.

3 This Recommendation does not consider Dedicated Circuit Connection Type (DCCT) and Packet Switched Connection Type (PSCT).

4 Packet switched ISDN services, teleservices and supplementary services are not within the scope of this Recommendation at present.

adjusted accordingly. Additionally, not all parameters reflect the way in which a user might view the QOS of service and the parameters and measurements method described herein are for network assessment only. The mapping of the measurement made with this Recommendation into parameters reflecting the customer view is beyond the scope of this Recommendation and is left to individual ROAs.

3 References

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

[1] ITU-T Recommendation E.438 (2000), *Performance parameters and measurement methods to assess N-ISDN 64 kbit/s circuit switched bearer service UDI in operation*.

[2] ITU-T Recommendation M.3650 (1997), *Network performance measurements of ISDN calls*.

[3] ITU-T Recommendation E.721 (1999), *Network grade of service parameters and target values for circuit-switched services in the evolving ISDN*.

[4] ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDNs*.

[5] ITU-T Recommendation I.352 (1993), *Network performance objectives for connection processing delays in an ISDN*.

[6] ITU-T Recommendation I.353 (1996), *Reference events for defining ISDN and B-ISDN performance parameters.*

[7] ITU-T Recommendation I.355 (1995), *ISDN 64 kbit/s connection type availability performance*.

[8] ITU-T Recommendation G.114 (1988), *Mean one-way propagation time*.

[9] ITU-T Recommendation G.821 (1996), *Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an integrated services digital network*.

[10] ITU-T Recommendation O.152 (1992), *Error performance measuring equipment for bit rates of 64 kbit/s and N × 64 kbit/s*.

[11] ITU-T Recommendation E.846 (1993), *Accessibility for 64 kbit/s circuit-switched international end-to-end ISDN connection types*.

[12] ITU-T Recommendation E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.

[13] ITU-T Recommendation E.820 (1992), *Call models for serveability and service integrity performance*.

[14] ITU-T Recommendation E.425 (1998), *Internal automatic observations*.

[15] ITU-T Recommendation I.430 (1995), *Basic user-network interface – Layer 1 specification*.

[16] ITU-T Recommendation Q.921 (1997), *ISDN user-network interface – Data link layer specification.*

[17] ITU-T Recommendation Q.931 (1998), *ISDN user-network interface layer 3 specification for basic call control*.

[18] ITU-T Recommendation E.600 (1993), *Terms and definitions of traffic engineering*.

[19] ITU-T Recommendation E.850 (1992), *Connection retainability objective for the international telephone service.*

[20] ITU-T Recommendation E.428 (1992), *Connection retention*.

[21] ITU-T Handbook on Quality of Service and Network Performance, Geneva 1993.

[22] ITU-T Recommendation I.112 (1993), *Vocabulary of terms for ISDNs.*

[23] ITU-T Recommendation I.431 (1993), *Primary rate user-network interface – Layer 1 specification*.

[24] ITU-T Recommendation E.845 (1988), *Connection accessibility objective for the international telephone service.*

4 Terms and definitions

For the purposes of this Recommendation, see definitions given in or referenced by E.438.

5 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

ABR	Answer Bid Ratio
ASR	Answer Seizure Ratio
BRA	Basic Rate Access
CDFR	Call Disengagement Failure Ratio
CSCT	Circuit Switched Connection Type
CSR	Call Success Ratio
DSS1	Digital Subscriber Signalling System No. 1
INMD	In-service, Non-intrusive Measurement Device
ISDN	Integrated Services Digital Network
MCDD	Mean Call Disengagement Delay
MCED	Mean Call Establishment Delay
MDOWPD	Mean Differential One-Way Propagation Delay
MES	Mean Errored Seconds
MOWPD	Mean One-Way Propagation Delay
MR	Misrouting Ratio
MSES	Mean Severely Errored Seconds
NER	Network Effectiveness Ratio
NP	Network Performance
OAM	Operation Administration and Maintenance
PRA	Primary Rate Access

PRR	Premature Release Rate
QOS	Quality of Service
TE	Terminal Equipment
UDI	Unrestricted Digital Information

6 General consideration on test call measurement for ISDN

All of the end-to-end ISDN NP/QOS parameters not involving the terminal's performance and the user's behaviour can be easily measured by test calls. Most of the serveability parameters are measured on the D-channel and are derived from observations of specific DSS1 protocol signals at the S/T interface and from call states transitions (user side), as defined in [16] and [17]. Those including the user behaviour (such as ASR, ABR) are not directly measurable by test calls. For these parameters, measurement of real traffic is recommended. For the parameters related to call transmission quality, test call measurements are taken on the B-channel. It is also possible to distinguish and to measure all the channels (and connections) involved in a multi-channel call using test calls. Additionally, misrouted calls can be easily detected. By analyzing these elementary data on connections suffering poor performance, it is possible to detect and locate the causes of failures and malfunctions in the network.

The test call measurements are normally performed only at the transport layers (layer 1-3 according to OSI model) of the bearer protocols, as the test call equipment is usually only able to emulate the bearer services. However, the trend is to include in test equipment the capability to emulate higher layers of standardized protocols for some popular teleservices (such as T4 for fax, H.221/H.242 for videocommunication or H.323 for videoconferencing)[5] making specific measurements closer to the QOS experienced by the users.

7 NP/QOS ISDN parameters considered

This clause gives methods and criteria for making end-to-end NP/QOS elementary measures in operation, on a per-call basis by test call devices. The related NP/QOS parameters defined in [1] are listed in Table 1[6], measures of these can be statistically derived from representative test call populations by using the formulae shown in Annex A. These parameters are all expressed as % values. Specific ISDN↔PSTN NP parameters are not included, being for further study.

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[5] Thus also including both the performance of the terminal and of interoperability with the network and with others terminals. Nevertheless, some terminal dependent implementation feature (such as timer, signalling options, processing times, functional procedures, etc.) cannot be precisely taken into account.

[6] For specific operational purposes, also the "Misrouting probability" parameter (see [12]) can be estimated.

Table 1/E.439 – Basic ISDN NP/QOS operational parameters

NP/QOS parameter	Symb	Rec.	NP elementary measure	Symb	Perform. Criterion
Connection Setup Phase					
Network Effectiveness Ratio	NER	E.425	connection setup outcome	cso	D
Call Success Ratio	CSR	E.438	connection setup outcome & destination test terminal	cso	D
Mean Call Establishment Delay	MCED	I.352	connection establishment delay	ced	S
Connection Information Transfer Phase					
Mean One-Way Propagation Delay	MOWPD	G.114	one-way propagation delay	owpd	S
Mean Differential OW Propagation Delay	MDOWPD		one-way propagation delay	owpd	S
Mean Errored Seconds	MES	G.821	bit error rate	ber	A
Mean Severely Errored Seconds	MSES	G.821	bit error rate	ber	A
Premature Release Rate	PRR	E.850 E.428	User information transfer outcome	uito	D
Connection Disengagement Phase					
Mean Call Disengagement Delay	MCDD	I.352	call disengagement delay	cdd	S
Call Disengagement Failure Ratio	CDFR	E.800	call disengagement outcome	cdo	D
A Accuracy D Dependability S Speed					

7.1 Test call measurements to assess NP/QOS parameters for ISDN calls using 64 kbit/s UDI single channel[7]

7.1.1 Call setup phase

Elementary performance measures (performed on a single call)

Connection setup outcome (cso)

Measurement: Reception at the S/T interface (calling user side) of a CONNECT[8] DSS1 message from the network (cso = Y → call effective), or not (cso = N → call ineffective).

[7] The accuracy of the testing performed to check the dependability criteria depends on how and how many optional parts of the protocol in the user side specified in [17] (necessary to point out any malfunctions in the DSS1 call control procedure performed by the network) are implemented in the TE. Moreover, for the handling of message type or sequence errors, the STATUS ENQUIRY shall be sent to the network in order to obtain the call state in the network side.

[8] All the NP/QOS measures referring to the ALERTING message are equivalent to those referring to CONNECT message (except in some cases for a negligible and constant processing time of the test call device when it generates both messages). The reason is that the test call equipment (and loop-back devices) is always regarded as being available (if not, the measure should be managed differently or discarded).

Call establishment delay (ced)

Measurement: Measure of the time interval (ced – expressed in milliseconds) for each effective call beginning at the instant in which *the first bit* of the first DSS1 layer 2 frame of the call attempt crosses the S/T interface, and ending when *the last bit* of the first layer 2 frame, coming from the network and containing the layer 3 CONNECT message relative to the same call, is received at the same interface[9].

Usage notes: The measured time intervals shall be representative of the setup sequence most commonly experienced by the user of a specific application requesting the circuit-switched bearer service under test.

NP/QOS parameters (estimated on a sample of calls)

Network Effectiveness Ratio (NER)[10]

Definition: E.425 [14]

Estimation: The NER is evaluated as the ratio of the number Na of *effective calls* (seizures with cso = Y) to the number Ns of *seizures* expressed as a percentage. A seizure is a bid (test call) that obtains a B-channel assignment notification under the assumption that the destination number, selected automatically by the test call device, is correctly provided.

Call Success Ratio (CSR)

Definition: E.438 [1]

Estimation: The CSR is evaluated as the ratio of the number Nd of *effective calls* (seizures with cso = Y) correctly routed to the destination terminal (recognized by the calling terminal's management system[11]) to the number Ns of *seizures* expressed as a percentage. A seizure is a bid (test call) that obtains a B-channel assignment notification under the assumption that the destination number, selected automatically by the test call device, is correctly provided.

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[9] In order to obtain a more accurate measure, the delay introduced by the layer 2 link establishment should be included, as in the case of a failure of the first attempt to obtain the establishment of multiple frame operation**,** a successive request cannot be sent before 1 second (the timers T200 implemented in the user and in the network side last after that time). This is due to the timer T200 activated at the setup of the layer 2 of the DSS1 protocol after a call request, when a SABME (Set Asynchronous Balanced Mode Extended) unnumbered frame is sent, and deactivated by the UA (Unnumbered Acknowledgment) unnumbered frame sent back by the Layer 2 entity which have received the SABME frame. In the case of a failure (the setup of Layer 2 cannot be completed) the same entity answers with a DM (Disconnect Mode) and the timer is stopped. But if neither a UA nor a DM frame is received within 1 second, the timer expires and the same procedure is reactivated for other 2 times, and then definitively terminated by sending to the layer 2 management entity an MDL-ERROR-INDICATION primitive.

[10] The complementary measure NER is also used in operation, according to [24].

[11] The procedure for the remote terminal recognition shall be as reliable and quick as possible in order to avoid errors (acknowledgment of a wrong TE or failed recognition of the right TE) and to limit as much as possible calls released by the a remote terminal before the procedure completion: in these cases it could be difficult to distinguish between misrouted connections and calls prematurely released by the network.

Mean Call Establishment Delay (MCED)

Definition: I.352 [5]

Estimation: The *Mean Call Establishment Delay* (MCED) is evaluated as the arithmetic mean of the *call establishment delay* (ced) values measured in a representative population of test calls having successfully performed the network access function[12].

7.1.2 User information transfer phase

Elementary performance measures (performed on a single call)

One-way propagation delay (owpd)

Definition: G.114 [8]

The *one-way propagation delay* of a connection is normally evaluated as the mean of the propagation delays in the two directions of transmission[13]. A sufficiently accurate one-way propagation delay measurement requires at present too complex and costly solutions (basically two test call devices very well synchronized).

Measurement: Ater a successful connection setup phase of a test call directed to a remote device capable of performing the loop-back function, if:

- T is the time interval in milliseconds beginning with the sending of the first bit of a binary sequence at S/T interface of the calling TE and ending with the reception at the same interface of the last bit of the same sequence reflected by the loop-back device on the same B-channel used by the calling device in transmission.
- N is the number of bits of the binary sequence.
- T_L is the delay in milliseconds introduced by the loop-back function performed in the remote terminal, previously measured as the time interval beginning with the reception of one bit at S/T interface and ending with the retransmission of the same bit over the same channel in the opposite direction.

The *mean one-way propagation delay* shall be computed as:

$$0.5 \times (T - N \times 0.015625 - T_L)$$

If the binary sequence is such that the relative contribution[14] ($N \times 0.015625$) added up to the loop-back function delay T_L is shorter than a millisecond, these terms can be regarded as irrelevant, if not then the above mentioned formula shall be used in order to obtain a propagation delay measurement independent of the particular implementation adopted.

Bit error rate (ber)

Definition: G.821 [9]

Measurement: In conformance with [9], the *bit error rate (ber)* over a single B-channel shall be measured by the direct comparison of a pseudorandom test pattern made up with 2047 bits ($2^{11} - 1$) transmitted and received over the same B-channel.

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[12] In case of a single channel call, this is an estimation of the average delay experienced by a user for effective calls from the completion of the access requests to the reception of the indications of a connection to a remote user.

[13] This parameter gives a reliable estimation of the delays characterizing the two directions of transmission if these are provided by the same media. This condition is generally accomplished by CSCT ISDN connections.

[14] 0.015625 is the mean transmission time in milliseconds of one bit through a 64 kbit/s channel.

Two are two possible alternatives:

- *One-way BER measurements*: performed transmitting a test pattern to a remote device comparing it to an identical one, the same being done on the opposite direction of the same B-channel. In this case, two values will be available for each test call.
- *Two-way BER measurements*: performed transmitting the test pattern to a remote loop-back device which retransmits transparently the data received over the same B-channel in the opposite direction.

The first solution shall be preferred to the second one. Whatever solution is chosen, it should be explicitly indicated (*one-way* or *two-way*).

stotal, sunavail, errored seconds (es), severely errorred seconds (ses)

Definitions: G.821 [9]

Measurements: Every **ber** measurement (one-way or two-way) shall be provided with the relative values of the following derived measures as defined in [9]:

- *stotal*: the total *ber* monitoring time in seconds.
- *sunavail:* the number of one second intervals where the connection is deemed not to be available[15].
- **es**: *errored seconds* is the number of one second intervals within *savail* (*savail = stotal – sunavail*), rounded off to the next higher integer) with at least one errored bit.
- **ses**: *severely errored seconds* is the number of one second intervals within *savail* (*savail = stotal – sunavail*, rounded off to the next higher integer) where *ber* is worse than 10^{-3}.

User information transfer outcome (uito)

Measurement: Correct release process started by the test call device (after the reception of the CONNECT DSS1 message) at the end of the test call duration through the sending of a DISCONNECT DSS1 message (uito = Y); on the contrary, if a DISCONNECT, RELEASE or RELEASE COMPLETE DSS1 message is received from the network before the ending of the test call duration, the call is considered as prematurely released (uito = N)

NP/QOS parameters (estimated on a sample of calls)

Mean One-Way Propagation Delay (MOWPD)

Estimation: The *mean one-way propagation delay* is evaluated as the arithmetic mean of the one-way propagation delay values measured in a representative population of test calls.

Mean Errored Seconds (MES)

Estimation: Percentage of *Errored Seconds* measured in the *Savail* periods, averaged over a significant population of test calls with BER measurements.

Mean Severely Errored Seconds (MSES)

Estimation: Percentage of Severely *Errored Seconds* in the *Savail* periods, averaged over a significant population of test calls with BER measurements.

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[15] An unavailability period begins with ten consecutive seconds with a BER worse than 10^{-3} for each second and ends with the first of ten seconds with a BER better than 10^{-3}.

Premature Release Rate (PRR)

Definitions: E.850 [19]; E.428 [20].

Estimation: The PRR is evaluated as the ratio of the number of prematurely released calls (uito = N) to the number of test calls having successfully performed the access function, normalized to the mean call holding time[16] expressed in minutes.

The formula for the calculation of the statistical parameter normalized to the mean call holding time (see [19]) is also given in Annex A.

7.1.3 Call disengagement phase

Elementary performance measures (performed on a single call)

Call disengagement delay (cdd)

Definition: The *disengagement delay*, for a successfully disengaged call, is the time interval beginning with the sending by the TE of a call clearing request and ending when an appropriate answer is received from the network.

Measurement: It shall be measured for calls successfully cleared by the TE and by the network:

- Call clearing by the TE: the *disengagement delay* is the time interval (expressed in milliseconds) beginning with the *sending* by the TE of the first message requesting a call clearing (DISCONNECT or RELEASE) and ending with the *receiving* from the network of the first message stating that the call has been cleared (RELEASE or RELEASE COMPLETE respectively)[17].
- Call clearing by the network: the *disengagement delay* is the time interval (expressed in milliseconds) beginning with the *sending* by the TE of the first message requesting the release of a call disengaged by the network (RELEASE) and ending with the *receiving* from the network of the first message stating that the call has been released (RELEASE COMPLETE).

Call disengagement outcome (cdo)

Measurement: Reception (cdo = Y) or not (cdo = N) from the network of a RELEASE or a RELEASE COMPLETE DSS1 message. cdo = y means connection correctly released (making the connection resources available for a new connection).

NP/QOS parameters (estimated on a sample of calls)

Mean Call Disengagement Delay (MCDD)

Definition: I.352[18] [5]

Estimation: The *Mean Call Disengagement Delay* is evaluated as the arithmetic mean of the call *disengagement delay* values measured in a representative test call population with a successfully performed disengagement function.

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[16] The duration of the mean call holding time, reflecting average ISDN call duration profiles could be derived from real traffic monitoring.

[17] The time of occurrence of the sending of a DSS1 layer 3 message (from a TE to the NT) is the time at which the first bit of the frame crosses the S/T interface, while that of receiving (from the NT to TE) is the time at which the last bit of the specified message crosses the same interface.

[18] The correspondent parameter in I.352 is called "release delay".

Call Disengagement Failure Ratio (CDFR)

Definition: E.800[19] [12] The *call disengagement failure probability* is the probability that a disengagement attempt is not successfully performed[20].

Estimation: Ratio of failed disengagement attempts (those with cdo = N) to the total number of test calls performed in a specified time period.

7.2 Test call measurements and criteria to assess NP parameters for ISDN calls using 64 kbit/s UDI multiple channels

7.2.1 Assessment of NP/QOS parameters for multi-channel calls

The measurements taken by test calls permit the assessment of not only connection related performance parameters, but also call[21] related parameters. In fact, in the case of a multi-channel call, the test call equipment is able to identify the channels used for each call to the destination terminal or loop-back device, and to measure the performances of the single connections involved between the S/T interfaces of each connection. So the overall end-to-end NP/QOS performance parameters, still estimated between the S/T interfaces, can be derived, from those of each channel involved in the call. The parameters are obtained (as mean values) by applying the performance criteria related composition formulae contained in Annex B[22]. For dependability parameters, it is sufficient to consider the multi-channel call not effective if at least one connection to the destination is not established.

Additional performance parameters, specific for multi-channel calls, should be measured. For example for videotelephony or videoconference (where audio and video share different channels), *the differential propagation delay between the channels involved* is a fundamental NP parameter used in operation for the user information transfer phase[23].

7.2.2 Specific NP/QOS parameters for multi-channel ISDN communications

Elementary performance measures

Differential one-way propagation delay (dowpd)

Definition: For the definition of the differential one-way propagation delay, see clause 4 of [1], [8] and 7.1.2.

Measurement: For a call using two B-channels (N = 2) it can be obtained by sending simultaneously[24] a recognizable bit (or sequence of bits) on both channels at the originating S/T interface (e.g. BRI), and measuring at the terminating S/T interface of the connection the time difference between the two instants of the reception of the same bit (or the last bit of the sequence).

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[19] In E.800 is called "release failure probability".

[20] For all the test calls, irrespective of their effectiveness and outcome.

[21] A call, related to a teleservice/application request, can be both single and multi-channel.

[22] It is important to distinguish in the evaluations, in the reports and as objectives between NP/QOS parameters related to single or to multi-channel call (for example NER, CSR, CED, ..., etc.)

[23] Depending on the allocation of the media services (voice, data, video) on the set of channels involved in a multi-channel call, there are some fundamental differences between connections performance and media QOS levels measured. If high level protocols, as well as the information exchanged on the B-channel, are also measurable by improved test call software tools (for standardized teleservices/application protocols), the resulting values are very close to the level of QOS experienced by the user.

[24] Simultaneously means that the maximum tolerated error, affecting the measured time, is one bit transmitting time.

For multi-channel calls (involving a number N > 2 B-channels), a vector of $2 \cdot \binom{N}{2}$ dowpd values (one for each couple of channels and for each way of transmission) can be obtained[25].

NP/QOS parameters (estimated on a sample of calls)

Mean Differential One-Way Propagation Delay (MDOWPD)[26]

Estimation: The *mean differential one-way propagation delay,* for a multi-channel ISDN communication, is the arithmetic mean, in a representative population of test multi-channel calls, of all the absolute values of the differences between the one-way propagation delays values in msec, measured between and referred to each pair of B-channels used in a multi-channel ISDN communication.

8 Consideration on ISDN calls using Primary Rate Interface

If an ISDN service call uses a subset or the whole number of the PRI channels, all the considerations and the NP/QOS parameters described in 7.1 and 7.2 apply. The measures are performed at the T interface, in accordance with [23].

ANNEX A

Calculation methods and procedures to derive NP/QOS parameters

This annex lists the main formulae that can be used to estimate (to evaluate, to assess) the NP/QOS parameters defined in clause 7.

For formulae involving dependability aspects (where the performance parameters is expressed as a ratio), the counters of the states and events in the call process (see also Figure A.1) are the following:

Nb Total number of test calls *(bids)* correctly made.

Ns Number of *seizures* (test calls with B-channel assigned).

Na Number of *bids (seizure*[27]*)* resulting in an answer signal (cso = Y).

Nd Number of effective bids correctly routed to the destination terminal.

Ne Number of completed test calls with errors on the information transferred (BER ≠ 0).

Ni Number of effective bids terminating correctly the user information transfer phase (uito = Y).

Nc Number of bids completing correctly and successfully all the communication phases.

Nr Number of effective calls not performing correctly the release function[28] (cdo = N).

Tc[29] Duration of the test call in case of normal release by the calling TE.

Th Average call duration (derived from traffic monitoring).

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[25] In this case the recognizable bit (or sequence of bits) must be sent simultaneously to all the N channels.

[26] This parameter is related to the speed criterion applied to the user information transfer phase.

[27] A bid must become a seizure to be effective.

[28] Including those prematurely released or not effective .

[29] The Tc, Th and Tp are call holding times.

Tp Estimated average call duration of prematurely released calls.

The elementary time measurements used for the formulae involving the speed criterion are:

ced Connection establishment delay for the effective calls in ms.

owpd One-way propagation delay in ms.

cdd Connection disengagement delay in ms.

While the measurements for the formulae involving the accuracy criterion are:

es Errored seconds.

ses Severely errored seconds.

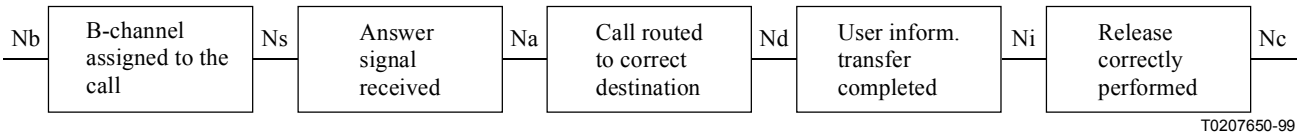

Figure A.1/E.439 – Counters (on a sample of Nb test calls) of the number of calls having performed correctly the related call processing function

Table A.1/E.439 – Formulae to evaluate the basic ISDN NP/QOS operational connection parameters

NP/QOS parameter	Estimation formulae
Connection Setup Phase (Note)	
Network Effectiveness Ratio	$NER^{\%} = \frac{Na}{Ns} \cdot 100$
Call Success Ratio	$CSR\% = \frac{Nd}{Ns} \cdot 100$
Mean Call Establishment Delay (ms)	$MCED = \frac{\sum_{i=1}^{Na} ced_i}{Na}$
Connection Information Transfer Phase	
Mean One-Way Propagation Delay (ms)	$MOWPD = \frac{\sum_{i=1}^{Na} owpd_i}{Na}$
Mean Differential OWPD between the channels i, j (ms)	$MDOWPD_{i,j} = \frac{\sum_{K=1}^{Na} (owpd_i^{(k)} - owpd_j^{(k)})}{Na}$
Mean Errored Seconds	$MES^{\%} = \frac{\sum_{1=1}^{Na} \frac{es_i}{savail}}{Na} \cdot 100$

Table A.1/E.439 – Formulae to evaluate the basic ISDN NP/QOS operational connection parameters *(concluded)*

NP/QOS parameter	Estimation formulae
Mean Severely Errored Seconds	$MSES^{\%} = \frac{\sum_{1=1}^{Na} \frac{ses_i}{savail}}{Na} \cdot 100$
Premature Release Rate	$PRR = \frac{1 - \frac{Ni}{Na}}{Th} \cdot 100$
Connection Disengagement Phase	
Mean Call Disengagement Delay (ms)	$MCDD = \frac{\sum_{i=1}^{Na} cdd_i}{Na}$
Call Disengagement Failure Ratio	$CDFR = \frac{Nr}{Na} \cdot 100$
NOTE – For specific operational purposes the misrouting probability MR (see [12]) can also be estimated, by applying the following formula: $MR = (1 - \frac{Nd}{Na}) \cdot 100$	

ANNEX B

Data collection principles and statistical procedure

In case of ISDN multi-channel communication, it is possible to derive the overall network related performance of the call by using performance data of single channel and the composition formulae.

B.1 Composition of ISDN speed criterion related performance parameters

For speed related NP parameters, if we assume that the delays d1, d2, ..., dn of each of the n channels varies randomly with mean D1, D2, ..., Dn and 95% points z1, z2, ..., zn respectively, then the total delay d = d1 + d2 + … + dn has a distribution with **mean D = D1 + D2 + ... Dn** with no further assumptions.

If, in addition, the delays are assumed to be statistically independent and that $z_i = D_i + k \cdot \sigma_i$ with the same k for all the portions (being σ_i the standard deviation of D_i), then the similar equality is also assumed for d, i.e. $Z = D + k \cdot \sigma_d$, where Z is the X% point (for example 95%) of d. These equalities are true for normal distributions with k = 1.645. Then the variance of d is the sum of the variances of the D_i. It follows that the 95% point of d is given by:

$$Z = D + [(z_1 - m_1)^2 + (z_1 - m_1)^2 + + (z_1 - m_1)^2]^{1/2}$$

The assumption of normality seems reasonable, but other assumptions are possible and could give substantially different answers.

Example: In a two-channel call, the channel c1 has a setup delay of 5 seconds, while the second channel c2 has a call setup delay of 7 seconds. The total delay introduced by the network between the S/T interfaces of the connection is globally of 12 seconds.

B.2 Composition of ISDN dependability criterion related performance parameters

The failure probability ratio (related to accessibility, retainability, integrity and release measures) of a call involving n channels can be roughly estimated as the sum of the failure probability of each channel by assuming that the success probability is high enough and does not change substantially among the channels used.

As an example, in the case of a call involving 2 channels (such as BRI videotelephony call), the formula can be easily derived:

Pr (failure 2B-channel call) =

= 1 – Pr (successful 2B-channel call) =

= 1 – Pr (successful 1B-channel call) · Pr (successful second B-channel call / Pr (successful first B-channel call) ≈

≈ 1 – Pr (successful 1B-channel call) · Pr (successful 1B-channel call) =

$= 1 - [\Pr(\text{successful 1B-channel call})]^2 =$

$= 1 - \{1 - [\Pr(\text{failure 1B-channel call})]\}^2 =$

$= 1 - \{1 - 2 \cdot [\Pr(\text{failure 1B-channel call})] + [\Pr(\text{failure 1B-channel call})]^2\} =$

$= 2 \cdot [\Pr(\text{failure 1B-channel call})] - [\Pr(\text{failure 1B-channel call})]^2$

If Pr (failure 1B-channel call) << 1 (acceptable hypothesis) then we can neglect the $[\Pr(\text{failure 1B-channel call})]^2$ term and we can conclude that :

$$\textbf{Pr (failure 2B-channel call)} \approx 2 \cdot \textbf{[Pr (failure 1B-channel call)]}$$

ANNEX C

Statistical treatment of ISDN NP parameters

In this annex some guidelines regarding the data collection and standard methods for their statistical processing (sample size and confidence interval estimation, compliance testing) are given.

All the NP/QOS parameters are categorized into four main sets as outlined in Table C.1. By using the appropriate class identified by this table, it is possible to estimate the confidence interval related to a measure, and to verify if the assessed values for that parameter complies with its objective threshold. The specific statistical treatment, referenced in Annex C of [21], should be applied.

The network performance parameters that are time related are normally evaluated as **mean**. Their objective values can also be obtained by fixing the one side statistical tolerance interval and estimating the fractile by the available sample. Sometimes the operator prefers to estimate the ratio of calls which have an achieved value satisfactory (or unsatisfactory) with respect to a prefixed threshold (or objective or outcome) to the total number of calls. In this case, the column **ratio** should be used. An example is the % age of calls exceeding x msec to establish the connection (or the call). The dependability and the accuracy parameters are normally estimated in terms of a **ratio**. The frequency of a prematurely released call is the only parameter expressed as a **rate**.

The statistical NP and QOS parameters shall be derived from representative test calls populations, each of them performed from a specific origin to a specific destination or between specific users (or class of users).

The test calls should be scheduled to reflect traffic variations over the hours of a day, the days of a week and the months of a year. Alternatively, they may be uniformly distributed and weighted according to the real traffic variations.

Table C.1/E.439 – Statistical classification of ISDN QOS/NP parameters

NP/QOS parameter	Mean	% Fractile	Ratio	Rate/ Intensity
MCED – Mean Call Establishment Delay	X	X		
NER – Network Effectiveness Ratio			X	
MOWPD – Mean One-Way Propagation Delay	X	X		
MDOPD – Mean Differential One-Way Propagation Delay	X	X		
MES – Mean Errored Seconds			X	
MSES – Mean Severely Errored Seconds			X	
PRR – Premature Release Rate				X
MCDD – Mean Call Disengagement Delay	X	X		
CDFR – Call Disengagement Failure Ratio			X	

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Printed in Switzerland
Geneva, 2001