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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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Measurements and metrics for characterizing facsimile transmission performance using non-intrusive techniques

ITU-T Recommendation E.459

(Previously CCITT Recommendation)

ITU-T E-SERIES RECOMMENDATIONS

OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

OPERATION, NUMBERING, ROUTING AND MOBILE SERVICES	
INTERNATIONAL OPERATION	
OPERATIONAL PROVISIONS RELATING TO CHARGING AND ACCOUNTING IN THE INTERNATIONAL TELEPHONE SERVICE	
UTILIZATION OF THE INTERNATIONAL TELEPHONE NETWORK FOR NON-TELEPHONY APPLICATIONS	
ISDN PROVISIONS CONCERNING USERS	E.330–E.399
QUALITY OF SERVICE, NETWORK MANAGEMENT AND TRAFFIC ENGINEERING	
NETWORK MANAGEMENT	
International service statistics	E.400–E.409
International network management	E.410–E.419
Checking the quality of the international telephone service	**E.420–E.489**
TRAFFIC ENGINEERING	
QUALITY OF TELECOMMUNICATION SERVICES: CONCEPTS, MODELS, OBJECTIVES AND DEPENDABILITY PLANNING	

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION E.459

MEASUREMENTS AND METRICS FOR CHARACTERIZING FACSIMILE TRANSMISSION PERFORMANCE USING NON-INTRUSIVE TECHNIQUES

Summary

This Recommendation provides specifications for the ways in which facsimile calls can be non-intrusively monitored. Non-intrusive fax performance monitoring is done from within a network, and can provide a broad view of fax performance over the network being monitored. These are some significant differences between end-to-end fax performance measurement and non-intrusive measurement. The chief advantage of non-intrusive measurements is that they provide a view of performance encompassing a range of physical locations and terminals that cannot be practically achieved when testing end-to-end.

Source

ITU-T Recommendation E.459 was prepared by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 9th of March 1998.

FOREWORD

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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

MEASUREMENTS AND METRICS FOR CHARACTERIZING FACSIMILE TRANSMISSION PERFORMANCE USING NON-INTRUSIVE TECHNIQUES

(Geneva, 1998)

1 Introduction

This Recommendation provides specifications for the ways in which facsimile calls can be non-intrusively monitored. Non-intrusive fax performance monitoring is done from within a network, and can provide a broad view of fax performance over the network being monitored. There are some significant differences between end-to-end fax performance measurement and non-intrusive measurement. The chief advantage of non-intrusive measurements is that they provide a view of performance encompassing a range of physical locations and terminals that cannot be practically achieved when testing end-to-end. Non-intrusive testing can provide an accurate view of the quality of fax service being observed by a large number of customers using the network under observation. However, results from non-intrusive testing are affected by human factors (such as paper jams, out of paper, user clears call before completion, transactions of various sizes), and the potential contribution of terminal incompatibilities.

2 Scope

This Recommendation provides a method by which large numbers of calls may be monitored, giving rise to a very large quantity of data which must be suitable for subsequent analysis. The process by which this data is gathered and subsequently analysed is divided into two operations. Firstly, **measurements** are taken on each individual call monitored, and these are then used to produce **metrics** which are useful to service providers. Some additional information is also collected, which may be of use in the further investigation of problems which have been revealed by the monitoring process. This Recommendation consists of five sections:

1) Definition of the **measurements** which must be taken on each individual call that is monitored, referred to as **call data**.

2) Definition of the **cumulative data** which can then be generated from the call data.

3) Definition of three **primary metrics** that can be used to easily compare the performance of fax traffic over various transmission paths.

4) Identification of some **secondary metrics** which are optional and correspond to those in Recommendation E.458 for test calls.

5) Identification of **optional metrics** which may be useful when investigating the reasons for poor performance.

The interface between the monitoring equipment and the network is outside the scope of this Recommendation.

The volume and sampling of calls monitored to achieve required statistical accuracy is described in Annex A/E.457.

The method defined in this Recommendation does not apply to V.34 facsimile. The monitoring of V.34 facsimile calls is for further study.

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.

– ITU-T Recommendation T.4 (1996), *Standardization of Group 3 facsimile terminals for document transmission*.

– CCITT Recommendation T.6 (1988), *Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus*.

– ITU-T Recommendation T.30 (1996), *Procedures for document facsimile transmission in the general switched telephone network*.

– ITU-T Recommendation E.450 (1993), *Facsimile quality of service on PSTN – General aspects*.

– ITU-T Recommendation E.451 (1993), *Facsimile call cut-off performance*.

– ITU-T Recommendation E.452 (1993), *Facsimile modem speed reduction and transaction times*.

– ITU-T Recommendation E.453 (1994), *Facsimile image quality as corrupted by transmission-induced scan line errors.*

– ITU-T Recommendation E.454 (1996), *Transmission performance metrics for Error Correction Mode (ECM) facsimile*.

– ITU-T Recommendation E.457 (1996), *Facsimile measurement methodologies*.

– ITU-T Recommendation E.458 (1996), *Figure of merit for facsimile transmission performance*.

4 Call Data measurements

Four types of **Call Data** measurement may be made:

1) Protocol-based measurements;

2) Image measurements;

3) Analogue measurements;

4) Signalling and routing information.

The principal Call Data measurements described in this Recommendation may be obtained from analysis of the T.30 binary coded protocol messages. Additional information may be gained by other methods, and these are described in Annexes A, B and C.

4.1 Protocol-based Call Data measurements

The following measurements must be recorded for each call. Measurements are either "information", which can be extracted from T.30 protocol messages, or simple "Yes/No" decisions on whether a condition was met. Where the type or contents of T.30 frames must be analysed, the frame must have a correct CRC.

Table 1/E.459 – Protocol-based call data measurements

Measurement	Type	Comments
TSI	Information	If present
CSI	Information	If present
CIG	Information	If present
Last frame of the call in each direction	Information	To determine whether call is complete, and if not, to provide diagnostic information. Recording of frames immediately before the last frame in each direction may be necessary and is for further study.
Call complete	Yes/No	Detected MCF then DCN. "No" indicates an incomplete call.
Number of RTP frames detected (Note)	Information	Indicates transmission errors
Number of RTN frames detected (Note)	Information	Indicates severe transmission errors
Fallback before first page (Note)	Yes/No	
FTT at all transmission rates (Note)	Yes/No	Indicates that call has failed

Table 1/E.459 – Protocol-based call data measurements *(concluded)*

Measurement	Type	Comments
Disconnect after DCS	Yes/No	Precise condition needs to be defined
DCN from transmitter	Yes/No	
DCN from receiver	Yes/No	
NSS or NSC detected	Yes/No	Indicates a non-standard call
CNG only	Yes/No	May indicate a mis-dialled fax call
DIS only	Yes/No	May indicate a mis-dialled voice call
Pages sent at V.17, 14.4 kbit/s	Information	Number of pages sent
Pages sent at V.17, 12 kbit/s	Information	Number of pages sent
Pages sent at V.17, 9.6 kbit/s	Information	Number of pages sent
Pages sent at V.17, 7.2 kbit/s	Information	Number of pages sent
Pages sent at V.29, 9.6 kbit/s	Information	Number of pages sent
Pages sent at V.29, 7.2 kbit/s	Information	Number of pages sent
Pages sent at V.27 *ter*, 4.8 kbit/s	Information	Number of pages sent
Pages sent at V.27 *ter*, 2.4 kbit/s	Information	Number of pages sent
T.30 Annex A (ECM)	Yes/No	"Yes" indicates T.30 error correction mode. "No" indicates T.30 basic mode
In ECM calls, capture PPR and corresponding PPS frames	Information	PPR and PPS frame information need not be captured beyond the 10th partial page
64-octet frames	Yes/No	Valid only for ECM transmissions. "No" implies 256 octets
NOTE – Some of the protocol based-measurements must be taken from non-standardized actions. For instance, the number or percentage of errored lines that will result in RTP/RTN is not standardized in Recommendations T.4, T.6 and T.30; neither is the response to TCF. This means that responses will vary from manufacturer to manufacturer and perhaps even between different machines from the same manufacturer.		

4.2 Image-related Call Data measurements

Image-related Call Data measurements are made by demodulation of the T.30 phase C image data so that the image quality can be assessed independently of the protocol measurements. The use of Image-related Call Data measurements avoids the assumptions which must be made to relate the numbers of errored lines with the occurrence of RTP and RTN messages.

Measurements based on Image-related Call Data are optional, and are described in Annex A.

4.3 Analogue Call Data measurements

Modern digital signal processing techniques permit the measurement of analogue transmission impairments in the presence of a modem signal. The physical connection point of the monitor will affect the measurements made. For instance, if the monitor tap point is on the 4-wire portion of network, then Echo Return Loss (ERL) and echo delay can be measured. ERL cannot be reliably measured at a 2-wire monitor point.

Analogue measurements are optional and are described in Annex B.

4.4 Signalling-related Call Data Measurements

Examples of information that can be extracted from signalling messages are:

– Called party number;

– Calling party number;

– Duration of call;

– Routing of call.

Signalling messages can also give a definite indication of the start and finish of a call without which it is difficult to determine call boundaries.

Collection of signalling-based information is optional, and is described in Annex C.

5 Cumulative data measurements

5.1 Cumulative data measurements based on T.30 protocol messages

The following data must be generated from the individual Call Data measurements. The cumulative data is used to generate the primary, secondary and optional metrics, as indicated in the columns headed P, S and O in Table 3.

The following definitions are for the purposes of this Recommendation only

A **fax call** is a call where either:

1) a CNG tone is detected from one terminal and a DIS signal is detected from the other; or

2) a DIS is detected followed by a T.30 message from the other terminal;

i.e. CED + DIS without any fax signal from the calling end does not constitute a fax call as this may be a misdialled voice call.

Table 2/E.459 – Definition of Image quality

Image quality	Basic mode	Error correction mode
A	Pages which are responded to with an MCF	Pages with less than 3% errored frames (Note)
B	Pages that are responded to with an RTP	Pages with greater than 3% but less than 10% errored frames (Note)
C	Pages that are responded to with an RTN	Pages with 10% or greater errored frames (Note)
NOTE – A page in error correction mode may be made up of a number of partial pages. These definitions differ from E.453, which assumes knowledge of the number and distribution of errored lines in a test call image. The definitions are based only on information that can be extracted from protocol messages. See also Annex B.		

Table 3/E.459 – Cumulative data measurements

Name	What	How	Comments	P	S	O
	CALL COMPLETION DATA					
T	Total number of fax calls		See definition of fax call above			√
T_{STD}	Total number of standard fax calls	Calls in which NSS or NSC is not returned	Defined to be all fax calls except those which use non-standard facilities	√	√	

Table 3/E.459 – Cumulative data measurements *(continued)*

Name	What	How	Comments	P	S	O
	CALL COMPLETION DATA					
T_C	Total number of standard facsimile calls which complete OK	Calls ending with MCF, DCN and do not contain NSS or NSC		√	√	
F_{1B}	Number of calls which disconnect after DCS	No CFR or FTT detected	Existing measure F_{1B} could be used but may need slight redefinition			√
F_m	Number of calls which fail after CFR	No post page response (MCF, RTP, RTN or PPR)	Existing measure F_m could be used but may need slight redefinition. This assists in identifying calls which fail due to poor echo control			√
F_{TT}	Number of calls which completely fail to train	FTT detected but no CFR	No pages sent – identifies lines of extremely poor quality			√
	TRANSMISSION RATE DATA					
C_1	Number of calls which connect at first choice transmission rate	CFR detected after DCS with first choice transmission rate No subsequent fallback		√		
C_R	Number of completed calls which connect at first choice transmission rate but retrain to lower rate after one or more pages sent	CFR detected after DCS with first choice transmission rate.				√
C_B	Number of completed calls with fallback	Calls in which FTT is returned in initial negotiation (before first page)				√
$C_{1;m;x}$	Number of calls which connect with first choice transmission rate using modulation type "m" and transmission rate "x"					√
$C_{B;m;x}$	Number of calls which fall back and use modulation type "m" and transmission rate "x"					√
	IMAGE QUALITY DATA					
I_{BQ1}	Number of calls which use Basic mode and have image quality A		See image quality definitions in Table 2	√		
new I_{EQ1}	Number of calls which use ECM and have image quality A		See image quality definitions in Table 2	√		
I_{BQ2}	Number of calls which use Basic mode and have image quality B		See image quality definitions in Table 2			√
I_{EQ2}	Number of calls which use ECM and have image quality B		See image quality definitions in Table 2			√

Table 3/E.459 – Cumulative data measurements *(concluded)*

Name	What	How	Comments	P	S	O
	IMAGE QUALITY DATA					
I_{BQ3}	Number of calls which use Basic mode and have image quality C		See image quality definitions in Table 2. Calls in which RTN occurs may be abandoned by the terminal equipment and may not end with MCF, DCN so will not be counted as completed			√
I_{EQ3}	Number of calls which use ECM and have image quality C		See image quality definitions in Table 2			√
I_B	Number of Basic mode calls in which at least one page was sent and acknowledged	At least one MCF, RTP or RTN was detected		√		
I_E	Number of ECM calls in which at least one partial page was sent and acknowledged	At least one MCF or PPR was detected		√		
	RATE AND QUALITY COMBINED DATA					
Q_{m1}	Number of calls completed at maximum speed with image quality A				√	
Q_{m2}	Number of calls completed at maximum speed with image quality B				√	
Q_{m3}	Number of calls completed at maximum speed with image quality C				√	
Q_{f1}	Number of calls completed at fallback speed with image quality A				√	
Q_{f2}	Number of calls completed at fallback speed with image quality B				√	
Q_{f3}	Number of calls completed at fallback speed with image quality C				√	

6 Metrics

6.1 Primary metrics

Service providers may desire to monitor performance on individual routes so that variation over time may be detected. They may also wish to compare performance of different routes. The principal metrics identified in clause 4/E.450 are facsimile call cut-offs (i.e. call completion), facsimile modem (speed transmission rate) and transaction times, and facsimile image quality. These metrics have been closely followed below in the definition of the three primary metrics suitable for the monitoring of large numbers of facsimile calls. These metrics are independent of each other.

Metric 1 % Call completion $= (T_C/T_{STD}) * 100$

Metric 2 % Calls using maximum transmission rate $= (C_1/T_{STD}) * 100$

Metric 3 % Calls with good image quality $= ((I_{BQ1} + I_{EQ1})/(I_B + I_E)) * 100$

6.2 Secondary metrics

The optional secondary metrics provide a comparison of the numbers of calls which meet the criteria for the seven types of transaction defined in clause 2/E.458.

Metric 4	% of calls completed at maximum speed and without transmission errors (E.458 Transaction type I)	$= (Q_{m1}/T_C) * 100$
Metric 5	% of calls completed at maximum speed and with transmission errors (E.458 Transaction type II)	$= (Q_{m2}/T_C) * 100$
Metric 6	% of calls completed at maximum speed and with severe transmission errors (E.458 Transaction type III)	$= (Q_{m3}/T_C) * 100$
Metric 7	% of calls completed at fallback speed and without transmission errors (E.458 Transaction type IV)	$= (Q_{f1}/T_C) * 100$
Metric 8	% of calls completed at fallback speed and with transmission errors (E.458 Transaction type V)	$= (Q_{f2}/ T_C) * 100$
Metric 9	% of calls completed at fallback speed and with severe transmission errors (E.458 Transaction type VI)	$= (Q_{f3}/T_C) * 100$
Metric 10	Incomplete call (E.458 Transaction type VII)	$= ((T_{STD} - T_C)/T_{STD}) * 100$

6.3 Optional metrics

% of non-standard facsimile calls	$= ((T - T_{STD})/T) * 100$
% of calls which disconnect after DCS	$= (F_{1B}/T_{STD}) * 100$
% of calls which fail after CFR	$= (F_m/T_{STD}) * 100$
% of calls which completely fail to train	$= (F_{TT}/T_{STD}) * 100$
% of completed calls which connect at first choice transmission rate but retrain to lower rate after one or more pages sent	$= (C_R/T_{STD}) * 100$
% of completed calls with fallback	$= (C_B/T_{STD}) * 100$
% of calls which connect with first choice transmission rate using modulation type "m" and transmission rate "x"	$= (C_{1;m;x}/T_{STD}) * 100$
% of calls which fall back and use modulation type "m" and transmission rate "x"	$= (C_{B;m;x}/T_{STD}) * 100$
% calls with image quality B (derived from both Basic mode and ECM measurements)	$= ((I_{BQ2} + I_{EQ2})/(I_B + I_E)) * 100$
% calls with image quality C (derived from both Basic mode and ECM measurements)	$= ((I_{BQ3} + I_{EQ3})/(I_B + I_E)) * 100$

Annex A

Image measurements

A non-intrusive measuring device may have the capability to demodulate the high-speed portion of a fax call so that errored lines or errored frames can be counted. This information may help to determine whether impairments which result in either RTP/RTN messages, or retransmission of frames in ECM, occur before or after the monitoring point.

Analysis of the *distribution* of errored lines or frames can also provide a useful indication of the type of any impairment that may be affecting fax calls.

The measurements and metrics for Error Correction Mode (ECM) calls and Basic mode (i.e. non-ECM) calls are described below.

A.1 Basic mode

To analyse basic mode, the high-speed modem signal must be demodulated. The measuring device must be capable of decompressing the various algorithms used by group 3 fax machines as described in Recommendations T.4 and T.6. The number and distribution of errored image lines and the total number of image lines can then be determined.

The number of errored lines can be compared with the response from the receiving fax machine, i.e. MCF, RTN, RTP. It should be remembered that the criteria for these responses are not defined, but from observation of many fax machines an RTN usually corresponds to > 10% errored lines, an RTP corresponds to > 5% errored lines and an MCF is transmitted in other cases.

Suggested measurements:

– Total number of image lines in one page (Ni);

– Total number of errored image lines in one page (Ne);

– Distribution of errored lines (specification is for further study);

– N4, NS and N23 as defined in Recommendation E.453.

Comparison of Ne/Ni with occurrences of RTP or RTN may indicate whether impairments occurred before or after the monitoring point.

N4, NS and N23 allows the performance to be described in terms of the image performance categories defined in 2.3/E.453.

A.2 Error Correction Mode

The parameters in ECM are based on the number and distribution of errored frames. Each frame should be checked for errors by examination of its CRC. This information can then be compared with any PPR returned by the receiving CPE.

Suggested measurements:

– Total number of frames in one partial page (Nf);

– Total number of errored CRCs in one partial page (Nec);

– Number of occurrences of n successive errored CRCs for $0 < n < 256$.

Comparison of Nec/Nf with the contents of the PPR message will give an accurate measure of the proportion of frame errors introduced between the monitoring point and the receiving terminal.

Counting the number of occurrences of n successive frames provides additional information about the distribution of noise bursts.

A.3 Comparison between ECM and non-ECM measurements

ECM-based parameters offer three advantages over non-ECM measurements:

- It is not necessary to decompress the image as sufficient information can be obtained from analysis of the CRCs.
- The protocol actions are fully defined as opposed to the use of RTN and RTP for non-ECM.
- Since the *contents* of the frames do not have to be analysed, any future image coding scheme, and also binary file transfers, can be checked for errors.

However, a large proportion of facsimile calls still do not use ECM, and much useful information would be lost if the high-speed modem signal were only analysed for ECM calls. It is therefore proposed that both methods of analysis should be included in this Annex.

Annex B

Analogue measurements

The following analogue parameters may contribute to poor performance and should be measured. They are also described in Recommendation P.561 for non-intrusive monitoring of voice calls. Some of the algorithms defined in Recommendation P.561 may not be applicable to fax-related measurements.

- **Echo return loss and delay**

  Echo may cause calls to fail if the return loss is low and the delay significant.

- **Facsimile send and receive signal levels at the point of measurement**
  Noise levels and any characteristic frequencies

  Signal and noise levels affect the modem speed that can be achieved. High noise levels may cause mis-operation due to other mechanisms.

- **Burst noise (length, gaps, nature, e.g. tones or random)**
  Transients such as impulse noise, drop-outs, gain hits and phase hits

  Burst noise and other transients may cause protocol frames to be errored or result in errored lines in the image.

- **Amplitude and Phase distortion**
  Saturation (peak) clipping
  Double talk

  Significant amplitude and phase distortion, double talk and peak clipping can all limit the achievable modem speed and may affect call completion.

If calibrated levels are measured at the monitor point and assumptions are made about the transmit levels of fax machines, it is possible to estimate the total loss of a connection and to deduce the receive levels. Where the transmission plans of the networks involved are known, it is also possible to estimate how much of the loss is due to the analogue access portions of the connection.

For noise measurements (especially burst noise) it is very useful to know on which channel (i.e. transmit or receive) it was measured.

NOTE – The definition of Analogue Call Data Measurements is for further study.

Annex C

Signalling information

Parameters extracted from the signalling associated with a call provide essential information required for tracking performance issues that may need to be investigated and reliably detecting the start and finish of a call. The following information should be extracted from the signalling associated with each call:

1) Time stamp of initial address message or equivalent;

2) Time stamp of start of supervisory tones (e.g. busy tone, ring tone);

3) Time stamp of release message;

4) Time stamp of network answer message (i.e. when called equipment connects to line);

5) Transit or Terminated;

6) Incoming or outgoing call;

7) A or B Terminated;

8) Release code (if available);

9) A Number (if available);

10) B Number (mandatory).

The time measurements may be used to provide the following information relative to the monitor point:

1) Post-dialling delay;

2) Duration of facsimile call.

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Series D	General tariff principles
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Series F	Non-telephone telecommunication services
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