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

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Transmission performance metrics based on Error Correction Mode (ECM) facsimile

ITU-T Recommendation E.454

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.454

TRANSMISSION PERFORMANCE METRICS BASED ON ERROR CORRECTION MODE (ECM) FACSIMILE

Summary

The purpose of this Recommendation is to define transmission performance metrics based on Error Correction Mode (ECM) facsimile. Performance parameters defined in Recommendations E.451, E.452 and E.453 have been modified to accommodate the error correction and partial page characteristics of ECM facsimile. Performance parameters for ECM that will help infer the image quality for non-ECM transmissions have also been defined.

The parameters defined in this Recommendation are intended for use when intrusive text techniques are employed.

Source

ITU-T Recommendation E.454 was prepared by ITU-T Study Group 2 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of October 1996.

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 (Helsinki, March 1-12, 1993).

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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Recommendation E.454

TRANSMISSION PERFORMANCE METRICS BASED ON ERROR CORRECTION MODE (ECM) FACSIMILE

(Geneva, 1996)

1 Summary

The purpose of this Recommendation is to define transmission performance metrics based on Error Correction Mode (ECM) facsimile. Performance parameters defined in Recommendations E.451, E.452 and E.453 have been modified to accommodate the error correction and Partial Page characteristics of ECM facsimile. Performance parameters for ECM that will help estimate the image quality for non-ECM transmissions have also been defined.

The parameters defined in this Recommendation are intended for use when intrusive test techniques are employed. These metrics may be extended for use with non-intrusive test methodologies.

ECM metrics for operation using V.34 modulation and the options for G3 terminals to operate at 64 kbit/s defined in Annex F/T.4 and Annex C/T.30 are for further study.

The various parameters relating to Group 3 Facsimile terminal characteristics have been selected in order to provide a common basis for the measurement of the transmission performance of networks.

The metrics defined in this Recommendation are not appropriate for the evaluation of the performance of facsimile terminals.

2 References

The following Recommendations contain material that is either relevant to or provides background for this Recommendation.

ITU-T Recommendation T.4 (1996), *Standardization of group 3 facsimile apparatus for document transmission*.

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

ITU-T Recommendation T.22 (1993), *Standardized test charts for document facsimile transmissions*.

ITU-T Recommendation F.182 (1993), *Operational provisions for the international public facsimile service between subscribers' stations with group 3 facsimile machines (telefax 3).*

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 time.*

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

ITU-T Recommendation E.456 (1994), *Test transactions for facsimile transmission performance*.

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

3 Definitions

For the purposes of this Recommendation, the definitions given in Recommendations E.450, E.451, E.452, E.453 and E.456 are applicable.

4 Abbreviations

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

ARQ	Automatic Repeat Request
CFR	Confirmation to Receive
CPE	Customer Premises Equipment
CRP	Command Repeat
CTC	Continue To Correct
CTR	Response to Continue to Correct
DCS	Digital Command Signal
ECM	Error Correction Mode
EOM	End of Message
EOP	End of Procedure
EOR	End of Retransmission
ERR	Response to End of Retransmission
FCD	Facsimile Coded Data
FCS	Frame Check Sequence
FTT	Failure to Train
HDLC	High-Level Data Link Control
MCF	Message Confirmation
MPS	Multipage Signal
PP	Partial Page
PPR	Partial Page Request
PPS	Partial Page Signal
PSTN	Public Switched Telephone Network
RCP	Return to Control Partial Page
RNR	Receiver Not Ready
RR	Receiver Ready
RTC	Return To Control
RTN	Retrain Negative
RTP	Retrain Positive

5 Introduction

The purpose of this Recommendation is to define transmission performance metrics based on Error Correction Mode (ECM) facsimile.

ECM facsimile has been defined in Annex A/T.4 and Annex A/T.30. The error correction is based on half-duplex page selective repeat ARQ (automatic repeat request) technique. An HDLC frame structure is utilized for all binary coded facsimile message procedures. The basic HDLC structure consists of a number of frames each of which is subdivided into a number of fields. These fields provide for frame labelling and error checking.

A facsimile page is divided into Partial Pages (PPs)consisting of up to 256 Facsimile Coded Data (FCD) frames and three Return to Control Partial Page (RCP) frames. Each FCD frame has a frame number field as well as a Frame Check Sequence (FCS). Two options are recognized for the FCD frames: The Facsimile Data Field may have a length of either 256 or 64 octets. The last PP may have less than 256 FCD frames and the last frame (including RTC) may have less than 256 or 64 octets. The choice of 256- or 64-octet frame size is made by the transmitter and communicated to the receiver via the DCS command (bit 28).

The transmitter sends one of a set of PPS messages at the end of a Partial Page. When an errored frame is declared by the receiver, it transmits a Partial Page Request (PPR) to the transmitter to indicate that the frames specified in the associated facsimile information field need to be retransmitted. When the PPR is received, the transmitting station retransmits the requested frames. If the PPR is received four times in the same block, either the End of Retransmission (EOR) for end of Retransmission or Continue to Correct (CTC) is sent for continuing the transmission.

In the following clauses, the facsimile performance parameters for ECM facsimile are discussed. ECM facsimile performance can be used to derive an estimate of the image quality of non-ECM facsimile and we specify how this could be accomplished.

6 Frame size for ECM-based test calls

Test calls for ECM facsimile can use either the 256- or 64-octet frame size.

It is recommended that the 256-octet frame size be chosen if the test calls are intended to evaluate:

- 256-octet ECM transmissions and/or;
- error-free page image quality metric only for non-ECM facsimile (from ECM facsimile).

The 256-octet choice means that $256 \times 8 \times 256 = 524\ 288$ bits of facsimile coded data can be transmitted in one Partial Page or block. A Partial Page of this size is sufficient to accommodate a T.22 Test Chart No. 4 (or the older T.21 Test Chart No. 2). This is helpful because ECM metrics defined in clause 9 b) and 9 c) closely correspond to the error-free page metrics defined in E.453 for non-ECM facsimile.

The 64-octet frame size may be used if the intent is to evaluate:

- 64-octet ECM transmissions and/or;
- a more fine-grained assessment of Image quality metrics for non-ECM facsimile (from ECM facsimile) including an approximate evaluation of Severely Errored pages.

7 Facsimile call cut-off performance

Recommendation E.451 defines performance parameters for facsimile call cut-offs. Most of the definitions in clause 3/E.451 apply to cut-off performance of ECM facsimile without any modifications and others require some modification:

a) A pre-message phase B failure is considered to have occurred if prior to the transmission of the first page, either the originating or the terminating facsimile terminal goes on-hook prior to the reception of CFR message by the originating terminal.

A post-message phase B failure is considered to have occurred if a phase B failure occurs after the transmission of any Partial Page.

b) A phase C/phase D failure at any Partial Page is considered to have occurred:

- if a valid post message response (MCF, PPR, CTR, ERR, RNR) is not received in response to PPS-NULL, PPS-EOM, PPS-MPS, PPS-EOP, PPS-PRI-Q; CTC, EOR-NULL, EOR-EOM, EOR-MPS, EOR-EOP, EOR-PRI-Q; RR, and CRP;
- if the transmitter aborts the transmission after receiving PPR for the fourth time;
- if the timer T_5 (which is reset at the beginning of the receipt of the first RNR from the receiver and has a limit of 60 ± 5 s) elapses.

Facsimile call cut-off ratios for test calls have been defined in Recommendation E.451. In clause 2/E.451, the conditions that apply to test calls have been established. These conditions apply to test calls in the ECM mode also. The size of the ECM test transactions shall be the same as for non-ECM transactions as specified in Recommendation E.456.

One key performance parameter for cut-off ratios defined in Recommendation E.451 is shown here:

$$\%\,C_N = \left(F_N / T\right) * 100$$

Where F_N is the number of N-Partial Page test transactions (Recommendation E.456) where there was a phase B, C or D failure, and T is the total number of test transactions that satisfy all the requirements stated in clause 2/E.451. (N is chosen to be 5 for the 256-octet frame size and 20 for the 64-octet frame size.)

Facsimile cut-off ratios for m Partial Pages ($1 \leq m \leq N$) is:

$$\%\,C_m = \left(F_m / T\right) * 100$$

Where F_m is the number of transactions that had a phase B, C or D failure at the m^{th} Partial Page.

Other metrics associated with cut-offs for ECM transmission follow the definitions in E.451.

Note the following difference between the call cut-off performance of ECM and non-ECM transmissions. For ECM transmissions, the modems must train more often if there are PPRs and associated frame retransmissions. Therefore, there are more chances for call cut-offs if the network impairments are such that the training sequences are affected.

8 Modem speed reductions and transaction time

Performance parameters for modem speed reduction and transaction time for non-ECM transmissions have been defined in Recommendation E.452. There are some differences in the manner in which speed reductions take place for ECM transmissions when compared to non-ECM transmissions:

- For both ECM and non-ECM transmissions, speed reductions can take place during Phase B negotiations. In this case, speed reductions take place until a CFR is transmitted by the receiver to the transmitter confirming that the TCF has been received at an acceptable error level.
- For ECM transmissions, additional speed reductions can take place if four PPRs have been received in the same block and the transmitter chooses to fall back in speed. This is similar

to but different from the speed fallback in non-ECM transmissions that may occur in response to RTP or RTN responses from the receiver.

a) A key performance parameter is the percentage of calls without modem speed reduction from the initial agreed upon speed Si (see clause 1/E.452):

$$\%\,C_I = C_I / T_C * 100$$

where T_C is the total number of completed test calls.

b) Partial Page based metrics can be defined by the number of Partial Pages at speed $S_n(N_{sn})$ for $S_n = S_i, S_{i-1}, S_{i-2}$, etc. This parameter can be expressed as a percentage of the total number of pages associated with completed transactions (N_t which is equal to $5*T_C$ for test transactions defined in Recommendation E.456).

$$\%\,N_{Si,Sn} = N_{Sn} / N_t * 100$$

c) The definition of Transaction Efficiency rating follows the definition in Recommendation E.452 except that pages are replaced by Partial Pages.

d) Transaction time

For ECM transmissions, the transaction time is affected by several factors:

- Transaction times are significantly affected by the choice of the frame size. In the 64-octet mode there are more turn-arounds and more overhead per page because the Partial Pages are smaller in size.
- In ECM, the receiver may transmit RNR for flow control to clear up congestion at the receiver. The transmitter responds by sending RR queries which are acknowledged by RNR or MCF. This exchange can take place up to the limit of the T_5 timer of 60 ± 5s. Both test call-based and non-intrusive monitoring could capture this additional delay. Note however that this increase in transaction time is caused by CPE effects and not the network.

Following Recommendation E.452, we define transaction time for completed transactions without modem speed reductions below S_i (T_{r1}): this is the average transaction time of all completed transactions without any modem speed reductions. The value of this parameter should be reported separately for the 256- and 64-octet frame size, for transactions with and without RNR-RR sequence, etc.

It may also be useful to measure the percentage of completed transactions that have RNR-RR sequences as a percentage of total transactions, the average duration of RNR-RR sequence times, etc. These metrics will be explored in a future Recommendation on non-intrusive measurements.

9 Image quality metrics

ECM transmissions are intended to produce error-free images. It is however possible to derive an estimate of the ability of networks to carry Error-Free images by examining the fraction of transactions that do not have PPR requests from the receiver.

a) Calls without any PPR requests (Error-Free calls)

C_{NPPR} is the number of completed transactions that had no PPRs.

Then represented as a percentage of T_C, where T_C is the number of completed transactions in the test,

$$\%\,C_{NPPR} = \left(C_{NPPR} / T_C\right) * 100$$

b) Number of Partial Pages without any PPR requests

P_{NPPR} is the total number of Partial Pages without any PPR in T_C completed transactions.

Then represented as a percentage of the total number of Partial Pages (N) in T_C completed test transactions,

$$\% P_{NPPR} = \left(P_{NPPR} / N\right) * 100$$

c) Number of Pages without any PPR requests

P_{GPPR} is the total number of Pages without any PPR messages in T_C completed transactions.

Then represented as a percentage of the total number of pages (NP) if T_C completed transactions,

$$\% P_{GPPR} = \left(P_{GPPR} / N_P\right) * 100$$

d) Per cent Frame Error Rate

Frame Error Rate is defined as:

$$FRER = EFR / TFR$$

where EFR is the number of errored frames that are requested for retransmissions (including repeat retransmissions) and TFR is the total number of frames transmitted including retransmissions. FRER closely represents the facsimile modem Block Error Rate for 2048-bit and 512-bit blocks for the 256-octet and 64-octet frame sizes, respectively.

e) The use of ECM does not guarantee that images will not be degraded due to transmission errors under severe conditions. The following metric could serve as an indicator of transactions with severely degraded image quality.

Per cent of Completed Transactions with one or more EOR message. A transaction with an EOR message will produce degraded images at the receiving terminal.

Per cent EOR is defined as:

$$\% N_{EOR} = \left(N_{EOR} / T_C\right) * 100$$

where N_{EOR} is the number of completed transactions with one or more EOR message.

f) Calls with PPRs on consecutive frames

For further study (Note).

NOTE – Calls with PPRs in consecutive frames may provide a measure of calls with Severely-Errored pages in non-ECM transmissions. This is for further study.

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