INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

E.845

TELECOMMUNICATION
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TELEPHONE NETWORK AND ISDN

QUALITY OF SERVICE, NETWORK MANAGEMENT AND TRAFFIC ENGINEERING

CONNECTION ACCESSIBILITY OBJECTIVE FOR THE INTERNATIONAL TELEPHONE SERVICE

ITU-T Recommendation E.845

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation E.845 was published in Fascicle II.3 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation E.845[1)]

CONNECTION ACCESSIBILITY OBJECTIVE FOR THE INTERNATIONAL TELEPHONE SERVICE[2)]

Introduction

This Recommendation is one of a set of closely related Recommendations, comprising Recommendations E.810, E.830, E.845, E.850 and E.855 concerned with the accessibility, retainability and integrity of telephone services.

Preamble

This Recommendation provides an overall end-to-end connection accessibility (availability) objective for *international* switched telephone service.

Connection accessibility is a component of service accessibility as defined in Recommendation E.800.

This Recommendation contains a measure of connection accessibility, an objective, and an allocation of the objective to the national systems and international chain of international connections. The Recommendation also relates the overall end-to-end performance to the reliability and availability of circuits and exchanges in a way useful for network design purposes.

The objective includes the effects of equipment faults and traffic congestion.

The CCITT,

considering

(a) that connection accessibility is defined in Recommendation E.800;

(b) that customers rank connection inaccessibility as one of the most annoying of call set-up impairments;

(c) that an objective for connection accessibility which takes into account customer opinion about the call set-up phase is consistent with other Recommendations which have recommended an objective for service retainability based, in part, on customer opinion;

(d) that connection accessibility will not be constant over time, even for a particular calling and called line pair. One suitable measure is a long-term average network connection failure probability. (Other suitable measures may also be required.);

(e) that the overall objective for connection accessibility should be allocable to the national systems and the international chain of the international connection;

(f) that the objective should take into account the concerns of network planners and system designers, provide useful guidance to both and may be used by Administrations in providing a method for verifying whether or not network performance is acceptable;

(g) that the overall connection accessibility should be controlled by the accessibility performances of individual exchanges and circuits, and that to obtain this control, the overall connection accessibility must be mathematically linked to the equipment availability and reliability,

recommends

1 Measure of connection accessibility

Connection accessibility shall be measured using the long-term average network connection failure probability, which is the complement of the connection access probability as defined in Recommendation E.800.

The network connection failure probability P_{NCF} can be estimated by using the following formula:

$$P_{NCF} = \frac{Q_N}{N}$$

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1) Formerly G.180, in *Red Book*, Fascicle III.1.

2) Some of the terms in this Recommendation, for example, the noun "measure", are used in the sense of their definition given in Recommendation E.800.

where Q_N is the number of unsuccessful connection access attempts and N is the total number of connection access attempts in some time period (to be determined).

A method for estimating the required call sample size is contained in Annex A.

For purposes of network design, the network connection failure probability, P_{NCF}, can also be calculated using the method outlined in Annex B. Annex C describes how the busy and non-busy hours affect the network connection failure (NCF).

Note 1 – Those unsuccessful connection access attempts reflecting failure of the *network* to work properly, from the user's perspective, are called network connection failure. They are call failures an astute caller can determine and are caused by network faults and congestion. A network connection failure is any valid bid for service which receives one of the following network responses:

1) dial tone returned after dialling is completed;

2) no ring and no answer;

3) all circuits busy signal or announcement;

4) connection to the wrong number (misrouting);

5) double connection.

This list may not be exhaustive.

Note 2 –This definition of network connection failure is based on the response the caller can hear.

Note 3 –There are two generic causes of network connection failures: equipment faults and traffic congestion.

Note 4 –The averaging interval (to be determined) used for estimating the connection failure probability shall include normal and peak hour traffic periods. In the event of exceptionally high traffic demand (public holiday, natural disaster, etc.) failure rates higher than the objective may be tolerated.

Note 5 –The network connection failure probability should be estimated by Administrations in a manner consistent with obtaining, from the Administration's point of view, reasonably accurate estimates.

2 Objective for connection accessibility

Connection accessibility is acceptable if the long-term average connection failure probability, expressed as a percentage, does not exceed a value (overall average for all international calls) of *A*% to *B*% (values to be determined). Additionally, the long-term average failure probability at any single international homing exchange should never exceed *C*% (value to be determined).

Note – Possible values for *A*, *B* and *C* are in the range of 10% to 20%.

3 Allocation of the overall objective to the national systems and international chain

The network connection failure probability objective shall be apportioned as follows:

X % to the originating national system,

Y % to the international chain,

Z % to the terminating national system,

where $X + Y + Z = P$, and *P* is the overall objective stated in § 2.

Note 1 –The connection access attempt may fail in the national systems or the international chain of the connection.

Note 2 –The objective takes into account all means of "defense" of the network against failure to complete the connection, including alternate routing, if used.

Note 3 –The network connection failure probability of the national systems or international chain is defined as the probability that the call access attempt will fail because of some problem (equipment fault or congestion) in the systems or chain.

Note 4 –Values for *X*, *Y* and *Z* are in the range of 3% to 7%.

ANNEX A

(to Recommendation E.845)

Method for selecting the required call sample size, N

The network connection failure probability shall be estimated by Administrations in a manner consistent with obtaining reasonably accurate estimates.

The number of call access attempts sampled shall be sufficiently large to obtain a good estimate of the probability.

A method of picking a sample size N could be used which could produce a maximum error of measurement, e, (to be determined) with confidence level, α (to be determined).

Recommendation E.850 contains a method for estimating the sample size required to estimate cutoff call probability. This method should be studied for application here.

ANNEX B

(to Recommendation E.845)

Method for relating overall network connection failure probability to the reliability and availability performance of exchanges and circuits

The following equation gives the relationship between the overall network connection failure probability, P_{NCF}, and the probabilities of connection failure in the national systems and international chain of the connection:

$$P_{NCF} = 1 - (1 - P_{OE})(1 - P_I)(1 - P_{TE})$$

where P_{OE} is the probability that the access attempt fails in the originating national system, P_I is the probability of failure in the international chain and P_{TE} is the probability of failure in the terminating national system.

Hypothetical reference connections for the three parts of an international connection are shown in Figure B 1/E.845. The proportion of calls (F_n) which are routed over the parts are also given in the figure. The values are taken from Table 1/G.101.

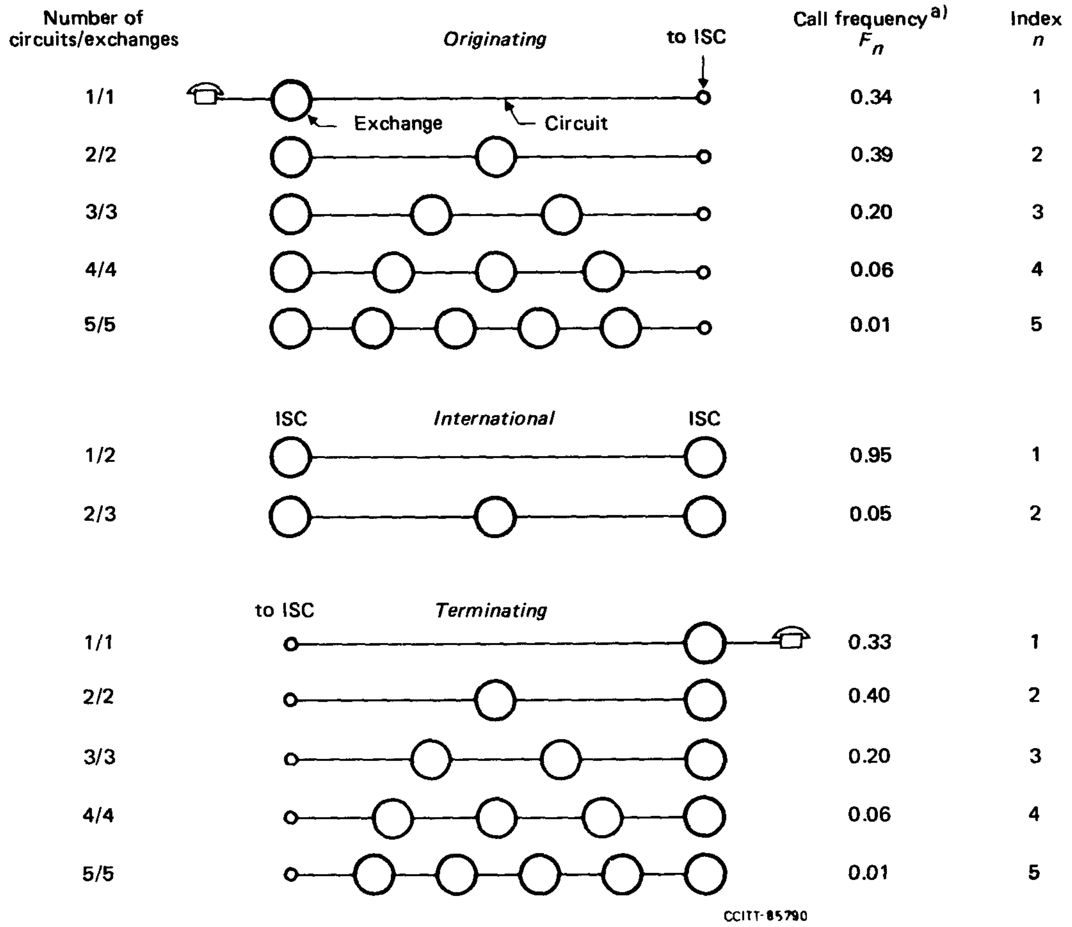
The probability that a connection access attempt fails in either of the parts is given by the following equations:

$$P_{OE} = 1 - \sum_{n=1}^{5} F_n \left(1 - P_c\right)^n \left(1 - P_s\right)^n$$

$$P_I = 1 - \sum_{n=1}^{2} F_n \left(1 - P'_c\right)^n \left(1 - P'_s\right)^{n+1}$$

$$P_{TE} = 1 - \sum_{n=1}^{5} F_n \left(1 - P''_c\right)^n \left(1 - P''_s\right)^n$$

where n is the number of circuits in a selected part. F_n is the call frequency for an n-circuit system or chain (from Figure B-1/E.845).



[a] Values taken from Table 1/G.101.

FIGURE B-1/E.845

Hypothetical reference connections as a function of call frequencies

P_C, P'_C and P''_C are the probabilities that the connection access fails in the originating system, international chain or terminating system circuits, respectively. (It is assumed here for simplicity that all circuits in a system or chain have the same probability of failure. However, this is not a requirement.)

P_S, P'_S and P''_S are the probabilities that the connection access attempt fails in the originating system, international chain (note that ISC is assumed part of the international chain) or terminating system exchanges, respectively. (For simplicity, all exchanges are assumed to have the same failure probability, but this is not a requirement.)

A circuit or exchange can cause a network connection failure for one of three reasons:

1) The call is blocked because of congestion. The probability of blockage is P_{CB} and P_{SB} for circuits and exchanges, respectively.

2) The circuit or exchange fails during the call set-up time. The probability of such a failure is P_{CF} and P_{SF} for circuits and exchanges, respectively.

3) The circuit or exchange is unavailable to arriving calls, so all calls arriving during the downtime fail to be completed. These probabilities are P_{CD} and P_{SD} for circuits and exchanges, respectively.

The probability that a circuit or exchange causes a network connection failure is given by the following equations, respectively:

$$P_C = 1 - (1 - P_{CB})\,(1 - P_{CF})\,(1 - P_{CD})$$

$$P_S = 1 - (1 - P_{SB})\,(1 - P_{SF})\,(1 - P_{SD})$$

The failure probabilities P_{CF}, and P_{SF} can be expressed in terms of the long-term mean failure intensifies Z_C and Z_S of circuits and exchanges, respectively, by the following equations:

$$P_{CF} = Z_c T_s,$$

$$P_{SF} = Z_s T_s,$$

where T_s is the long-term average call set-up time.

Similarly, the failure probabilities P_{CD} and P_{SD} can be expressed in terms of the long-term mean accumulated downtime $(MADT)_c$ and $(MADT)_s$, of circuits and exchanges, respectively, by the following equations:

$$P_{CD} = \frac{(MADT)_c \times \alpha_c}{K \times N}$$

$$P_{SD} = \frac{(MADT)_s \times \alpha_s}{K \times N}$$

α_c and α_s are the long-term average call arrival rates for circuits and exchanges, respectively, and N is the long-term average number of call attempts (in some interval, such as one year).

K is a constant equal to the number of units of time (minutes or seconds) used to express the downtime in the long-term averaging interval selected (such as a year).

For example, if the downtime is expressed in minutes and the averaging interval is one year, then K = 525 600 min./year.

ANNEX C

(to Recommendation E.845)

Effects of busy hours and non-busy hours on the network connection failure

The two major components of network connection failure (NCF) are the blocking rate due to congestion and connection access attempt failures due to equipment faults. Equipment faults are further divided into major and minor faults. These components affect NCF differently.

C.1 *Influences of faults*

Faults of subsystems in a telephone network may be divided into two categories, according to their influence on network performance. Table C-1/E.845 shows two fault categories: major and minor.

TABLE C-1/E.845

Failure category	Definition	Network components
Major (considerable) influence fault	Fault wherein a connection access attempt encounters a situation such that service degradation of network component(s) lasts for some period of time, owing to large scale failure of equipment, and a subscriber cannot be assured of normal service	Subscribers line, subscriber terminal [b)] exchange, transmission line, service center
Minor (less important) influence fault[a)]	Small scale fault wherein a connection access attempt is handled incorrectly and encounters no signal (e.g. dial tone, ring-back tone), no connection, low level speech signal, etc., i.e. less important service degradation is experienced	

[a)] Intermittent fault is excluded and its treatment is an unresolved problem.

[b)] In some Administrations the subscriber terminal is not considered a network component.

C.2 *Relationship between NCF, congestion and fault*

Congestion-related NCF depends on the traffic offered to a system being considered (a switching system, a network, etc.).

The effects of a minor fault will be considered as so-called white noise where the absolute value is small and fluctuates at random.

The effects of a major (complete) fault depend on the offered traffic volume at the time of fault. If a major fault occurred during busy hours, there would be an extremely high value for NCF. Conversely, a major fault during non-busy hours will merely yield a small NCF, no matter how large the affected system is. This is because the traffic load itself is small. Since it is usually expected that major faults will be very rare, NCF characteristics under major fault conditions are different from those under minor fault conditions which may be daily occurrences.

C.3 *Long-term NCF (averaged throughout a year)*

The long-term NCF concerned with traffic congestion during non-busy hours will be much smaller than that during busy hours. Since both cumulative call failures N_f and total calls offered N_o during non-busy hours are much smaller than those during busy hours, the averaged 24-hour NCF including non-busy and busy hours effects will not be much different from the busy hour NCF.

A major fault can be identified but a minor fault cannot be specified correctly when network operators maintain network equipment. By measuring long-term NCF during non-busy hours, the effect of minor faults can be estimated because NCF during non-busy hours is attributed not to traffic congestion but to minor faults.

C.4 *NCF and busy hour pattern*

In a country (international region) with several standard time zones, there will be several busy hours. In such cases, a connection in the network may include busy and non-busy network components. Thus, an averaged 24-hour NCF would be helpful to administer a network with different time zones.

However, the averaged 24-hour NCF does not seem to be appropriate to administer a network having only one standard time zone because its fault-related term is too small to affect the total NCF, and it might be too late by the time an extraordinary NCF value has been detected. The NCF averaged during non-busy hours would be one measure for monitoring the effect of equipment faults (minor faults) on subscribers, since this will become a major factor during non-busy hours.