SECTION 5

GRADE OF SERVICE

Recommendation E.540

OVERALL GRADE OF SERVICE OF THE INTERNATIONAL PART OF AN INTERNATIONAL CONNECTION

1 The International Routing Plan envisages that international traffic relations may be served by any of the following routing arrangements:

a) direct circuits ;

b) transit operation involving one or more transit centres for all connections,

c) direct high-usage circuits with overflow via one or more transit centres.

In principle there would be merit in dimensioning international facilities to provide the same grade of service for all relations, however served. Practical considerations make it advisable to depart from one universal value.

2 Direct circuit groups are dimensioned, according to Recommendation E.520 on the basis of $p = 1\%$ loss probability during the mean busy hour circuits for which $p = 3\%$ loss probability is accepted for six or fewer circuits. As the traffic increases the grade of service improves progressively until $p = 1\%$ loss value is reached for 20 circuits.

3 For the relations served exclusively by transit operation the grade of service will deteriorate with the number of transit centres in the connection. Measurements made on congestion in such circumstances suggest that the overall grade of service for up to six links in tandem is less than twice the congestion of any of the six links in the chain. Hence, for a series of routes, each dimensioned for $p = 1\%$, the overall grade of service should seldom exceed 2%. An East-West type of connection would have the advantage of different busy hours on the various links. Corresponding advantage would not apply to North-South circuits.

In the case of relations served by high-usage circuits the overflow traffic will route over at least two links and, hence, will be subject to the same deterioration of service as in the case for transit traffic high-usage circuits and the overall grade of service will approximate that of the relations served solely by direct circuits.

It is desirable that at least one high-usage circuit should always be provided between a CT3 and its homing CT1, even though the circuit may not be wholly justified on economic considerations alone. However, such a circuit should not be provided unless there is a measurable amount of traffic which exists, or can be foreseen in the busy hour circuits would improve the transmission as well as the grade of service; these considerations should encourage an increase both in traffic and in the revenue-earning capacity of the circuits provided.

The overall grade of service for the international part of a connection is a contributory factor to the overall grade of service from the calling party in one country to the called party in another.

Recommendation E.541

OVERALL GRADE OF SERVICE FOR INTERNATIONAL CONNECTIONS

(SUBSCRIBER-TO-SUBSCRIBER)

1 Introduction

1.1 The overall grade of service (subscriber-to-subscriber) on international connections — relating only to the phenomena of congestion in the entire network as a result of the traffic flow — depends on a number of different factors, such as the routing arrangements in the national and international parts of the connection, congestion allowed per switching stage, the methods used to measure traffic and compute the traffic base, and the time differences between the busy hours of the various links involved in the connection.

1.2 The most satisfactory way in which this grade of service could be described would be to give its distribution. The design average grade of service during the busy hour of the complete connection would be the most useful single parameter. However, until such time as continuous traffic measurements are carried out during the busy season in all parts of the network on a routine basis, it is not possible to compute this average grade of service. Therefore, at this stage it cannot be used as a criterion for the dimensioning of the network.

1.3 The only practical way of ensuring an acceptable overall grade of service on international calls is to specify an upper limit on the design loss probability per connecting link in the national network as is done for the links in the international network (see Recommendation E.540).

2 General considerations

2.1 Since the success of the international automatic service is highly dependent on the grade of service of all links involved in the connection from subscriber-to-subscriber, it is desirable that the originating and terminating national network involved in the connection has grade of service standards comparable with those of the international network.

2.2 It is especially important that the links in the country of destination should have a good grade of service for handling the traffic, since high congestion in the terminating national network could have serious effects on the international network country of destination causes added retrials with consequent increased loading on common switching devices as well as increased occupation of the routes with ineffective calls.

3 Design objectives

3.1 It is recommended that the links in the national network should be designed for a loss probability not exceeding 1 per cent per link in the final choice route during its applicable busy hour. It is recognized, however, that in some countries additional congestion is permitted for the internal switching stages of the transit exchanges service is not provided for the national service, it may not be economically feasible to provide it for international relations.

The loss probability mentioned refers to busy hour traffic values as defined in Recommendation E.500.

3.2 The maximum number of links in tandem used by an international connection is defined by Recommendation E.171 [1].

3.3 Although the worst overall grade of service would be approximated by the sum of loss probabilities for individual links connected in tandem, on most calls the overall grade of service will be significantly better.

4 Maximum traffic loading

4.1 An acceptable automatic service on a final circuit group is difficult to maintain if the traffic loading on the group exceeds a level corresponding to a calculated Erlang grade of service of 10 per cent. Beyond this traffic loading, service on the route may rapidly deteriorate. This condition will be accentuated under the cumulative effect of repeat attempt calls if these should occur.

4.2 The curves of Figure 1/E.541 indicate the proportionate reduction in circuits that may be tolerated for a short period, 15 minutes for example, under normal busy-hour conditions, on a full-availability circuit group dimensioned for 1 per cent Erlang loss, in accordance with the above traffic overload criterion. Table 1/E.541 gives the figures used to plot the curves.

Figure 1/E.541 p.

H.T. [T1.541]

TABLE 1/E.541

Percentage reduction in the number of circuits if the calculated

Erlang grade of service is not to exceed 10 |

Number of circuits	{ { Peakedness factor | | .5	
5	37.7	—
10	32.3	40.2
20	27.2	33.3
30	24.8	30.1
50	21.7	26.5
100	18.3	22.4
150	16.7	19.7

Table 1/E.541 [T1.541] p.

4.3 The curves of Figure 1/E.541 are intended merely as a guide. If the breakdown occurs during an exceptionally busy hour, the permissible proportionate reduction will be less. Conversely, if the breakdown occurs during an hour of light traffic, a higher proportionate reduction in circuits could be tolerated. A higher reduction might also be acceptable after an appropriate oral announcement has been introduced. In the general case, a knowledge of the circuit occupancy will enable an estimate to be made of the prevailing Erlang loss figure with the reduced number of circuits

The permissible reduction in the case of large groups should not be exceeded; otherwise very serious congestion can result from repeated attempts

5 General notes

Note 1 — Teletraffic implications for international switching and operational procedures under failure of a transmission facility are discussed in Supplement No. 5 of this fascicle.

Note 2 — Alternative routing in the national and in the international networks provides on average a grade of service that is better than that provided in the theoretical final route.

Note 3 — Non-coincidence of traffic peaks in the national and international networks will provide reduction in the overall grade of service compared with the sum of the design grade of service values per link.

Note 4 — Time differences will also improve the resulting grade of service.

Note 5 — The methods of measuring and calculating the traffic base for provisioning purposes in the national networks may be different in various countries and differ from the methods for the international network given in Recommendation E.500. This means that the national traffic values are not always comparable among themselves or with the values of the international network. Each Administration must estimate how its design traffic level compares with that recommended for the international network.

Note 6 — The design grade of service value of each link will only apply if the traffic at each switching stage is equal to the forecast. In practice, such a situation will seldom occur. Furthermore, the planning procedure normally is such that the specified grade of service should not be exceeded until the end of the planning period. In a growing network, this means that the circuit groups during almost the whole planning period give a better service than the specified critical standard.

In conclusion, the overall grade of service depends on the accuracy of forecasts made and the planning procedure used, i.e. it depends on the interval between plant additions and on the specific traffic value in future to which the grade of service is related.

Reference

[1] CCITT Recommendation *International routing plan* , Rec. E.171.

Recommendation E.543

GRADES OF SERVICE IN DIGITAL

INTERNATIONAL TELEPHONE EXCHANGES

1 Introduction

1.1 The grade of service (GOS) parameters and values to be used as dimensioning standards and as performance objectives for international telephone exchanges are indicated below. Procedures to monitor the actual GOS performance of the exchanges are also recommended.

1.2 The GOS standards for international telephone exchanges defined in this Recommendation assume ‘‘fully operative’’ conditions for the exchange and they are based on the load levels specified in Recommendation E.500.

2 Scope of the Recommendation

2.1 The GOS standards are specified for an exchange as a whole, i.e. neither the delay nor the loss parameters are associated solely with the control area or with the connecting network, so that no particular system concept is favoured.

2.2 Although the GOS parameters defined in this Recommendation apply to the digital as well as to the analogue exchanges, the numerical values recommended for these parameters are primarily intended for digital exchanges analogue exchanges and Administrations are advised to make suitable allowances when applying to the analogue exchanges.

Administrations may also consider these GOS values for dimensioning the national transit exchanges so that the end-to-end GOS performance for international connections is maintained at a high level.

3 Grade of service parameters

The loss and delay GOS standards are defined as follows:

3.1 *Loss grade of service*

internal loss probability : for any call attempt, it is the probability that an overall connection cannot be set up between a given incoming circuit and any suitable free outgoing circuit within the switching network.

The loss grade of service is to be met by every pair of incoming and outgoing trunk groups averaged over all inlets of the incoming group.

This approach takes explicit account of the fact that the Administrations will take actions such as the favourable loading of switch blocks in order to balance access to all trunk groups. These actions will minimize the impact of the worst case upon the traffic flow capacity of the switch, by confining the necessary adjustments to localized regions of the switching network

These actions should ensure that the switching system operates as efficiently as possible within the constraints imposed by this loss standard.

3.2 *Delay grade of service in case of channel-associated signalling*

incoming response delay : The interval from the instant when an incoming seizure signal has arrived at the incoming side of the exchange to the instant when a proceed-to-send signal is returned to the preceding exchange by the receiving exchange.

The incoming response delay may affect the holding time of the preceding trunks and of the common control equipment in the preceding exchange(s). It may also be perceived by the subscriber as dial-tone delay, in case of special dial tone for international calls in outgoing international exchanges, or may contribute to the post-dialling delay experienced by the subscriber in all other cases. The contribution to post-dialling delay does not necessarily comprise the whole of the incoming response delay.

Note — The above definition of incoming response delay does not explicitly mention that it includes receiver attachment delay. However, for the purpose of this Recommendation, it is assumed that receiver attachment delay is a part of the incoming response delay.

3.3 *Delay grade of service in case of any combination of channel-associated and common channel signalling*

exchange call set-up delay : The interval from the instant when the address information required for setting up a call is received at the incoming side of the exchange to the instant when the seizing signal or the corresponding address information is sent to the subsequent exchange.

through-connection delay (end-to-end channel associated or common channel signalling) : the interval from the instant when the information required for setting up a through-connection in an exchange is available for processing in the exchange to the instant when the switching network through-connection is established between the incoming and outgoing circuits.

through-connection delay (link-by-link channel associated signalling) : the interval from the completion of outpulsing to the establishment of a communication path through the exchange between the incoming and the outgoing circuits.

4 Grade of service standards

The values shown in Table 1/E.543 are recommended for GOS standards of international digital telephone exchanges. The normal and high load levels are the ones defined in Recommendation E.500.

H.T. [T1.543]

TABLE 1/E.543

<table>
<tr><td>Normal load</td><td>High load</td><td></td></tr>
<tr><td>Incoming response delay | ua) | ub)</td><td>P | > | .5 sec.) 5 |</td><td>P | > | sec.) 5 |</td></tr>
<tr><td>Exchange call set-up delay | ub)</td><td>P | > | .5 sec.) 5 |</td><td>P | > | sec.) 5 |</td></tr>
<tr><td>Through-connection delay | ub)</td><td>P | > | .5 sec.) 5 |</td><td>P | > | sec.) 5 |</td></tr>
<tr><td>Internal loss probability | uc)</td><td>0.002</td><td>0.01</td></tr>
</table>

a) See Note in § 3.2.

b) The determination of the number of bids for the different devices or exchange modules at normal and high load levels should be made according to Rec. E.500. Circuit group or exchange load levels will be used according to the devices or exchange modules affected.

c) The values of traffic offered to the circuit group and to the switching network of the exchange, to be used for loss probability evaluation, should correspond to the traffic flow levels defined for circuit groups and exchanges, respectively, in Rec. E.500.

Table 1/E.543 [T1.543]

In case of differences between exchange and circuit group busy hours it is recommended to use models which can take account of the different traffic values in the different parts of the exchange. For example, models used for dimensioning the auxiliary equipment could take advantage of the differences of busy hour of the different circuit groups using the same auxiliary equipment.

5 Measurements to monitor exchange GOS performance

In the context of traffic Administration, monitoring the GOS performance in an exchange is a means of detecting potential problems which can affect the GOS performance of that exchange. By analysing deviations from previously established GOS performance thresholds, problem areas can be detected. After having identified the problems, actions such as load balancing, fault removal, extensions, etc., can be derived from GOS performance monitoring. These actions are not taken on a real-time basis, and consequently the data collection and analysis do not have real-time constraints. The traffic measurements recommended below do not separate the causes of call attempt failure or excessive delay.

When the values of the GOS performance are consistently worse than the GOS standards specified in § 4, it will be necessary to identify the causes of such a situation through the analysis of ad-hoc measurement procedures. Considering the above framework, errors in GOS estimation are only important to the extent that they can generate over- or under-reactions to exchange situations.

For each of the GOS parameters a statistical estimator has been defined. The measurements must be made on a per circuit group and per exchange basis. Eventually, savings could be derived from delay measurements made on the basis of signalling types when several circuit groups share the same auxiliary devices. All measurements described below refer to a specific measurement period.

5.1 *Delay measurements*

5.1.1 *Incoming response delay*

The exchange GOS performance with respect to this parameter can be estimated by means of the ratio:

$$p = \frac{B}{A},$$

where

A is the number of call attempts accepted for processing from a given incoming circuit group

B is the number of call attempts out of the set *A* , for which the incoming response delay exceeded the predetermined value *X*

Note — In SPC exchanges a certain time may elapse from the moment that the incoming seizure signal appears at the incoming circuit until the moment that the processor accepts the call attempt for processing. Measuring this delay would require external equipment to the call handling processors. The above measurement only provides an indication of the incoming response delay after the call has been accepted for call processing. In the case where this delay is significant, it should be taken into account in dimensioning and should be subtracted from the total time allowed for the incoming response delay.

5.1.2 *Exchange call set-up delay*

The exchange performance with respect to this parameter can be measured by means of the following ratio:

$$q = \frac{D}{C},$$

where

C is the number of call attempts for which sufficient address information has been received at the incoming side of the exchange, which are addressed to a certain outgoing circuit group and for which the seizing signal or the corresponding address information is sent to the subsequent exchange.

D is the number of call attempts already counted in *C* for which the call set-up delay exceeds the predetermined value, *T* .

5.1.3 *Through-connection delay*

The exchange performance with respect to this parameter can be measured by means of the following ratio:

$$r = \frac{F}{E},$$

where

E (for end-to-end channel associated and common channel signalling) is the number of call attempts for which the required information for setting up a through-connection is available for processing in the exchange for a certain circuit group.

E (for link-by-link channel associated signalling) is the number of call attempts which have completed outpulsing in a certain circuit group.

F is the number of call attempts already counted in *E* for which the through-connection delay has exceeded the predetermined value *V* .

Note 1 — The loss of call attempts caused by the exchange itself, premature subscriber release or time-out expiration in an upstream exchange may modify the outcome of the above delay measurements. However, the effect will only be significant under abnormal conditions which should be investigated separately.

Note 2 — It is recommended that values for X, T, and V be either 0.5 s (normal load) or 1 s (high load).

Note 3 — Measuring delays on a per call basis could produce severe cost penalties to the exchange. Since the accuracy requirements from the statistical viewpoint are not very high, call sampling procedures or test calls can be sufficient for GOS monitoring purposes.

5.2 *Loss measurements*

One estimator of this parameter per circuit group is:

$$s = \frac{H}{G},$$

where:

G is the number of call attempts which require a connection from an inlet to the desired outgoing circuit group having at least one free circuit and for which sufficient call handling information was made available to the exchange.

H is the number of those call attempts described by G which failed to build up the required connection.

Note — The loss of call attempts caused by premature subscriber release or time-out expiration in an upstream exchange, may modify the outcome of the above measurement.

Recommendation E.550

GRADE-OF-SERVICE AND NEW PERFORMANCE CRITERIA UNDER FAILURE CONDITIONS IN INTERNATIONAL TELEPHONE EXCHANGES

1 Introduction

1.1 This Recommendation is confined to failures in a single exchange and their impact on calls within that exchange — network impacts are not covered in these Recommendations.

1.2 This Recommendation from the viewpoint of exchange Grade of Service (GOS) has been established.

1.3 In conformity with Recommendation E.543 for transit exchanges under normal operation, this Recommendation applies primarily to international digital exchanges. However, Administrations may consider these Recommendations for their national networks.

1.4 The GOS seen by a subscriber (blocking and/or delay in establishing calls) is not only affected by the variations in traffic loads but also by the partial or complete faults of network components. The concept of customer-perceived GOS is not restricted to specific fault and restoration conditions. For example, the customer is usually not aware of the fact that a network problem has occurred, and he is unable to distinguish a failure condition from a number of other conditions such as peak traffic demands or equipment shortages due to routine maintenance activity. It is therefore necessary that suitable performance criteria and GOS objectives for international telephone exchanges be formulated that take account of the impact of partial and total failures of the exchange. Further, appropriate definitions, models and measurement and calculation methods need to be developed as part of this activity.

1.5 From the subscriber's point of view, the GOS should not only be defined by the level of unsatisfactory service but also by the duration of the intervals in which the GOS is unsatisfactory and by the frequency with which it occurs. Thus, in its most general form the performance criteria should take into account such factors as: intensity of failures and duration of resulting

faults, traffic demand at time of failures, number of subscribers affected by the failures and the distortions in traffic patterns caused by the failures.

However, from a practical viewpoint, it will be desirable to start with simpler criteria that could be gradually developed to account for all the factors mentioned above.

1.6 Total or partial failures within the international part of the network have a much more severe effect than similar failures in the national networks because the failed components in the national networks can be isolated and affected traffic can be rerouted.

Failures in the international part of the network may therefore lead to degraded service in terms of increased blocking delays and even complete denial of service for some time. The purpose of this Recommendation is to set some service objectives for international exchanges so that the subscribers demanding international connections are assured a certain level of service.

It should be noted however that where there are multi-gateway exchanges providing access to and from a country, with diversity of circuits and provision for restoration, the actual GOS will be better than that for the single exchange.

2 General considerations

2.1 The new performance criteria being sought involve concepts from the field of ''availability'' (intensity of failures and duration of faults) and ''traffic congestion'' (levels of blocking and/or delay). It is therefore necessary that the terminology, definitions and models considered should be consistent with the appropriate CCITT Recommendations on terminology and vocabulary.

2.2 During periods of heavy congestion, caused either by traffic peaks or due to malfunction in the exchange, a significant increase in repeated attempts is likely to occur. Further, it is expected that due to accumulated demands during a period of complete faults, the exchange will experience a heavy traffic load immediately after a failure condition has been removed and service restored. The potential effects of these phenomena on the proposed GOS under failure conditions should be taken into account (for further study).

3 Exchange performance characteristics under fault situations

3.1 The exchange is considered to be in a fault situation if any failure in the exchange (hardware, software, human errors) reduces its throughput when it is needed to handle traffic. The following four classes of exchange faults are included in this Recommendation:

a) complete exchange faults;

b) partial faults resulting in capacity reduction in all traffic flows to the same extent;

c) partial faults in which traffic flows to or from a particular point are restricted or totally isolated from their intended route;

d) intermittent fault affecting a certain proportion of calls.

3.2 To the extent practical, an exchange should be designed so that the failure of a unit (or units) within the exchange should have as little as possible adverse affect on its throughput. In addition, the exchange should be able to take measures within itself to lessen the impact of any overload resulting from failure of any of its units. Units within an exchange whose failure reduces the exchange throughput by greater amounts than other units should have proportionally higher availability (Recommendation Q.504, § 4).

3.3 When a failure reduces exchange throughput and congestion occurs, the exchange should be able to initiate congestion control indications to other exchanges and network management systems so as to help control the offered load to the exchange, (Recommendations E.410 and Q.506).

4 GOS and applicable models

4.1 In this section, the terms ''accessible'' and ''inaccessible'' are used in the sense defined in Recommendation G.106 (*Red Book*). The GOS for exchanges under failure conditions can be formulated at the following two conceptual levels from a subscriber's viewpoint:

4.1.1 *Instantaneous service accessibility (inaccessibility)*

At this level, one focuses on the probability that the service is accessible (not accessible) to the subscriber at the instant he places a demand.

4.1.2 *Mean service accessibility (inaccessibility)*

At this level, one extends the concept of ''downtime'' used in availability specifications for exchanges to include the effects of partial failures and traffic overloads over a long period of time.

4.2 Based on the GOS concept outlined in § 4.1, the GOS parameters for exchanges under failure conditions are defined as follows:

4.2.1 **instantaneous exchange inaccessibility** is the probability that the exchange in question cannot perform the required function (i.e. cannot successfully process calls) under stated conditions at the time a request for service is placed.

4.2.2 **mean exchange service inaccessibility** is the average of instantaneous exchange service inaccessibility over a prespecified observation period (e.g. one year).

4.2.3 *Note 1* — The GOS model in the case of instantaneous exchange inaccessibility parallels the concept of the call congestion in traffic theory and needs to be extended to include the call congestion caused by exchange failures classified in § 3.1. The GOS value can then be assigned on a basis similar to Recommendation E.543 for transit exchanges under normal operation.

Note 2 — A model for estimating the mean exchange inaccessibility is provided in Annex A. Though the model provides a simple and hence attractive approach, some practical issues related to measurement and monitoring and the potential effects of network management controls and scheduled maintenance on the GOS need further study.

4.3 The model in Figure 1/E.550 outlines the change in the nature of traffic offered under failure conditions.

Figure 1/E.550, p.

In normal conditions the congestion factor B | is low and there should be few repeat attempts: as a consequence the traffic A_t approximates A_o.

Under failure conditions there is a reduction in resources and the congestion factor B increases. This provokes the phenomenon of repeat attempts and hence the load A_t on the exchange becomes greater than the original A_o.

Therefore it is necessary to evaluate the congestion with the new load A_t | assuming system stability exists, which may not always be the case.

Recommendation E.501 furnishes the appropriate models to detect the traffic offered from the carried traffic taking into account the repeat attempts.

4.4 The impact on the GOS for each of the exchange fault modes can be characterized by:

— load in Erlangs (A_t) and busy hour call attempts (BHCA);

— inaccessibility (instantaneous and mean), congestion and delay parameters (call set-up, through-connection, etc.);

— fault duration;

— failure intensity.

5 GOS standards and inaccessibility

5.1 Exchange fault situations can create similar effects to overload traffic conditions applied to an exchange under fault free conditions.

In general, digital exchanges operating in the network should be capable of taking action to ensure maximum throughput when they encounter an overload condition, including any that have been caused by a fault condition within the exchange.

Calls that have been accepted for processing by the exchange should continue to be processed as expeditiously as possible, consistent with the overload protection strategies recommended in § 3 of Recommendation Q.543.

5.2 One of the actions the exchange may take to preserve call processing capacity is to initiate congestion controls and/or other network management actions, to control the load offered to the exchange (Recommandations E.410, E.413 and Q.506). The most obvious impact from the caller's viewpoint may be a lowering of the probability that the network as a whole will be able to complete some portion of the call attempts that the exchange is unable to accept during the failure condition.

5.3 International exchanges occupy a prominent place in the network and it is important that their processing capacity have high availability. There are likely to be many variations in exchange architectures and sizes that will have different impacts in the categories of failure and the resulting loss of capacity.

In general, failures that cause large proportions of exchange capacity to be lost must have a low probability of occurring and a short downtime. It is important that maintenance procedures to achieve appropriate exchange availability performance be adopted.

5.4 The formal expression of the criterion of mean exchange service inaccessibility is as follows:

Let:

$y(t)$: Intensity of call attempts gaining access through the exchange assuming no failures.

$s(t)$: Intensity of call attempts actually given access through the exchange, taking into account the fault conditions which occur in the exchange.

Then the mean exchange service inaccessibility during a period of time T | is given by

Annex A describes a practical implementation of this criterion.

For periods in which the exchange experiences a complete fault, i.e. $s(t) = 0$, the expression:

$$\frac{f\,Iy(t) - s(t)}{f\,Iy(t)} \quad \text{is equal to 1.}$$

The contribution of such periods to the total criterion P | ay then be expressed simply as the fraction P_{total} of the evaluation period T during which complete exchange outage due to failure occurred.

The objective for P_{total} | is given as P_{total} | not more than 0.4 hours per year.

For the period of partial failure, it is convenient to also express the objective as equivalent hours per year — the term equivalent is used because the duration of partial faults is weighted by the fraction:

$$\frac{f\,Iy(t) - s(t)}{f\,Iy(t)}$$

of call attempts denied access. The objectives for the contribution of period of partial exchange faults to the total criterion P | is given by:

$P_{partial}$ | not more than 1.0 equivalent hours per year.

Note that by definition $P = P_{total} + P_{partial}$

The inaccessibility criterion does not cover:

— planned outages

— faults with duration of less than 10 seconds

— accidental damage to equipment during maintenance

— external failures such as power failures, etc.

It does cover failures resulting from both hardware and software faults.

In addition, the objectives relate to the exchange under normal operating conditions and do not include failures just after cut-over of an exchange or those during the end of the period it is in service, i.e. the well known ‘‘bath tub’’ distribution.

6 Performance monitoring

Certain failure conditions [i.e. the type mentioned in § 3.1, b)] usually will be reflected in the normal GOS performance measurements called for in Recommendation E.543.

Other failure conditions [i.e. the type mentioned in § 3.1, c)] can result in a reduced performance for a portion of traffic flows but with little or no impact on measured exchange GOS. For example if a trunk module in a digital exchange fails, the traffic normally associated with that module is completely blocked, but since the attempts are also not measured the failure does not change the monitoring of the exchange GOS.

For this second situation, the mean inaccessibility can be calculated using direct measurement of unit outages to provide m_i and t_i information and estimates of b_i together with the model of Annex A. (See Annex A for an explanation of these symbols.)

The estimates of b_i | can incorporate both fixed factors based on exchange architecture and variable factors based on traffic measurements just prior to the time of failure.

ANNEX A

(to Recommendation E.550)

A model for mean exchange inaccessibility

A.1 Let P | e the probability that a call attempt is not processed due to a fault in the exchange, then:

where:

p_i is the probability of fault mode i . Each fault mode denotes a specific combination of faulty exchange components

N is the number of the fault mode

b_i is the average proportion of traffic which cannot be processed due to the fault mode i . It is a function of the specific fault present and the offered traffic load at the time of the failure condition.

During a period of time T , the fault probability p_i | may be estimated by:

where:

m_i is the number of occurrences of fault mode i
| uring the period T

t_i is the average duration of occurrences of fault mode i

As a practical matter, one may wish to exclude from the calculation faults of duration less than 15 seconds.

Note 1 — A given fault mode causes the exchange to enter the corresponding fault state, which is characterized by a given mean duration and a function b_i giving the proportion of offered traffic affected. In principle, the possible number of fault modes can be very large because of the number of combinations which can occur. In practice this number can be reduced by considering all fault modes with the same b_i and t_i as equivalent.

Note 2 — b_i should take into account the distribution of traffic during a day and the probability of fault mode i occurring in a given time period. The value assigned in the above model should be the average b_i value for all hours considered in these distributions. For example, a partial fault affecting 20% of the exchange traffic throughput in the busy hour and 2 similar hours, could be evaluated to effect a 10% reduction in 4 other moderately busy hours and to have negligible impact during all other hours. If this fault is considered to be equally probable in time, the average value of b_i can be obtained as follows:

$$b_i = \text{Sum of} \left(\frac{\text{ercentage of traffic affected} \times \text{number of relevant busy hours}}{4\ hours} \right) =$$

Note 3 — The probability that a call attempt is not processed relates to the category of traffic affected by the fault. Other traffic will experience a different GOS depending on system architecture which is not taken into account in this Recommendation. For example, partial faults which remove from service blocks of trunks connected to an exchange have the effect of reducing the total traffic offered to the exchange. The traffic flows not using the failed trunks could thus have a slightly improved GOS.

A.2 *Example for calculating the inaccessibility, P*

See Table A-1/E.550.

H.T. [T1.550]

TABLE A.1/E.550

An example of using the model for calculating the inaccessibility P

(*T*
= | year | | 760 hours)

b i *p* *i* | (mu | fIb *i* }	*m i*	*t i*	{

{
Average proportion
of traffic which
cannot be processed
}
Number of failures
of type *i*
per year
}
Average duration
of failure type *i*
(hours)
}
Probability that a call attempt is not processed
(× 10DlF2615)
}
	
	{
	
	{
	
	{		

1.00	2	0.2	4.56
0.40	3	0.22	3.01
0.20	4	0.3	2.74
0.10	6	0.4	2.74
0.05	10	0.5	2.85

Table A-1 [T1.550], p.

The value of *P* | s the sum of the individual $p_i \times b_i$ terms in Table A-1/E.550. In this example *P* = 15.90 × 10DlF2615 which is equivalent to 1.39 hours of inaccessibility per year (1.39 = 15.90 × 10DlF2615 × 8760). *P* decomposes as follows:

P_{total} | = 0.40 hours per year (4.56 × 10DlF2615 × 8760)

$P_{partial}$ = 0.99 hours per year (the remaining part of *P*)

A.3 As a further example consider a circuit group where exchange failures may occur which disable one or more circuits (see Figure A-1/E.550). It is possible to expand the formula (A-1).

Figure A-1/E.550, p.

The average proportion of traffic $b(n, k, A)$, which cannot be processed due to failures on circuits is now a function of:

— n, the size of the circuit group;

— k, number of circuits out of order because of the failure;

— A, the mean traffic offered to the circuit group, in the absence of faults.

Let the throughput of a circuit group of size n | with a traffic offered A be $C(A)$ — then the throughput of the same circuit group is $C_{n\backslash dk}(A)$ where k circuits are out of order — hence the average proportion of traffic $b(n, k, A)$ which cannot be processed because of the failure is given by:

Let

$f(k, A)$ be the probability for having k | circuits in a fault condition and the mean offered traffic A.

The probability, P_n, that a call attempt is not processed due to a failure on a circuit group of size n, is given by:

where $f_1(k)$ may satisfy a binomial distribution and $f_2(A)$ a Poisson distribution.

Suppose the traffic follows an Erlang distribution, $C_n(A)$ is proportional to A | (mu | 1 — $E_n(A)$), where $E_n(A)$ is the blocking probability expressed by the Erlang loss formula. Hence:

can be found by using the Erlang tables and then inserting the value into equation (A-4).

Blanc

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SECTION 6

DEFINITIONS

Recommendation E.600

TERMS AND DEFINITIONS OF TRAFFIC ENGINEERING

Introduction

This Recommendation provides terms and definitions for use in the field of traffic engineering. Traffic engineering includes measurements, forecasting, planning, dimensioning and performance monitoring. Traffic engineering has a goal of ensuring trafficability performance objectives for telecommunications services. Trafficability performance is one of the major factors in Quality of Service (QOS). Recommendation E.800 explains the relation of various Quality of Service factors and gives terms and definitions for Quality of Service concepts and for availability and reliability aspects.

The purpose of this vocabulary is to aid in the understanding of traffic engineering and related Recommendations. The terms defined here may also be defined differently for applications outside the area of traffic engineering.

Alternatives for the preferred terms are given following a semi-colon.

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1 General theory

1.1 **communication**

F: communication

S: comunicaci´on

Transfer of information according to agreed conventions. The information flow need not be bidirectional.

1.2 **connection**

F: connexion

S: conexión

An association of resources providing means for communication between two or more devices in, or attached to, a telecommunication network.

1.3 **resource**

F: ressource

S: órgano

Any set of physically or conceptually identifiable entities within a telecommunications network, the use of which can be unambiguously determined.

1.4 **user**

F: usager

S: usuario

Any entity external to the network which utilizes connections through the network for communication.

1.5 **telecommunications traffic; teletraffic**

F: trafic de télécommunications: télétrafic

S: tráfico de telecomunicación; teletráfico

A process of arrivals and releases of demands for resources in a network.

Note — The unit for the variable traffic is the Erlang (symbol: E).

1.6 **observed traffic**

F: trafic observé

S: tráfico observado

Instantaneous observed traffic is the amount of occupied resources at a given instant. Average observed traffic is the time average of instantaneous observed traffic over a given period.

1.7 **poisson traffic; pure chance traffic**

F: trafic poissonnien: trafic de pur hasard

S: tráfico poissoniano

Traffic that has a Poisson distribution of arrivals.

Note — Poisson traffic has a peakedness factor equal to 1.

1.8 **peakedness factor**

F: facteur d’irr´egularit´e

S: factor de irregularidad

The ratio of variance to mean of a traffic.

1.9 **smooth traffic**

F: trafic r´egularis´e

S: tr´afico con distribuci´on uniforme

Traffic that has a peakedness factor less than 1.

1.10 **peaked traffic**

F: trafic survariant

S: tr´afico con distribuci´on en pico

Traffic that has a peakedness factor greater than 1.

1.11 **traffic volume**

F: volume de trafic

S: volumen de tráfico

The integral of the instantaneous traffic over a given time interval.

Note 1 — Traffic volume is equal to the sum of the holding times of the resources.

Note 2 — A unit used for traffic volume is the Erlang hour (symbol: E).

1.12 **erlang**

F: erlang

S: erlang

The unit of traffic (symbol: E). In traditional telephony the number of Erlangs is the number of busy resources or the expected number of busy resources under stated conditions.

1.13 **bid**

F: tentative de prise

S: tentativa de toma

A single attempt to obtain the use of a resource of the type under consideration.

Note — In a network management context, the absence of a qualification implies a bid to a circuit group, a route or a destination.

1.14 **seizure**

F: prise

S: toma

A bid that obtains the use of a resource of the type under consideration.

1.15 **idle (state)**

F: libre

S: reposo (estado de); estado libre

Condition of a resource that is free to be seized.

1.16 **busy (state)**

F: occupé

S: ocupado (estado de)

Condition of a resource following its seizure.

1.17 **release**

F: lib´eration

S: liberaci´on

The event which changes the condition of a resource from busy to idle.

1.18 **holding time**

F: dur´ee d'occupation

S: tiempo de ocupaci´on; tiempo de retenci´on

The time between the seizure of a resource and its release.

1.19 **blocked mode of operation**

F: mode d'exploitation avec blocage

S: modo de operaci´on con bloqueo (de llamadas)

A mode of operation in which bids which find no suitable resources idle and accessible are not permitted to wait.

1.20 **delay mode of operation**

F: mode d'exploitation avec attente

S: modo de operaci´on con espera (de llamadas)

A mode of operation in which bids which find no suitable resources idle and accessible are permitted to wait.

1.21 **call congestion**

F: encombrement d’appel

S: congesti´on de llamadas

The probability that a bid to a particular pool or resources will not result in an immediate seizure.

1.22 **time congestion**

F: congestion temporelle

S: congesti´on temporal

The proportion of time that a particular pool of resources does not contain any idle resource.

1.23 **waiting time; queuing time**

F: temps de mise en attente

S: tiempo de espera; tiempo de cola

In delay mode of operation, the time interval between the bid for a resource and its seizure.

2 Calls

2.1 **call**

F: appel

S: llamada

A generic term related to the establishment, utilization and release of a connection. Normally a qualifier is necessary to make clear the aspect being considered, e.g. call attempt.

2.2 **call intent**

F: intention d’appel

S: intenci´on de llamada; intento de llamada

The desire to establish a connection to a user.

Note — This would normally be manifested by a call demand. However, demands may be suppressed or delayed by the calling user’s expectation of poor Quality of Service performance at a particular time.

2.3 **call demand**

F: demande d’appel

S: demanda de llamada

A call intent that results in a first call attempt.

2.4 **call attempt**

F: tentative d'appel

S: tentativa de llamada

An attempt to achieve a connection to one or more devices attached to a telecommunications network.

Note — At a given point in the network a call attempt is manifested by a single unsuccessful bid, or a successful bid and all subsequent activity related to the establishment of the connection.

2.5 **first call attempt**

F: première tentative d'appel

S: primera tentativa de llamada

The first attempt of a call demand that reaches a given point of the network.

2.6 **repeated call attempt; reattempt**

F: tentative d'appel répétée

S: tentativa de llamada repetida

Any of the call attempts subsequent to a first call attempt related to a given call demand.

Note — Repeated call attempts may be manual, i.e. generated by humans, or automatic, i.e. generated by machines.

2.7 **call string**

F: cha | ne d'appel

S: cadena de llamada

All the call attempts related to a single demand.

2.8 **blocked call attempt**

F: tentative d'appel bloqu´ee

S: tentativa de llamada bloqueada

A call attempt that is rejected owing to a lack of resources in the network.

2.9 **abandoned call attempt**

F: tentative d'appel abandonn´ee

S: tentativa de llamada abandonada

A call attempt aborted by the calling user.

2.10 **successful call attempt; fully routed call attempt**

F: tentative d'appel achemin´ee

S: tentativa de llamada fructuosa; tentativa de llamada totalmente encaminada

A call attempt that receives intelligible information about the state of the called user.

2.11 **completed call attempt; effective call attempt**

F: tentative d'appel ayant abouti; tentative d'appel efficace

S: tentativa de llamada completada; tentativa de llamada eficaz

A successful call attempt that receives an answer signal.

2.12 **successful call**

F: appel ayant abouti

S: llamada fructuosa

A call that has reached the wanted number and allows the conversation to proceed.

2.13 **completion ratio**

F: taux d'efficacit´e

S: relaci´on respuesta/toma; tasa de compleci´on; tasa de eficacia

The ratio of the number of completed call attempts to the total number of call attempts, at a given point of a network.

2.14 **answer seizure ratio (ASR)**

F: taux de prise avec réponse (TPR)

S: tasa de tomas con respuesta (TTR)

On a route or a destination code basis, and during a specified time interval, the ratio of the number of seizures that result in an answer signal, to the total number of seizures.

2.15 **answer bid radio (ABR)**

F: taux de tentatives de prise avec réponse (TTPR)

S: tasa de tentativas de toma con respuesta (TTTR)

On a route or a destination code basis and during a specified time period, the ratio of the number of bids that result in an answer signal, to the total number of bids.

2.16 **calling rate**

F: taux d’appel

S: tasa de llamadas

The number of call attempts at a given point, over a period of time, divided by the duration of the period.

2.17 **dialling-time**

F: durée de numérotation

S: tiempo de marcación

Time interval between the reception of dial tone and the end of dialling of the calling user.

3 Circuits

3.1 circuit

F: circuit (de t´el´ecommunication)

S: circuito

A transmission means which allows communication between two points.

3.2 trunk circuit

F: circuit (commut´e)

S: circuito (entre centrales); circuito troncal

A circuit terminating in two switching centres.

3.3 one way; unidirectional

F: à sens unique; unidirectionnel

S: en un solo sentido; unidireccional

A qualification applying to traffic or circuits which implies that the establishment of a connection always occurs in one direction.

3.4 two way; bidirectional

F: à double sens; bidirectionnel

S: en ambos sentidos; bidireccional

A qualification applying to traffic or circuits which implies that the establishment of a connection may occur in either direction.

3.5 circuit group

F: faisceau (de circuits)

S: haz de circuitos

A group of circuits which are traffic engineered as a unit.

3.6 circuit subgroup

F: sous-faisceau

S: subhaz de circuitos

A part of a circuit group with similar characteristics (e.g. type of signalling, type of transmission path, etc.).

3.7 first choice circuit group

F: faisceau de premier choix

S: haz de circuitos de primera elección

With respect to a particular traffic relation, the circuit group to which this traffic is first offered.

3.8 **high usage circuit group**

F: faisceau débordant

S: haz de circuitos de gran utilización

With respect to a particular traffic relation, a circuit group that is traffic engineered to overflow to one or more other circuit groups.

3.9 **final circuit group**

F: faisceau final

S: haz final de circuitos

With respect to a particular traffic relation, a circuit group from which there is no possibility of overflow to another circuit group within the routing scheme currently in effect.

3.10 **fully provided circuit group**

F: faisceau totalement fourni

S: haz de circuitos totalmente provisto

With respect to a particular traffic relation, a circuit group which is the first choice circuit group for this traffic and which is traffic engineered as a final circuit group.

4 Grade of service

4.1 grade of service (GOS)

F: qualité d’écoulement du trafic

S: grado de servicio (GDS)

A number of traffic engineering variables used to provide a measure of adequacy of a group of resources under specified conditions; these grade of service variables may be probability of loss, dial tone delay, etc.

Note 1 — The parameter values assigned as objectives for grade of service variables are called grade of service standards.

Note 2 — The values of grade of service parameters achieved under actual conditions are called grade of service results.

4.2 quality of service variable

F: variable de qualité de service

S: variable de calidad de servicio

Any performance variable (such as congestion, delay, etc.) which is perceivable by a user.

Note — For a description of the relations of quality of service factors see Recommendation E.800.

4.3 dial-tone delay

F: durée d’attente de tonalité

S: demora del tono de invitación a marcas; periodo de espera del tono de invitación a marcar

Time interval between off hook and reception of dial tone.

4.4 post-dialling delay

F: attente après numérotation

S: demora después de marcar; periodo de espera después de marcar

Time interval between the end of dialling by the user and the reception by him of the appropriate tone or recorded announcement, or the abandon of the call without tone.

4.5 answer-signal delay

F: délai du signal de réponse

S: demora de la señal de respuesta

Time interval between the establishment of a connection between calling and called users, and the detection of an answer signal at the originating exchange.

4.6 incoming response delay

F: durée de présélection

S: demora de la preselección; duración de la preselección

The interval from the instant when an incoming seizure is recognizable at the incoming side of the exchange to the instant when the proceed to send signal is sent to the preceding exchange by the receiving exchange.

Note — This definition is only applicable in the case of channel associated signalling.

4.7 **exchange call set-up delay**

F: durée de sélection d'un commutateur

S: demora de establecimiento de la comunicación por una central; tiempo de establecimiento de la comunicación por una central

The interval from the instant when the address information required for setting up a call is received at the incoming side of the exchange to the instant when the seizing signal or the corresponding address information is sent to the subsequent exchange.

4.8 **through-connection delay**

F: durée d'établissement d'un commutateur

S: demora de transconexión; tiempo de transferencia de una central

The interval from the instant when the information required for setting up a through-connection in an exchange is available for processing in the exchange, to the instant when the switching network through-connection is established and available for communication.

4.9 **internal blocking**

F: blocage interne

S: bloqueo interno

The probability that a connection cannot be made between a given point in a network and any suitable idle resource in an external pool of resources owing to call congestion within the portion of the network being considered.

4.10 **external blocking**

F: blocage externe

S: bloqueo externo

The probability that a connection cannot be made between a given point in a network and any suitable resource in an external pool of resources owing to call congestion within the pool of resources.

5 Traffic engineering

5.1 **busy hour**

F: heure chargée

S: hora cargada

The continuous 1-hour period lying wholly in the time interval concerned for which the traffic or the number of call attempts is greatest.

5.2 **average daily peak hour traffic**

F: moyenne du trafic des heures chargées

S: tráfico medio de las horas punta

The average busy hour traffic of several days; it is usually not related to the same hour each day.

5.3 **time consistent busy hour**

F: heure chargée moyenne

S: hora cargada media repetitiva o sistemática

The 1-hour period starting at the same time each day for which the average traffic of the resource group concerned is greatest over the days under consideration.

5.4 **day to busy hour ratio**

F: rapport du trafic journalier au trafic à l'heure chargée

S: relación del tráfico diario al tráfico en la hora cargada

The ratio of the 24-hour day traffic volume to the busy hour traffic volume.

Note — Busy hour to day ratio is also used.

5.5 **traffic carried**

F: trafic écoulé

S: tráfico cursado

The traffic served by a pool of resources.

5.6 **traffic offered**

F: trafic offert

S: tráfico ofrecido

The traffic that would be carried by an infinitely large pool of resources.

5.7 **effective traffic**

F: trafic efficace

S: tráfico eficaz

The traffic corresponding only to the conversational portion of effective call attempts.

5.8 **overflow traffic**

F: trafic de d´ebordement

S: tr´afico de desbordamiento

The part of the traffic offered to a pool of resources which is not carried by that pool of resources.

5.9 **blocked traffic**

F: trafic bloqu´e

S: tr´afico bloqueado

The part of the overflow traffic that is not carried by subsequent pools of resources.

5.10 **lost traffic; abandoned traffic**

F: trafic perdu; trafic abandonn´e

S: tr´afico perdido; tr´afico abandonado

That part of the blocked traffic which does not result in reattempts.

5.11 **suppressed traffic**

F: trafic non exprim´e; trafic supprim´e

S: tr´afico suprimido

The traffic that is withheld by users who anticipate a poor quality of service (QOS) performance.

5.12 **origin**

F: origine

S: origen

The location of the calling user. This may be specified to whatever accuracy is necessary.

5.13 **destination**

F: destination

S: destino

The location of the called network termination. This may be specified to whatever accuracy is necessary; in international working, the area or country code is usually sufficient.

5.14 **traffic relation**

F: flux de trafic

S: relaci´on de tr´afico

The traffic between a particular origin and a particular destination.

5.15 **traffic matrix**

F: matrice de trafic

S: matriz de tr´afico

A structured presentation of the traffic between a number of origins and destinations.

5.16 **originating traffic**

F: trafic de d´epart

S: tr´afico de origen

Traffic generated within the network considered, whatever its destination.

5.17 **terminating traffic**

F: trafic d'arriv´ee

S: tr´afico de destino

Traffic which has its destination within the network considered, whatever its origin.

5.18 **internal traffic**

F: trafic interne

S: tr´afico interno

Traffic originating and terminating within the network considered.

5.19 **incoming traffic**

F: trafic entrant

S: tr´afico entrante

Traffic entering the network considered, from outside it, whatever its destination.

5.20 **outgoing traffic**

F: trafic sortant

S: tr´afico saliente

Traffic leaving the network considered, destined for sinks located outside it, whatever its origin.

5.21 **transit traffic**

F: trafic de transit

S: tr´afico de tr´ansito

Traffic passing through the network considered.

5.22 **traffic distribution imbalance**

F: d´es´equilibre interne de trafic

S: desequilibrio de la distribuci´on interna de tr´afico

Unevenly distributed traffic among similar resources.

5.23 **route**

F: voie d'acheminement

S: ruta

One or more circuit groups providing a connection between switching centres.

5.24 **traffic routing**

F: acheminement de trafic

S: encaminamiento de tr´afico

The selection of routes, for a given traffic relation; this term is applicable to the selection of circuit groups by switching systems or operators, or to the planning of routes.

5.25 **call routing**

F: acheminement d'appel

S: encaminamiento de la llamada

The selection of appropriate circuit subgroups or individual circuits for a particular call attempt.

5.26 **alternative route; alternate route**

F: voie d'acheminement d´etourn´e

S: ruta alternativa

A second, or subsequent choice route between two switching centres usually consisting of two or more circuit groups in tandem.

5.27 **network cluster**

F: faisceau de faisceaux

S: agrupaci´on de haces

A final circuit group and all the high usage circuit groups which have at least one traffic relation for which the final circuit group is in the last choice route.

5.28 **equivalent random traffic**

F: trafic equivalent

S: tr´afico aleatorio equivalente

The theoretical poisson traffic that, when offered to a theoretical circuit group (equivalent random circuit group) produces an overflow traffic with a mean and variance equal to that of a given offered traffic.

Note — The equivalent random traffic and circuit group represent the traffic impact of a more complex arrangement of offered traffics and high usage circuit groups.

ALPHABETICAL INDEX