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TELEPHONE NETWORK AND ISDN

QUALITY OF SERVICE, NETWORK MANAGEMENT AND TRAFFIC ENGINEERING

DIMENSIONING A CIRCUIT GROUP WITH MULTI-SLOT BEARER SERVICES AND NO OVERFLOW INPUTS

ITU-T Recommendation E.526

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. 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, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation E.526 was prepared by the ITU-T Study Group II (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

CONTENTS

DIMENSIONING A CIRCUIT GROUP WITH MULTI-SLOT BEARER SERVICES AND NO OVERFLOW INPUTS

(Helsinki, 1993)

1 Introduction

This Recommendation describes methods for calculating the number of circuits in a final circuit group, which has no overflow inputs, carrying on demand circuit switched ISDN bearer services with different bit rates. Examples of channel classes and information transfer rates for the bearer services up to the primary rate interface are as follows (see Recommendation I.211).

- B-channel: 64 kbit/s;
- H0-channel: 384 kbit/s;
- H11-channel: 1536 kbit/s;
- H12-channel: 1920 kbit/s.

Different implementation providing these services is possible, such as dedicated circuit groups for each channel class or common circuit groups for two or more channel classes. Choice of implementation depends on available switching architecture, network structure, operational simplicity and flexibility, required Grade of Service, traffic demand, accuracy of the demand forecasting and others. Recommendation E.520 provides a dimensioning method for a dedicated circuit group. This Recommendation deals with the dimensioning methods for a common circuit group that is shared by the bearer services at different bit rates.

Definition

A unit circuit is defined as a circuit with the lowest information transfer rate among the bearer service classes sharing a circuit group. A unit circuit is the elementary unit for dimensioning a circuit group and, hereafter, it will simply be called "circuit".

A single call for a class i bearer service requires d_i circuits; d_i is called the bandwidth factor of this class i service.

Example:

If B, H0 and H12-channel rate bearer services share a circuit group, the bandwidth factors are 1, 6 and 30.

If H0 and H11-channel rate bearer services share a circuit group, the bandwidth factors are 1 and 4.

2 Grade of Service objectives

The Grade of Service (GOS) objectives used in a first approach is that the individual blocking probability for each service class will not exceed 1% for a normal load and 7% for a high load. The normal and high load levels are defined in Recommendation E.500. It will be desirable to consider the differences of the busy-hour and day-to-day traffic variations for the service classes. A more complicated situation with different GOS standards for each service class X_i% and Y_i%, respectively is for further study.

3 Dimensioning methods

3.1 Full availability group

A full availability group is described as follows. If a class i call arrives when there are fewer than d_i circuits idle in the group, it is lost, otherwise it seizes d_i circuits, even if they are not adjacent.

The number of circuits needed for the group may be calculated based on a product form solution (see Annex A). Annex B shows samples of the capacity table. It is desirable to use a computer or a programmable calculator. Calculation algorithms for the blocking probabilities of a full availability group are presented in [1], [2], [5] and [8]. No comparative evaluation of different methods is currently available.

3.2 Trunk modularity

According to Recommendation I.211, multi-slot bearer services with "unrestricted", "8 kHz structured" attributes require Time Slot Sequence Integrity (TSSI). One technique for ensuring TSSI is to route all the time slots of a call over the same transmission systems. This introduces the restriction that all d_i circuits for class i call have to be allocated to the same trunk module (e.g. primary PCM multiplex). In the case of such a restriction, blocking performance is dependent on circuit hunting strategies.

Examples of hunting strategies:

- random hunting strategy – Calls are placed on any available trunk module in random order;
- sequential hunting strategy – Idle circuits are searched in the same fixed order and calls are placed on the first available trunk module found;
- call packing strategy – Calls are placed on the most heavily loaded available trunk module.

The random hunting strategy should not be used because it has the worst traffic performance, especially for wideband calls. The call packing strategy is theoretically superior, but does not show practically significant differences from the simple sequential hunting strategy [1].

Approximation methods for blocking probabilities that use the sequential hunting strategy are proposed for one-way [1] and both-way circuits [3].

3.3 Service protection

In the full availability system, the individual blocking probabilities of each class increase with the bandwidth factor [4]. To improve the performance of wideband calls, the service protection methods in Recommendation E.525 are available.

If all classes must meet the same blocking standards, the easiest method is to use trunk reservation with the same limit (maximum bandwidth factor –1) applied to all classes. This means that calls are lost if the number of idle circuits at the arrival epoch is fewer than the largest bandwidth factor of all the classes.

The approximation methods for blocking probabilities that use trunk reservation are proposed in [5], [6], [7] and [8].

Annex A presents some considerations about the calculation of individual blocking probabilities in case of trunk reservation.

Annex A

Blocking probabilities of a full availability group

(This annex forms an integral part of this Recommendation)

List of symbols

N	is the number of circuits in a group;
M	is the number of service classes;
a_i	is the traffic offered of class i service measured by each bandwidth;

d_i	is the bandwidth factor for a class i service;
$P(n_1, ..., n_M)$	is the probability distribution of the number of calls for each class in a circuit group;
B_i	is the blocking probabilities for class i calls.

A product form solution:

$$P(n_1, ..., n_M) = \prod_{i=1}^{M} \frac{a_i^{n_i}}{n_i!} P(0, ..., 0)$$

$$P(0, ..., 0) = \left\{ \sum_{0 \le d_1 n_1 + ... + d_M n_M \le N} \prod_{i=1}^{M} \frac{a_i^{n_i}}{n_i!} \right\}^{-1}$$

$$B_i = \sum_{d_1 n_1 + ... + d_M n_M \ge N - d_i + 1} P(n_1, ..., n_M)$$

An approximate algorithm for practical calculations:

We consider now the case where the N slots of a trunk group share the various multi-slot traffic flows to be handled, *the accessibility being total* (without restriction) for each traffic flow. These traffic flows are poissonian and identified by an index i = 1, 2, ..., x.

Notations

Traffic flow No. i

! Traffic intensity per each time slot: b_i

! Number of simultaneous time slots: d_i

! Call congestion: B_i

! Time congestion: Π

Overall parameters

! Total traffic flow offered (in calls): $b = \sum_{i=1}^{x} b_i$

!

!

!

! Total traffic flow offered (in circuits): $M = \sum_{i=1}^{x} b_i d_i$

$$V = \sum_{i=1}^{x} b_i d_i^2, \quad Z = V/M, \quad K = [N/M]^{1/Z} \qquad \text{(A-1)}$$

In [5] we find an algorithm which allows an evaluation of the call congestion B_i. From [8] we can apply the "*reduced network method*" and use the very simple approximated expression below:

$$B_i = B_1 H_i, \text{ with: } H_i = \frac{K^{d_i} - 1}{K - 1} \qquad \text{(A-2)}$$

where i = 1 corresponds to the case of ordinary calls: $d_1 = 1$.

Moreover, we have:

$$B_1 = \Pi \approx (1/Z)\, E_{N/Z}\,(M/Z) \qquad \text{(A-3)}$$

where E_m (a) is the Erlang loss formula for m fractional.

We have:

$$B_i > B_1 \text{ if } d_i > 1$$

With the "*circuit reservation*" *method* of Recommendation E.525, the evaluation of H_i, is much more complex and it depends on the mean seizure durations associated with each traffic flow. However, if these mean durations increase with the value given to (d_i) the corresponding B_i values decrease in relation to the case where all these mean durations would be equal. Moreover, the circuit reservation method mentioned above aims at decreasing the difference between the B_i values. For the upper values of (d_i) the corresponding B_i values decrease slightly whereas B_1 increases significantly to approach the highest B_i values.

Finally, the formulas (A-2) and (A-3) mentioned above, for the upper values of (d_i), give estimated excess values for B_i in the case of an approximate equalization of the B_i values.

Annex B

Sample of the capacity table (full availability group)

(This annex forms an integral part of this Recommendation)

Let

p = blocking probability

Y_i = individual traffic offered = $d_i a_i$

r = traffic mix ratio = (y_1:y_2: .... :Y_M)

y = total traffic offered $= \sum_{i=1}^{M} y_i$

N = number of unit circuits

p = X%

	r = ?
N	y

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