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**SERIES E: OVERALL NETWORK OPERATION,
TELEPHONE SERVICE, SERVICE OPERATION AND
HUMAN FACTORS**

Quality of service, network management and traffic
engineering – Traffic engineering – Measurement and
recording of traffic

Estimation of traffic offered in the network

ITU-T Recommendation E.501

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.501

ESTIMATION OF TRAFFIC OFFERED IN THE NETWORK

Summary

This Recommendation contains estimation procedures for the traffic offered to a circuit-switched network. Methods to estimate the traffic offered to a circuit group and the origin-destination traffic, based on circuit group measurements, are described.

Source

ITU-T Recommendation E.501 was revised by ITU-T Study Group 2 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 26th of May 1997.

FOREWORD

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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.

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.501

ESTIMATION OF TRAFFIC OFFERED IN THE NETWORK*(revised 1997)***1 Introduction**

For planning the growth of the network, the following quantities must be estimated from measurements:

- traffic offered to circuit groups;
- traffic offered to destinations, on an origin-destination basis;
- traffic offered to exchanges;
- call attempts offered to exchanges;
- traffic offered to signalling links.

These quantities are normally estimated from measurements of busy-hour carried traffic and call attempts, but there are a number of factors which may need to be taken into account within the measurement and estimation procedures:

- a) Measurements may need to be subdivided, e.g. on a destination basis, or by call type (for example, calls using different signalling systems).
- b) It may not be possible to obtain a complete record of traffic carried. For example, in a network with high usage and final groups, it may not be possible to measure the traffic overflowing from each high usage group.
- c) Measurements may be affected by congestion. This will generally result in a decrease in traffic carried, but the decrease may be affected by customer's repeat attempts and by the actions (for example, automatic repeat attempts) of other network components.
- d) When high levels of congestion persist for a lengthy period (many days), some customers may avoid making calls during the congested period of each day. This apparent missing component of offered traffic is known as suppressed traffic. It should be taken into account in planning since the offered traffic will increase when the equipment is augmented. At present, suitable algorithms for estimating suppressed traffic have not been defined.

Three situations should be distinguished:

- i) Congestion upstream of the measurement point – This is not directly observable.
- ii) Congestion due to the measured equipment – Congestion measurements should be used to detect this.
- iii) Congestion downstream of the measurement point – This can often be detected from measurements of ineffective traffic or completion ratio. Note that where groups are both way, congestion elsewhere in the network may be both upstream and downstream of the measurement point for different parcels of traffic.

When congestion is due to the measured equipment, this must be properly accounted for in the estimation of traffic offered which is used for planning the growth of the measured equipment.

When congestion arises elsewhere in the network, the planner needs to consider whether or not the congestion will remain throughout the considered planning period. This may be difficult if he does not have control of the congested equipment.

This Recommendation presents estimation procedures for two of the situations described above. Clauses 4 and 5 have the aim of the determination of traffic offered to circuit group, and namely clause 4 deals with the estimation of traffic offered to a fully-operative only-path circuit group which may be in significant congestion. Clause 5 deals with a high-usage and final group arrangement with no significant congestion. Clause 6 provides a procedure to determine traffic offered to destinations on an origin-destination basis, when only measurements of traffic intensity on circuit groups are available or when direct measurements on origin-destination traffic offered are also available.

In clause 6 the estimated traffic offered is the "equivalent traffic offered" used in the pure lost call model as defined in Annex B, while in clauses 4 and 5 in the evaluation of traffic offered, the user's repeat attempts are taken into account.

These estimation procedures should be applied to individual busy-hour measurements. The resulting estimates of traffic offered in each hour should then be accumulated according to the procedures described in Recommendation E.500.

2 Scope

This Recommendation provides means of estimating the traffic offered to circuit groups based on measurements of traffic carried and means of estimating origin-destination traffic flows based on circuit group measurements.

3 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- CCITT Recommendation E.500 (1992), *Traffic intensity measurement principles*.
- CCITT Recommendation E.502 (1992), *Traffic measurement requirements for digital telecommunication exchanges*.

4 Only-path circuit group

4.1 No significant congestion

Traffic offered will equal traffic carried measured according to Recommendation E.500. No estimation is required.

4.2 Significant congestion

Let A_C be the *traffic carried* on the circuit group. Then, on the assumption that augmentation of the circuit group would have no effect on the mean holding time of calls carried or on the completion ratio of calls carried, the *traffic offered* to the circuit group may be expressed as:

$$A = A_C \frac{(1 - WB)}{(1 - B)} \quad (4-1)$$

where B is the present average loss probability for all call attempts to the considered circuit group, and W is a parameter representing the effect of call repetitions. Models for W are presented in Annex A.

To facilitate the quick determination of offered traffic according to the approximate procedure in Annex A, Table A.1 including numerical values of the factor $(1 - WB)/(1 - B)$ was prepared for a wide range of B , H and r' (for the definition of H and r' , see Annex A). For the use of Table A.1, see Note 2 in Annex A.

NOTE 1 – Annex A gives a derivation of this relationship, and also describes a more complex model which may be of use when measurements of completion ratios are available.

NOTE 2 – When measurements of completion ratios are not available a W value may be selected from the range 0.6 to 0.9. It should be noted that a lower value of W corresponds to a higher estimate of traffic offered. Administrations are encouraged to exchange the values of W that they propose to use.

NOTE 3 – Administrations should maintain records of data collected before and after augmentations of circuit groups. This data will enable a check on the validity of the above formula, and on the validity of the value of W used.

NOTE 4 – In order to apply this formula, it is normally assumed that the circuit group is in a fully operative condition or that any faulty circuits have been taken out of service. If faulty circuits or faulty transmission or signalling equipment associated with these circuits remain in service, then the formula may give incorrect results.

5 High-usage/final circuit group arrangement

5.1 High-usage group with no significant congestion on the final group

5.1.1 Where a relation is served by a high-usage and final group arrangement, it is necessary to take simultaneous measurements on both circuit groups.

Let A_H be the traffic carried on the high-usage group, and A_F the traffic overflowing from this high-usage group and carried on the final group. With no significant congestion on the final group, the traffic offered to the high-usage group is:

$$A = A_H + A_F \quad (5-1)$$

5.1.2 Two distinct types of procedure are recommended, each with several possible approaches. The method given in 5.1.2.1 a) is preferred because it is the most accurate, although it may be the most difficult to apply. The methods of 5.1.2.2 may be used as additional estimates.

5.1.2.1 Simultaneous measurements are taken of A_H and the total traffic carried on the final group. Three methods are given for estimating A_F , in decreasing order of preference:

- A_F is measured directly. In most circumstances this may be achieved by measuring traffic carried on the final group on a destination basis.
- The total traffic carried on the final group is broken down by destination in proportion to the number of effective calls to each destination.
- The traffic carried on the final group is broken down according to ratios between the bids from the high-usage groups and the total number of bids to the final group.

5.1.2.2 Two alternative methods are given for estimating the traffic offered to the high-usage group which, in this circumstance, equals the equivalent traffic offered:

- A is estimated from the relationship:

$$A_H = A [1 - E_N(A)] \quad (5-2)$$

here $E_N(A)$ is the Erlang loss formula, N is the number of working circuits on the high-usage group. The estimation may be made by an iterative computer programme, or manually by the use of tables or graphs.

The accuracy of this method may be adversely affected by the non-randomness of the offered traffic, intensity variation during the measurement period, or use of an incorrect value for N .

- A is estimated from:

$$A = A_H / (1 - B) \quad (5-3)$$

where B is the measured overflow probability. The accuracy of this method may be adversely affected by the presence of repeat bids generated by the exchange if they are included in the circuit group bid register.

It is recommended to apply both methods a) and b); any significant discrepancy would then require further investigation. It should be noted however that both of these methods may become unreliable for high-usage groups with high overflow probability; in this situation a longer measurement period may be required for reliable results.

5.2 High-usage group with significant congestion on the final group

In this case, estimation of the traffic offered requires a combination of the methods of 4.2 and 5.1. A proper understanding of the different parameters, through further study, is required before a detailed procedure can be recommended.

6 Origin-destination equivalent traffic offered

This clause deals with the determination of equivalent traffic model according to the model described in Annex B.

An accurate estimate of origin-destination traffic offered is essential to design, engineer and service any communications network. This is especially, but not uniquely, true for dynamic routing networks.

The accuracy of this estimation depends on the availability of measurements and on the network structure.

As a matter of fact, the origin-destination offered traffic can be obtained in three different ways, by elaborating:

- i) the measurements of traffic dispersion and duration (see Recommendation E.502), accomplished by the network switches on the total traffic;
- ii) the measurements of traffic dispersion and duration (see Recommendation E.502), accomplished by the network switches on a sampling basis;
- iii) the measurements on the circuit groups and nodes.

6.1 Determination of origin-destination traffic offered when origin-destination traffic measurements on the totality of call attempts are available

In this case the problem of determining the origin-destination traffic offered is directly solved by the measurements as it is specified in 4.2.4/E.502, and no further computations are needed.

6.2 Determination of origin-destination traffic offered when origin-destination traffic measurements only on a sampling basis are available

These measurements should be supported by consistent measurements on the traffic volume (erlang) on the totality of outgoing traffic. More precisely, if the set of origin-destination measurements, as specified in 4.2.4/E.502, type 15: "traffic dispersion", is a sampling of the total traffic outgoing the exchange, the relevant measurements on traffic volume should be the overall measurements on originating outgoing traffic and on transit traffic (type 3 and type 6 respectively of Recommendation E.502). If "the traffic dispersion" is performed on a specific circuit group, of course the relevant measurement on traffic volume should be performed on the same circuit group (measurement type 10). The determination of the traffic offered from measurements of the carried traffic should be achieved by using the procedure described in clause 4.

6.3 Determination of origin-destination traffic offered when only circuit-group based measurements of traffic intensity are available

This subclause refers to the switches which do not perform any origin-destination measurements but only circuit group based traffic intensity measurements. The following method [1] can be applied to hierarchical and non-hierarchical networks whose routing scheme can be either fixed or updated periodically with period dT , provided that the updated interval dT is long enough to guarantee the stationary traffic conditions.

These three assumptions are made:

- i) on each link, calls from different traffic relations see the same blocking which is the given measured circuit group blocking;
- ii) the event that a call will be blocked on a path link is independent of the event that it will be blocked on the other links;
- iii) a path is composed by at least two links.

Simulation studies have shown that these assumptions produce estimates of traffic offered for individual origin-destination pairs that are within 6% to 7% of actual values when the network congestion values are as low as the ones assumed in the network dimensioning.

The following information is supposed to be available at each time interval:

- i) the circuit group measurements which include the carried load and blocking on each circuit group TG ;
- ii) the (fixed) routing sequence during the dT period.