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CCITT

E.525 (rev.1)

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

TELEPHONE NETWORK AND ISDN

**QUALITY OF SERVICE,
NETWORK MANAGEMENT AND TRAFFIC
ENGINEERING**

DESIGNING NETWORKS TO CONTROL GRADE OF SERVICE

Recommendation E.525 (rev.1)

Geneva, 1992

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT 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 Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation E.525 was prepared by Study Group II and was approved under the Resolution No. 2 procedure on the 16th of June 1992.

CCITT NOTE

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

Recommendation E.525

DESIGNING NETWORKS TO CONTROL GRADE OF SERVICE

(*revised 1992*)

1 Introduction

Network design may have two objectives to control grade of service (GOS). One is to provide an overall GOS for all traffic offered to the network. This can be achieved by the choice of a routing scheme that reduces the effect of adverse network conditions. Routing schemes that allow more flexible routing choices generally provide greater resilience, especially in the case of forecast errors or focused overload, than traditional hierarchical routing methods.

The second objective is to control the grade of service for certain streams of traffic by restricting the access to circuit groups. Several service protection methods are available, with the common feature that they may reject certain call attempts when the considered circuit group has little idle capacity. Service protection is generally used in alternative routing networks to restrict overflow traffic, but can also be used to give priority service to one class of traffic over another.

Failure or overload conditions may require temporary changes to service protection parameters. This is considered to be network management action which is described in the E.400-Series Recommendations.

Applications of service protection methods are described in § 2, and the available methods are described in § 3.

Cluster and end-to-end engineering concepts are introduced in § 4.

The use of service protection generally increases the complexity of dimensioning algorithms. Appropriate dimensioning algorithms are presented in § 5.

The choice between available methods will generally depend on performance characteristics and ease of implementation. These are discussed in §§ 6 and 7.

Flexible and/or dynamic routing schemes can be viewed as "network level" methods. Service protection methods can be viewed as "circuit group level" methods. It is possible to provide methods on one of the levels only or to provide both levels in conjunction with each other.

2 Applications

2.1 *Bothway circuit groups*

In bothway circuit groups, calls from A to B and B to A in Figure 1/E.525 would share the same set of circuits, which will lead to a better efficiency especially in cases of non- coincident busy hours.

In bothway operation it is necessary to take steps to protect traffic in one direction from abnormal behavior of the traffic in the other direction.

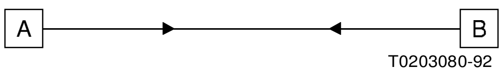

FIGURE 1/E.525

2.2 *Traffic routing*

2.2.1 *Overflow routing strategies – General principles*

Routing strategies that involve overflow often have direct first-choice (high-usage) routes, and indirect alternative routes. In conditions of traffic overload the proportion of alternatively-routed traffic increases rapidly, with the risk of severe degradation of network performance. Service protection methods should be used to prevent calls overflowing from a direct route to an alternative route when circuit groups on the alternative route are heavily loaded. In Figure 2/E.525, which shows a hierarchical case only for the sake of simplification, calls from A to B have a direct first-choice route and an alternative route via D. Exchange A should apply service protection on the circuit group AD, such that when AD is occupied over a certain limit, overflow calls (e.g. from AB) are rejected and it will imply that priority is given to first-choice traffic (e.g. from A to C). This control of grade of service allows optimal (minimum cost) dimensioning for planned traffic loads in addition to giving protection against heavy overloads

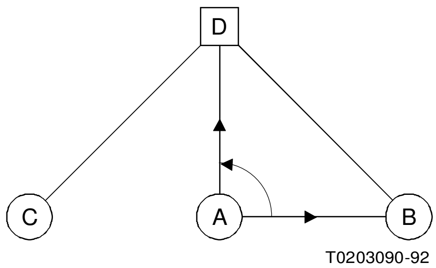

FIGURE 2/E.525

2.2.2 *Fixed hierarchical alternative routing*

An example of fixed hierarchical alternative routing is illustrated in Figure 2/E.525. Here exchange D is a tandem exchange at a higher hierarchical level than A, B and C. Direct routes at the lower level (e.g. AB) overflow via the hierarchical route (ADB). This hierarchical route is always the final alternative routing. In such networks it is highly recommended to apply service protection to restrict traffic overflowing to final choice routes.

2.2.3 *Fixed non-hierarchical alternative routing*

This term describes routing strategies which are based on fixed sequences of alternative routes (as in hierarchical alternative routing) but which do not have a hierarchical final-choice route for all overflow traffic. Figure 3/E.525 may be used to illustrate some simple but common cases. Traffic from A to B has a first-choice route AB and an alternative ACB which is final to this traffic, while traffic from A to C may use AC as a first choice and then overflow to ADC. Traffic from D to B is either first offered to the route DAB and then overflowing to DCB or vice versa. The latter routing principle is commonly known as mutual overflow.

Mutual overflow can be viewed as a "network level" method in the following sense. If either the switch at A or the AD link fails, then DB traffic can still complete via C. In this situation, it may be necessary to provide service protection methods to protect first choice traffic on the BC and/or CD links from the increased DB traffic [11].

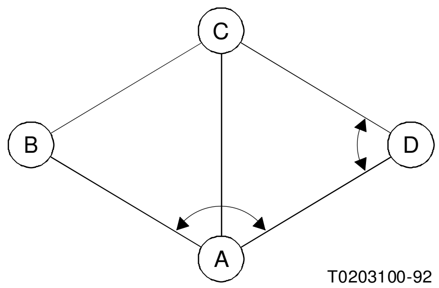

FIGURE 3/E.525

In both routing schemes a certain difference between classes of switches is distinguishable. They are however, non-hierarchical, in the sense that no hierarchical trunk group that is final to all its carried traffic can be found. The application of service protection methods may be less simple than for hierarchical routing, but the general principles presented in § 2.2.1 still apply.

2.2.4 *Dynamic routing*

Many different forms of preplanned or adaptive dynamic routing are possible, with either centralized or distributed control (see Recommendation E.170). One feature that is common to most dynamic routing schemes is the availability of a large number of potential alternative routes for any given connection. With this type of routing scheme, service protection is of crucial importance and has several special features:

- Protection should be stronger than with other overflow routing schemes (i.e. larger protection parameters should be used).
- If possible, service protection should be applied on all circuit groups in an alternative route. This may require a certain amount of information-passing between exchanges or to a central processor.
- In connection with adaptive routing, the service protection concept can be used not only to block overflow calls but also in the selection of a good alternative route (generally this will be a route on which all circuit groups have at least a requested number of free circuits).

2.3 *Priority service*

Service protection methods can also be used to give priority service to one type of traffic, for example in a multiservice network, e.g. integrated services digital network (ISDN).

2.4 *Stability*

In order to provide stability in networks with non-hierarchical routing schemes, service protection should be used to restrict overflow traffic if that traffic overflows to an alternative route which is shared with first-choice traffic.

3 Available methods

3.1 *Split circuit group*

A straightforward technique is to divide a circuit group into two subgroups. Priority traffic is allowed access to the whole circuit group, while non-priority (usually overflow) traffic is only allowed access to one subgroup. Normally the priority traffic is offered first to the reserved subgroup – this is then equivalent to a separate high usage group. For bothway circuit groups, a circuit group is divided into three subgroups. One subgroup is used only for traffic in one direction, another is only for traffic in the other direction, and the third subgroup is for common use.

3.2 *Circuit reservation*

Non-priority calls are accepted on the considered circuit group only when the momentary number of idle circuits in that group observed at the arrival of a non-priority call, exceeds a specified lower limit (irrespective of which particular circuits are idle). If the number of idle circuits is lower or equal to the specified limit, then some percentage (that may be 100) of the non-priority calls are rejected (see Rec. E.412). Priority calls are always accepted if any circuits are idle.

Circuit reservation may also be applied selectively, to restrict call attempts to hard-to-reach destinations. In bothway circuit groups the grade of service (GOS) of traffic in one direction may be degraded due to an increase in traffic in the other direction. For this problem, circuit reservation may be applied conditionally to restrict the increased traffic. The condition may be the number of calls in progress for the increased traffic stream.

3.3 *Virtual circuits*

This method restricts the usable number of circuits for each class of traffic. A call belonging to a certain class is given an idle circuit whenever the number of circuits occupied by this class of calls is less than a predefined value.

4 Network design objectives

4.1 *Cluster engineering concept*

In hierarchical automatic alternative routing a cluster consists of a final-choice circuit group together with those high usage groups from which traffic overflows to the final group. This cluster should be engineered as a whole. This implies firstly that GOS criteria should be applied to the whole cluster rather than separately to final groups. Secondly, the question of high-load dimensioning must be considered for the whole cluster. In order to meet normal and high load cluster GOS criteria in the most efficient way, the parameters of service protection methods must be determined appropriately as a part of the dimensioning process.

4.2 *End-to-end engineering*

In non-hierarchical routing the GOS criteria should be applied to all routes that can be used to achieve the end-to-end connection. In order to meet normal and high load end-to-end GOS criteria in the most efficient way, the parameters of service protection methods must be determined appropriately as a part of the dimensioning process.

5 Evaluation and dimensioning

5.1 *Split circuit group*

With hierarchical alternative routing the split final circuit group creates a separate high-usage group for first-choice traffic. This should be dimensioned so as to achieve the cluster GOS criteria. Standard evaluation methods that can be used include the Wilkinson equivalent random traffic theory [1]. Interrupted Poisson process methods can be used to give more precise evaluation [2], [3] and to evaluate network performance [4].

Split circuit groups may be useful to control GOS in non-hierarchical routing. The precise dimensioning and evaluation depends on the individual situation and it is generally more practical to use 1-moment methods of analysis [5], [6].

5.2 *Circuit reservation*

With hierarchical alternative routing circuit reservation, parameter should be applied to the final group so as to achieve the cluster GOS criteria optimally for all traffic offered to the cluster. For evaluation of Poisson streams, a recursion method is available which may be extended, using equivalent random traffic techniques, into overflow situations [7]. Interrupted Poisson process [3] methods can be used to give a more precise approximation and to evaluate network performance [8]. Analytical methods are available for traffic streams with different holding times, peakedness and bit rates [12].

For non-hierarchical strategies, 1-moment evaluation methods are again recommended. Simple recursion formulas are available for a circuit group using circuit reservation and offered Poisson traffics. 1-moment [7] methods can also be extended to give better accuracy by taking account of downstream blocking and traffic correlations [6] and [8].

5.3 *Virtual circuits*

Analytical evaluation methods are available for virtual circuits [12].

6 Performance characteristics

6.1 *Efficiency*

Efficiency can be measured by traffic capacity required to carry 1 erlang of traffic at normal load subject to GOS criteria. In this respect, there is little to choose between circuit reservation, split circuit group and virtual circuit methods, provided each is correctly dimensioned.

6.2 *Overload protection*

The two service protection methods, circuit reservation and split final with a reserved high usage group, provide considerably better overload protection for first-choice-final traffic in cases of general and overflow overload than do the less usual methods split final with reserved final group and virtual circuits. Further, circuit reservation outperforms split final with reserved high usage group under a wide variety of overload conditions like excessive priority traffic, excessive non-priority traffic or uniform overload of both traffic streams.

6.3 *Robustness*

A significant advantage of reservation is that it provides a robust performance profile with respect to traffic load variations (decreasing priority traffic in combination with increasing non-priority traffic) and reservation parameter settings. Independent of the circuit group size, traffic variations (which have not been forecasted) are relatively well carried.

With circuit reservation the same parameter value is likely to be optimal for a wide range of configurations at both normal load and overloads.

In contrast, the reserved section of a split circuit group and the parameter values for the virtual circuits method should be redimensioned for different configurations and (when dimensioned according to the normal traffic load pattern), will not give optimal values at overload.

6.4 *Peakedness*

Changes in the peakedness of overflowing traffic have a slightly greater impact on the blocking probabilities within split circuit group arrangements in comparison with circuit reservation.

The impact of changes in the peakedness of overflowing traffic on the blocking probabilities for the virtual circuits method is for further study.

7 Implementation consequences

7.1 *Dimensioning methods*

Methods for the calculation of virtual circuits, a split circuit group or a circuit reservation parameter, are available, e.g. [7], [8], [9], [10] and [12].

7.2 *Traffic measurements*

All service protection methods require the estimates of the traffic which is to be protected and all other traffic parcels involved.

For effective application of service protection methods, traffic measurements other than simple circuit group data may be required.

With the split circuit group method, first routed traffic can be easily measured on a circuit group basis. With the circuit reservation method, measurements other than traditional are required to identify the first offered traffic.

7.3 *Operational aspects*

Since circuit reservation and virtual circuits are software controlled techniques, protection for different traffic streams can easily be changed by changing parameters in the software. This allows temporary changes to be made under network management control. Precautions should be taken in such situations to restore design parameter values.

7.4 *Technology requirements*

Split circuit group methods can be installed in both electromechanical and processor controlled exchanges.

Circuit reservation and virtual circuits may, in practice, only be realized in software as a conditional overflow facility and consequently, only be installed in SPC exchanges.

These methods require that the exchange has the ability to distinguish between priority and non-priority traffic.

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