CCITT - A CHANCE TO UNIFY THE BASIC TRAFFIC ENGINEERING PRACTICE

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ABSTRACT

This report on CCITT traffic engineering activity covers some final results of the 1977-80 period and summarizes the present status. Since the 9. ITC some new areas of study have been allotted to CCITT. The determination of offered traffic, the cluster approach of network grade of service /GOS/ calculation, consideration of service availability performance criteria and alternate routing network optimization in a multi-hour setting are examples. Traffic requirements for SPC exchanges /including traffic measurements and GOS supervision/ are also to be specified.

The effectiveness of CCITT traffic engineering depends on the input /contributions and delegates/ supplied by the organizations taking part in the work. The participants of the ITC form the solid background of this input and CCITT needs their support.

INTRODUCTION

The first review of CCITT traffic engineering activities was presented to the Teletraffic Congress in Paris more than twenty years ago, in 1961. The last one, that of Torremolinos in 1979 reported some of the most important results of the 1977-80 Study Period and gave also a recapitulation of CCITT organization, working methods and main objectives [1]./See also the CCITT refresher in Appendix A./

The majority of ITC participants is not familiar with CCITT work, although the traffic engineering methods recommended by this body cover more and more areas and their practical importance is steadily increasing. Therefore it seems to be justified to give an inside account of CCITT trends, results and problems with the not hidden wish to improve cooperation between ITC and CCITT.

To understand CCITT efforts it should be borne in mind that its mainly practical results are double-faced. They furnish a common language for advanced traffic engineers and give reliable methods for those who need support.

The following report is not restricted to those items on which an overall agreement has already been arrived at. Problems still to be solved are also presented and the personal view of the author - not necessarily the same as that of others involved in this work - is given as well.

1. CCITT TRAFFIC ENGINEERING STUDIES AT PRESENT

1.1. CHANGES IN ORGANIZATION

In the 1981-84 Study Period telephone traffic engineering in wider sense is performed in two Working Parties of Study Group II, see Figure 1. The necessity of good contacts within the S.G. is evident. Some other Study Groups a cooperation with which is very important and has already been set up are: S.G.IV /Maintenance/, S.G.XI. /Telephone

Figure 1. Organization of traffic engineering studies in CCITT.
switching and signalling, CMHD/Circuit noise and availability.

1.2. RECOMMENDATIONS

There was no change in the scheme of traffic engineering Recommendations. One group deals the traffic to be carried /measurements, forecasting/, the other specifies the grade of service for the links and nodes of the world-wide telephone network, the third group treats with methods of GOS calculation. Some Recommendations refer not directly and only to GOS but are concerned wholly or partly with the estimation and maintenance of GOS including also general quality of service /QS/ aspects /e.g. efficiency rate objectives, network management/.

1.3. TERMINOLOGY

The Nomenclature Committee of ITC reported on its activities to the Congress in 1964 and 1967 [3,4]. The result of this work was to my knowledge the first international list of teletraffic terms. Many other similar lists were published by different organizations up to now but the "List of terms and definitions of teletraffic" prepared in the previous Study Period by S.G. II is very likely the second international attempt [5]. A team representing several languages was responsible for this list, the variants in English, French and Spanish are of the same quality. The work on terminology is going on, it would be very good if the permanently improving list could serve not only CCITT but the whole community of traffic engineers as well.

1.4. NEW STUDY AREAS

Traffic engineering work in CCITT is rather a continuous process than a series of independent tasks. However in all Study Periods there are, at least from the CCITT point of view, new study areas or new approaches of old questions. Between 1977-80 the exchange GOS question, the use of the efficiency rate to characterise traffic relations, the global revision of the agenda in the traffic measurement field and the increased activity in network management represented these types of problems.

Now the study on offered traffic, the cluster approach of network GOS, the exchange traffic performance criteria under failure conditions and the use of 24 hour traffic profiles in dimensioning of alternate routing may be regarded as new areas.

Many other problems exist, some of them are mentioned in the forthcoming paragraphs, but in this type of report to mention more would mean less.

There is however one further important question. A very old wish of traffic engineers will very likely be fulfilled. As answer to an urgent question the traffic and operational requirements for SPC exchanges have to be compiled. Not the traffic capacity is asked for but the built in traffic measurement and GOS supervising functions should be specified.

1.5. THE PRESSURE OF PROGRESS

CCITT should rather indicate the main trends in traffic engineering practice than be behind the facts and try to make not easy compromises afterwards. The existing broad international participation of many good experts shows that the above objective is realistic.

The new international routing plan, to be published soon, does not recommend the hierarchical structure of the previous plan. This has a very important bearing on the dimensioning of alternate routing.

To facilitate the design and implementation of modern SPC digital exchanges the related GOS problems should be quickly solved and the traffic requirements should also be clearly outlined as soon as possible. International cooperation requires this type of standardization.

The growth of traffic and the steadily increasing level of automation urges to improve network management procedures.

As a consequence of the above and other factors the workload of traffic experts in CCITT has considerably increased.

2. THE TRAFFIC TO BE CARRIED

Traffic measurements form the starting point and the verification of all traffic engineering activities. Thus the clear understanding of the concepts used is important.

2.1. LOAD LEVELS

GOS values given in Recommendations refer to time consistent busy hour load levels which were defined in their present form at the end of the previous Study Period and appear in Table 1. and Table 2. [6].

2.2. MEASUREMENT METHODS

The wording of Tables 1. and 2. assumes a continuous measurement from the data base of which the appropriate values can be selected. The majority of Administrations however does not measure traffic continuously. To arrive at the same load level values with non-continuous measurements the estimation procedure summarized below is on the way to be included in the Recommendation.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal load</th>
<th>High load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic flow</td>
<td>Mean of the 30 highest working days during a 12-month period</td>
<td>Mean of the five highest days in the same period as normal load</td>
</tr>
<tr>
<td>Number of bids</td>
<td>Mean of the same 30 days on which the traffic flows are highest</td>
<td>Mean of same five days on which the traffic flows are the highest</td>
</tr>
</tbody>
</table>

(usually working days are used, but administrations may also require other measurements to provide for particular cases as described in § 3.

Table 1. Circuit group load levels [6].

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal load</th>
<th>High load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic flow</td>
<td>Mean of the ten highest days during a 12-month period</td>
<td>Mean of the five highest days in the same period as normal load</td>
</tr>
<tr>
<td>Number of bids</td>
<td>Mean of the ten highest days (not necessarily the same as the highest traffic flow days) during a 12-month period</td>
<td>Mean of the five highest days (not necessarily the same as the highest traffic flow days) in the same period as normal load</td>
</tr>
</tbody>
</table>

Table 2. Exchange load levels [6].

Measurements are taken on a limited sample of days and the mean \( M \) and standard deviation \( S \) of the daily time consistent busy hour traffic loads are calculated. Normal and high load level estimates \( L \) are given by:

\[
L = M + kS,
\]

different values of \( k \) being used for normal and high load levels.

It is assumed that the measurement sample is reasonably evenly distributed over the "base period" covering all the days which are busy day candidates. Multiplication factors \( k \) are derived from tables of order statistics from the normal distribution and depend on the length of the "base period". To ensure reliable estimates the limited sample should comprise at least 30 days.

The method of the determination of the "base period", the estimation error in the case of smaller samples, other possibilities to arrive at a reliable estimation of the standard deviation, etc. need further study.

2.3. MML AND TRAFFIC MEASUREMENT

A very ambitious effort of CCITT is to standardize languages related to the design, programming and operating of SPC exchanges /SDL, CHILL and MML, respectively/. The methodology of how to use MML /Man Machine Language/ for traffic administration is under consideration in the present Study Period. Traffic measurement administration functions have already been defined and work has begun on traffic analysis programs administration functions. This is a pioneer work inside CCITT, it clearly separates the responsibilities of traffic and language experts and will serve as example for similar applications.

2.4. TRAFFIC OFFERED

Traffic offered used in traffic engineering calculations /dimensioning, forecasting/ should and can only be derived from measurements of carried traffic. Two questions should be answered:

- what is traffic offered?
- how can it be calculated?

2.41. DEFINITION

Traffic offered - the traffic that would be served by a pool of resources sufficiently large to serve that traffic without limitation. [5]

Traffic offered to a circuit group - the traffic that would be served by a circuit group sufficiently large to serve that traffic without limitation in this circuit group. [7]

Undoubtedly traffic offered should be defined relative to a group of traffic carrying devices, disregarding the relationship of this traffic to the demand of the customers, not describing the influence of the surrounding network and without any further indication of how to use it in calculations.

2.42. PRACTICE

For practical applications the offered traffic can be defined or rather explained as: the call attempt rate arriving to the "input" of the considered group multiplied by the average holding time of calls carried...
by the same group. See Appendix B.

For a given situation this is correct, but normally we want to use the offered traffic e.g. to calculate the necessary extension of a circuit group. Can the offered traffic at a given point of the network be considered to remain the same? Unfortunately not. One has to calculate the offered traffic for a future situation, as both the call attempt rate and the average holding time may change.

The average holding time of carried calls takes all occupations into account irrespective of the ultimate success of the call attempts. If for example the extension of the considered circuit group removed a serious bottleneck, the efficiency rate behind the group may suddenly decrease with a parallel decrease in the average holding time of carried calls.

The call attempt rate is in all cases a mixture of first calls and repetitions. Even in the best networks of our days with about 0.7 efficiency rate repetitions amount to 25%-35% of all call attempts. The number of additional i.e. repeated attempts depends on human factors /perseverance, repetition interval/ and on the efficiency rate experienced by the call attempts. The efficiency rate takes all causes of call attempt failure into account and represents the network call handling capacity in a general way.

To make the picture even more complex one should observe that the calling rate and the average holding time both depend not only on network GOS but on all types of call attempt failures /including call interruptions, the called subscriber, etc./ i.e. on the quality of service. Bearing all this in mind and with our present knowledge simplifying assumptions remain as solution.

The first step towards a Recommendation on offered traffic calculation have already been done. The methods will not be explained here, it would be premature to report on first drafts. It should be mentioned however that now for the first time the effect of call repetition will explicitly be taken into account in CCITT traffic engineering.

2.5. FORECASTING

In this Study Period the Recommendation on forecasting will be entirely restructured to include also econometric models and to give better guidance for the use of the different methods. Up to now two models have been incorporated. The so called direct strategy is based on the well known relationship of carried traffic, offered traffic and GOS. The composite strategy makes use of monthly paid minutes data and calculates offered traffic from these with several conversion factors.

3. GOS AND ITS ENVIRONMENT

The objective of traffic engineering is to maintain a suitable GOS together with the optimum utilization of the traffic handling plant. Subscribers can not observe GOS, for them the network appears as an entity with some quality of service /QS/. They interpret the QS according to their personal sampling pattern, are disturbed mainly by peaks of bad quality and good average levels do not make them really satisfied.

Taking this into account the links between QS and GOS should be clearly outlined, a broader interpretation of GOS is necessary, the methods of how to avoid sudden drastic GOS and/or QS reductions should carefully be investigated and future factors which may strongly influence the network traffic capacity should also be considered in due time.

3.1. FROM GOS TO QS

The hierarchy of QS constituents as given in a new Recommendation [8] appears in Fig. 2. Emphasis is given to performance i.e. to realized values but for prediction purposes the same factors should be taken into account. GOS characterizes trafficability. There are mathematical models which combine traffic and availability aspects to arrive at a service availability parameter e.g. [9,10,11] / e.g. [9,10,11] / These investigations are restricted to groups of devices but many details /types of failures, maintenance strategies, etc./ can be taken into account. No relevant CCITT Question or Recommendation exist.

The study of a similar problem but related to exchanges started in this period in the framework of a Question on new performance criteria under failure conditions. Up to now an agreement has been reached that several types of failures should be covered, namely:

a. total failure, and
b. partial failures resulting in
   - capacity reduction
   - isolation of a group of units
   - one or more faulty components.

It is very likely that the /loss and delay/ GOS parameters /not the values !/ defined for exchanges in failure-free condition [12] are applicable to each of the above classes. Of course these parameters will characterize service availability including the original GOS aspect.
3.2. THE GOS AND QS SPACE

The Question on GOS in telephone exchanges origins from 1973, the important results gained up to 1979 were summarized in [1]. The already existing Recommendation [12] will be augmented with numerical values of GOS parameters, see Table 3. and with measurements of GOS performance.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal load#</th>
<th>High load#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming response delay</td>
<td>P/&gt;0.5 sec/≤5%</td>
<td>P/&gt;1 sec/≤5%</td>
</tr>
<tr>
<td>Exchange call set up delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through connection delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal loss probability</td>
<td>0.002</td>
<td>0.01</td>
</tr>
</tbody>
</table>

# Offered load levels should be determined in accordance with the Recommendation on traffic measurement [6].

Table 3. GOS values in exchanges.

The values in Table 3. apply first of all to digital exchanges and should be considered also for dimensioning national transit exchanges thus maintaining a high level end-to-end GOS.

Thus the GOS of an exchange is not a single value but should be regarded as a point in the GOS space, see Fig.3. A point outside the predefined part of this space is not acceptable. A similar interpretation of QS is also necessary since it is hardly possible to derive a single overall QS parameter [13]. It is very doubtful if combined calculations of QS /e.g. as for service availability/ can be performed.

3.3. THE CLUSTER GOS

The GOS of trunk groups is now studied again and discussions took place whether the reconsideration of basic dimensioning objectives would be necessary. The traditional way of dimensioning the last choice group for e.g. 1% blocking results in a lower blocking for the whole traffic/of a cluster/overflowing to that last choice group. It would be possible to maintain this 1% blocking probability for the whole traffic of the considered part of the network with the clear consequence that a higher blocking could be allowed for the last choice group. Some evident problems as how to ensure this overall blocking for the traffic parcels entering directly the last choice group, seem to have solutions. The benefits need no explanation, the network would be cheaper. Whether it is advisable to sacrifice the hidden traffic capacity reserve of the network built

Figure 2. Hierarchy of concepts relevant to the quality of service. /Not all relationships are shown in the figure./ [6]

Figure 3. The GOS space. A,B and C are GOS parameters.
in by traditional dimensioning may be questioned.

3.4. NETWORK MANAGEMENT

Network management can be considered as the real time part of traffic engineering. With the growing complexity of the network the importance of manual and automatic network management actions is steadily increasing. Following a field trial a Network Management Development Group /NMDG/ was formed in the previous Study Period now counting about twenty Administrations. The NMDG has regular meetings, plans coordinated actions for predictable overload situations /Xmas, Chinese New Year/, exchanges experience regularly /e.g.[14]/ and established a library for case studies accessible through the CCITT Secretariat.

Network management at the international level can be successful only if it is supported by similar activities at the national level. To give proper guidance the preparation of a "Handbook on service quality, network maintenance and management" is in progress.

3.5. NON-TELEPHONE TRAFFIC

The world-wide telephone network is used more and more to carry non-telephone traffic. ISDN is the reality of tomorrow. The characteristics of data or telematic services /teletex, facsimile etc./ differ from those of telephone traffic. Our present traffic engineering assumptions and practice perhaps need reconsideration very soon.

The necessity to study this problem is indicated in a broader question, but discussions on traffic problems have not yet started. Some traffic engineering investigations of data services already exist in Study Group VII /Data networks/ but there are no contacts in this respect.

Some combination or perhaps concentration of CCITT traffic engineering activities would probably be advantageous.

4. IMPORTANT PROBLEMS TO BE SOLVED

The list below is a collection of important traffic engineering topics to be studied by CCITT in the near future. Backing by ITC would be very advantageous.

- How can reliable estimates be made with non-continuous measurements if the sample is very small /e.g. ten days per year/?
- How to derive offered traffic for the different groups of an alternate routing arrangements if blocking in the last choice group is not negligible?
- How can the problems related to network cluster engineering be solved in a simple, practical way?
- What method could be used to characterize the effect of partial failures in exchanges?
- Would it be of any advantage to recommend a load limit to avoid frequent call attempt failures due to busy subscribers?
- How do non-telephone services influence the traffic capacity of the telephone network?

5. THE ITC-CCITT COOPERATION

The following thoughts are practically the same as those of a similar section of [1]. Nevertheless it was decided to repeat them as the situation is similar to that in 1979, and no new methods of effective cooperation have been identified. It should be emphasized however that there is no less need of ITC support than earlier.

To achieve an essential progress in the teletraffic field considerably efforts are necessary in our days. This refers also to CCITT traffic engineering work. CCITT disregarding exceptional cases has no resources to perform studies. The preparation of contributions and to perform previous investigations require the support of CCITT members, including ITC.

The International Teletraffic Congress has neither the suitable organization, nor the staff, nor the budget to conduct traffic engineering studies for CCITT purposes. Considering this one can conclude that

a/ neither ITC as an organization nor anybody solely in his capacity as an ITC participant is able to perform traffic engineering research work for CCITT purposes. However

b/ ITC as an assembly with wide international participation is most suited to draw the attention to important CCITT traffic engineering problems, and to discuss them in a not CCITT but nevertheless international environment.

c/ ITC can assist CCITT work by gathering and disseminating essential knowledge of the teletraffic field by the activities of the Training Working Party, by the proper selection of topics for ITC seminars, etc.
Thus the ITC may act as a catalyst for the reagents in this "CCITT process".

Nevertheless some further points are worthwhile mentioning.

d/ Traffic engineering research and the collecting of corresponding practical experience takes place in many organizations. The results in a suitable form would in many cases be answers to some CCITT problem.

e/ It is very likely that CCITT problems are not known by all traffic engineers. In addition to CCITT participants also traffic engineering managers are expected to dispose of necessary information. It rests with them whether or not the traffic engineering experience of their organization has any impact on current CCITT studies.

It should be considered that CCITT work is not only necessary to render the smooth functioning of international telecommunications but is also a service for the human community we are members of.

CONCLUSIONS

The above report was intended to give a representative sample of CCITT traffic engineering problems and results. The Questions to be answered cover many fields of theoretical and practical nature and the related studies are in most cases interesting by themselves too. At present CCITT is the only frequent, regular and in the strict sense international forum for the discussions on many important traffic engineering issues. The scope and depth of the studies guarantees more and more that traffic engineers world-wide will be able to speak the same language and also will understand it in the same way.

ACKNOWLEDGEMENTS

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REFERENCES


standards, but intended for general use. Their content should be unambiguous, easy to apply and exact in results. In many cases alternative solutions are offered to allow the fitting of the method to actual requirements. "In fact the set of CCITT Recommendations are treated likely a book of international laws, particularly high in favour with developing countries which consider them as guarantee for quality"[2]. Handbooks are mainly oriented on problems specific to national networks. They are not design aids in the strict sense of the term but have a tutorial character with the aim of providing the reader with general knowledge.

CCITT activities are carried out in Study Groups /and other similar groups/ which formally answer Questions allotted to them by the Plenary. For this aim meetings are held regularly where contributions coming from participants are discussed. The outcome may be: simple answers, amended or new Recommendations and Questions for the next Study Period. CCITT works in a pragmatic way, the practical point of view is dominant.

Formally the terms of reference of CCITT are restricted to the international level but recently national aspects are more and more in the spotlight, as international point-to-point connections of any kind necessarily include the national links.

Last but not least the CCITT Secretariat is worth mentioning. It ensures that background in organization and documentation which is indispensable.

Appendix B

INTERPRETATION OF TRAFFIC OFFERED

To a group of N lines call attempts arrive according to a Poisson process with intensity $\lambda$. Call attempts can be unsuccessful /lost/ for two reasons:

/a/ all lines are occupied,

/b/ carried calls are rejected with probability $s$ by the network "behind" the group.

Successful calls are supposed to have exponentially distributed holding times with $1/\mu$ as average. Lost call attempts have - for the sake of simplicity - zero holding time in all cases. There is no call repetition.

The probability of $i$ lines being occupied can be expressed as:

$$P_i = \frac{\lambda^i (1-s)^i}{i!} \sum_{j=0}^{N} \frac{\lambda^j (1-s)^j}{j!}$$

The total loss probability can be calculated as:

$$B = \frac{s \lambda P_0 + \lambda P_N}{\sum_{i=0}^{N} \lambda P_i} = s(1-P_N) + P_N$$

The group itself is responsible only for $P_N$, that is for the blocking by the group.

The direct calculation of the carried traffic gives:

$$Y = \sum_{i=1}^{N} i P_i = (1-P_N) \frac{\lambda}{1-s}$$

If the offered traffic is derived from $Y=\lambda_i/1-B/ then A_i=\lambda_i/\mu$, but this offered traffic can not be carried by the group even if $P_N=0$, because of rejections with probability $s$ behind the group.

However, if the offered traffic is derived from $Y=\lambda_2/1-P_N/ then A_2=\lambda_i/1-s/ \lambda_i/\mu$ is obtained.

This is the traffic which would be carried if there were no limitation of traffic handling in the group itself. $A_2$ is in agreement with the definition of offered traffic as given in 2.4., because the average holding time of carried calls is $(1-s)/\mu$. This holding time takes the effect of other parts of the network into account.
Q.1 (J.G. Kappel)
The GOS proposals in Table 3, for new local digital switches, would insure a QS much better than current Bell System Standards. In a metro environment with (largely) analog ESS, can this be justified economically? What cost studies have been made in support of these recommendations?

A.1 (G. Gosztony)
Any CCITT recommendation is the result of contributions coming from participants (Administrations, etc.) and following discussions. CCITT does not perform own studies, it has neither staff nor budget for this purpose. The GOS values questioned are recommended but of course not obligatory and have been agreed upon bearing in mind the continuous improvement of service quality due to advanced Technologies. Unfortunately the service quality recommendations of CCITT are treated differently than Technical Rec's are (these latter cater for cooperation of exchanges, networks, etc.), because it is up to every operating company to decide on the quality of service level given to customers.
ITC 10

Summary of Questions/Answers

Date: 13 June 1983
Session: 2.3
Paper: 1

Q.1 (P. LeGall)

About the new CCITT definition of the traffic offered, for what reason is it not mentioned that the pool of resources or the circuit groups are fully operative? The possibility of any kind of failures would introduce an unnecessary overdimensioning of the network.

A.1 (G. Gosztony)

To my understanding the definition itself is valid also in the case if there are eg. faulty trunks in the circuit group. For practical reasons however, the offered traffic should not be determined prior to having been considered the failure free status of the group considered. There may be situations in which faulty trunks are removed only at a time in which some extension takes place, and estimation of offered traffic should be calculated also for these cases.

Q.2 (J.R. De Los Mozos)

In the CCITT, traffic has been traditionally considered under the scope of operations with eventual excursions into engineering procedures.

The future ISDN is demanding new traffic and GOS definitions based on commonly accepted models of the network and the services being or to be offered.

Are those modeling activities within present scope of the CCITT? If not, is the scope going to be enlarged during the next study period?

A.2 (G. Gosztomy)

ISDN will very probably be based on the existing Public Switched Telephone Network (PSTN) therefore, the service quality requirements (including GOS) of all services should be harmonized. ISDN requires a new approach in traffic engineering practice in CCITT. This of course is only possible if new traffic and operational models are established. CCITT has to move towards a merger of relevant traffic engineering activities, because only discussions in groups including experts of all services can solve the problems.