Newstead, I.A. — Articles and speeches (1968)

WHAT THE CCITT EXPECTS OF TRAFFIC THEORY

I. A. Newstead*
International Bank for Reconstruction and Development
Washington, D. C. USA

and I. Tånge
Swedish Telecommunications Administration
Farsta, Sweden

I. INTRODUCTION

Because of the diverse organizations represented by members of this Congress, it would be as well to introduce the subject "What the CCITT Expects of Traffic Theory", by first outlining briefly the background of the CCITT, its objectives and working methods.

The CCITT is one of the main organs of the International Telecommunications Union (ITU), an organization which is the accredited United Nations agency for telecommunications, but which is the endproduct of an international body established over 100 years ago to deal with the early problems of international communication - this was then, of course, confined to the Morse telegraph service.

The objectives of the CCITT reflect, in the technical fields of telephony and telegraphy, those of the ITU, which are to promote and harmonize communications between nations. The CCITT has a permanent secretariat at ITU Headquarters, Geneva, and CCITT membership is open to all countries who are members of United Nations; representation is from appropriate government agencies and from telecommunications administrations or recognized operating companies.

The work of the CCITT is carried out by its various Study Groups and flows from questions approved for study by the CCITT plenary assembly at the beginning of each plenary period. The current (1968-1972) study program was approved by the Fourth CCITT Plenary at Mar del Plata in November 1968.

The work of a study group proceeds through written contributions of members on the various questions assigned, and by scheduled meetings of the study group and of working parties which it may establish. The outcome of this work consists of answers to questions, which are submitted to the next plenary assembly in the form of Recommendations which, when approved, are published in the official CCITT document series. Special arrangements exist for interim approval to be given to urgent Recommendations (through the written agreement of a prescribed number of member countries) in advance of the next plenary assembly.

The traffic engineering recommendations are documented in the CCITT white books, Volume II A, PART V (Volume VI, PART VI). These recommendations cover traffic measurement and dimensioning practices for the international network. They rest firmly on classical traffic theory and its more recent extension to the treatment of alternate routing networks.

At this stage, due tribute should be paid to Mr. E. P. G. Wright, who for so many years fathered the development of traffic engineering in the CCITT and saw the present recommendations to their final form at the CCITT Plenary Assembly in Mar del Plata in 1968.

CCITT Recommendations are, of course, not mandatory. But in practice, they are given a very high degree of accord by nearly all countries and they exert a strong influence on the specifications for new telecommunications plant and equipment. For this reason, study group meetings are usually well attended by representatives of the telecommunications manufacturing industry, in the capacity of observers.

Questions on traffic engineering and network planning are assigned to Study Group XIII (Chairman, Dr. S. Kuhn, Poland) which also deals with questions concerning international switching maintenance and quality of service. This study group has two Standing Working Parties one of which, W.P. 2 (Chairman, Mr. I. Tange) concentrates on traffic engineering and related questions.

*Mr. Newstead was formerly Chairman, CCITT Study Group XIII.
Mr. Tange is Chairman of Working Party 2 (Traffic Engineering) of S.G. XIII.

II. IMPORTANCE OF TRAFFIC ENGINEERING

The CCITT and its members all respect the fundamental importance of traffic engineering, both to the economic development of telecommunication networks and to the quality of service provided. In a national network, about 55 % of the value of all network telecommunications plant is traffic-carrying common-plant, shared by subscribers in accordance with their collective traffic loads. National common-plant has an installed capital asset value of at least US$600 million for each million subscribers in larger networks, and it is the optimum dimensioning of network common-plant that is the mainstream of traffic engineering. In the international network practically all plant is common-plant, and the cost of an individual circuit can exceed $1 million.

Clearly, improved traffic engineering will return enormous financial dividends if it results in an increased utilization of network common-plant; for example, in a national network of one-million subscribers, raising the average common-plant circuit occupancy from say, 0.60E to 0.65E (without penalizing congestion service-standards) would reduce the network capital cost by over $40 million. Economic gains of this magnitude and more, have and will continue to be made by traffic engineering through more accurate traffic measurement and forecasting techniques (which permit a reduction in the dimensioning safety-margins applied), more efficient trunking arrangements, or the use of better statistical models which more correctly reflect the characteristics of real traffic and of the telecommunications systems which carry it.

For these reasons the CCITT welcomed the approach made in 1968 by Professor Jensen, Chairman of the permanent ITC Advisory Committee, to strengthen the links between the two organizations, of which this joint meeting is one outcome.

III. SPECIAL ASPECTS OF CCITT WORK

At this stage, two important aspects of CCITT activities should be stressed. The first is that the CCITT essentially reflects the collective views of telecommunications operating authorities. Thus, it is basically concerned with finding practical solutions that can be applied, as uniformly as possible, by all its members to problems either immediately at hand or known to be imminent. This is in no way to under-rate the value and importance of basic theoretical studies but such research is not normally undertaken as part of the CCITT work program. For this reason, whilst close ties between the ITC and the CCITT are essential, it is right and proper that the ITC, incorporating as it does, a membership far wider than telecommunications administrations, should continue to remain a separate and autonomous body. Again, let me stress therefore, the essentially pragmatic aspect of CCITT work.

The second point to be made is that CCITT questions are, in principle, restricted to matters effecting the international network. I say "in principle", because in practice, it is impossible to study and prescribe for the international network in isolation. In matters of technical compatibility and service standards as well as operational and financial aspects, national and international practices are closely inter-meshed. For example, the grade of service in a national network will strongly effect the overall grade of service of that country's international connections. International standards also lean heavily on national experience and, particularly as international automatic operation is implemented, study of the international network requires a thorough examination of the conditions in the terminal national networks.

IV. DIFFERENCES BETWEEN THE INTERNATIONAL AND NATIONAL NETWORK

Nevertheless, in considering traffic engineering in relation to the CCITT, with its primary emphasis on international communications, it is important to highlight some basic differences between the international and national networks.

(i) In a national network, one authority usually has total responsibility and control. In contrast, the international network is multi-owned with many competing and conflicting interests. For example, each international carrier tries to maximize the collective usage of his own facilities. Again, countries may favour certain routings and wish to prohibit others for political reasons.

(ii) The overall design and dimensioning objectives are different. In a national network the objective is to minimize the total cost of the network to carry the traffic at prescribed service standards. Ideally, the same objective should apply to the international network. In practice however, each country is primarily concerned with disposing of its outgoing international traffic (to prescribed service standards) so as to minimize the cost to itself.

For example, in dimensioning circuits in an alternate routing situation, unless the charges levied against the users of international circuits always bear the same relation to the circuit costs, these two objectives will produce different dimensioning results.

(iii) The different nationalities using the international network, all have different telephone behavior and different criteria of acceptable-performance.

(iv) In general, the ratio of external circuit costs to switching costs is much greater for the international network, leading to different strategies; e.g., international switching costs can be greatly increased if this achieves higher external circuit utilization. Hence, full-availability trunking (or very low internal blocking) is usually employed in the design of international switching equipment.

(v) The effect of time-difference between terminal ends of the connections can be of dominant importance to optimum traffic disposal in die international network.

Some of the traffic engineering problems resulting from these special characteristics of the international network are discussed in Sections V and VI.

V. THEORETICAL STUDIES

From what has been said it is apparent that the CCITT is not equipped to carry out fundamental traffic engineering research. Many problems, however, are of such a nature that theoretical studies are desirable or even essential for the proper solution of the problems. It is therefore natural that the CCITT looks to ITC for such studies.

Before we touch specific CCITT questions, some areas may be mentioned where fundamental traffic engineering research is particularly topical for optimal design of the international network.

(i) Time-Difference Effects

The exploitation of time-difference effects can be of great importance to the economic disposal of international traffic.

For a traffic relation with no time-difference between the originating and destination exchanges there is a fairly wide spread of mutually convenient hours; the 24-hour traffic profile has a generally consistent form with a morning busy-hour and nearly equivalent side-hours, an afternoon activity period of several hours and, in the case of social traffic, an evening busy period also. The net effect is that the busy-hour accounts for between 1/6 - 1/9 of the total 24-hour traffic.

A time-difference between origin and destination locations reduces the hours of mutual convenience and concentrates the traffic to an extent which depends on the magnitude of the time-difference. The resultant traffic-time profile is some function, as yet undefined, of two profiles of maximum convenience, time-displaced with respect to each other.

A corollary of the traffic concentration is the increased idle periods and the consequent potential for carrying traffic of other relations during these periods. Such a situation applies, for example, to the intermediate links in a connection between near-antipodal countries.

These effects were studied in the last two plenary periods by Study Group XIII and it was shown that large network economies (as high as 30 %) could be made in the disposal of total international traffic over a region which encompassed a time-difference of 5 - 8 hours. However, to obtain these savings new rules were necessary in the International Routing Plan which had been developed initially from the experience of national networks where time-difference effects are generally not of great significance.

The studies and the new routing rules were largely empirical and so far there has been no satisfactory theoretical model developed for studying this phenomenon; that is for, (a) predicting for the traffic profile for a relation with a given time-difference and mean traffic; (b) systematizing the routing tactics to optimize total traffic disposal. (As against minimizing costs for one particular traffic stream.)

Further studies in this field will be valuable as the international network traffic grows in volume and complexity.

(ii) Models for International Traffic

The greater part of practically all methods applied for dimensioning telecommunications plant is based on a traffic theory where it is fundamental that traffic intensity is fairly constant. This adaptation to real traffic is, as is well known, roughly simplified and in some cases strongly divergent. The traffic shows variations apart from the quite random ones. Consider, for instance, a busy-hour measurement comprising a number of days representative of the traffic. As basis for the dimensioning, an average value for the traffic of the hours is applied. We know that variations, except those of entirely random character, appear partly within the individual hours, partly between the hours and, taken together, more or less deviate from what is presupposed in the dimensioning model. Experience shows that in national traffic the deviation around the average value has a tendency to be greater for trunk traffic than for local traffic. We can presume that the variations will be still greater for more extended international traffic. This problem is not new, having been the object of studies of several scientists. Models have been developed to describe the traffic with variable average intensity; Palm attempted to regard the traffic as a stochastic variable. These models, however, became complicated theoretically as well as in the measurement techniques.

The need for improved mathematical models which better describe the characteristics of traffic has lately been brought to the fore through the automatization of international traffic. The application, in the practical dimensioning work, of more complicated theories should now be facilitated through the use of computer for analytical solutions and simulations. From the techniques of measurement point of view, the production of traffic data is facilitated through the increased application of automatic traffic measurement equipment that may easily be adapted to new demands, if any.

(iii) Subscribers Reactions

A connected problem of great importance for the dimensioning and utilization of the international network is the calling subscribers' way of reacting to disturbances in the network due to congestion, engaged or not answering B-subscriber, technical faults etc. The degree of these disturbances has influence on the frequency of repeated call attempts. Applied theories do not take into account the effect of these calls. The assembled impact of such calls complicates the interpretation of results from traffic meters from periods of overloading making a determination of the truly offered traffic difficult and inaccurate.

During the current period of studies the French Administration has given to the CCITT valuable contributions containing results from exclusive tests on real traffic as well as an account of a calculating method considering repeated calls. Studies have also been made by various other Administrations and recognized operating agencies, and the results show that repeated dialling attempts strongly impair the efficiency of the network with serious consequence particularly for the international network.

This state of things has led to a proposal for a new question being drawn up, the purpose of which is ultimately to take into account in traffic engineering practices the phenomenon of repeated dialling attempts. Current problems in the matter are:

- the impact of repeated dialling attempts on the overall grade of service for international traffic
- appropriate maximum values for the acceptable level of the overall grade of service in international and national automatic working with respect to repeated dialling attempts.

For the study of the new question further investigations are necessary and the Administrations will be asked to participate in a study of the repeated dialling patterns made by their subscribers. To this end a detailed specification has been prepared containing necessary statistical data on subscriber dialling behavior.

(iv) Forecasting International Traffic

As is well known, in the last years the collection of data has been considerably facilitated through the use of automatic measurement equipment with built-in logic to some extent and with output into a form direct adjusted for computer processing. The principle aim of the data collection is to obtain a basis for the continuous supervision of the accessibility in the network as well as for forecasts--more or less long-range -- concerning future equipment needs. Regarding the hardware we can say that the requirements are well met and that today the problems concern the software.

- For efficient traffic supervision, measurement quantities are wanted that, in a better way than the ones traditionally used, meet the new requirements. The purpose of the supervision is to follow load changes in the network and to make the most of the capacity of the total network through re-routings etc. Therefore there is a need for as quick and reliable information as possible about over- and underload of different degrees. The measuring quantity should (e.g. during traffic growth) inform about this growth as soon as possible. If a traditional measuring of the traffic flow is used to follow the change of load in a route, on the one hand this procedure is rather slow, on the other the result comprises inactual data, if the traffic load has been rising or falling during the measuring period.
- The economic importance of the most reliable traffic forecasts is evident and increased research in this field will be welcome.

In a first step the research may be directed to decide which variables form the best bases for forecasts. The next step would be to investigate which other variables would, à priori, influence these variables. In this connection, the question arises how to formulate the mathematical models that are relevant to describe this influence and their effect on the accuracy of the forecast.

VI. QUESTIONS PRESENTLY UNDER STUDY BY THE CCITT

(i) International network management - Recommendations for planning and operating procedures.

The aim of network management is to minimize service deterioration under abnormal conditions caused by unpredictable excessive overloading, break-down in transmission facilities etc. to increase network traffic efficiency under normal conditions by utilizing spare capacity on temporary underloaded circuit groups to offset traffic peaks on other routes. These peaks may be caused by random variations or predictable variations due to e.g. time differences.

The studies now going on have been concentrated to the following main points:

Objectives and gains of network management
Listing of management actions to be taken
Circuit groups and equipment to be supervised
Criteria defining the start of a congestion condition
When action should be taken

As mentioned before, traffic research regarding adequate traffic parameters is desirable.

(ii) Advantage to be obtained by departing from the busy-hour basis in traffic engineering

The busy-hour basis refers to traffic measurements carried out in order to collect basic data for dimensioning purposes. Earlier rather comprehensive studies concerning traffic measurement methods resulted in the existing CCITT recommendation which uses a time-consistent busy-hour as the reference base for traffic engineering. Most administrations employ this concept of busy-hour when specifying traffic volumes.

There are many factors in favor of the busy-hour approach but also limitations. There are e.g. periods outside the busy-hour when the traffic exceeds the busy-hour average value. The aim of traffic dimensioning is to comply with the service criterion set

up and it is important that the collected traffic data closely reflect what is essential for meeting the service requirement. An essential factor in this context is therefore the definition of the service quality. In this study it also still remains to define the requirements - account taken of theoretical aspects and of the practical application - which may be placed on the measurement and indication of traffic volumes.

(iii) Use of automatic traffic-measuring equipment for traffic forecasts

The study of this question is a continuation of earlier studies and is now also focussed towards forecasting methods for computer application.

The studies are now concentrated on the following points:

- base data for forecasting
- factors affecting traffic growth
- the importance of discontinuities in traffic growth
- forecasting on a point-to-point basis (not only for individual routes)
- models appropriate to international forecasting
- comparisons between forecasts made and subsequent observed growth

As mentioned earlier increased research in this field is desirable.

(iv) Overall grade of service for international connections, subscriber-to-subscriber

The overall grade of service for a network depends on the grade of service given to the various links in a connection. A link grade of service specification is on the other hand based on some numerical value (e.g. call congestion) applied to calculated traffic values from a defined measurement period. There already exists a recommendation for the overall grade of service in the international part of a connection based on CCITT standards as regards the traffic measuring and dimensioning methods and the network structure. The aim of the question is to include in that recommendation also the national parts of an international connection. One problem is to get comparable values for the different parts of the connection since the traffic measuring and dimensioning methods used in the national networks may differ from the ones recommended for the international network and of course also be different in various countries. It is suggested that the national parts of an international subscriber-to-subscriber connection should in principle have the same grade of service standards as those recommended for the international network for international automatic working. The A.T. & T. has proposed numerical values on such standards.

(v) Use of computers for network planning and circuit group dimensioning

Computers are more and more in use for network design and associated problems and it is felt appropriate to exchange views and agree on practices to be recommended. As regards the international network it is desirable that the results from processing are on a comparable basis for bilateral agreements. Automatic data processing also paves the way for new and more sophisticated techniques as regards dimensioning methods and so on which may prove beneficial. That aspect will of course be taken into account in the study.