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Problems of Traffic Theory in the Design of International Direct Distance Dialling Networks

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1. Introduction and Statement of the Problem

The telephone traffic theory should among other things contribute to the fulfilment of two important requirements, which have to be imposed on world-wide automatic telephone networks:

1a) Economically high utilization of expensive long-distance traffic groups, while at the same time maintaining the specified grade of service.

1b) Flexibility in the event of overload — i. e., as small as possible an increase in the probability of loss — in a center of transit.

These two requirements cannot both be optimally fulfilled at the same time. The higher the group utilization can be pushed in the case of systematic loading, the fewer are the reserves, which the network can still retain for unexpected supplementary loads. Endeavours have, therefore, to be made to achieve a reasonable compromise.

2. Type of Network and Traffic Routing

We will at first neglect requirement 1b and aim only at a high group utilization. In this connection we have to remind ourselves of three characteristics of telephone trunk groups (*Fig. 1*):

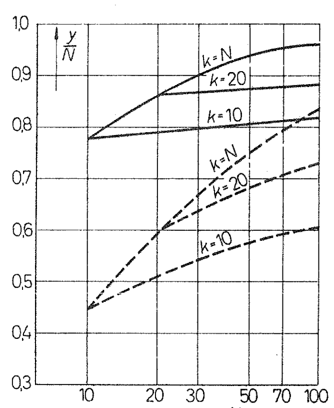

Fig. 1. Mean line utilization y/N for offered Poisson traffic as a function of the accessibility k, the permitted loss B and the number of lines N.

2a) For a fixed value of the probability of loss B — for example, for $0.01 \triangleq 1\,\%$ — the line utilization y/N increases with the size of group N.

2b) Similarly, y/N increases with the accessibility k of the selectors, hunting this group.

2c) For a given accessibility k an a fixed number of trunks N the utilization y/N increases very considerably with the permitted loss B.

*) From a paper presented at the NTG Meeting on World Wide Telephone Traffic, 15th to 17th September 1965, Munich.

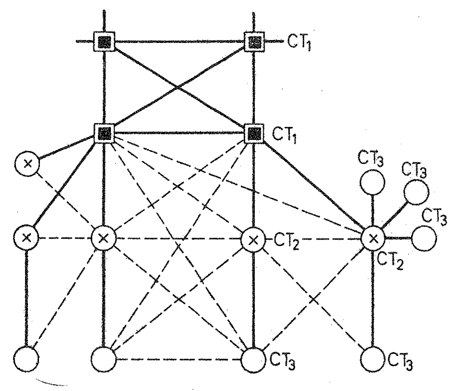

Fig. 2. Form of network for the future world-wide automatic telephone network.

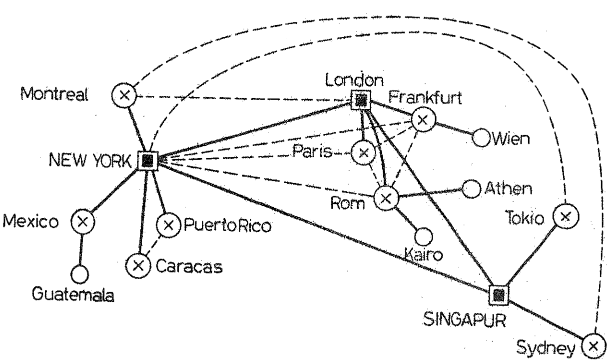

Fig. 3. Example of direct routes – – – – and last choise routes ——— in the international automatic telephone network. (The sketch probably does not represent the definitive division into CT_1, CT_2 and so on.)

On the basis of these three characteristics the form of network and traffic routing for the international network has been hierarchically organized in a similar manner to that already known from the German direct distance dialling network (*Fig. 2*).

The centers of transit of the world-wide trunk-dialling network (center of transit = centre de transit) are divided up, in a similar manner to the primary, secondary and tertiary exchanges of the German direct distance dialling service, into three categories.

To the highest grade belong the transit exchanges of the CT_1 group for international traffic. They should be as fully inter-meshed with one another as possible. (The international CT_1 for Western Europe and the countries bordering the Mediterranean will, for example, be London (*Fig. 3*); the CT_1 for North America is New York.)

Connected in a star-shaped manner to each CT_1 are the transit exchanges of grade CT_2 of the same "telephone continent". (For example, Paris, Rome, Frankfurt-on-Main and other CT_2 exchanges are connected to London.)

Each CT_2 in its turn provides for a number of transit exchanges of category CT_3 that are likewise connected up in a star-shaped manner; thus, for example, the Frankfurt CT_2 exchange serves the CT_3 exchanges of Luxembourg, Vienna and others.

Since, however, with good line utilization short high-usage direct routes will as a rule be more economic than longer connections through a large number of CT's in the basic network, here again, as for the national distance-dialling service, direct high-usage routes are provided:

The mass of the international traffic is first offered by the CT_3 in the originating country to a direct high-usage route — and alternatively possibly also to other such routes — which runs more directly to the destination than a route in the basic network.

The basic network thus consists of the last choice routes, which collect together the traffics overflowing from the direct routes. Direct routes — and particularly those containing small trunk-groups — should be operated with high losses, i. e., with high probabilities of overflow, so that they too can be highly utilized. Last choice routes, on the other hand, must be operated with low losses. In this case owing to the better utilization large trunk-groups are desirable.

After this review of the type of network and the traffic routing method will now be given to those individual questions of traffic theory, on the knowledge and the observance of which depend both the economic utilization and also the flexibility of the network. In this connection a report will be given in the following paragraphs only on results obtained from investigations carried out on the basis of traffic theory; from these are derived the conclusions required. The theoretical principles, from which these results are obtained, will be found discussed in [1] to [13] among others.

3. Traffic-theory Characteristics of Networks with Alternative Routing

3.1. *The Variance Coefficient of Overflow Traffic*

We will consider overflow traffics, which are not carried by a high usage group, i. e. the case where calls cannot find an idle trunk and thus overflow to a succeeding group (for example, the last choice route). Such an overflow traffic R consists of individual traffic peaks, which are frequently separated in point of time and which overflow only in periods, during which the accessible lines in the high usage group hunted before are just blocked.

The various statistical characteristics of Poisson traffic, on the one hand, and such of overflow traffic, on the other hand, can be characterized with adequate accuracy by the following parameters, the mean value R and the variance V (or the variance coefficient D) of the overflow traffic.

For Poisson traffic the following equations are valid:

Variance V = Mean offered traffic A,
Variance coefficient $D = (V - A) = 0$.

For overflow traffic R we have:

Variance $V > R$,
Variance coefficient $D > 0$.

As long ago as 1954 *Bretschneider* [10, 11] calculated and tabulated the variance coefficient D for full accessible groups as a function of the offered traffic and the number of trunks. In [11, 12] it is also shown that it is possible with this method to calculate in a simple manner those full-available "second choice routes", to which is offered such overflow traffic that is affected by the variance coefficient (e. g., last choice routes). An equivalent method is suggested by *Wilkinson* [13]. A general solution for calculating the variance coefficient of overflow traffic behind single-stage trunk groups with full or limited accessibility has been published in [3]. In addition, there is derived in [6] a solution for calculating variance coefficients behind connecting arrays with any number of stages.

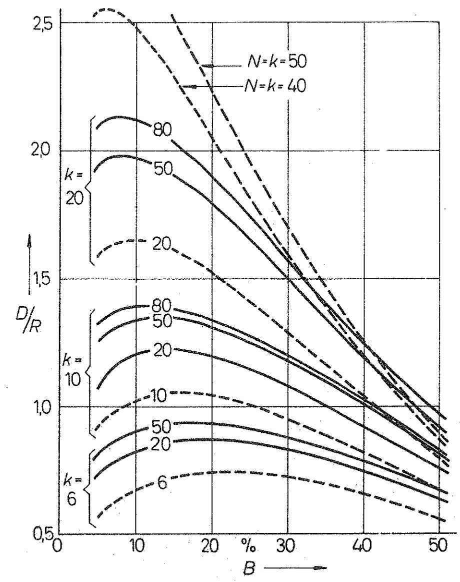

Fig. 4. The relative variance coefficient D/R of the overflow traffic behind primary groups as a function of their accessibility k, the number of lines N and the overflow probability B.

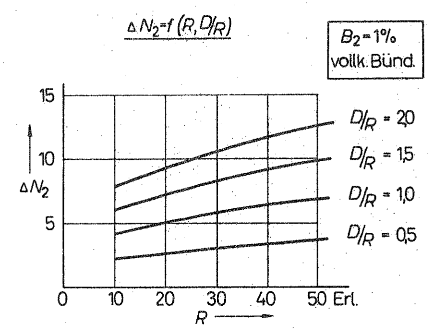

Fig. 5. The number of extra trunks required ΔN_2 in a full-availability group with the nominal loss $B_2 = 1\,\%$ when overflow traffic (R, $D > 0$) is offered instead of Poisson traffic (A, $D = 0$).

Some numerical values of the relative variance coefficient D/R are shown in *Fig. 4*. Versus the loss B the relative variance coefficient D/R is plotted there for various values of the accessibility k — and with a given k value for various group sizes. The following characteristics can be clearly seen to emerge:

a) With a constant loss B the relative variance coefficient D/R increases with the group size.

b) Moreover, D/R increases very sharply with increasing accessibility k. Groups with full accessibility have the greatest relative variance coefficient.

c) With increasing loss, D/R reaches a maximum — which lies at about $A = 0.9\,N$ [2] —, thereafter again reverting to the value 0 at the limiting value of $B = 1.0 \triangleq 100\,\%$. This is also reasonable, since a $100\,\%$ overflowing offered traffic must have the character of random traffic.

3.2. *Calculation of Secondary Groups to which Overflow Traffic is offered*

Understandably the variance coefficient of the offered overflow traffic influences the number of lines N in a final route. The more the overflow traffic R is peaked, which is offered to the last choice route, or in other words the greater D/R is, the greater also is the number of extra trunks required ΔN for a specified loss B_2 and for the same mean value R (overflow traffic). The determination of ΔN

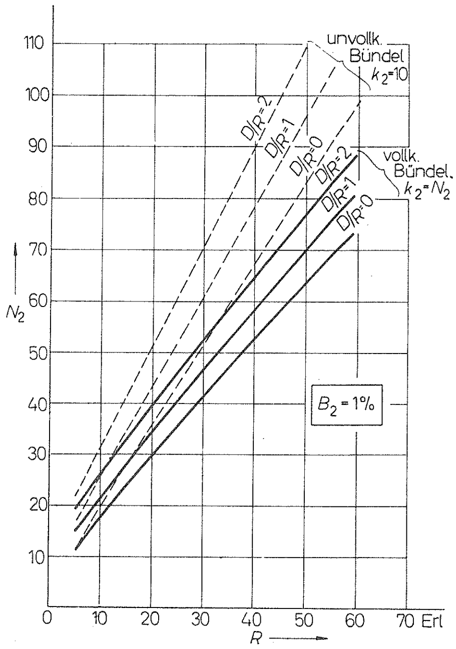

Fig. 6. The number of lines required N_2 for a specified loss $B_2 = 1\,\%$ with offered overflow traffic R_1 having a varying relative variance coefficient D/R ($D/R = 0$ corresponds to Poisson traffic).
(unvollk. (vollk.) Bündel = limited-(full-)availability groups)

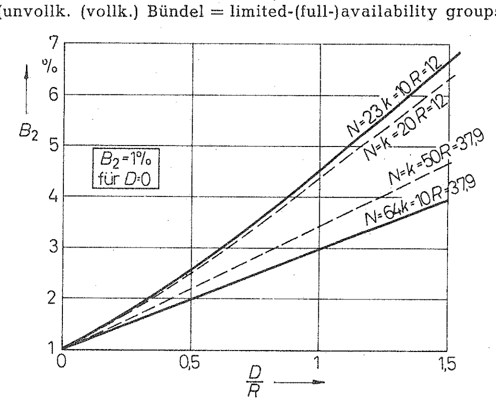

Fig. 7. The increase in the loss B_2 as a function of the relative variance coefficient D/R for secondary groups, whose number of lines N_2 was designed for $B = 1\,\%$ and $D/R = 0$ (Poisson traffic).

in accordance with the method described in [1, 2] is very simple in practice (cf. also the relevant tables in [7, 8]).

Fig. 5 shows by way of example the number of extra trunks required ΔN_2 in a full accessible last choice route, to which overflow traffic is offered. For offered Poisson traffic of $A = 30$ Erlangs $N = 41$ lines are required with $B_2 = 1\,\%$. For an overflow traffic of the same mean value, i. e., with $R = 30$ Erlangs and the relative variance coefficient $D/R = 2$ the number of extra trunks required amounts according to Fig. 5 to $\Delta N = 11$ lines; thus, 52 lines are required, which means an increase of 26.8 %.

If the last choice route has limited availability (for example, with $k = 10$), then in the same case (see *Fig. 6)* we even get $N = 71$ (instead of 52 with $D = 0$); i. e., $\Delta N = 19$ and we require 36.5 % more trunks than with offered Poisson traffic of the same mean value.

On the basis of Figs. 4, 5 and 6 it can be established that:

a) fully accessible direct routes provide overflow traffic with the gratest relative variance coefficient;

b) fully accessible last choice routes carry offered overflow traffic with the smallest number of extra trunks.

With the new RDA-method it will in future be possible for automatic telephone networks, which operate with alternative routing and with overflow traffic, to be correctly designed in every case, i. e., with due observance of the variance coefficient.

In the past, when networks with alternative routing were being calculated, the influence of the variance coefficient on the number of trunks required in those groups, to which overflow traffics are offered, were frequently neglected.

The effect of such neglect is, that their actual losses may rise considerably above the planned value. *Fig. 7* shows by way of example two trunk groups with full accessibility or with limited accessibility $k = 10$, to each of which 37.9 Erlangs of overflow traffic are offered and also two other groups ($k = N$ or $k = 10$), to each of which 12 Erlangs of overflow traffic are offered. All four line-groups have been designed in accordance with the loss tables for Poisson traffic with $B = 1\,\%$ loss. With increasing relative variance coefficient the actual losses increase. With a relative variance coefficient of $D/R = 1.5$ — that indeed occurs quite frequently in practice — the actually occurring losses already amount to between 4.0 % and 6.7 % depending on the trunk group concerned. From this it can be seen that such groups must be designed with due observance of the variance coefficient, if self-deception with regard to the actual grade of service is to be avoided.

3.3. *Economic Distribution of the Traffic over high usage Routes and Last Choice Routes*

Both the overflow traffic and its variance coefficient behind direct routes can be calculated in a simple manner — in accordance with Sections 3.1. and 3.2. — and second choice routes and/or last choice routes can be designed correctly, i. e., with due observance of the variance coefficient, for the specified losses.

One question remains to be solved relating to the way in which telephone traffic can be carried most advantageously from the economic point of view, namely, on the one hand, over high usage routes and, on the other hand, — with overflowing traffic — over the last choice route.

This distribution depends on the so-called cost factor q. It gives the ratio of the costs of a speech circuit in the last choice route to that of a speech circuit in the direct group. In all the plans made for the national direct distance dialling network the most economic distribution is also calculated with the help of the cost factor q and theoretical dimensioning tables. The former method can still be improved on the basis of the new RDA-method for limited-availability trunk groups ([1] to [9]) without additional expenditure on the planning. Special articles are published in this journal on the variance coefficient theory of limited-availability line-groups and on the new method of optimum network calculation [3, 5].

3.4. *The Effective Loss* B_{eff}

High usage routes and last choice routes are now determined according to the offered traffics, overflow traffics, accessibilities and numbers of trunks. Thus, for each transit exchange, there is also established the probability of loss, with which a transit connection to a given destination "gets lost" at that point, i. e., cannot reach a free line in any succeeding high usage route or last choice route.

One or more high usage routes offer their overflow traffics to a last choice route (sometimes to the last choice route is also additionally offered direct Poisson traffic). If the direct route for a considered connection has the loss probability B_1 (i. e., an overflow traffic $R_1 = A_1 \cdot B_1$) and the last choice route has the loss probability B_2 — which obviously relates only to the overflow traffic R_1 — then the effective overall loss is

$$B_{\text{eff}} = B_1 \cdot B_2 .$$

With two high usage routes in series and an associated last choice route the effective loss would be

$$B_{\text{eff}} = B_{11} \cdot B_{12} \cdot B_2 .$$

To this relationship we revert in the next Section.

3.5. *Overload Factor, Overflow Factor and Loss Factor of Direct Routes*

Overload may occur, for example, when a transatlantic cable temporarily fails, a repeater station becomes faulty or a synchronous satellite is put out of service by meteorites. The traffic of the defective section will always flow over alternative routes, which are then additionally loaded and frequently overloaded.

It will now be investigated how the losses change in cases of overload.

We will first define the overload behaviour of direct and last choice groups by means of a few characeristic values *(Fig. 8)*.

The offered overload (sometimes offered underload) to the direct route is described by the overload factor

$$\alpha_1 = \frac{A_{\text{actual}}}{A_{\text{planned}}} \left(\equiv \frac{A_{\text{ist}}}{A_{\text{plan}}} \text{ in Fig. 8 etc.} \right)$$

A value $\alpha_1 > 1$ causes an increase in the loss- (or better overflow-)probability B_1 of the direct route concerned. In addition we define

$$\lambda_1 = \frac{B_{1\,\text{actual}}}{B_{1\,\text{planned}}} \left(\equiv \frac{B_{1\,\text{ist}}}{B_{1\,\text{plan}}} \text{ in Fig. 8 etc.} \right)$$

as the loss factor of the direct route.

The associated rise in the overflow traffic behind our overloaded direct route we describe correspondingly by the overflow factor

$$\varrho = \frac{R_{1\,\text{actual}}}{R_{1\,\text{planned}}} = \alpha_1 \cdot \lambda_1 .$$

Thus, we come to a subject, the importance of which can be recognized from *Fig. 9*. It shows with $\varrho = f(\alpha_1)$ the increase in the overflow factor as a function of the increase α_1 in the traffic offered to some direct routes of various sizes and accessibilities.

Let us first consider the — rare — case where the direct group is operated with $B = 1\,\%$ and let us assume a 30 % overload, i. e., $\alpha_1 = 1.3$. Then for $(N = 50,\ k = 50)$ the overflow factor becomes $\varrho \approx 11$; this means that after a 50-line group there already overflows an overflow traffic, which is 11 times greater than its planned value!

With $(N = 20,\ k = 10)$ in the same case we at any rate still get $\varrho \approx 6.5$.

For a planned loss of $B = 5\,\%$ the overflow factor becomes in such cases $\varrho = 5$ or $\varrho = 3.7$ respectively and finally for $B = 20\,\%$ $\varrho = 2.4$ or $\varrho = 2.2$ respectively.

Such increase of the overflowing traffic causes the overloading of a succeeding 2nd choice route or of the last choice route. Even the relatively most favourable case in *Fig. 9* (planned 20 % overflow probability) with $\alpha_1 = 1.3$ still results in an increase in the residual traffic to more than twice the planned value.

Thus, from this diagram we can deduce the four following important characteristics:

1. Every direct route with overflow acts as a very strong "overload intensifier" for a succeeding group (e. g., the last choice route).
2. Two high usage routes in series correspondingly act as two "overload intensifiers" in series for a last choice route following in third place.
3. Heavily loaded direct routes, i. e., those with a high overflow probability B_1, have smaller and therefore more favourable values of ϱ.
4. In the range of very high values of $B_{1\,\text{plan}}$ direct route groups with full and with limited accessibility no longer differ as much with respect to ϱ as in the case of low loss values (though they do indeed with respect to the variance coefficient).

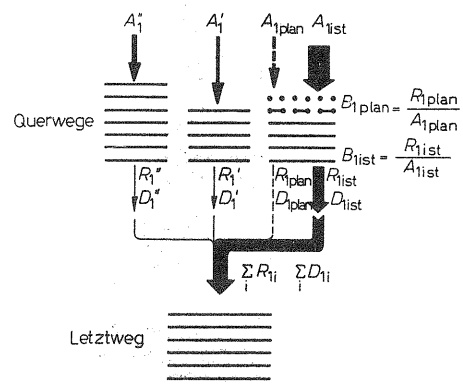

Fig. 8. The overloading of direct routes with overflow. (Querwege = direct routes; Letztweg = last choice route)

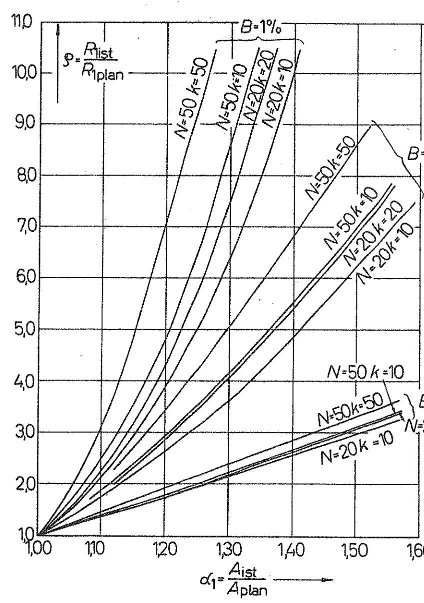

Fig. 9. The overflow factor ϱ as a function of the overload factor α_1 (primary group with offered Poisson trafic A_{actual}). The loss values $B = 1\,\%$, $5\,\%$ and $20\,\%$ plotted correspond to the planned offerede traffic A_{plan}.

Thus, it is not sufficient for a network with alternative routing to be designed optimally from the economic point of view and with due observance of the variance coefficient. We should — at least in the case of international dialing networks — also examine their overload characteristics and sometimes effect corresponding improvements by generously designing certain routes (spare lines in the last choice route!).

3.6. *Last Choice Route Overloading*

We will consider a last choice route, to which several overflow traffics are offered *(Fig. 10)*. The total traffic offered has, therefore, the data:

$$\text{Overflow traffic} = \Sigma\, R_{1\,\text{plan}}$$
$$\text{Variance coefficient} = \Sigma\, D_{1\,\text{plan}} .$$

If now one or more high usage groups are overloaded, to the last choice route is offered a larger amount of traffic $\Sigma\, R_{\text{actual}}$, $\Sigma\, D_{\text{actual}}$. We, therefore, define

$$\alpha_2 = \frac{\Sigma\, R_{1\,\text{actual}}}{\Sigma\, R_{1\,\text{planned}}} \left(\equiv \frac{\Sigma\, R_{1\,\text{plan}}}{\Sigma\, R_{1\,\text{ist}}} \text{ in Fig. 10 etc.} \right)$$

as the last choice route overload factor and

$$\lambda_2 = \frac{B_{2\,\text{planned}}}{B_{2\,\text{actual}}} \left(\equiv \frac{B_{2\,\text{ist}}}{B_{2\,\text{plan}}} \text{ in Fig. 10 etc.} \right)$$

as the loss factor of the last choice route.

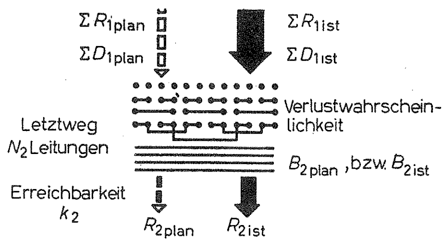

Fig. 10. The overloading of last choice routes.
(Letztweg = last choice route; Leitungen = trunks; Verlustwahrscheinlichkeit = propability of loss; Erreichbarkeit = accessibility)

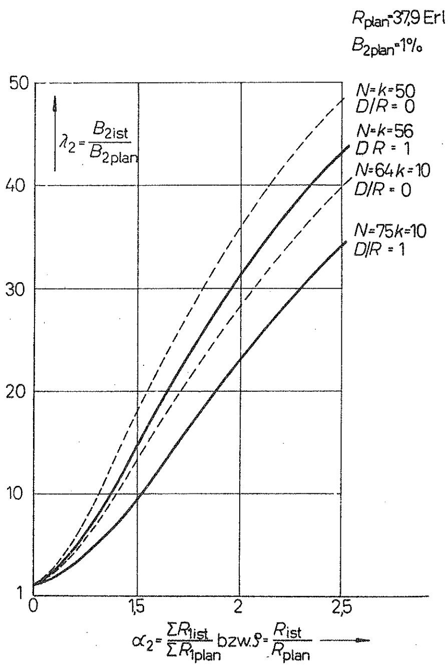

Fig. 11. The loss factor λ_2 for last choice routes of various sizes and accessibilities as a function of the overload factor α_2. Last choice routes, which are correctly designed for overflow traffic (D, R), are somewhat less sensitive to overload than those groups, which are operated with Poisson traffic ($D/R = 0$) both in accordance with plan and also in the case of overload.

The effective loss of any traffic, which also makes use of this last choice route in the transit exchange under consideration, is increased thereby. It becomes

$$B_{\text{eff actual}} = B_{1\text{planned}} \cdot \lambda_1 \cdot B_{2\text{planned}} \cdot \lambda_2 = B_{\text{eff planned}} \cdot \lambda_1 \cdot \lambda_2 .$$

The effective loss of a traffic, whose own high usage routes are not overloaded, is influenced only by the factor λ_2. On the other hand, with a traffic, whose own direct route is overloaded, the effective loss is raised by $\lambda_1 > 1$ and $\lambda_2 > 1$.

In *Fig. 11* a few curves are plotted for the loss factor λ_2 of a last choice route.

If, for example, the overflow traffic is doubled — a case, which not infrequently occurs in practice — and if the relative variance coefficient $D/R = 1$, the loss of a full accessible group with $N = 56$ lines, planned for 1 %, rises from 1 % to 31.2 % ($\lambda_2 = 31.2$).

A 75-trunk group with $k = 10$ would for the same planned value of 37.9 Erlangs increase its loss B_2 from 1 % to 22.8 %. Obviously the effective loss B_{eff} would then also rise by the factor $\lambda_2 = 22.8$.

3.7. *The Increase in Loss of Poisson Traffic, Offered Directly to the Last Choice Route*

Up to the present, consideration has been given only to traffic relationships, which have at least one high usage route available. Traffic relationships, which have no direct route and thus offer their Poisson traffic directly to a last choice route in the basic network, are, however, at a particular disadvantage in the case of overload. *Fig. 12* shows an example in this connection.

On the left is shown an A-grouping, in which two full accessible direct routes each containing 22 lines offer their 20 % overflow traffics to the same last choice route. In addition, there is a direct Poisson traffic of $A_c = 24$ Erlangs. Thus, the total traffic offered to the last choice route has the following data:

$$\text{Total offered traffic } R = 33.6 \text{ Erlangs;}$$
$$\text{Variance coefficient } D = 15.4.$$

For a last choice route with the loss of $B_2 = 1$ % calculation gives a requirement of $N_2 = 48$ full accessible lines in the last choice route. The total number of lines amounts, therefore, to $22 + 22 + 48 = 92$ lines.

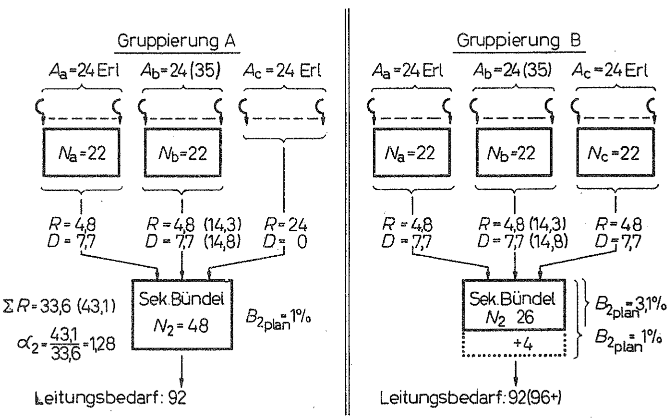

Fig. 12. Two groupings for direct routes and last choice routes. The B grouping avoids the disadvantage of Poisson traffic being offered directly to the last choice route in the case of overload. (Gruppierung = grouping; Sek. Bündel = secondary group; Leitungsbedarf = number of lines required)

On the right-hand side of Fig. 12 the B-grouping is sketched. Here the previous Poisson traffic A_c is also first presented to an associated high usage group, although this traffic flows over the path of the last choice route! The last choice route (designated second choice group in the diagram) now receives a total residual traffic of only 3 times 4.8 Erlangs. If the total of all lines, $N = 92$, is kept constant (i. e., N_2 now equals 26), the loss B_2 rises to 3.1 %. If a further 4 lines are added to the last choice route, the secondary loss remains at $B_2 = 1$ %, as in the case of arrangement *A*.

Now in both groupings let the direct route N_b be overloaded by about 50 % ($A_b = 35$ Erlangs instead of $A_b = 24$ Erlangs).

Without overload the A-grouping (see also *Fig. 13*) has the loss $B_{\text{eff a, b}} = 0.2 \cdot 0.01 \triangleq 0.2$ % for the two direct routes to which A_a and A_b are offered. The direct basic traffic A_c has $B_{\text{eff c}} = B_2 = 1$ %. With overload we get $B_2 \approx 7.8$ %, which takes full effect on this basic traffic; in this case, therefore, the loss rises to $B_{\text{eff c}} = B_{2\,\text{actual}} = 7.8$ %!

The traffic A_a of the direct route N_a which is not overloaded has an effective loss $B_{\text{eff a}} \approx 1.6$ % and the traffic A_b, offered to the overloaded group N_b one of $B_{\text{eff b}} \approx 3.2$ %.

With grouping B all 3 traffis A_a, A_b, A_c have in normal operation the effective loss

$$B_{\text{eff}} \approx 0.6 \text{ \% (92 lines)}$$

or

$$B_{\text{eff}} = 0.2 \text{ \% (92 + 4 lines).}$$

With overload the effective loss of the offer A_b that is responsible for it, rises to 6.7 % (or only to 3.8 %). On the other hand, the offers A_a and A_c, which do not participate in the overload, increase their loss to only 3.3 % (or 1.9 % with 92 + 4 lines).

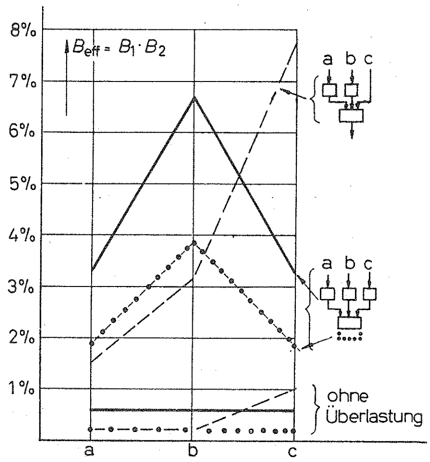

Fig. 13. Effective losses in groupings A and B in Fig. 12, on the one hand with normal load and on the other hand in the case of the direct route b being overloaded by 46 % ($\alpha_1 = 35/24$). (ohne Überlastung = without overload).

Already from this example it can be seen that:

1. Very large increases in losses in the last choice route are already very easily possible with relatively small overloadings of a direct route. The effects of such an increase in losses on directly carried basic traffic are frequently intolerably severe.
2. Last choice routes should, therefore, be fed only with overflow traffic and never in principle with basic traffic at the same time (not even for the sake of a small saving in lines).
3. If the loss of the last choice route increases by the factor λ_2, the effective loss also rises by at least the same factor.
4. If, therefore, the effective loss B_{eff} is to be kept tolerably small in the case of overload, it must be made extremely low for normal operation!
   This end is most economically achieved by hunting over not one but at least two high usage routes in each transit exchange before the call concerned overflows to the last choice route.

3.8. *Variable Routing Plan*

If the requirements discussed in the preceding sections are fulfilled, a variable routing plan — for the "more perfect" utilization of trunk groups — is obviously no longer urgently necessary. It could merely offer increased reliability in the event of failure of heavily loaded international cable routes or radio links. For this purpose, however, the following solution would also be fully adequate and it would not necessitate any worldwide exchange of traffic data and current loads (as is also being discussed at the moment! [14]).

It would suffice in important centers of transit to measure the traffic and load structures of all incoming and outgoing trunk groups in the transit exchange by the aid of a small, probably commercial digital computer and to evaluate such data continously on a statistical basis. Then with the help of such statistics the computer can in the event of overload — and only then — bring into operation one of several previously prepared alternative routing programmes.

Another and indeed somewhat more expensive possibility would be for the computer itself in the event of overload to calculate a new routing programme in accordance with prescribed guiding principles. A certain limited interplay of question and answer with a few neighbouring CT's may sometimes be necessary for this purpose, so as to obtain the agreement of such CT's to the change of programm.

A continous exchange of traffic data between all the CT's in a worldwide network and a continuously variable routing for the highest possible utilization of the network might prove a very poor solution for several reasons. Two of these reasons may be mentioned:

a) This method leads to the spares in the last choice routes, which are obviously quite indispensable for cases of overload, being neglected in favour of a perfect maximum utilization of all trunk groups.
b) This method presages a separate data network for the continuous transmission of the traffic parameters and the destination information between the CT's. The routes, which are traversed by the destination data and the data for the routing control in the network, may be entirely different from those routes, over which the connection concerned is ultimately set up.
   On the range of influence of a fault in such a central data network — or in its highly centralized data processing equipments — there are at present no sort of investigation results available. The results obtained in Section 3 of this article (see the overflow factors and the overload factors) give rise, however, to the fear that in the event of overloads in the speech network or even of faults within the separate data network the perfection of an international routing, highly centralized in this manner, might in certain circumstances have to be expensively purchased at the cost of worldwide traffic restrictions.

Finally, it should also be borne in mind that in the event of international political tensions a separate international data network might offer the possibility of paralyzing the long-distance traffic of other countries by the systematic feeding in of certain destination and control information.

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