DISCUSSION RECORD
Session No. 42 – NETWORK PLANNING

PAPER No. 421
Authors: P A CABALLERO and F DIAZ

Question by J FUREN WIDER
1. How would you take into account the switching cost where switching machines usually have a cost expressed as
   \[ C = BxN \]
   where \( N \) = number of lines (or trunks)
   \( B = \) cost per line (or trunk)?

2. How would you take into account a non-linear cost of trunk routes due to different kinds of trunk facilities such as analog trunks, and digital sharing the same route?

Answer
For the sake of simplicity we have presented the method assuming linear cost.

We have developed in our laboratories a computer program of which the basic was described in a paper presented at the ITC 6 in Munich. In the program, that assumes busy-hour coincidence, costs are defined as follows:

1. Switching Costs
   \[ S = A + BxN + CxT \]
   where \( N \) = number of circuits (junctions)
   \( T = \) traffic passing through the switching center.

2. Transmission Costs
   \[ \text{cost/junction} = \text{number of junctions} \times \text{cost per junction and km} \]
   Cost per junction and km is a non-linear function of the number of junctions. Different curves can be assigned to different routes. With this cost definition components of the gradient vector can be obtained. The general methods remain the same.

Question by W LÖRCHER
I should like to ask you whether you have made already a computer program of your optimization procedure?

If yes, can you give some results?

Answer
The method has not yet been programmed. However, it is interesting to say that we have developed a computer program for junction networks optimization with busy-hour coincidence by using the same basic idea (use of the gradient algorithm and Fibonacci minimization). This program is now operational.

Question by W LÖRCHER
1. For your optimization procedure you are considering principally mean and variance as the characterizing figures. How do you calculate in Fig. 6 of your paper the variance of a traffic flowing from C to D' in both cases originating in node A?

2. Did you consider also the case that - e.g. in node C - additional traffic is offered from other nodes?

3. You define the quality of service as
   - final trunk group blocking or
   - exchange to exchange blocking respectively
   (Section 1.4).

In your general equations (e.g. equation 3.3) the partial derivatives are independent of these probabilities of loss. Is this correct in both cases?

Answer
1. The following assumption is made:
   \[ \nu_1^1 = \nu_1 \nu_1^1 / \nu_1 \]
   \[ \nu_1^1 = \nu_1 \nu_1^1 / \nu_1 \]

   (This refers to Fig. 6 of the paper.)

2. Yes, it is considered.

3. Derivatives (\( \psi_1 \) and \( \psi_2 \)) are not independent on the quality of service criteria used. Depending on the criteria used, they are computed in a different way. In case of "final group blocking" derivatives need to be computed taking into account that the admitted lost traffic is a function of \( M_1 \), that is, the offered traffic to the considered final route.

In case of "exchange to exchange blocking" the derivative are computed at a constant value of the admitted lost traffic.

PAPER No. 422
Author: A PARVIALA

Question by A LOTZE
On page 2 of your paper, Moe's principle is formulated as
   \[ F_n = H \frac{\text{cost per trunk}}{\text{dollars per erlang}} (F_n < 0) \]

Without a comment one reads from this formula, "incoming money per erlang > cost per trunk".

This would be too favourable! Do you refer to erlang-hours per year and trunk costs per year?

Answer
In the formulas the different factors are to be taken from the same point of view, so that the dimensions fit together. So is clearly in the formula (5), where
   \[ F \text{[erlang-hours per extra circuit and year]} = H \text{[dollars per extra circuit and year]} \]

But in formulas (1), (2) and (3) absolute values are handled, for instance belonging to a busy hour. Thus the formula (3) reads
   \[ F \text{[erlangs per extra circuit]} = H \text{[dollars per extra circuit]} \]

Here the w has nothing to do directly with the call fees payed by a subscriber.

PAPER No. 423
Author: E SZYBICKI

Question by S MUNSHI
1. Do you have any recommendations regarding determination for H, i.e. the probability of reattempt given the previous attempt has failed?

2. Please explain why \( (1 - P_1) \) appears twice in the product defined on the r.h.s. of equation 6. Same question relates to equations 7 and 8 and I think the answer/explanation would be the same.

3. I feel that it is easy to include rejection due to abandon calls. Any comments?
1. In my study I have assumed the probability of re-attempt, when the previous has failed, to be constant. Studies performed by P le Gall and by A Myska show that this is not the case. It varies with the number of attempts made, and probably also is different for different countries. However, the value chosen in my paper Ho,8 gives a well to values observed in several European countries.

2. The expression for total rejection should reflect the real system operation. In this particular case the call has to be identified by the common control system. On this occasion it can be rejected due to time out with the probability $P_j$. After dialling the register has to be set up to the common control system for transfer of information. Also here the call may be rejected due to time out with the probability $P_j$.

3. I agree. I assume that the call has first to be identified by the CCS. On this occasion it may be rejected due to time out. After the dialling the Reg has to be set up to the CCS for the same call and here again the call may be rejected due to time out.

In case when different time outs are used for identification and for communication to CCS, one of the $P_j$ should be replaced by separate variable.

Question by T RÖGEBERG

You have presented an interesting paper on a method for the determination of overload ability in a particular type of systems. You have carried through approximate calculations of quite a complicated kind, and then used simulations to control the results (and with good agreement indeed). I cannot help feeling, however, that in many cases, one could arrive at results quicker and easier by using simulation alone. Would you kindly make a comment on this point?

Answer

The speed of a simulation depends on the programmer, the computer and the simulation model used. For overload investigations the simulation model is rather complicated, it takes into account the entire exchange, including the subscriber behaviour. The simulation time for a single traffic point in my simple example is greater than the time needed for calculation of corresponding results. The system studied in my example consists of a very simple network and a single common control device. As the simulation time normally increases rapidly with increasing complexity of the system (connecting network, CCS), while the increase of calculation time can be held on a moderate level, we can conclude that calculations here to be preferred. Simulations should be used for checking purposes only.

Question by H WEISSCHUK

In the paper you give a study on a simple telephone system with internal traffic only. Can you please comment how to get the functions which characterize the switching system, e.g. $P_1$, $P_2$, $P_3$, also for systems with external traffic.

Answer

It was not my intention to study the incoming traffic so I assumed it to be very small during the period studied. Consequently I do not specify the equipment necessary for handling of this type of traffic. The congestion formula for incoming traffic will depend on the connecting network used. The function used is the corresponding function $R_1$. The function $R_1$, corresponding to $P_1$, depends on the strategy for incoming calls, for instance whether they will be assigned to priorities or not. In my paper I discriminate the two functions $P_1$ and $R_1$.
some minor approximations in the subscribers' network.

2. A method for optimizing extensions in the subscribers' network has been given by Y. Rapp. (See ref. 7.) The proposed infinite site costs should be regarded in connection with 4.2e) rather than with Fig. 4 which illustrates the general problem.

Question by W. KRÄMER
For the determination of the distances between exchanges and from an exchange to a subscriber two methods (hypotheneuse and cathetic) are given.

Could you please give a comment on the background, that means, which method becomes suitably applied to which cases?

Answer
In applications of the described optimization method to local networks the method of calculating distances will be chosen with regard to the actual layout of the area. Thus, for an area with pronounced right-angled street pattern, method 2.3.1 should be used, and for other patterns as well as for rural areas, method 2.3.2 is preferable.

PAPER No. 425
Author: T. OHTA

Question by W. LÖRCHER
In section 2 of your paper you consider the sum of outgoing and incoming traffic in the case, when 24 hours of time difference exist between the hourly traffic distributions (basic patterns).

Please can you explain why you calculate the sum by means of convolution and not the arithmetic sum of these two traffics?

Answer
The hourly distribution of eq (1) or eq (5) is not the sum of the incoming and outgoing traffic, but is obtained by means of convolution of the so called convolution functions of the calling and the called sides. Therefore, it is of course possible to obtain the hourly distribution of the bothway traffic as the sum of incoming and outgoing traffic distribution separately obtained as in eq (2) and eq (3).

PAPER No. 426
Authors: Y. NAKAGOME and H. MORI

Question by D.G. HAENSCHEK
I would like to draw the authors' attention to the fact that a similar hysteresis phenomenon can also be observed during switching congestion which remains after the offered load drops back to normal. However, based on simulations we have not been able to demonstrate a significant decline in network efficiency when offered loads exceed engineered limits in hierarchical networks without switching congestion. I would like to ask if the authors believe their results to be applicable to correctly dimensioned hierarchical networks, especially in regard to loss in network efficiency during overloads without the presence of switching delays?

Answer
Answer is "no". In the hierarchical networks, routing is rather simple and is well controlled. That is, the overflows are allowed only to a certain direction. This is the reason why such a hysteresis-like effect doesn't occur in the hierarchical networks.

Question by L. A. GIMPELSON
I am concerned about your conclusion that flexible and therefore circuitous routing is "very effective" for networks of small trunk groups. If graphs had shown the distribution of number of links per call as loads increased, it is probable that it would have been seen that the probability of blocking per link was so high (note much higher blocking for K=10 than K=100 in figure 5) that the probability of setting up multiple-link calls became very small. (In this sense thin nets may be self-limiting.) Do you have this data?

Further, simulations which do not assume independently blocked links and negligible control times have shown hysteresis-like effects for "thin" networks as well. Also the width of this hysteresis was considerably wider than shown in your figures. I hope you will continue this analytic approach without these two assumptions, as a better balance between analysis and simulation is needed in this area.

Answer
In the first part of your question, you pointed out that the probability of setting up multiple-link calls is small. I have no exact data of this probability in the general case, but it is easy to calculate it by our theory. Today, we will show a very simple example. Let's consider the connection between station 1 and 2 in the network shown in Fig. 1. In this connection, the direct path is \( X_1 \) and alternate route is \( X_1 X_2 \). If we assume that the blocking probability of each link is \( b \), then the probability \( P_e \) that the connection through direct path succeeds is \( b^2 \). The probability \( P_a \) that direct path is busy and alternate route is available is \( b(1-b)^2 \). Therefore, the ratio of \( P_a \) to \( P_d \) is

\[
\frac{P_a}{P_d} = \frac{b(1-b)^2}{b} = (1-b).
\]

This is plotted in Fig. 2. \( P_a/P_d \) has the maximum value when \( b=0.5 \). If \( b \) is extremely large, say larger than 0.5, the network will be in perfect congestion. \( b \) is not so large, say smaller than 0.5, \( P_a/P_d \) increases as \( b \) increases. Therefore, overflow to the alternate route increases as the network is heavily loaded.

To the second part of your question (comment), I think that further analysis and simulation in more general case is desirable. Since it is very difficult to analyse the more general models because of the increase of arguments, we intend to make simulation and continue our studies.

PAPER No. 427
Author: R. J. HARRIS

Question by W. LÖRCHER
In your paper you compare three optimization strategies for alternate route networks. You assume the number of trunks as a continuous variable and the probability of loss for an origination-destination pair as a prescribed value.

1. In your optimization conditions of eq. (8), (9) and (12) the probability of loss is - as far as I can see - not included. Can you explain this to me?

2. In the example of section 4 you show differences between the three strategies which are smaller than 1%. Have you found the same result also for your more realistic systems (page 5)?

3. Have you also determined the total costs under the condition that the number of trunks per group must be integer?

Answer
1. In order to determine the equilibrium conditions...
for the problem described by equations (7) in the paper, the following approach is used by Khun and Tucker in their paper (See Reference 9).

From the Lagrangian function

$$\mathcal{L}(h_j, \lambda) = C(j) + \sum_{k=1}^{n} \lambda_k \left[ (1-B_k)x^k - \sum_{j=1}^{n} h_j^k \right]$$

where \(\lambda\) is the n-vector of Lagrange multipliers

The Khun-Tucker optimality criteria for a stationary point are

(i) \(\frac{\partial \mathcal{L}(h_j, \lambda)}{\partial h_j} \leq 0\) and \(\frac{\partial \mathcal{L}(h_j, \lambda)}{\partial h_j} = 0\) and \(h_j^k \geq 0\)

for \(j=1, \ldots, m_k\) and \(k=1, \ldots, n\).

(ii) \(\lambda_k = -\frac{\partial \mathcal{L}(h_j, \lambda)}{\partial h_j^k}\) for \(k=1, \ldots, n\).

From (i) we obtain the constraint common to each type of optimization considered (i.e., System, User, Game Theoretic).

\[ \sum_{j=1}^{n} h_j^k = (1-B_k)x^k \quad k=1, \ldots, n \]

From (i) we obtain \(h_j^k \geq 0\) for \(j=1, \ldots, m_k\) and \(k=1, \ldots, n\)

Consider the two cases

(a) If \(h_j^k > 0\) then equation (x) implies that

\[ D_j^k(h) = \frac{\partial \mathcal{L}(h)}{\partial h_j^k} = \lambda_k \quad j=1, \ldots, m_k \quad \text{and} \quad k=1, \ldots, n \]

(b) If \(h_j^k = 0\) then equation (xx) is automatically satisfied, and thus from equation (x) we obtain

\[ \lambda_k = D_j^k(h) = \frac{\partial \mathcal{L}(h)}{\partial h_j^k} \quad j=1, \ldots, m_k \quad \text{and} \quad k=1, \ldots, n \]

and hence we obtain the result of Theorem 1 in the paper. It will be noted that in differentiating \(\mathcal{L}(h_j, \lambda)\) with respect to the chain flows, the Origin-Destination grade of service \(B^k\) was cancelled out, as it was taken to be constant, and thus it does not appear in the optimality conditions.

Similar arguments can be used to explain why the grade of service \(B^k\) does not appear in the relations (9) and (12) of the paper. The constraint

\[ \sum_{j=1}^{m_k} h_j^k = (1-B_k)x^k \quad k=1, \ldots, n \]

must be satisfied by each type of optimal solution and this is the only point where the grade of service \(B^k\) is required.

2. It is certainly true that the small network considered in section 4 of my paper has "optimal" solutions which only differ by about 1%. It was also reported in Section 6 that for a small 4 exchange network, all three optimizing principles were equivalent. However, when the User optimizing principle was applied to the Adelaide network, it was found that the System and User optimal solutions differed by approximately 14%. A close investigation of the User optimized solution revealed that this solution made extensive use of the first choice routes and failed to recognize the advantages of bulking traffic in the alternate routes.

It should be noted here that it was not my intention that a User optimized solution should replace the System optimized solution. Studies of User optimization revealed that the User optimized solution to a network can be located very rapidly, and I hoped to obtain the System optimized solution by first obtaining the User solution, and then iterating from that point to the System solution, thus achieving a considerable saving in computer time.

3. I have determined the total costs for integer numbers of trunks in the Adelaide network and I have found that the total costs for the two types of optimization (System and User) have increased by approximately the same magnitude. (A change of approximately 1% in overall cost is produced.) It should also be noted that the relative positions of the integerized solutions have remained the same for the practical network, i.e., Integer User Solution, Integer System Solution.