CONTINUAL CHECKING OF ROUTE LOADING IN TELEPHONE TRAFFIC

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ABSTRACT

Although the busy-hour Erlang figure is used for dimensioning telephone routes, it is seldom possible to base route enlargements on measured traffic. As enlargements take time - often months, or even years - estimates have to be employed to forecast when the lines will become fully loaded and require enlargement. To ensure service up to the approved standards, the Erlang figure should be measured with sufficient frequency on all the routes under survey. Ordinary Erlang measurements are expensive and time-consuming, so results are obtained too infrequently and are often out-of-date when they are needed. What is required is a method of checking that provides the minimum continual advance information necessary for route enlargements, and is cheap and simple enough for simultaneous use on all routes.

One interesting possibility is to register the total duration of all traffic peaks. Described below is a system of measuring traffic that has been tried out by the Helsinki Telephone Company.

1. BASES OF THE METHOD

The principle of the method is to register all the periods during which the number of lines occupied simultaneously exceeds a given load limit $x_0$, and to measure the total duration of these periods in some suitable unit of time, such as a month. The value of $x_0$ is fixed according to the properties of the route and to the desired "Sensitivity of measurement" in such a way that the value measured will exceed $x_0$ in sufficient time before the enlargement becomes necessary. Given a suitable value of $x_0$, the results are more reliable than those based on simple blocking measurements, because $x_0$ is exceeded at points in the traffic distribution that are statistically more significant than blocking.

2. PRINCIPLES OF EQUIPMENT USED

On each route is installed a bridge circuit in which the unknown resistance is formed by the registration resistors (20 kilo-ohms) of the lines under survey, connected in parallel, and the known resistance is $R_v$ (Fig. 1). Two other branches of the bridge are formed of 10 kilo-ohm resistors. The indicator is a transistor $T_3$. 
If the number of registration resistors connected - in other words, the number \( n \) of lines occupied - is so small that \( 20 \text{ kilo-ohms} > R_v \) (load-limit resistance), the potential of the base of transistor \( T_3 \) is positive to the emitter and the transistor is non-conductive. When \( 20 \text{ kilo-ohms} < R_v \), the potential becomes negative and the transistors \( T_3 \) and \( T_2 \) conductive. This makes the potential of the base of the transistor \( T_1 \) negative, so that it becomes conductive and actuates the counter \( Z \).

The measurement is made by sampling: the circuit is closed at suitable intervals, such as once every six seconds (\( t = 6 \text{ s} \)), and the equipment is ready to register. If \( R_v \) is set to correspond to \( x_0 \) resistors connected in parallel (\( R_v = 20 \text{ kilo-ohms} \)), for instance, the contact \( a \) is closed and the counter \( Z \) registers a pulse as soon as \( x_0 + 1 \) lines are occupied simultaneously.

The registration resistors are fitted permanently at the exchanges. Each route thus has a counter-and-checking circuit, the resistance \( R_v \) of which is set according to the desired load limit \( x_0 \). A single time pulse generator \( a \) can be used for several counting devices.

If one wants to get a detailed picture of the traffic and correspondingly read the counters daily or hourly, the reading may cause too much work. When \( t_2 \) has functioned 14 times (for 2 weeks), a zero command is transmitted from the pole \( t_3 \) to the counter \( C_3 \), upon which a new 14-day measurement cycle begins automatically. If \( C_3 \) reaches a reading of 5 within the measurement cycle, the lamp lights up when the thyristor \( T_4 \) becomes conductive by receiving a positive voltage in its base. The thyristor remains conductive until it is turned off by pressing the button \( P_1 \). Resetting the lamp during a measurement cycle does not halt the measurement.

The functioning of the device in Fig. 2 can be varied by altering the time-switch controls \( t_1 \), \( t_2 \) and \( t_3 \) and by resetting the lamp-connection limit in the counter \( C_3 \) as desired. If \( t = 6 \text{ s} \), the total time when the limit \( x_0 \) is exceeded, is 24 minutes; if \( t = 7.5 \text{ s} \), the corresponding time is 30 minutes.

If desired, a smaller counter can be used instead of a 240-counter. Using a single 4-bit binary counter would reduce the cost of the equipment considerably. In this case, the sample interval \( t \) would be 2 minutes.
Blocks 7493 are 4-bit binary counters
IN = input
A, B, C, D = binary outputs after the 1st, 2nd, 3rd and 4th flip-flop
R0 = reset zero input. If R0 = logic one, then all the outputs A, B, C and D are returned simultaneously to a logic zero state
Z₁ = measuring input
P₁ = push button for resetting the lamp signal
T₁ = 1-hour information
T₂ = 24-hour information
T₃ = 2-week information

Fig. 2 Automatic system for checking counter pulses. When the traffic reaches a given intensity, the alarm goes off.

A burning lamp means that, during the observation period T₃ (two weeks containing ten normal weekdays), there have been at least five days on which the number of lines occupied simultaneously has exceeded x₀ during more than half of the busy hours. The device registers the first full hour of a day on which x₀ has been exceeded for at least 240₃. If no such hour occurs during a day, no pulse for that day enters the memory.

The equipment functions in 14-day cycles, so the lamp can be inspected and turned off every other week if necessary. Naturally, the lamp can be inspected at longer intervals; it does not need to be checked at fixed times.

By changing the time-switch programme, the equipment can also be adjusted to survey only given hours of the day and given days of the week. This enables the principles of measurement recommended by CCITT to be followed more closely.

3. TRAFFIC-THEORY ASPECTS

Hourly traffic is checked according to the principle shown in Figs. 3 and 4. Fig. 3 depicts the intensity of the traffic as a function of time and Fig. 4 the traffic distribution during the same hour. If the traffic is distributed equally to either side of x₀, this means that at least x₀ + 1 lines have been occupied for a total of 30 minutes during the hour. If the distribution is symmetrical, it also indicates that the traffic mean y = x₀.

Fig. 3 Traffic intensity as function of time.
Shaded areas: load limit exceeded.

Fig. 4 Location of load limit x₀ in frequency distribution of traffic intensity during the hour illustrated in Fig. 3.
The more days there are on which the busy-hour traffic limit is exceeded, the greater the busy-hour traffic mean becomes. A special case is when half of the days are overlimit days (not counting Saturdays and Sundays). In this case it can be assumed that the busy-hour traffic mean is approximately $x_0$.

The traffic values mentioned above refer to the moment at which the traffic exceeds the intensity limit in its normal growth. In other words, $x_0$ should be such that, once it is exceeded, the time has come to begin enlarging the route. If it is assumed that the busy-hour traffic follows a Poisson distribution, it is also possible to estimate the route blocking at that moment.

4. MEASUREMENT RESULTS

Fig. 5 shows the mean traffic intensity for all full hours between 8.00 and 16.00 h on a certain route, and the times $t_{x_0}$ per hour that $x_0$ exceeded 53. The lines N numbered 100, the accessibility $k$ was 20 and the measurements were made for 320 hours between 8.00 and 16.00 h from 7th July to 29th August 1969. It can clearly be seen that the swarm of dots passes through the points $x_0 = 53$ and $t = 30 \text{ min}$. This means that, when $y \approx x_0$, $x_0$ is exceeded for 30 minutes an hour. Very similar results were obtained for the other routes.

Fig. 6 shows the situation on another route, on which the traffic $y$ was under the checking limit $x_0$ but was steadily growing, so that it was about to reach the critical value of $x_0$. Fig. 7 illustrates the sensitivity of the method: as soon as the daily peaks attain the value of $x_0$, the number of Z-counter readings begins to grow. The diagram shows the number of times $t_{x_0}$ per day, on which $x_0$ is exceeded, the daily traffic means $\bar{x}$, and the traffic during the busiest hour $y$. The counter readings $(t_{x_0})$ indicate very clearly when the busy-hour value $y = x_0 = 85$ is being approached. A similar indication would have been obtained if the counter had been read once a week or month.
Fig. 6 Here the hourly means of traffic intensity are under the load limit $x_o$, but $x_o$ is on the point of being exceeded as the traffic grows.

Fig. 7 The method presented in this article follows the real situation with great sensitivity, as can be seen by comparing the lower histogram depicting $t_{xo}$ with the upper histogram and dots depicting conventional measurements.
5. SUMMARY

This simple method can be used to check on the growth of the load on telephone routes. The traffic peaks occurring during a long period are the particular subject for this checking.

In general it may be sufficient to read the counters a few times a year or once a month. The equipment does not actually measure the traffic but gives an indication that the traffic has in its normal growth reached a preselected limit value. If one wants to save in the counter-reading expenses, the device can be completed with e.g. the previously described electronic counter which gives an alarm when the limit value has been reached. At the same time it is possible to program the load checking so that it corresponds to the CCITT recommendations or other fixed standards. Provided the approximate rate of growth is known, this method indicates in good time when enlargements should be started. The equipment is simple to use and does not call for special personnel.