ABSTRACT

The provision of services in telecommunications involves a great number of actions. These are the causes for the level of quality of the service provided. Are all technical actions performed? If they are performed, how complete is its scope and is it reasonable the delay between the beginning of a problem and the respective solution? Taking as a start point the Theory of Repeated Calls the work develops concepts such as spurious traffic, fundamental cause of spurious traffic, apparent cause of spurious traffic, and so on and gives some examples to make explicit a part of the more relevant culture concerning actions that maximize the productivity of the Telecommunications System.

1. INTRODUCTION

The executives that manage Telecommunications Operating Companies coordinate a large number of activities aiming at fulfilling the excellence in providing telecommunications services (1). New ways are been opened and the field of action of the specialities become more and more limited, running the risk of missing the overall view. The development of specialities concerned with systems such as operational research, traffic, reliability theory and applied statistics are making it possible to obtain more powerful models for telecommunications systems as a whole. This work is an attempt to synthesize the relationship between the various engineering specialities in order to improve NETWORK COST EFFETIVINESS.

2. PRODUCTIVITY

The maximum productivity of a telecommunications system would be achieved if the rate indicated below would be the maximum economically-wise.

\[ \text{SNEU} = \frac{\text{A}_{0k}}{\text{A}_{C}} \times 100\% \]
SNEU - switching network efficient use

A_{ok} - average rated conversation traffic per hour, considered all the hours in a fiscal year of an operating company.

A_{c} - rated traffic capacity

3. SPURIOUS TRAFFIC

Modern traffic theory created the concepts of efficient and inefficient traffics(2). The first one is the one resulting from completed calls, while the second the complement for the total traffic. Each switching section of a good quality system, in local service, should show losses of 1% for congestion in final route, 0,5% for internal congestion and 0,1% for equipment failure. Looking at the local system the subscriber should perceive don't answer (DA) of 6% and busy line (BY) of 18%. These losses added to the time spent on leading the completed calls constitute the inefficient traffic having as a consequence that a good quality system should complete about 70% of the attempts in local service and about 60% of long distance calls (2). If any of the causes of losses start to occur with an abnormal frequency, the inefficient traffic starts to increase amounting to an abnormal or unadmissible value. This unadmissible inefficient traffic we call spurious traffic

4. SNOWBALLING EFFECT

The telecommunication system is a queuing network. If, due to a congestion or failure, holding times increases at the incoming node, each i node holding time is increased by $\Delta i$, due to a greater holding time of the server node and $\Delta i+1$ for waiting more for the server node. Loops of positive feedback of traffic are formed in several points of the network resulting in what we usually call the SNOWBALLING EFFECT. The system normally doesn't crash due to the fact that as the OK* rate decrease, increases the abandonment rate (2).

Figure 1 shows upper limit straight lines which indicates the physical impossibility to maintain the volume of completed calls as OK decreases (3).

OK = rate of completed calls.
5. FUNDAMENTAL CAUSE OF SPURIOUS TRAFFIC

Spurious traffic is an effect. It is a parcel of the space-time used with no reason at all. The main purpose for eliminating it has to deal, of course, with its causes. The efficiency of our actions depends on going directly to the fundamental cause and eliminating those works acting on apparent causes. In order to make this concept clear, consider the following field case.

In 1972 a great congestion took place at the control devices of a switched network. The mean nominal holding times of senders and local registers was supposed to be 5s and 15s. The problem was considered to be equipment underdimensioning. A big expansion was contracted and several millions of dollars were invested. A technical analysis revealed that even the slower MF cycle did not justify mean holding time of senders greater than 4.0s on local completed calls. Only a very serious problem might increase the time for the value measured. Six months in field research revealed that the time out of an MF signal in local calls did not have to last more than 5s and in long-distance calls no longer than 15s. The time out adopted at the network was of 30s. Each temporized call would hold both register and senders about 30s or more. A gross correction was made, in 10 minutes, in all the exchanges at the same day, lowering the time out to 15s. The resulting income increase is shown in Fig. 2 (4).
The mean holding time immediately fell to the 6 and 15s range which became the new parameters for dimensioning the senders and registers respectively. We achieved then savings of about US$100,000.00 in the implementation of each new 10,000 terminals exchanges.

Apparent cause: Control devices congestion
Fundamental cause: Oversized time out

Notice how, a limited approach to traffic engineering, without considering the switching aspects involved, may lead to the loss of money and efforts.

6. FAMILIES OF FUNDAMENTAL CAUSES

After holding three seminars on Network Management for about 200 specialists of the TELEBRAS system, we arrived to the conclusion that the FUNDAMENTAL CAUSES FOR SPURIOUS TRAFFIC belong to one of the following five families:

- BAD BEHAVIOR OF USER
- EQUIPMENT FAILURE
- DESIGN ERROR
- HUMAN FAILURE
- EVENTUAL OVERLOAD

6.1. DESIGN ERROR

Design errors may be due to dimensioning, reliability, programming and circuit designs. In the electromechanical technology, the programming level is very small when compared to the one employed in SPC exchanges. Under
that technology, programming takes place through jumpers including mainly registers, senders, markers and translators. There are few records of programming errors in electromechanical telephone exchanges. The new generation, on the other hand, with stored-program control carries with itself, together with tremendous operational advantages, all the quality problems of a software design. A great effort is being made these days in the whole world to improve the quality of software design (5) (6). Mainly concerning SPC exchanges with a more centralized control, it is large the number of total outages due to software failure (7).

6.2. HUMAN FAILURE

Whenever professionals with operational experience in telecommunications get together, it is possible to hear various cases of little disasters caused by inadequate technical intervention. Most part of the examples are concerned with action. Recently, by employing computers at the maintenance administration, it was possible to quantify human failure due to omission. Figure 3 illustrate the case. Therein, it is indicated, for each maintenance technician, the estimate of probability of localizing a failure considering that a report was handed.

7. ACTIONS

The main purpose of TOTAL SYSTEM MANAGEMENT AND ADMINISTRATION
(TSMA) is to eliminate the FUNDAMENTAL CAUSES OF SPURIOUS TRAFFIC. This means that certain actions, once effectively taken, assure the coverage of the desired main purpose. Figure 4 shows a list of ACTIONS and their connection to the family of FUNDAMENTAL CAUSES.

The action cycle covers three stages: detection, location and removal. At the detection stage, one gets to know about the existence of a cause for the spurious traffic; in the location one, the exact point it is occurring is located and at the removal one, the cause is eliminated.

The action may be preventive when the cause of the spurious traffic is removed before it comes up and corrective in the opposite case. For instance, a good congestion forecast algorithm may indicate the expansion of a route and avoid that systematic overload occur (8).

The complete cycle of an action may last from a few seconds up to a few years. Figure 5 shows the length of the various ACTIONS already listed.

**RELATIVE LENGTH OF ACTIONS**

- Network Management
- Maintenance
- LCS Management
- Traffic Administration
- Personnel Development
- Design Correction
- Maintenance Administration
- Users Development
- Modernization
- Expansion

Figure 5
the broken line indicates that there are causes which are not covered by the diagnose system or that the cause is well-known but it is decided to live with it.

7.1. NETWORK MANAGEMENT

The main enhancements obtained with the introduction of 4ESS switching systems are the three types of automatic overload control implemented (9). It is possible today to take automatic protective actions at an individual level for switching and transmission facilities. The attempts sequence and successful attempts, the sequences of holding times in communication circuits, the sign bits of the codec in A/D conversion and the absolute levels of voltage provided by the codec of digital SPC; all these sequences may be treated as Bernoulli attempts sequences and derive an automatic blocking parameter provided by:

\[ BP = \left[ - \frac{\ln(N_p + 1)}{\ln(1 - p)} \right] + 1 \]

\([x]\) - greater full number greater than "x"
N - number of attempts per year
p - probability of "1" in the Bernoulli attempts sequence

The automatic blocking of individual killers is a protective action of Network Management. Some of the sequence mentioned above, has been automatically controlled in Brazil since 1979 in hundreds of electromechanical exchanges and more recently in the SPC TROPICO digital exchanges.

7.2. MAINTENANCE

In 1977 it was proved that the random variables average holding time, efficiency and average efficient time respect the Strong Law of the Large Numbers and the Central Limit Theorem when the switching units involved are statistically identical; for example, the trunks of a single route. For each group of identical units in an exchange it is then possible to define:

a) a robust estimate \( \hat{\mu} \) for the expectation
b) a robust estimate \( \hat{\sigma} \) for the standard deviation
c) an acceptance interval \([ LI, LS ]\) considering:

\[ LI = \hat{\mu} - \frac{\alpha_1 \hat{\sigma}}{\sqrt{n}} \quad \text{and} \quad LS = \hat{\mu} + \frac{\alpha_2 \hat{\sigma}}{\sqrt{n}} \]

A certain unit "j" shall be considered suspect due to bad performance if: \( \hat{\mu}_j \notin [ LI, LS ] \)

. For time variables \( \hat{\sigma} = \hat{\mu} \)
. For the efficiency variable \( \hat{\sigma} = \sqrt{\hat{\mu} (1 - \hat{\mu})} \)
. n is the average number of busies in the group.
Note that \( \hat{\mu} \) is a quality estimate for the supervision period considered. The interval \([L_I, L_S]\) will always be the possible quality and is inversely proportional to the amount of information \( \sqrt{\frac{M}{n}} \). This algorithm broadened the coverage (7)(11)(12) of the diagnosis by detecting the "CONVERSATION KILLERS" and detecting temporary failures of relative low frequency (Table 1) (13) (14). About a million units are supervised nowadays in Brazil with these algorithms.

### PERFORMANCE EXCEPTIONS

<table>
<thead>
<tr>
<th>#</th>
<th>PEG COUNT</th>
<th>MEAN HOLDING TIME</th>
<th>EFFECTIVENESS %</th>
<th>EFFECTIVE MEAN TIME</th>
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<td>37</td>
<td>248*</td>
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</tr>
</tbody>
</table>

* EXCEPTIONS

#### TABLE 1

8. CONCLUSION

The success in creating a broad NETWORK MANAGEMENT, as stated at the TELECOM 87, shall mean the constitution of brain to the Telecommunications System and a greater probability in overcoming one of the biggest challenge of the next decade (15). The development of NETWORK MANAGEMENT will point out the importance of a new system engineering that joins the classical equipments interworking with applied mathematic models covering traffic, reliability, dynamic and real time statistical quality control, logistics, and so on.

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