TRAFFIC ADMINISTRATION IN THE BRAZILIAN NETWORK

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ABSTRACT

The Telecommunication Company's final objective is to render good service to its users, in an economic manner, that will lead to reasonable rates and an adequate return on investments made.

In order to attain this objective, plant equipment must be as suitable as possible to the volume of traffic. Thus, it is essential that, within the Company, there be a system of traffic administration, so that, by means of monitoring the central switching offices, it may be possible to detect distortions from the optimal conditions and allow the same to be corrected.

The implementation of a systematic traffic administration policy in Brazil, went into effect from 1979 on, coordinated by the telecommunications holding company, TELEBRAS. The results already obtained on a national scale, and by TELEMIG in particular, has made a marked contribution to improving the quality of the service.

1. INTRODUCTION

The telecommunications organization in Brazil is composed of 28 state companies, responsible for local and intrastate services, and another company, EMBRATEL in charge of the interstate services.

These companies constitute a system led by Telecomunicações Brasileiras S.A. - TELEBRAS, a holding company, directly connected with the Ministry of Communications.

Figure 1 shows this system within the framework of the Brazilian telecommunications system.

Upon setting up TELEBRAS in 1972, Brazil had only 2,380,000 telephones (2.4 telephones per hundred inhabitants). At this time special stress was placed upon an increase in the number of main stations. Figure 2 shows the growth in telephone density in the Brazilian network during the period of 1972 to 1984.

![Figure 1 - The Brazilian Communications System](image)

![Figure 2 - Telephones per 100 Inhabitants](image)

In 1978, when a total of 5,552,000 telephones was reached (4.9 telephones per hundred inhabitants) the quality of the service rendered became a serious problem. The rate of dial tone delay longer than 3 seconds was 95%, the completion rate was 36.3%, and the rate of equipment blockage and failure was 23.6%.

On the basis of these observations, it was determined that there was a need for a systematic effort aimed at improving the quality of the service, as well as to utilize the plant equipment more efficiently, through the introduction of new operational methods and procedures.

One of the responses to this need was development and implementation of the Traffic Administration System (TAS) in the operating companies.
Traffic Administration and the Program for Reduction of Loss due to the Called Subscriber (LCS), in addition to other programs, were responsible for improving the quality of the Brazilian network service, as can be seen by the changes in some of the indicators shown on the graphs in figures 3 to 8.

2. THE TRAFFIC ADMINISTRATION SYSTEM IN BRAZIL

2.1 Concept

TAS's objective is to monitor and control telephone system traffic flow in order to assure:
- good traffic flow, in relation to the number of facilities;
- efficient utilization of existing traffic facilities;
- maximization of traffic flow capacity;
- quality as uniform as possible in the service rendered to the various users, from the point of view of traffic flow;

As to philosophy, TAS can be divided into two phases:

A preventive phase carried out on the basis of short term (1 to 2 year) traffic forecasts, with the objective of foreseeing congestion and under-utilization of equipment, far enough in advance to program preventive action in order to avoid these problems materializing.

A corrective phase, that fundamentally encompasses action required to eliminate the actual congestion verified.

2.2 TAS organization

TAS, according to the characteristics of its activities, is organized in two operational groups:

First Group - Encompasses the job of continually monitoring the system, and actions of a preventive and corrective nature.

This group includes the following activities:
- acquiring, checking and summarizing traffic data and quality of service indicators;
- forecasting short term (1 to 2 years) traffic data;
- analysing measured traffic data and forecasts;
- assignment of main stations and subscriber's telephone numbers;
- evaluation of the degree of traffic balance between switching offices, and its effects;
- definition and implementation of corrective actions to solve problems that either actually exist or are foreseen;
- determination of switching office traffic load capacities.

TAS, in order to make its implementation process easier, was divided into the following sets of functions:
- main station administration;
- traffic administration at local central offices;
- traffic administration at toll center offices;
- traffic administration at toll switchboards;
- traffic administration in trunk groups.

Second Group - This group includes activities that constitute network management.

Network management is the group of activities carried out in real time, with the objective of assuring efficient utilization of existing facilities, when a traffic overload or equipment failure takes place, and maximizing traffic flow capacity in the telephone network.

Networks with alternate routes, and common control equipment, although very efficient when operating under design conditions, suffer rapid deterioration when submitted to traffic overloads. This makes an efficient system of monitoring and control convenient, not to say necessary, so that it may be possible to minimize undesirable effects of most serious traffic overloads and equipment failures. The vital role that the telecommunications network plays, in a country during emergencies, justifies the investments necessary to implement a Network Management System.

At present, only EMBRATEL operates a Network Management System in Brazil, called SSCTC, illustrated in Figure 9. SSCTC is basically a telesupervision and telecontrol system.

The telesupervision function, performed by analysing the conditions of various supervision points in the toll center offices, and by centralized data processing, in the control center. In this manner, it is possible to gain a rapid cognizance of the performance of equipment at these toll center offices and the conditions of traffic flowing through them.

Through the telecontrol function, protective and expansive actions are carried out, such as rerouting, blocking, and announcement machine
At present the SSCTC supervises around 250,000 points at the 33 EMBRATEL toll center offices.

2.3 Supervision Resources

Toll was developed in such a way, that all functions, except network management, could be implemented by utilizing the conventional supervision resources at the mechanical-electrical central offices, that constitute almost the entire Brazilian network.

Nevertheless, in order to keep abreast of developments, both in technology and operational procedures, stress has been placed on the development and production of modern traffic supervision systems, by domestic manufacturers.

The main one of these systems, SITASU, was developed by a state operator company, Telecomunicações do Rio de Janeiro S.A. - TELERJ.

SITASU, as it was conceived utilizes ICUP technology, and in addition to this, incorporates the most recent developments in the theory of repeated calls, in the theory of renovation, and in applied statistics. SITASU, in the functions of traffic supervision and switching, can be organized on up to 3 levels: remote unit, regional center, and system center. The remote unit level can cover up to 16,000 points of data acquisition and 4,000 points for blocking (Figure 9). The Regional Center can take care of up to 16 remote units, and the System Center can take care of up to 16 Regional Centers.

A summary of SITASU’s main new characteristics is as follows:

- Intelligent remote unit, capable of complete local data processing, including finding the busy hour;
- Measuring of efficient traffic in trunks and common control equipment, besides the traditional measurement of occupancy traffic;
- Detection and blocking of killer switches, through algorithms based on the renovation theory.

In table 1, some typical time lags between failures and automatic blocks are shown, for switches whose efficiency is nil, belonging to groups with normal traffic;

<table>
<thead>
<tr>
<th>SWITCH</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marker</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Register</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Junctor</td>
<td>15 minutes</td>
</tr>
</tbody>
</table>

Table 1 - Time Lag for Automatic Block

- Precise probability model, for the random variables involved, in order to determine exceptions per facility group. As a result, besides confirming the killer effect, it is possible to identify the "killer efficient", a junctor that systematically disconnects the call during the conversation;
- Non-parametric probability model, to determine the time basis for measuring traffic, in order to assure a previously specified precision. The SITASU time basis for data acquisition is programmable, as shown below:

Events: 25 ms, 250 ms, 1 s, and 5 s;
Times: 1 s, 5 s, 20 s, and 50 s;

For equipment with a very rapid switching time, it is possible to employ a processor to supervise switches of up to a level of 4 ms occupation time and 4 ms idle time.

In addition to SITASU, the following supervision equipment can be mentioned:

- Portable Traffic Recorder: equipment used to measure and process traffic data of up to 500 points individually, utilizing the ICUP technique;
- Automatic Answer Time Recorder: equipment used to measure the answer time in manual services. It collects and processes data in up to 256 trunks. Basically, it gives the rate at which calls are answered, in a shorter time than a programmable set reference time.

The automatic toll ticketing system is also utilized as a supervision resource for DDD calls. A program is put into effect every month, that allows all calls to be recorded, whether completed or not. The uncompleted calls are detailed, in regard to the following reasons for not being completed: line busy, no answer, equipment blockage, and failure and others. The data obtained from this program is also utilized for study of subscriber behavior.

2.4 Training Resources

To back up implementation of TAS, in the operating companies, a training program was developed based on the following resources:

- Traffic Theory Course: a course developed for personalized instruction, involving telephone
Traffic theory and its application. This course is aimed at university level personnel, with training in the field of mathematics;

- Traffic Seminar: the Traffic Seminar is similar to the previous course, that takes up telephone traffic theory only superficially, with greater emphasis on practical applications;

- Traffic Seminar: the Traffic Seminar is a resource that is being utilized for publicizing, on a national level, studies, experiences and developments in connection with the traffic sphere, as well as the results obtained from implementing TAS. Three seminars have been held since 1978, with a fourth scheduled for 1986.

3. THE TELEMIG TRAFFIC ADMINISTRATION SYSTEM

3.1 Concept

Telecomunicações de Minas Gerais S.A. - TELEMIG, one of the 28 state companies, operates in the State of Minas Gerais, located in the Southeastern Region of the Country, which also includes the states of São Paulo and Rio de Janeiro, among others. These three states are the economically most important in the Country. The TELEMIG telecommunications system has about one million telephones (7.30 telephones per hundred inhabitants), and serves 635 municipalities.

From the point of view of marketing, for TELEMIG, TAS represents the management of its main product — Teletraffic. Implementation of TAS, in a systematic manner, took place from 1980 on, in relation to the various sets of functions already described, except in regard to network management, which the Company plans to implement in the near future, utilizing the SITASU system. Prior to this, although traffic administration was carried out, it was in a rather inefficient manner. TAS was implemented in accordance with the TELEBRAS holding company, taking TELEMIG's peculiar characteristics into consideration.

3.2 Organization

Geographically, TELEMIG is divided into seven operational areas, called Operational Regions. Each Operational Region is subdivided into districts, making a total of 20, and these in turn are divided into subdistricts. The seven Operational Regions, together with the staff, composed of the Marketing, Data Communications, and Operational Planning and Engineering Departments, report to the Operations Director's Office.

TAS activities are decentralized at the regional, district and operational unit levels. An operational unit can be understood as the portion of the system, such as toll center offices, switchboard centers, operations centers, etc., where each set of traffic administration functions is carried out. Traffic Managers are assigned to each one of these levels, who are organized on the basis of rank, to carry out their duties (Figure 11), under the direction of the Traffic Division, that reports to the Operational Planning and Engineering Department. This Division is also in charge of the physical control of trunk facilities.

The gratifying results obtained from this policy of TAS decentralization at TELEMIG, is evidenced by the fact that a traffic doctrine has spread throughout the whole operational sphere, with the equipment maintenance, commercial and marketing sectors engaged in carrying out these activities. Furthermore, this process made it feasible to obtain the human resources needed, mostly personnel who can give only part of their time to these duties, and whose help would be difficult to obtain for a centralized staff.

In Figure 11 we also stress the two main TAS interfaces: the fields of Traffic Engineering and Marketing. At TELEMIG, Traffic Engineering reports to the Technical Planning Department, and Technical Planning in turn reports to the Technical Director's Office. Its principal interface with Traffic Administration is in respect to network expansion, and the solution of problems of traffic congestion. On the other hand, the Marketing Department interfaces with Traffic Administration, in the solution of network underutilization problems, increasing utilization of the services offered and proposing new ones.

3.3 The traffic administration process at TELEMIG

Figure 12 illustrates the traffic administration process employed by TELEMIG, as well as the interfaces.

Figure 11 - Decentralized Traffic Administration Organization

Figure 12 - Traffic Administration at TELEMIG

3.3.1 Data Acquisition

The first step in the process consists in acquiring traffic data through supervision equipment installed at local central offices, toll center offices, tandems, PBX, and toll...
switchboards. These measurements are carried out every month, during 5 working days at the busy hour, except at local central offices with less than a thousand main stations, at which measurements are taken quarterly. Based on this data, the representative traffic figures are found for traffic during the month (VRM), the year (VRA), yearly movable traffic (VRAM), and the yearly forecast (VRAP), that will serve as a basis for Traffic Administration to decide on actions to be put into effect. These concepts are defined below:

VRM - second highest figure during the 5 measuring days;
VRA - second highest VRM for the traffic year, that covers a period of 12 consecutive months, in regard to which the traffic data is consolidated;
VRAM - second highest VRM for the last 12 months;
VRAP - VRA forecasts for the next traffic year.

The busy hour, during which this information is obtained, is found every year.

Table 2 shows the distribution of the several types of supervision equipment used by TELEMIG. It can be seen that the great majority of the supervision equipment is not automatic, and that it monitors central offices with cross-bar or cross-point technology. Installation of the first SPC central offices at TELEMIG is scheduled for 1986.

<table>
<thead>
<tr>
<th>CENTER OFFICE</th>
<th>MONITORING DEVICE</th>
<th>MECHANICAL-ELECTRICAL CONTROL</th>
<th>PAPER TAPE</th>
<th>AUTOMATIC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCAL</td>
<td></td>
<td>192</td>
<td>11</td>
<td>2</td>
<td>222</td>
</tr>
<tr>
<td>TOLL</td>
<td></td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>TASSU</td>
<td></td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>PBX</td>
<td></td>
<td>-</td>
<td>(n)</td>
<td>(n)</td>
<td>0</td>
</tr>
<tr>
<td>SWITCHBOARD</td>
<td></td>
<td>-</td>
<td>9</td>
<td>9</td>
<td>18</td>
</tr>
</tbody>
</table>

(*) The PBX do not possess permanent equipment and are monitored by portable equipment on a rotation basis.

Table 2 - Supervised Central Offices, According to Type of Monitoring Equipment

Data obtained by nonautomatic equipment is processed by computerized systems, generating reports that, when added to those supplied by automatic equipment, are fed to a Traffic Data Base. The automatic monitoring equipment is SITASU type or similar. TELEMIG is carrying out a plan to install this new equipment and substitute conventional equipment.

3.3.2 Traffic Data Base

The Traffic Data Base constitutes the second step in the process. This is a base implanted in the Company's main computer, utilizing Data Bank software, that allows on-line access by the various sectors. As shown in figure 12, this Base is fed by traffic data and information in regard to the network's physical configuration, both now and in the future, on a short, medium, and long term basis. Furthermore, by means of monthly updating, it supplies historical data to carry out traffic forecasts.

Fundamentally therefore, the data fed to the Base are the representative figures for average traffic; the figures found for congestion, the number of facilities installed and in service, their traffic capacities, and the estimated traffic figures, and the respective number of facilities during the next 7 years, as well as 3 five year periods, besides the monitored limits of traffic.

The main benefits observed as a result of Base utilization are:

a) uniformity in the data available at the several Company sectors;
b) management reports, containing information on the state of the network, are issued;
c) it supplies information, on which Administration and Traffic Engineering can act;
d) reliable traffic data is quickly available;
e) it provides an overall view of the network.

As an example of Base potential and flexibility, examples of some of the answers it can supply are given below:
a) traffic intensity in trunks;
b) total number of facilities programmed for a given central office;
c) over engineered routes;
d) under engineered routes;
e) alterations programmed in the network for a given date;
f) number of outgoing routes from a given central office.

3.3.3 Traffic Administration

The third step is traffic administration itself, that consists of the decision-making process in regard to traffic flow control, based on the continuous monitoring of the system in operation, as described in items 3.3.1 and 3.3.2. This process aims at achieving efficient utilization of the system's traffic facilities. This objective can only be reached by means of a conscious effort by all the technical and operational sectors involved.

The decision-making process at TAS has given top priority to preventive, rather than corrective administration, seeking to act before overloads occur in the system. For the purpose of controlling traffic flow, in the various sets of functions, TAS utilizes parameters set according to the type of facility, described as follows:

a) Trunk Facilities - upper (UL) and lower (LL) limits of control are utilized for each route, for which the traffic figures indicate normal conditions. Otherwise, measures are taken to increase trunk group capacity, or to provide available facilities for future rearrangements. These limits are set according to the route grade of service. At TELEMIG, the following equation is used: \[ UL = 3 \text{ GOS} \text{ and } LL = 0.1 \text{ GOS} \].
b) Local Central Offices Facilities and Main Stations - the parameter utilized for Traffic Administration in local central offices and Main Station Administration is load capacity, that represent the largest possible number of main stations that can be connected by the end of the next traffic year. Load capacity is figured according to the amount of traffic forecast, and the grade of service rendered by the various facilities at the central office. Should this load capacity be less than the physical capacity, it would hinder the assignment of all of the central office main stations, until the recommended measures are
put into effect (for instance: rearrangements, extensions). In addition to this, a balance of traffic and main stations, among basic groups of subscribers, is aimed at, through assignment of telephone numbers.

c) Toll Center Office Facilities - Traffic Administration at toll center offices employs load capacity as a parameter, which is the same as the one utilized for traffic administration at local central offices. In the case of toll centers, load capacity is the maximum incoming traffic that can be handled by the center office without congestion in its common control equipment.

d) Toll Switchboard Facilities - the toll switchboard trunk facilities are evaluated by means of the same UL and LL parameters as those described in "a". Furthermore, the manual service answer time is also evaluated, so as to fill the proper number of positions.

Figures 13 and 14 show the preventive and corrective flows employed by Traffic Administration at TELEMIG. As is shown in Figure 13, preventive administration is based on the VRA forecasts for 1 and 2 year terms. These forecasts are analysed, which makes it possible to foresee future congestion and slack in the facilities. Facilities in these conditions are considered exceptions. From this phase on, the process is centralized, and fundamentally consists of consolidating, on a company-wide basis, all the regional results and analyses, the Series of Preventive Administration Meetings, and the solutions decided upon. These solutions, that consist of the basic proposals made by Traffic Administration, along with the Traffic Engineering programs, constitute the Traffic Expansion Plan. Execution of this Plan is subject to the limitations imposed by the Company's investment budget.

Figure 13 - Preventive Traffic Administration

The figure for Corrective Traffic Administration shows that the monthly analysis, carried out by the several decentralized levels of Traffic Administration, generates a list of exceptions that are exceptions. This list, for management purposes, comprises a consolidated Exception Report by the staff, and which, besides exceptions, gives the figures for performance of the various TAS sets of functions, and the overall figures for completed calls in the TELEMIG network. Measurements to be taken by Corrective Administration, when they require financial resources, are fitted within the limits for year n.

Figure 14 - Corrective Traffic Administration

3.4 Human resources involved

Decentralization of activities was the main device found to engage the largest number of personnel in the Traffic Administration process. Consequently, at present 1.1% of the total TELEMIG work force of 7,697 employees is involved in these activities. Nevertheless, only 20% of this personnel work for Traffic Administration full time.

An important factor in this process is training. Training has been provided by means of courses on Telephone Traffic Theory, and Introduction to Telephone Traffic Theory, described in item 2.4. Besides these, TELEMIG used its own resources to develop courses such as the Telephone Traffic Administration Course, and the training module designed for Company managers who work in this field.

A group that includes all the Traffic Managers within the decentralized organization, called the Traffic Administration Group, engages in exchanging accounts of experiences among the managers, and evaluation of the overall results obtained by Traffic Administration at TELEMIG. This group meets twice a year.

Another event which has contributed to training and developing personnel is the TELEBRAS System Traffic Seminar.

3.5 Operational results

The results seen in the present stage of Traffic Administration have indicated that the policy has been a success. The measures implemented by this system have contributed to improving the quality of the service rendered by the TELEMIG network, as shown in figure 15.

It shows that the completion rate has grown progressively. The present completion rate, around 57%, represents a very gratifying result, when compared to international standards.

In regard specifically to TAS sets, of functions, there are figures that allow its performance to be evaluated. Among others, we stress the rate of congested DDD routes.

Figure 16 shows the growth of this figure, and figure 17 shows the relative distribution of congested DDD routes per traffic flow. It shows that out of a total of 98 congested routes, in December 1984, 85% have a traffic flow of 5 erlangs. These low capacity routes serve small places (50 to 300 main stations) with a high
unsatisfied demand. The solution of these cases normally would require substitution of the transmission system, involving significant investments with low returns. Therefore, the problem of these cases are being solved progressively. This is not the case for medium and high capacity routes, for which the equipment is modular and the short term returns on the investment are higher.

Figure 15 - Completion Rate in the TELEMIG Network

Figure 16 - Rate of Congested DDD Routes

Figure 17 - Relative Distribution of Congested DDD Routes per Traffic Flow - Dec. 1984

The proportion of TELEMIG participation in traffic expansion, within the total amount invested, is growing every year, showing the effort the Company is making to solve these cases, and its recognition of what it means in relation to its operational income. In 1985, for instance, TELEMIG will invest approximately 5% of its total investments in traffic expansion, without taking into consideration the expansion of its facilities, together with the projects for expansion of the number of main stations.

On the other hand, Traffic Administration measures are not limited to network expansion alone. Slack facilities are frequently utilized for solving cases of congestion.

4. CONCLUSION

This paper gives priority to stressing the process of development and implementation of Traffic Administration in the Brazilian network, and at TELEMIG in particular.

The operational results that can be reaped from a traffic administration system, fully justify its introduction.

In Brazil, in addition to the highly satisfactory results reported in this paper, we have the fact that a new teletraffic approach has been spread throughout the whole corporation.

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