ABSTRACT

A system of hard and software is in use which collects and analyzes traffic data in an intercontinental telex exchange. The software accepts data from punched cards or from magnetic tape and prepares a daily and a monthly summary.

1. GENERAL

Intercontinental telex service is offered by ITT World Communications in New York City by means of a 7-E type rotary switching system and a new electronic telex switch (Telex III) which complements the 7-E equipment.

The traffic data recording system (TORS) employed (Fig. 1) is a system of hard and software which records happenings within the 7-E equipment and produces an analysis of these data. The software portion analyzes similar happenings within the Telex III. These reports provide the justifications for recommendations that more or less equipment is needed now or will be needed at a certain time in the future and also provide a measure of the day-to-day performance by giving an indication of where difficulties exist or are impending.

To do these things, a series of graphs are produced of the nature shown in Fig. 2. This figure is discussed in more detail later, but in general the traffic history of some particular collection of equipments (trunks in a group, registers, etc.) is used to produce a forecast. Superimposed is a family of horizontal lines which depict the number of equipments required if some defined service objective is to be met. One such graph must be prepared and maintained for each collection or group of equipments in the exchange.

A major objective of the TORS system is that all observations and calculations should be done in a consistent way, making use of a computer whenever practicable to perform all calculations that are needed to plot the data base. The extrapolation or projection then can be made by any technique which appears to be suitable, following which the critical date can be derived easily.
Fig. 1 Block diagram of TDRS.

Fig. 2 Method of forecasting needs.
The intent always has been to produce computer programs that are simple to administer rather than simple to write. Also, the attempt has been made to make the software insensitive to changes in processors, hence all programs are written in Fortran or Cobol so that the software systems can be operated on various processors with minimal changes.

2. TEST SYSTEM
2.1 MANUAL RECORDER

The mechanical recorders associated with the 7-E are arranged to run for intervals of 15, 30 and 60 minutes, during which time the scan is exercised each 36 seconds. At the end of one hour 100 scans will have been made, and it is noteworthy that the erlangs carried then becomes the number in each accumulator with the decimal point moved two places from the right. These recorders are read manually and the information is placed on punched cards for subsequent calculations by Programs 2 and 2A in Fig. 1.

These counters manifest several distinct disadvantages:

a) It is difficult to obtain observations for intervals other than 15, 30 or 60 minutes.

b) The basic scan cycle of 36 seconds is rather coarse with the result that fairly large errors are inherent in the measurements, particularly on groups with low traffic.

c) It is very difficult to make measurements on trunk groups that have different busy intervals.

The last objection is particularly serious and the manual recorders provide no economical method for obtaining information about individual groups.

2.2 ELECTRONIC RECORDER

To overcome these objections, an electronic recorder was designed by Worldcom to replace the manual counters used on the 7-E equipment. This electronic device operates in the same general manner as the mechanical system except that a small computer is used to control the scanning and to associate points within the 7-E into groups. Any of 3040 input leads can be associated without restriction with any of 512 accumulators, these associations being made by entering appropriate instructions on the keyboard of the administrative printer.

One of the essential features of the electronic recorder is the capability to make records within a short time. All of the 3040 input points can be scanned and the results accumulated within two seconds.

A new scan can be initiated at any interval which is 5K seconds long, where K = 1, 2, 3 ....... 199.

The results of N scans are added in the 512 accumulators, where

\[ N = 1, 2, 3, ..., 9999 \]

at which time the information is written onto magnetic tape. The number in the accumulator is limited to 5 digits therefore, the maximum number of accumulations in any accumulator should never exceed 99,999. The usual setting is for a scan repetition of 10 seconds (K=2) and for an accumulation interval of five minutes (N=60). Using these parameters, all of the 3040 points could be assigned to one accumulator and not suffer overflow. For special studies, it is possible to record, at 5 second intervals, for days at a time.

Each recording on the tape contains the following data -

- Year
- Day in Julian date
- Time in 24 hour clock, usually Greenwich Mean Time (GMT)
- Number of Basic Frames, or Scans
- Highest Numbered Accumulator used
- Contents of Accumulator 1
- Contents of Accumulator 2
- Contents of Accumulator 3
- Contents of Highest Numbered Accumulator used

Note that the number of lines of data must equal the number of the highest numbered accumulator used. It is not necessary to use all accumulators.

2.3 TELEX III

A magnetic tape is generated by this system that contains the same information as produced by the electronic recorder. Program 3 merely converts the format to be compatible with the programs which follow.

2.4 SOFTWARE FOR TRAFFIC CALCULATIONS
2.4.1 Determination of Busy Interval

This software actually consists of two programs, WC1 and WC1A, only one of which is used at any time. Both programs employ a control card which defines the overall interval of interest. Thus, if the recorder had run continuously all day, this card would be used to confine the analysis between say 0800 and 1300.
Program WC1 inspects the data within this time interval for each group and calculates the busy interval for each group. Only the data within each busy interval then are used by subsequent programs. For each group program WC1 then -

a) Adds all of the accumulations in the busy interval.
b) Adds all of the scans within each interval.
c) Writes onto magnetic tape in card image form in sequential order by trunk group accumulator number.

1. Items a) and b), and
2. The beginning and the end of the busy interval of each group.

It was anticipated that WC1 would be expensive to operate, consequently, program WCIA was written so that the busy interval for each trunk group can be defined by punched cards. In other respects WCIA operates the same as WC1.

2.4.2 Daily Summary

Either the magnetic tapes from WC1 or WCIA or the punched cards from the manual recorders are supplied to program WC2 to obtain a daily summary (See Table I). This program performs the following functions:

a) Converts year and julian date into day of month, automatically allowing for leap year.
b) Converts Greenwich Mean Time into local time.
c) For each equipment group, calculates erlangs carried from the total accumulations and the number of scans.
d) For each group, if applicable, converts erlangs carried to erlangs offered, deriving the actual grade of service offered during this particular observation period, using whatever equation is appropriate for the particular group.
e) Calculates the number of equipments required if as many as five escalating grades of service were to be offered.
f) Prints out all of these results and also stores most on a magnetic disc for further processing.

To produce these results, several types of data are required other than the average traffic intensity. Specifically, for each trunk group -

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The output is an image of the punched card used with the manual recorder.

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a) DECK 1 provides:
1. The effective date of the card (this information is not processed).
2. Name of the area of the destination, (example EUR for Europe).
3. The names of the country and city in which the group terminates (example Vienna Austria).
4. The literal code sometimes used to identify these places (example VA for Vienna Austria).
5. Destination code of the country.
6. The accumulator numbers assigned to each directional group in 3.
7. The number of trunks in service as incoming, bothway or outgoing.
8. Combining scheme for handling bothway and unidirectional trunks.
9. Linkage identifying other accumulators to be used in calculation if required.
10. Calculation scheme, i.e. the equation to be employed. As many as 100 different equations could be employed although the erlang B and C equations were used initially.

Three cards are required for each destination, one each for incoming, bothway and outgoing trunks. If no trunks exist in some of these categories, then zero is entered for the number of trunks. This deck is stored on a disc and only the daily changes need be added before each run.

b) DECK 2 provides an escalating scale of objectives for each destination such as 0.01, 0.02, etc. A maximum of 5 objectives can be set for each group, this information being used to calculate the number of trunks required each day to handle the traffic of that day.
c) DECK 3 allows for special studies. If the deck is empty, all groups will be processed. The output can be restricted to one or more groups by inserting cards which identify the groups of interest.
d) DECK 4 provides information about time. The local time zone is identified as well as the differential from GMT.
e) DECK 5 exists only if the traffic data are entered by cards. If this deck is not used then data are entered by magnetic tape.

All of these decks (except DECK 5) are stored on a disc. All changes should be entered each time before the system is operated.

For calculations relating to registers and other internal points, a different set of card decks is required.

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### TABLE I

**EXAMPLE OF DAILY SUMMARY**

**ITT WORLDCOM PROGRAM WC2**

**DAILY SUMMARY**

**** TRAFFIC MEASUREMENTS AND CALCULATIONS FOR INTERNATIONAL TRUNKS AND EQUIPMENTS ****

**DATE** DEC 10, 1968

**SHEET 6**

**BRASIL, RIO DE JANEIRO**

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**CHILE, SANTIAGO**

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**ITT WORLDCOM PROGRAM WC3**

**BRASIL, RIO DE JANEIRO**

**RIO**

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### TABLE II

**EXAMPLE OF MONTHLY SUMMARY**

**MONTHLY TRAFFIC SUMMARY**

**DEC 9, 1968 THROUGH DEC 23, 1968**

**DATE** | BUSY PERIOD | FOR GOS OF STD. MOVING | TRUNKS REGO. AVER. | TRAFF. AVER. | TRUNKS REGO. AVER. | TRAFF. AVER. |
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<td>0 9 10</td>
<td>6.071 4.403 4.153 0.000</td>
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2.4.3 Monthly Summary

After a sufficient number of daily records have accumulated, WC2A is used to produce a monthly summary similar to that shown in Table II. The results of this program are discussed in the next section.

2.4.4 Interpretation of Graphs

Figure 2 is a representation of a typical graph which is used to forecast future requirements. The horizontal axis is calibrated in days and months for an interval of one year. The left vertical axis represents the traffic offered (in Erlangs) to the trunk group during the busy interval of each day. The tick marks on the right vertical axis represent the number of trunks required to handle at a defined grade of service, the magnitude of offered traffic which is found immediately opposite on the left axis. Thus, as 13 trunks can be offered 6.61 Erlangs at a grade of service of 0.01, the tick mark for 13 trunks (right axis) would be even with 6.61 erlangs (left axis). If a lower grade of service were permissible, then the tick mark representing a particular number of trunks would be moved upward. Conversely, a better grade would necessitate moving the mark downward.

In the body of the graph will be found -

a) Individual points,
b) A line marked "running average", and
c) A second line marked "standard error".

A given point represents the experience on a particular day and as described above is the result of -

a) Reading the erlang meters or operating the electronic recorder to obtain erlangs carried, and when necessary,
b) Correcting this datum to obtain erlangs offered.

The "running average" is calculated from 5 sequential points or, stated otherwise, from the data obtained on five days in sequence. For the purposes here Monday, Tuesday, Wednesday, Thursday, Friday and Monday or Wednesday, Thursday, Friday, Monday, Tuesday. Should a holiday intervene so that the data are not representative, and if the holiday were on Tuesday, the sequence would be Monday, Wednesday, Thursday, Friday, Monday and so on.

The choice of five points represents a compromise between:

a) The need to have an up-to-date average. With five points, the average always must be two days behind; greater lags would accompany more averaging points.
b) The need to divide time into intervals compatible with business habits. Intervals which are multiples of one working week are favored, hence 5, 10, 15, - - - averaging points are most suitable.

c) As the data for each day are collected, the oldest datum is abandoned and the newest is inserted and a new average is calculated using these five points. Thus, any given point will affect the value of five consecutive calculations.

The line marked "standard error" wants a better name, but in essence this represents an interval of one standard deviation greater than the average, where the same five points are used to calculate both the average and the standard deviation for that particular set.

An interpretation which is approximately correct and which is simple to apply is that over an extended interval, about one half of the points will be below the average line and slightly more than 84% below the standard error line. Because some relaxation of rigor is present here, the 84% criteria is (arbitrarily) made 85%.

With continual growth, both the average and the standard error lines ultimately will intersect at a and b a horizontal line drawn through the tick mark representing any given number of trunks, with the standard error line intersecting first. At a, the service will be worse than the standard about 15% of the time, if many samples were taken of many similar groups of five days. At b, the service would be worse than standard 50% of the time, again for many samples obtained on many such days. Depending upon the objective desired, the time at a or b is termed the "critical date".

Interval B represents the lead time required to obtain and install trunks, consequently, interval A remains to place the order if the performance at time F can be tolerated, and no time remains if E is the objective. If the company has some minimum period C that should expire between additions to the same group, then the group should be increased to the size indicated by lines G or H.