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Total Network Data System:

Performance Measurement/Trouble Location

By D. R. ANDERSON* and M. J. EVANS*

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The Total Network Data System (TNDS) includes a subsystem that measures TNDS performance and assists network administrators and those responsible for network traffic data collection in finding TNDS troubles. This interactive subsystem provides the telephone company managers with a versatile tool for a performance analysis of the many systems and organizations associated with TNDS. The troubleshooting features usually provide sufficient detail from which to specify corrective action. The performance information can be aggregated across all organizational levels from the single traffic unit to the entire Bell System.

I. INTRODUCTION AND SUMMARY

Good service to the customer has always been a hallmark of the Bell System. This service is ensured by a number of measurement plans used by Bell System managers to monitor the quality of service to the customer. Operations such as those associated with the Total Network Data System (TNDS) do not all have an immediate effect on the customer, but if neglected for a long period of time, could result in costly engineering mistakes. Thus, a TNDS performance measurment plan is needed so that the efficiency and integrity of TNDS operations are maintained at a level sufficient to support continued good service

* Bell Laboratories.

to the customer at reasonable cost. A TNDS Performance Measurement Plan (TPMP) was introduced in 1980. This measurement plan is highly automated, using a computerized support system called the Centralized System for Analysis and Reporting (CSAR).

In addition to highlighting performance, measurement plans often provide supplementary data useful to those responsible for assuring good performance. This function is especially important in TNDS operations because of the wide diversity in systems, organizations, geography, and timing associated with TNDS. Thus, assisting troubleshooting is an important feature of CSAR. It often allows the analyzer to identify the specific source of a data problem while still at the terminal.

II. TNDS PERFORMANCE MEASUREMENT PLAN (TPMP)

2.1 Need and objectives

In 1976, as the TNDS systems were being widely deployed in the Operating Telephone Companies (OTCs), TNDS project managers at AT&T and systems engineers at Bell Labs undertook a field study of TNDS Operations in South Central Bell. This company offered an ideal environment for observing TNDS operations. Its applications included rural areas and large metropolitan areas across five states.

With the help of South Central employees, personnel at Bell Laboratories and AT&T were able to obtain valuable insight into TNDS performance and typical operations. Over several months the AT&T/Bell Labs team observed just how TNDS traffic data reports were obtained, and how accompanying TNDS administrative information was analyzed and used in a variety of operating company offices. It was observed that managers often had difficulty obtaining an overview of performance from the administrative reports generated by the various systems of the TNDS. Also, the geographical diversity of these systems, the time interval over which traffic data progress through the TNDS, and the volume of the reports from the systems all made it difficult and time-consuming to detect and pinpoint data problems. These difficulties were the result of the increasing size and complexity of TNDS and its wide deployment.

This study clearly pointed out a need for a comprehensive, automated performance measurement plan that could help to localize traffic data problems. The reports associated with the measurement plan should provide a concise management overview with enough detail about the type and location of problems to allow managers to apply resources to bring about solutions. The system generating the measurements should also make available to the TNDS administrators selected, detailed information about data as the data pass through the various systems in the TNDS. The measurement system should allow enough investigation, in increasing detail, to identify the location and time of problems. Such investigation should also identify enough about their cause to determine either the corrective measures or the testing and analysis that is required. The traffic data problems should be identified as quickly as possible so that critical traffic data studies are not jeopardized.

All of these requirements are best met by a system that obtains performance data directly from the other TNDS systems and provides a variety of reports on an on-line, interactive basis.

In considering measurement plans for TNDS, we noted a significant trend in other Bell System measurement plans. A measurement task force has recommended that measurement plans should avoid averaging results since they are aggregated together for several measured entities. This is important so that poor performance in one or two entities is not masked by good performance in a number of other entities. This principle is extremely valid in TNDS operations measurements where consistently poor performance in obtaining traffic data for an office could deny engineers the data needed to plan for its growth.

The method being adopted in Bell System measurement plans to preserve isolated indications of poor performance is to associate the results obtained for each measured entity into one of four bands: H, O, L, or U. The bands are designated as Higher than objective, Objective, Lower than objective, and Unsatisfactory. Then, aggregated results give the number of entity measurements in each of the bands. Thus, a poor performer is never lost in the crowd. In TPMP, there is usually no extra expenditure for flawless performance so there is no need for the Higher than objective category. Thus, TPMP only includes bands O, L, and U.

The measures important in monitoring TNDS performance are related to data completeness, data validity, and the accuracy of the record bases that associate the data with the telecommunications equipment. The TNDS Central Office Equipment Reports (COER) systems,[1,2] Trunk Servicing System (TSS),[3] and Load Balance System (LBS)[1] all present traffic data to end users (engineers or administrators) and, thus, can supply comprehensive information about TNDS performance. They all provide performance data to CSAR. The Trunk Forecasting System (TFS),[3] also an end-user system, does not provide data to CSAR at this time, but its inputs are directly dependent on the (CSAR-measured) TSS. The Traffic Data Administration System (TDAS),[1] which is an intermediate system in TNDS data flow, also makes available performance data to CSAR. This is done because TDAS is the final TNDS system for certain special study information and equipment types, and because analysis of TDAS results can allow early detection and isolation of data-gathering problems.

The above systems generate performance data pertinent to data completeness, data validity, and record base accuracy. In addition, the Individual Circuit Analysis System (ICAN)[1] was designed primarily to help administer the record base for usage data acquired on individual circuits through the Individual Circuit Usage Recording (ICUR) version of the Engineering and Administrative Data Acquisition System (EADAS).[4] As such, ICAN is an important source of CSAR record base performance data for those switching systems served by EADAS/ICUR.

2.2 Performance measures

Each system that furnishes CSAR with performance data has its own validity checks, record bases, and schedules. Each has its own way of measuring data completeness, data accuracy, and record base accuracy. Hence, the first level of the hierarchy for CSAR reporting is by the TNDS. Table I shows the TNDS performance measures generated by CSAR and gives a brief explanation for each. The results are reported as "problems," i.e., as percentage of missing data, validity failures, or record base errors. Two thresholds are assigned to each measure to distinguish between the three bands, O, L, and U. The threshold settings are determined differently for each measure because each is associated with a different part of the TNDS process, different operations, or different equipment. There is a guiding rationale, however, applied to all. The Objective band starts at zero and includes performance levels where minor flaws occur but are being attended to. The first threshold marks the transition to Band L, where the equipment errors and record base errors become significant and systematic. The upper threshold, which marks the beginning of band U, is set to indicate equipment problems that persist longer than is normally necessary for their remedy or to indicate the accumulation of record base errors.

2.3 Reporting

TPMP is designed to assist operating company TNDS managers at all organizational levels. Their access to reports is through the on-line, interactive computer system, CSAR. As mentioned earlier, the first level in the CSAR reporting hierarchy is the TNDS, from which CSAR has obtained the performance data. The second level is the organization for which the manager is responsible. For a given request, results from all reporting units, switching offices, trunk services, etc., in that organization are summarized or delineated according to the request. The dialogue with the computer enables the manager to get a

Table I—TPMP/CSAR performance measures

Measures	Performance Data Source	Description
DCU—Intervals missing	TDAS	The half-hour DCU* intervals that are required to satisfy all of the requests for obtaining data through TDAS, but where data are not recorded.
DCU—Intervals with any verification-device failures	TDAS	The half-hour DCU intervals where data are obtained but where one, or more, of the devices used to verify data accuracy have an imperfect score.
Detector test failures (only for TUs obtaining usage data through a TUR-traffic usage recorder)	TDAS	The number of discrepancies encountered when comparing a CU record base containing the number of circuits in each measured group with the usage inputs during a test scan when all circuits are simulated as busy.
Invalid detector test scans	TDAS	Discrepancies detected by the verification devices when the detector test is run.
ICAN/CU count mismatch	ICAN	The number of discrepancies encountered when ICAN compares the number of individual circuits in each circuit group in its record base with that in the CU record base.
ICAN/CU other error	ICAN	Any other discrepancies found when performing the record base comparison between ICAN and CU (e.g., circuit group type).
Suspect SCHV assignment	ICAN	The number of cases when ICAN reports an individual circuit assignment to a circuit group to be "suspicious" (these should be resolved by data administrators).
UA/UE SCHV usage	ICAN	The number of individual circuits that have measured usage but are designated in the EADAS/ICUR record base as being unassigned (UA) or unequipped (UE).
CGMT with insufficient data	TSS	The number of circuit group measurement (CGMT) types for which there was insufficient valid traffic data to use as a basis for trunk servicing or forecasting.
CGMT other invalid	TSS	Trunk group validity failures in CGMTs with sufficient valid data.
CGMT unassociated	TSS	The number of CGMTs for which traffic data were received but cannot be associated with a group in the record base.
LU invalid for LBI	LBS	The number of load units [(LUs) concentrators to which circuits are assigned] for which no valid data were provided for the load balance index (LBI) calculation.
LU measurements invalid	LBS	The number of load units where some data were obtained in the loading division but for which the LU had insufficient valid data (excludes cases where entire loading division missed data).
5XB COER control file with error	5XB COER	Indicates that data are not processed by 5XB COER because 5XB COER has detected an unresolved error in its record base.
5XB COER end hour missing	5XB COER	The number of hourly intervals for which 5XB COER expected data but did not receive it.
5XB COER validation failures	5XB COER	The number of failures detected when 5XB COER checked data validity.
SPCS COER missing data	SPCS COER	The number of hourly intervals for which 1 SPCS COER expected data but insufficient data were received.
SPCS COER sanity failures	SPCS COER	The number of data sanity check failures (gross data inconsistencies—tight thresholds apply).
SPCS COER cross-measure type test failures	SPCS COER	The number of cross-measure type tests that have failed (inconsistencies between data items—looser thresholds apply because peculiar switching environments may result in false alarms).

* The physical embodiment of DCUs (data collection units) differ from one type of switching machine to another. However, a DCU may generally be thought of as an aggregate of traffic data items that are scheduled and collected as a set.

breakdown by the next lower organizational level. More will be said later about these reports and the manager's use of them. In addition, CSAR furnishes detailed information for trouble analysis.

An overall summary of results for each TNDS operating company is made available to AT&T every month. The percentage of reporting-unit measures (see Table I) in the bands L and U are included in a Bell System measurement summary called "Network Results," which is published monthly for Bell System use.

III. THE CENTRALIZED SYSTEM FOR ANALYSIS AND REPORTING

CSAR is an on-line, interactive computer system that provides dial-up access six days a week to centralized databases holding over 250M bytes of information. The system combines the cost effectiveness of batch processing large volumes of data with the speed and convenience of on-line database access. CSAR can be accessed using almost any 110-, 300-, or 1200-baud asynchronous terminal. The daily operation of CSAR combines the resources of OTC computer facilities in 24 states, a Bell System data transmission network, a centralized computer system at AT&T, and the Direct Distance Dialing (DDD) network to support the TPMP and generate extensive information to assist in the operation and administration of TNDS. The reporting capabilities offer timely assessments of the performance of the traffic data collection and processing tasks, as seen by each system in the TNDS. Currently, eighteen OTCs use CSAR. Each TNDS installation within these companies becomes a remote source of TNDS performance data analyzed by CSAR and maintained in the central databases. Authorized users in each of these companies have dial-up access to the interactive component of CSAR, allowing flexible retrieval of information pertinent to their own company and certain Bell System results.

3.1 System configuration

The major component in the CSAR system configuration resides at the centralized computer site and receives the majority of its data from the distributed OTC TNDS processing sites via the Bell System telecommunications software system for computer-to-computer data exchange with OTCs (T-TRAN) data transmission network. The CSAR users gain access to the central computer system from existing remote terminals using the standard DDD telephone network. Thus, the system includes five major components that effectively combine existing Bell System facilities:

1. Distributed OTC computer sites
2. A T-TRAN data network
3. A Central AT&T computer site

4. A DDD telephone network
5. Existing remote terminals.

Figure 1 shows the CSAR computer system configuration. The CSAR implementation utilizes and coordinates a number of different hardware and operating system environments. Brief descriptions of the first three system components listed above illustrate the overall CSAR operating environment.

3.1.1 OTC computer facilities

The CSAR measurement process begins at the OTC's computer facility when the batch TNDS subsystem modules are run. It uses the Standard Operating Environment of IBM 370 series mainframe or a compatible computer running the Multiple Virtual Storage (MVS) operating systems. The performance data are gathered by software embedded in the individual TNDS subsystem modules. Thus, the individual TNDS subsystems accumulate the majority of the raw data required for CSAR performance measurement and analysis. A standalone CSAR module executes under this environment at the remote computer facilities to merge the data files from the separate TNDS components and prepare a single standard interface for data transmission.

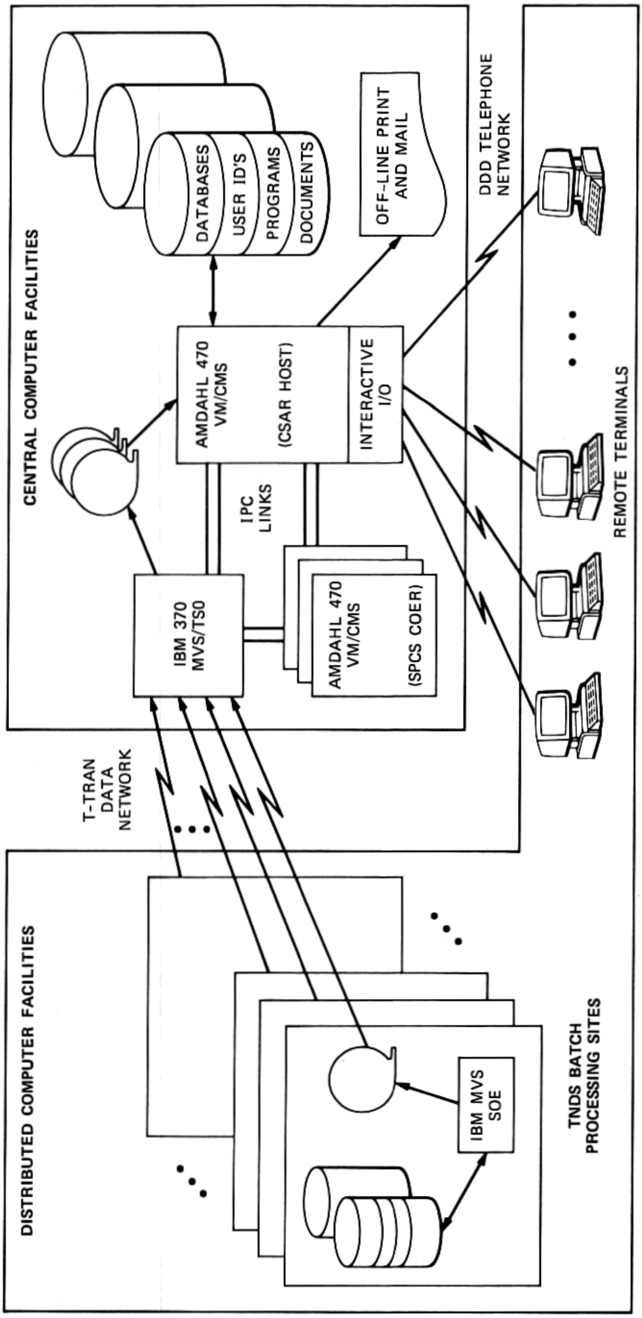
3.1.2 T-TRAN data network

Each OTC uses the T-TRAN network as a data link for the transmission of its TNDS performance data to the central computer site at an AT&T Corporate Computer Center in New Jersey. Weekly CSAR transmissions are an integral part of the TNDS operations in the OTCs. Backup data are retained in each company on disk or tape.

The receipt of a transmission at the AT&T T-TRAN site (an IBM 370 system running MVS with the time-sharing option) automatically invokes a CSAR program that initiates the CSAR batch processing sequence. This first step identifies the incoming CSAR data files and sends all necessary information to a second computer system that is the actual host for the primary CSAR batch and on-line interactive processes. The program under the Multiple Virtual Storage/Time-Sharing Option (MVS/TSO) communicates to the CSAR host machine via a local Inter-Processor Communication (IPC) network.

3.1.3 Central host computer

The heart of the CSAR system also resides on one of the many computers that comprise the AT&T Corporate Computer Center. The CSAR software is developed and centrally executed on an Amdahl 470 series mainframe running under the Virtual Machine (VM) operating system using the Conversational Monitor System (CMS). This VM/



CSAR – CENTRALIZED SYSTEM FOR ANALYSIS AND REPORTING
ID – IDENTIFICATION
IPC – INTERPROCESSOR COMMUNICATION
MVS – MULTIPLE VIRTUAL STORAGE
SOE – STANDARD OPERATING ENVIRONMENT
MVS/TSO – MULTIPLE VIRTUAL STORAGE/TIME-SHARING OPTION
SPCS COER – STORED PROGRAM CONTROL SYSTEMS CENTRAL OFFICE EQUIPMENT REPORTS
TNDS – TOTAL NETWORK DATA SYSTEM
VM/CMS – VIRTUAL MACHINE/CONVERSATIONAL MONITOR SYSTEM

Fig. 1—CSAR computer system configuration.

CMS computer facility is the home of two other TNDS centralized operation support systems: the Stored Program Control System Central Office Equipment Reports system (SPCS COER)[2] and the Small Office Network Data System (SONDS).[5] Performance data are sent directly from SPCS COER to CSAR through a VM/CMS remote spooling interface.

This central host computer system offers the facilities and the processing capacity required by CSAR functions. The large volumes of data received from the 26 remote TNDS processing sites currently sending data to CSAR are scheduled for overnight processing using the VM/CMS batch facility. The analysis, correlation, and database loading occur during off-business hours at a reduced cost and without interfering with the typical interactive user.

IV. CSAR ON-LINE FEATURES

The primary purpose of CSAR is to provide on-line interactive access to central databases that contain extensive TNDS performance information. The on-line CSAR features can be logically grouped into four general categories:

1. On-line user documentation
2. TNDS performance reporting
3. Database and processing controls
4. Administrative information reporting.

The many features work together, thereby enabling each OTC to tailor the database capacity and reporting strategy to its own data requirements, organizational structure, and management needs.

The following paragraphs present an overview of the CSAR features categorized above. The description will also highlight the on-line reporting techniques and selected features that distinguish CSAR as an innovative approach to special-purpose on-line database access and reporting.

4.1 Interactive user dialogue

The CSAR interactive dialogue begins with the highest-level prompt: REQUEST =, which allows the user to select a system feature. The dialogue proceeds in a question and answer fashion until the user enters a specific request or inquiry.

The CSAR interactive user dialogue is designed to offer a user-friendly interface. The dialogue design gives the inexperienced user specific direction and guidance when questions and problems arise. For the experienced user, an abbreviated dialogue sequence can be strung together on a single line to save typing and interaction time. The user dialogue allows flexible inquiry and reporting. For frequent requests of tailored reports, the dialogue sequence can be defined once, saved, and activated when the need arises.

4.2 On-line documentation

A fundamental goal of CSAR is to be a totally on-line interactive tool that includes all necessary user documentation. Within CSAR, user documentation is available on-line in the form of 40 lessons that cover all aspects of CSAR use and administration. A particular lesson can be retrieved on-line at the user's terminal or printed off-line and mailed to specified address. This form of documentation is timely and easy to maintain, and eliminates the many problems associated with distribution lists and central reproduction.

4.3 Performance reporting

CSAR performance reports present data in predefined formats. Report content, however, is dynamically retrieved and prepared to satisfy specific user needs. The flexibility of the CSAR reporting mechanism lies in four levels of data selection available to the user. The first level, Report Type, identifies a particular enumeration or summarization of the performance data and implies an associated physical format. The second level, System, selects one, or possibly all, systems in the TNDS. The third and most versatile level of selection is Organization. The user can select one or more reportable entities, traffic units, by naming the organization to which they belong. The company organization structure (known as the organizational map) is defined to the system by the CSAR company coordinator or administrative user as part of start-up procedures and can be dynamically modified whenever necessary. The CSAR map is more fully described later in this section. The fourth level, Time, specifies the calendar dates for which results are desired. The performance report request, and the underlying database retrieval, are defined by the composite of these selection criteria: Report Type, System, Organization, and Time. Any additional specifications are supported by a list of Options that are different for each report type.

There are four general types of performance reports:

1. Performance Indicator reports
2. Performance Summary reports
3. Performance Monitor reports
4. Unsatisfactory Results Display reports.

The following paragraphs describe the purpose and basic characteristics of these four report types. Specific examples of reports, their use by the OTC personnel, and the benefits to overall TNDS operations are discussed.

4.3.1 Performance indicators

The Performance Indicator Reports (PIRs) are intended for weekly troubleshooting of TNDS operational problems and data abnormalities. Those personnel most immediately responsible for data administration for the various TNDS systems access CSAR on a regular basis to detect these problems and isolate their causes. A PIR exists for each system in the TNDS scored under the TPMP. A PIR request retrieves weekly traffic unit data pertinent to one system in TNDS for any specified company organization. The performance measurements that appear on these weekly reports include those listed in Table I. The measurements typically quantify indications of missing data, validation failures, and record base inconsistency or errors. The report content is formatted as one line per traffic unit so the data for many traffic units can be scanned quickly. All performance measurement values that fall into the Unsatisfactory band are highlighted on the report.

Options are available with the PIR that make it even more powerful as a troubleshooting tool. These include "history" and "exception" options, which can be included in the initial PIR request, and the "detail" option, which can be selected after the PIR has been printed and perused. The history option allows inclusion of up to 15 previous weeks of information on the PIR. The exception option causes CSAR to report information on only those units for which one or more of the week's performance measures exceed the band U threshold. The history and exception options may both be exercised on the same PIR request to highlight offices consistently performing unsatisfactorily.

The detail option is somewhat open-ended. After the PIR is printed for a given week, organization, and TNDS system, the user can request details for any Traffic Unit (TU) in the report. After the detailed report for that unit is produced for the given week and TNDS system, the user is asked if details are desired for the same unit and week for another system in the TNDS. Thus, where applicable, the user can look upstream in the TNDS to see where problems first appeared in the TNDS process or downstream to see their ultimate effect. This may be very helpful in tracking down subtle problems.

There are too many combinations of PIRs and options to describe here, but a typical example of analyzing results and problems using a few reports should be indicative of the assistance provided by CSAR. Figure 2 shows a PIR for the No. 5 Crossbar Central Office Equipment Reports System (5XB COER)[1] for one district. An administrator responsible for monitoring 5XB COER results can obtain this report through the dialogue shown on the top two lines of the figure. In the dialogue, the questions from CSAR are in the large type to the left of "=:" followed by the user inputs in the smaller type. No options were selected in this example.

The report header identifies the report type, organization, and study date. As we can see in Fig. 2, this is the 5XB COER Performance

```
REQUEST = :repo indi 5xb nod district 111581
OPTIONS("D"BLSPC,"E"XCPTN,"H"ISTORY,"P"AGING)=:


        SCB                          CSAR 5XBCOER                  DATE 12/17/81
MOD            DISTRICT       PERFORMANCE INDICATOR REPORT          RPT TC034
                                      STUDY DATE 11/15/81

  TRAFFIC       -----INPUT DATA ENDHOURS-----  --VALIDATIONS--  CF
   UNIT                        DEF  DEF  CM   NOT                    ERR
              EXP    MISSING   TMR  SCH  OUT  EXP  PERFORM  FAILED

   NOD1       MANAGER
NWORLAMUMGO   80     0-  0.0%   0    0    X    0    1590    75-  4.7%   N
   NOD2       MANAGER
FKLNLAMAMGO   25     0-  0.0%   0    0    X    0    1634    83-  5.1%   N
MRCYLAINMGO   30     5- 16.7%*  5    0    X    0    2570    88-  3.4%   N
   NOD4       MANAGER
BURSLAMAMGO   10     0-  0.0%   0    0    X    0     401    29-  7.2%   N
NWORLAARMGO  115     0-  0.0%   0    0    X    0    2902   126-  4.3%   N

* =UNSATISFACTORY PERFORMANCE
X =COLLECTION MACHINE OUTAGE NOT YET CORRELATED


DETAILS? ENTER TUNAME OR NO:mrcylainmg0
```

Fig. 2—Performance indicator report for the 5XB COER for one district.

Indicator Report for the New Orleans District of South Central Bell for the traffic study week of 11/15/81. A data header (feature ① of the figure) identifies the performance measurement data below. Under TRAFFIC UNIT, feature ②, five 11-character TU Common Language codes are shown. These are grouped together by the various organizations directly subordinate to the district being reported. Three subdistricts (NOD1, NOD2 and NOD4) are shown. Thus, any performance pattern associated with the subordinate organizational level would be obvious to the district level.

The next two columns, feature ③, pertain to the 5XB COER performance measure, MISSING DATA. The first of these columns shows the number of one-hour intervals expected for each TU by the 5XB COER system. These expectations are a part of the 5XB COER record base. The next column indicates missing traffic data, both the expected percentage and the number of one-hour intervals. The asterisk for MRCYLAINMGO indicates the percent of missing data for this week exceeds the band U threshold. Quick response to correct the deficiency will prevent it from persisting long enough to be band U for the official reporting period of one month.

The next four columns, feature ④, provide supplementary information resulting from CSAR automatically attempting to indicate the source of any missing data. In this case, the five one-hour missing intervals for MRCYLAINMGO are accounted for in the first column by a deficient Traffic Measurement Request (TMR). (TMRs are used to request that intervals be passed from TDAS to the downstream systems such as 5XB COER, if perhaps an interval was missing from the TMR.) The next column of this feature contains supplementary information indicating that there were no deficiencies in the scheduling of this data from the collection machine to TDAS. The "X" in the following column, Collection Machine Outage (CM OUT), indicates that there were disturbances in the collection phase of TNDS sometime during the intervals when data were gathered for 5XB COER. But since all data have been accounted for, these must have been minor. The last of these four columns indicates that no unexpected data (NOT EXP) was received for any TU. That is, TDAS did not forward to 5XB COER any data that were not expected (excess TMR). Thus, all 5XB COER data missing for this district are accounted for by the DEF TMR, which is the difference between what COER was told to expect and what TDAS was told to forward by their respective record bases.

The next two columns of the PIR, feature ⑤, give the number of validation tests performed by COER and the number and percent that failed. Validation failures are performance measurements, but the absence of asterisks indicates that none of the TU's are in band U for that measure. If the administrator, however, sees the failures exceeding reasonable rates for any TU, detailed information can be obtained as described later.

The last column of the PIR indicates where the COER internal record base validation tests have detected a record base inconsistency (control file error). None has been detected in this district.

Thus, perusal of this week's PIR indicates that the only severe problem is a data loss for one TU caused by a scheduling mismatch between the TDAS and 5XB COER record bases.

After the PIR and its accompanying footnotes are printed, CSAR asks the user to enter a TU name if further details are desired. In this typical example, the last line of Fig. 2 shows that the user responded with MRCYLAINMGO, the TU having the missing data. A 5XB COER Traffic Unit Details Report, Fig. 3, is generated from that request. The top section of this report, feature ①, is a repeat of the PIR format for the one TU. This redundant information is included in the details report so that the report is complete for that TU without requiring reference to the PIR. A few lines below, feature ② shows the status of the data input to 5XB COER. The interpretation of this information, guided by the appropriate on-line lesson, is that six one-hour intervals (ending at 10:00, 10:30, 11:00, 11:30, 16:00, and 16:30) are expected by COER on all of the weekdays. However, the data expected for the one hour ending at 11:30 (between 11 and 12 on the

```
SCB                              CSAR 5XBCOER                        DATE 12/17/81
MRCYLAINMGO TU            TRAFFIC UNIT DETAILS REPORT                RPT TC036
                               STUDY DATE 11/15/81

  TRAFFIC    ----- INPUT DATA ENDHOURS -----     -- VALIDATIONS --          CF
   UNIT                     DEF  DEF  CM   NOT                               ERR      ①
              EXP   MISSING  TMR  SCH  OUT  EXP  PERFORM      FAILED

MRCYLAINMGO   30   5- 16.7%*    5    0    X    0     2570       88- 3.4%       N

INPUT DATA SUMMARY:        # RECORDS    EARLIEST - LATEST
          NEW                   7475    11/16/81  - 11/20/81
          SAVE                     0
          PURGED                   0

INPUT DATA STATUS CODES ON AN ENDHOUR BASIS:
                                       1 1 1 1 1 1 1 1 1 1 2 2 2 2 2
                 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
11/15/81  SUN
          MON                        ...D        ..
          TUE                        ...D        ..
          WED                        ...D        ..                          ②
          THU                        ...D        ..
          FRI                        ...D        ..
          SAT

  KEY TO THE INPUT DATA STATUS CODES USED ABOVE:
  . =AVAILABLE, >90% DATA RECVD          M =MISSING, <=90% DATA RECVD
  D =DEFICIENT TMR                       I =INVALID IN TDAS
  E =EXCESS TMR                          U =UNAVAILABLE TO TDAS
  (^) BELOW ENDHR WITH CM OUTAGE         BLANK =DATA NOT REQUIRED

DATA VALIDATION TEST RESULTS ON AN EQUIPMENT COMPONENT BASIS:

  COMPONENT   # EXPECTED   # PERFORMED   # FAILED   % FAILED
     AM              100            75          0       0.0%
     CM              250           248          1       0.4%
     CS                0             0          0       0.0%
     CX                0             0          0       0.0%
     DM              231           214         11       5.1%
     DT               75            75          0       0.0%
     ET                0             0          0       0.0%                  ③
     IR              525           437         19       4.3%
     LL              438           383          4       1.0%
     MC               75            75          0       0.0%
     OR              177           165          0       0.0%
     OS              541           428         53      12.4%
     TK              500           470          0       0.0%
* =UNSATISFACTORY PERFORMANCE
X =COLLECTION MACHINE OUTAGE NOT YET CORRELATED

ENTER OTHER SYSTEM OR NO:tdas
ENTER DETAIL TYPE(S) <DCU,SCH,TMR,VD,ALL,NONE> : :tmr
```

Fig. 3—A 5XB COER traffic unit details report.

figure) were not provided to 5XB COER because they were not scheduled through TDAS on a TMR.

Thus, the 5XB COER details report can serve as a comprehensive trouble indication to organization(s) responsible for scheduling 5XB traffic data for this TU. In this case, the analysis and trouble referral would be complete after a brief on-line computer session.

The bottom of Fig. 3, feature ③, gives details on the data validation tests. When the TU validation failures are higher than an experienced administrator thinks is normal, they could use these details to determine which component tests have abnormal failure rates.

The last two lines of Fig. 3 show the dialogue for optionally obtaining access to further information from other systems in the TNDS for this same TU. In this example the user continues the analysis by requesting complete TDAS details on all TMRs for this TU week.

4.3.2 Performance summaries

The Performance Summary Reports (PSRs), derived from weekly results in the database, evaluate performance in the TNDS operation for management at all levels of the telephone company organization. The summaries are available for one or all systems in the TNDS. The summarization technique determines individual traffic unit results for each performance measurement and places each traffic unit measurement into the appropriate band: Objective, Lower than Objective, or Unsatisfactory. As we discussed earlier, this banding technique avoids averaging the results across entities and masking specific cases of poor performance. As shown in Fig. 4, the summarized results reported are the number of traffic units and the percentage of traffic units in each performance band for each measurement. Totals are included on a system basis in the TNDS, along with grand totals. The on-line summarization is computed for the time period specified by the user (one or more study weeks) and for a requested organization (one or more traffic units).

As part of the regular CSAR processing, an official performance summary is run for monthly results of the total company. These results for the Service Observing Month (SOM) are then retained as part of the CSAR database. The grand total results for each company constitute the official input to TPMP.

As an aid to isolating and correcting problems CSAR also generates an optional list of all traffic units that appear in the unsatisfactory category (Fig. 5). This list can serve as a trouble list, and appropriate remarks regarding disposition and/or remedy can be made in the comments column.

4.3.3 Performance monitors

In addition to traffic unit banding and summary aggregation, CSAR also monitors other aspects of TNDS operations that are not within the scope of TPMP. Performance Monitor reports serve this important purpose and include the following areas of interest:

1. Common Update transaction statistics
2. Collection machine downtime
3. TNDS processing timeliness
4. TNDS software abnormal terminations and run times

REQUEST = :repo offsum all miss area 1081
OPTIONS ("B"RIEF)=:b

SCB MISS AREA — CSAR ALL — OFFICIAL PERFORMANCE SUMMARY REPORT — STUDY PERIOD 09/27/81-10/24/81 — DATE 12/17/81 — RPT TC900

MEASUREMENT CATEGORY	BAND "L" RANGE	TU'S TEST	NO. OF OFC-WK	NUMBER AND % TESTED IN BAND "O"		"L"		"U"	
DCU-INT MISSING	7%-15%	95	291	86	91%	7	7%	2	2%
DCU-INT ANY VER FAIL	10%-25%	95	291	85	89%	8	8%	2	2%
DET TEST FAILURES	3%- 5%	0	0	0	0%	0	0%	0	0%
INVAL DET TEST SCAN	20%-30%	24	54	24	100%	0	0%	0	0%
TOTALS-TDAS		214		195	91%	15	7%	4	2%
ICAN/CU COUNT MSMTCH	3%- 5%	25	96	25	100%	0	0%	0	0%
ICAN/CU OTHER ERROR	.5%- 1%	25	96	25	100%	0	0%	0	0%
SUSPECT SCHV ASSIGN	1%- 2%	25	96	23	92%	1	4%	1	4%
UA/UE SCHV USAGE	3%- 5%	25	96	24	96%	1	4%	0	0%
TOTALS-ICAN		100		97	97%	2	2%	1	1%
CGMT INSUFF DATA	5%-10%	93	146	85	91%	5	5%	3	3%
CGMT OTHER INVALID	15%-25%	93	146	83	89%	3	3%	7	8%
CGMT UNASSOCIATED	5%-10%	93	146	90	97%	1	1%	2	2%
TOTALS-TSS		279		258	92%	9	3%	12	4%
LU INVALID FOR LBI	10%-25%	69	143	66	96%	3	4%	0	0%
LU MEAS INVALID	5%-15%	69	143	66	96%	3	4%	0	0%
TOTALS-LBS		138		132	96%	6	4%	0	0%
5XCOER CNTRL FILE ER	25%-75%	35	138	34	97%	1	3%	0	0%
5XCOER ENDHR MISSING	10%-15%	35	138	33	94%	0	0%	2	6%
5XCOER VAL FAIL/PERF	5%-10%	35	138	35	100%	0	0%	0	0%
TOTALS-5XBC		105		102	97%	1	1%	2	2%
TOTALS		836		784	94%	33	4%	19	2%

Fig. 4—Performance summary report.

5. TSS data by servicer responsibility.

These reports present an additional view of the effectiveness of data collection equipment and various company organizations.

4.3.4 Unsatisfactory results display

The management users of CSAR often prefer results that more clearly reflect general performance levels, trends over time, and direct comparison between organizations or between the component systems of the TNDS. The Unsatisfactory Results Display reports plot the poor performance (band U) in a series of horizontal bar graphs. The graphs are simple in appearance and offer a wide variety of options that reveal performance trends at a glance. The results can be plotted with subtotals by any system in the TNDS, or by the organizations that are directly subordinate to the one requested. For example, as we

REQUEST = :repo summ tss ma district 102581-111581
OPTIONS ("B"RIEF OR "L"LIST)=:1

SCB		CSAR TSS	DATE 12/17/81
MA	DISTRICT	PERFORMANCE SUMMARY REPORT	RPT TC601
		STUDY PERIOD 10/25/81-11/21/81	

MEASUREMENT CATEGORY	BAND "L" RANGE	TU'S TEST	NO. OF OFC-WK	NUMBER AND % TESTED IN BAND "O"		"L"		"U"	
CGMT INSUFF DATA	5%-10%	18	67	17	94%	0	0%	1	6%
CGMT OTHER INVALID	15%-25%	18	67	18	100%	0	0%	0	0%
CGMT UNASSOCIATED	5%-10%	18	67	17	94%	0	0%	1	6%
TOTALS		54		52	96%	0	0%	2	4%

SCB		CSAR TSS	DATE 12/17/81
MA	DISTRICT	BAND U LIST	
		STUDY PERIOD 10/25/81-11/21/82	

TRAFFIC UNITS	CATEGORIES	VALUE	COMMENTS
BLZNMSMA247	CGMT UNASSOCIATED	(22.6%)	
CLEVMSMA84A	CGMT INSUFF DATA	(33.3%)	
	2 BAND U TRAFFIC UNITS OF 18		

Fig. 5—Performance summary report showing unsatisfactory traffic units.

see in Fig. 6, an area manager can request a five-week performance graph containing an area total and subtotals for each of the divisions in that area. The official summary results are also available as graphs.

4.3.5 Bell System summaries

Analysis of TNDS performance can extend to the level of the entire Bell System when the performance results for all OTCs are aggregated together. Here, there is an opportunity to assess the need to modify TNDS, systems or operating methods in the CSAR itself. There are four types of reports available at this level. One gives Bell System total results in the form of the "Brief" version of the Performance Summary report (no band U list). The "Company" option, when exercised, produces a report of the number of performance measurements falling into each of the bands O, L, and U for each company. The "graph" option generates a graph of the band L and band U results by company. The remaining option is especially valuable for TNDS and CSAR project managers at AT&T and Bell Laboratories. This "Measure" option generates a list of each company's percentages and the Bell System totals in bands O, L, and U for each of the performance measures. Thus, problems common to a large cross sec-

```
REQUEST = :repo offdisp all miss area 1081(5
OPTION("SU"BTEND OR "SY"STEM)=:su

         SCB                              CSAR ALL                        DATE 12/17/81
MISS          AREA      OFFICIAL UNSATISFACTORY RESULTS DISPLAY             RPT TC905

TU-MEASURES  INTVLS
   TESTED                                     % IN BAND-U
                        0    5    10   15   20   25   30   35   40   >40%
                       -+----+----+----+----+----+----+----+----+----+----+-
                        .
                        .
AREA    :MISS           .
  876  05/24-06/27      .=====*
  865  06/28-07/27      .===*
  910  07/26-08/22      .=====+*
  874  08/23-09/26      .====*
  836  09/27-10/24      .==*
                        .
                        .
DISTRICT:MA             .
  317  05/24-06/27      .====*
  306  06/28-07/25      .=*
  341  07/26-08/22      .=====*
  291  08/23-09/26      .==*
  292  09/27-10/24      .==*
                        .
                        .
DISTRICT:MB             .
  257  05/24-06/27      .=====+*
  265  06/28-07/25      .====*
  269  07/26-08/22      .=====*
  259  08/23-09/26      .=====*
  244  09/27-10/24      .==*
                        .
                        .
DISTRICT:MC             .
  300  05/24-06/27      .====*
  294  06/28-07/25      .=====*
  300  07/26-08/22      .=====+===*
  324  08/23-09/26      .=====+*
  300  09/27-10/24      .==*
                        .
                        .
                        .
                       -+----+----+----+----+----+----+----+----+----+----+-
                        0    5    10   15   20   25   30   35   40   >40%
```

Fig. 6—Unsatisfactory results display.

tion of users can be examined to determine what system design or training efforts might be appropriate.

4.4 Database controls

CSAR creates and maintains separate central databases for each OTC using the system. On-line database controls permit the CSAR coordinator or Headquarters staff personnel to decide on the size of the database, the retention periods of three classes of performance information, the timing of certain automatic CSAR processing, and the organizational structure to be used for reporting purposes. Each of these controls may be exercised at any time to adapt to changes in data needs, company reorganization, storage costs, and other considerations.

4.4.1 Data retention

While the current week or current Service Observing Month (SOM) performance results are of primary interest, past results can also be examined for evidence of trends or persistence. To provide this historical perspective, CSAR databases contain fundamental performance data organized on a TNDS subsystem and traffic unit basis for distinct study weeks. In addition, summarized performance results are stored for each SOM. Because different classes of performance data serve distinct purposes and make significantly different demands on the physical database storage capacity, three data retention parameters are available to the user:

1. Short-term Retention (STR) (from 6 to 16 weeks)
2. Long-term retention [from (STR+5) to 52 weeks]
3. Official results retention (from 12 to 30 months).

The most voluminous data, deleted after the short-term retention period, are the supporting details from which the weekly results are derived. These details reflect TNDS processing at the half-hour, or hourly, level, and include measurements in terms of TDAS Data Collection Units (DCUs), switching office equipment components, Trunk Servicer responsibility codes, etc. This fine level of detail helps the CSAR user to track and isolate specific problems. The data analysis algorithms also require these data to correlate cross-system effects, and accurately calculate the weekly traffic unit measures.

Weekly performance results are kept for a period of several months (long-term retention), and SOM results are retained for more than a year (official results retention) so that performance can be compared under similar seasonal conditions.

During the CSAR Batch processing the data retention restrictions are applied, all outdated database information is automatically deleted, and the storage space is freed for future use.

4.4.2 Organizational map

The user-defined CSAR organization map provides a direct and dynamic control over database retrievals. The CSAR user is presented with a hierarchical logical view of the performance database for on-line retrieval purposes. Unlike most hierarchical database management systems, the hierarchy is not a static structure defined at database generation time; instead CSAR provides a flexible structure that can be modified easily on-line without database reorganization.

The basic reporting unit for most CSAR information is the traffic unit. Data tracking and problem diagnosis for the TNDS is most successfully accomplished by analyzing the scheduling, collection, processing, and validation activities at a fundamental traffic unit level. Data reported at this low level reveal problems that can be isolated to specific physical devices, user transactions, record base items, or operational procedures. For performance measurement of complete systems, functions, or company organizations, and for more effective management use of the information, aggregate views of traffic unit data are more appropriate. Responding to these needs, CSAR provides flexible multi-level views that permit data access at any organizational level, from the elementary traffic unit up to the entire company.

The user defines a hierarchical structure (up to nine levels) that establishes a company organization desired for CSAR reporting purposes. The first or top level is reserved for the company name, and the lowest level is designated as the traffic unit level. The remaining seven hierarchical levels can be named to represent the company structure and levels of management responsibility (i.e., district level, division level, area level, etc.). Not all seven intermediate levels have to be defined. At each of the levels two through eight, one or more entities can be named and placed subordinate to an entity named in the level above it. Figure 7 shows an organizational map with a total of five levels.

The CSAR map logically associates each of the many company traffic units to the desired organizations identified in this hierarchical structure. The physical database storage of traffic unit performance data is completely independent of this logical hierarchy. The CSAR dialogue then allows groups of traffic units to be collectively requested by any designated organization at any level.

The map's structure and the association of traffic units to higher-level organizations is defined using special data-entry features of the CSAR dialogue. A complete set of update commands allow the user to add, delete, change, rename, and move individual traffic units, complete organizations, or levels. The changes are performed on-line with the resulting organization in effect immediately for all subsequent report requests. CSAR features also include the ability to list the map in a variety of ways to determine or verify the current company organizational structure.

The direct control over a retrieval hierarchy and the ability to modify it easily make the CSAR organizational map a most versatile and innovative system feature.

4.5 Processing controls

CSAR on-line features can override certain automatic batch processing functions. These controls are enacted through the normal CSAR dialogue, but only by the privileged headquarter's users. The overrides exist to meet two types of needs: (1) a management demand for an early assessment of official monthly results; and (2) an administrative need to respond quickly and conveniently to batch processing problems.

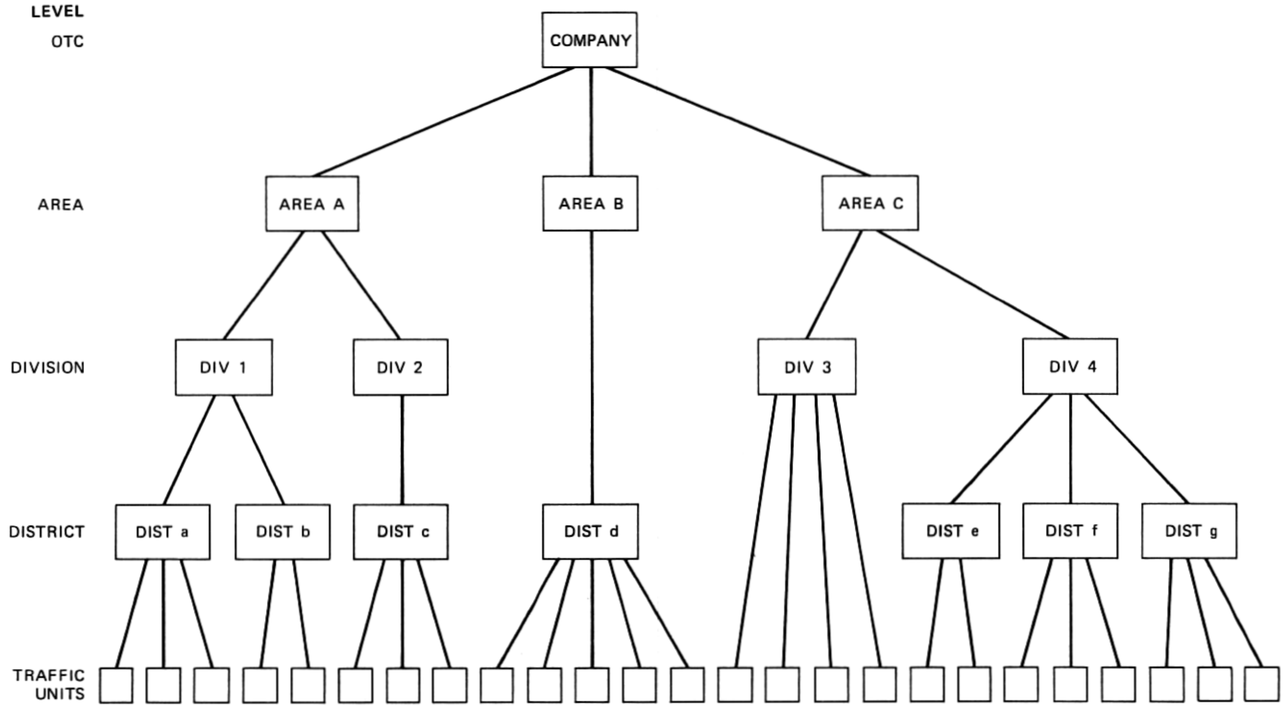


Fig. 7—Organizational map structure.

4.5.1 *Generating official results*

A process delay parameter, entered as a company option, defines the longest expected delay between the collection of traffic data and the delivery of the TNDS performance data to CSAR. The database loading process closely monitors actual data delay, particularly to determine late data impact on official TPMP monthly results. The official performance summary results are generated automatically during the CSAR batch process after the appropriate period of time has elapsed. In cases where management personnel require official results prior to the expiration of the process delay period, CSAR permits on-line interactive generation of the official performance summary. This on-line feature enables the administrator to satisfy immediate needs or to correct past results by regenerating summaries in the event of unexpected, very late data.

4.5.2 *Batch job control*

Process control features also exist to simplify overseeing the data transmission and CSAR batch database loading process, described in Sections 3.1.2 and 3.1.3. Each OTC's administrator responds to abnormal completion of CSAR batch jobs. Interactive features include Rerun and Remove commands allowing direct control over the disposition of individual data transmissions that were received but not successfully processed. These controls are exercised after the administrator determines the nature of the problem using diagnostic and error recovery information supplied by the system.

4.6 *Administrative reporting*

The telephone company administration of the CSAR software system requires activities such as: initial implementation, organizational map definitions and maintenance, selection of company options, coordination of data transmissions, and monitoring of the ongoing data processing. Each OTC has a designated CSAR administrator. Some of CSAR's features simplify the administrator's job. The data transmission and database entry operation have been automated to the fullest extent possible. The CSAR database provides on-line interactive access to status information and various reports that assist in system administration. The administrator relies on several sources of information to monitor the overall operation of CSAR:

1. Local and global login messages
2. News items
3. Tape processing status
4. Batch data processing summary
5. Map Data Discrepancy report

6. Interactive feature usage statistics
7. Operational cost information.

When an administrative user logs on, the Messages, News Items, and Tape Processing Status display important happenings without the need for database query. Based on any abnormal terminations indicated on the tape status, the corresponding batch job is investigated by accessing the Batch Data Processing Summary. The summary serves as a log of all processing activities and contains any error diagnostics identified by the CSAR software. Many conditions can be effectively identified and corrected by the administrator. Other problems may require investigation by the central development organization, and the error message would instruct the user to initiate the trouble referral.

The entry of new data into the CSAR database may involve traffic units that had not been anticipated, or for some reason not properly defined in the company organization map. The performance data are retained for these traffic units and are entered into the database. In addition, each previously unknown traffic unit is temporarily added to the map directly subordinate to the company level, where it remains until the administrator uses the CSAR dialogue to move the traffic unit to the appropriate position in the organization hierarchy. CSAR alerts the users of any such unexpected or unusual conditions via a Map Data Discrepancy report, and by Input Data Anomaly sections of the Batch Data Processing Summary. The software system design incorporates similar error detection and supporting diagnostic information throughout to simplify system administration and maintenance.

V. CSAR SOFTWARE DESIGN

In the design of a software system several conflicting factors are addressed and balanced to provide an efficient, flexible system that is responsive to the user needs. Three aspects of CSAR software design deserve specific mention and are covered in the following paragraphs.

5.1 On-line response time

A primary concern in the design of CSAR was flexibility in selecting the set of traffic units, TNDS systems, and time periods over which performance can be summarized. Depending on the particular request, tens of thousands of data items would have to be summarized on line and reported to the user. To accomplish this summarization with good on-line response time required special attention in the CSAR design. The physical database organization chosen reflects the high-level summarization options of "system" and "time period." Unique files exist for each system/week that contain the key performance information for all reporting traffic units. CMS files are organized and accessed with a physical block size of 800 bytes. The key performance indicators for many traffic units are stored together in logical records whose lengths are an integral multiple of 800 (one TU requires much less than 800 bytes) to make efficient use of the operating system's file structure. File pointer tables exist to identify the CMS record (block) and location within the block for each active TU. The internal traffic unit identification scheme utilizes a hashing function together with the file pointer table to efficiently access the data for a particular TU within a file. The logical structure of the map efficiently converts the OTC organizational level to a set of reportable TU hash indices. Finally, the TU access order is optimized based upon the file pointers to minimize the amount of I/O necessary to read the raw performance data. These techniques used together result in worst-case summarization response times typically less than six seconds in an average size OTC.

5.2 Flexibility in reportable measures

The measurement plan consists of 19 individual performance indicators. These basic indicators have been refined several times since the measurement plan was first introduced to provide equitable reporting across companies and to encourage continued performance improvement.

The design of the software to support these changing requirements had to be robust and easy to modify. The identification of distinct measures, the start and stop effective dates, the banding thresholds, and other key information are all specified in a single file external to the software programs. During system execution this file is accessed to load tables that control the summarization process. This table-driven summarization approach is also beneficial in that the effects of proposed changes to the mesurement plan can be observed by editing a development copy of this file and using this modified version when accessing the OTC data. Many such modifications can be studied and later implemented without changing or recompiling any software.

5.3 Overlay structure

User chargeback generated by using this AT&T VM/CMS facility is highly sensitive to the core size of the virtual machine required for the application program. To minimize this aspect of chargeback, and to improve efficiency by reducing virtual storage paging, the system was designed with an overlay structure consisting of over 120 separate modules. The design of these modules reduced the total amount of code generated by combining approximately 560 functional routines as building blocks.

The overlay structure maintains common routines and information required throughout the on-line session in a root area that is never overlayed. Specific software required to respond to a particular user request is overlayed in multiple levels below the root. In the most complex request, eleven individual overlays are used, reducing the amount of incore storage required from 500 to 130 kilobytes.

VI. CONCLUSION

The goal of bringing performance measurements and operations analysis information to the TNDS has been achieved by implementing the TPMP through CSAR. TNDS managers and administrators now receive reports that are comprehensive, easy to obtain and use and on time. CSAR can be readily adapted and documented as TNDS changes. In fact, method changes are currently under way to improve the effectiveness of CSAR in isolating TNDS data collection and provisioning problems. Recent changes and future plans, not reflected in this article, include the revision or elimination of certain performance measurements. These changes will shift the emphasis from strictly end-system analysis to measurements that detect and quantify problems of data availability earlier in the flow of data through TNDS. As data responsibilities have become better focused organizationally, TPMP has been reexamined to ensure the plan meets the changing needs of OTC managers. This article reflects the CSAR software system and TPMP methods as of the middle of 1982.

CSAR became available to the OTCs in the last half of 1979. No official TPMP reporting was required by AT&T, however, until July of 1980. During the introductory interval, the OTCs began to use CSAR reports as effective tools for traffic data administration and management. At the start of the official reporting, the Bell System average for band U measurements was about 10 percent. (This is thought to be about one-half of what it was at the beginning of the introductory period.) The current Bell System average of band U measurements is about 5 percent. Thus, CSAR is providing effective in improving the delivery of valid traffic data so that the Bell System network can respond efficiently to customer needs.

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AUTHORS

Dennis R. Anderson, B.S.C.S., 1976, Michigan State University; M.S.C.S., 1978, Purdue University; Bell Laboratories, 1977—. Mr. Anderson initially worked on software development for the No. 5 Crossbar Central Office Equipment Reports system. He later worked on performance measurement of the traffic data collection and processing functions performed by the Total Network Data System. He defined new measurement methods and designed interactive software for efficient data analysis, database access, and performance summarization. In addition to development responsibilities, he wrote feature requirements and participated in project planning. He is currently working on the Digital Ordering and Planning System for No. 5 *ESS*® switching equipment. Member, ACM, Tau Beta Pi.

Melvin J. Evans, B.S.E.E., 1957, University of Utah; M.E.E., 1959, New York University; Bell Laboratories, 1957—. After joining Bell Laboratories, Mr. Evans worked on guidance equations used by the Bell Laboratories Command Guidance System for rocket launch vehicles. He has supervised guidance equation work, lunar mission studies, and military system effectiveness studies. He has also supervised work on operations support systems that assist Bell System network and data administrators. Starting in 1976, his group took part in a study of Total Network Data System performance, and then developed the Centralized System for Analysis and Reporting (CSAR). Currently, he supervises the Planning Mechanization group, which provides computerized support for operations planning.