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Automated Repair Service Bureau:

Data Base System

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The role of the data base system of the Loop Maintenance Operations System (LMOS) is to maintain up-to-date information about the customer's telephone service and trouble history to facilitate customer trouble repair. The discussion covers data base content, rationale for the data base system architecture, and methods for keeping the data current.

I. OVERVIEW—LMOS

To provide an understanding of the data base system issues of LMOS, this overview shows functional linkage between the various system parts and briefly discusses the host architecture design, data base conversion, and data base update. The remaining sections of the paper provide detailed discussions of the evolution of the host data base system architecture, data base conversion strategy, and methods and types of data base update required to keep the operational data base current.

The Automated Repair Service Bureau (ARSB), described in this issue of *The Bell System Technical Journal*,[1,2] consists of two major functions: mechanized management of customer repair data and mechanized testing. The LMOS, a distributed system, is the customer repair data management system. The LMOS host maintains customer line record and trouble data so that repair personnel have up-to-date information about the facilities being repaired. The LMOS front-end transaction processors record and track troubles on telephone equipment from the time the troubles are reported until they are repaired.

For simplicity, discussion of other ARSB systems, such as Mechanized Loop Testing (MLT), Loop Cable Administration and Maintenance

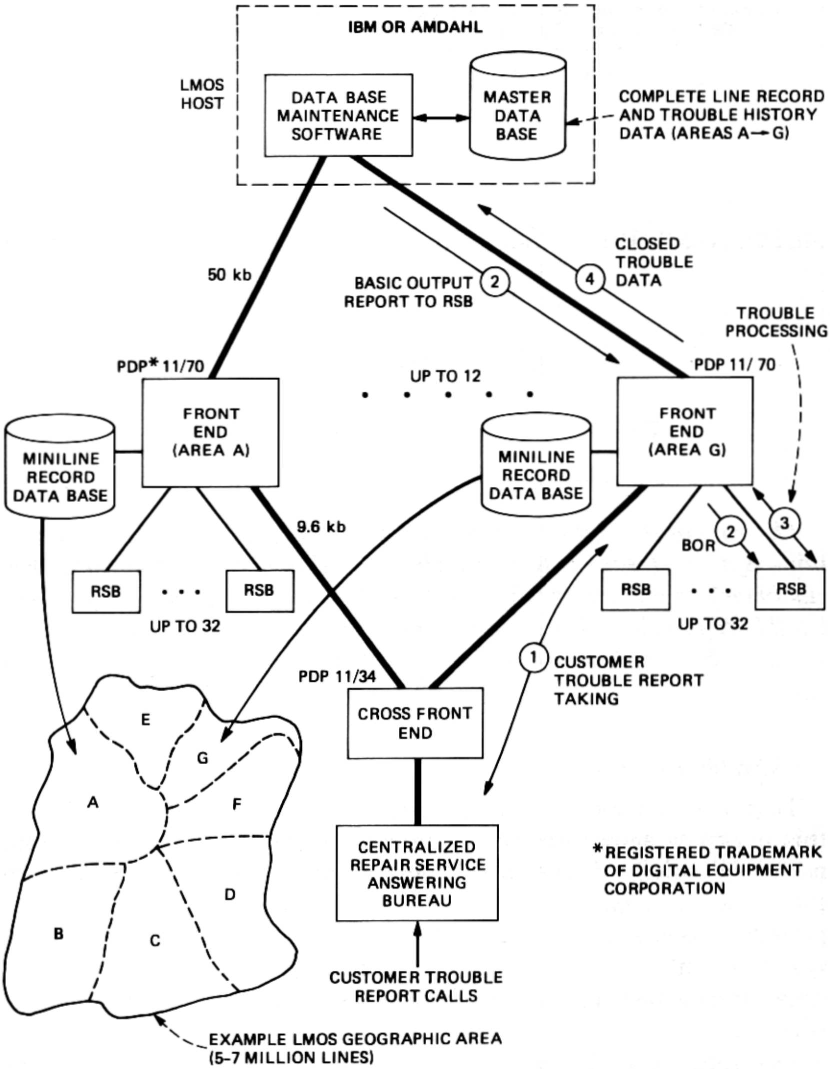

Fig. 1—Loop maintenance operations system (LMOS).

Operations System (LCAMOS), and Trouble Report Evaluation and Analysis Tool (TREAT) are not covered in this paper. See Refs. 3, 4, and 5 appearing in this issue.

1.2 System organization

Figure 1 illustrates geographic overlay of the system on a typical Bell operating company's (BOC's) area of application (from five to seven million lines) and the trouble processing functions supported by major elements of the system.

The LMOS host data base stores in a large "master data base" complete information on the customer's telephone service including premise equipment data; class of service; network facilities assigned to the customer's circuit; and trouble history. In the example LMOS geographic area of Fig. 1, complete "line card" and trouble history files for all customer lines in the five-to-seven-million-line area of application exist in the host data base.

The distributed front-end transaction processors form the real-time interface with customers via the Centralized Repair Service Answering Bureau.[6] An LMOS installation can have up to 12 front-end transaction processors. The maximum capacity of a single transaction processor is approximately one million lines. The actual number of transaction processors installed will depend on considerations such as transaction rates and area boundaries.

In the example shown, we assume seven transaction processors, each mapping into one of the subareas A through G. The data base for each front-end processor contains a subset of the line record data in the host and is called a miniline record. The miniline record contains essential information for repair and is used principally for trouble report taking. If the host is down, the miniline record can also provide basic information for processing troubles to a "closed" status. It is about one-seventh the size of the full line record on the host. In addition, a given transaction processor contains miniline records only for customers in its subarea.

1.3 Trouble processing

Figure 1 also illustrates how the distributed architecture of LMOS supports customer report processing. Assume the customer's phone service is in subarea G and is out-of-order. The customer may report the trouble from any location within the total area; however, the cross front end links the Centralized Repair Service Answering Bureau with the front-end data base serving subarea G, while the trouble report is being taken (event 1).[7] When the trouble report is forwarded to transaction processor G, it requests a Basic Output Report (BOR) from the host. The BOR, containing complete line record data, test results, and trouble history, is transmitted to a printer in the RSB serving that customer (event 2). The BOR is screened for the appropriate next step, which may include further tests, a craft dispatch or other activity as required to repair the trouble (event 3). When the telephone circuit is repaired, trouble report closeout information is transmitted to the host (event 4).

1.4 Host data base architecture

Figure 2 shows the architecture of the LMOS host data base system.

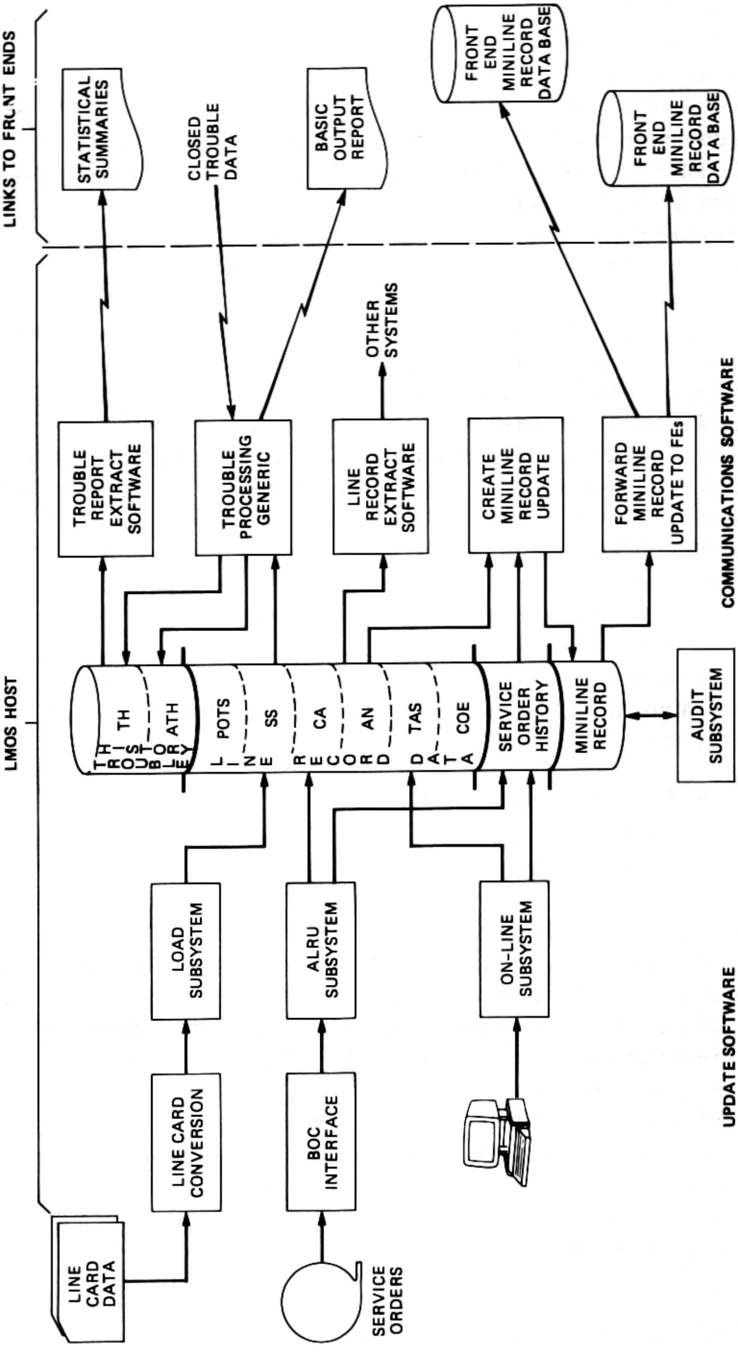

Fig. 2—LMOS data base systems architecture.

The three host software generics on the left keep the data bases current. To the right are data base interfaces with the front-end transaction processors and the statistical report generation software, Trouble Report Evaluation and Analysis Tool (TREAT).[5] Major divisions of data are as follows:

Past trouble history—The Abbreviated Trouble History (ATH) data base contains, as a minimum, the most recent 40 days of history. The Trouble History (TH) data base contains histories of troubles closed during the day and is used to support TREAT statistical reports.

Line record—These data bases contain information about the customer's telephone circuit. The Plain Old Telephone Service (POTS) and Special Services (SS) data bases are identical structures, except the POTS key is the 10-digit telephone number, while the SS key can be any alpha-numeric up to 16 characters, plus number plan area (NPA). These two data bases form the basic line record information. (Note that for LMOS convenience, the LMOS definition of an SS is any circuit having an identifier that is other than 10-digit numeric with a real NPA.) The Cable (CA), Associated Number (AN), Telephone Answering Service (TAS) and Central Office Equipment (COE) data bases contain data common to the line record file but have been "inverted" for access by cable and pair number, telephone number associated with a main account, TAS number associated with a customer's telephone service, and central office exchange key and switching equipment number, respectively.

Miniline record—These are reduced versions of the POTS and SS line record data bases described above. There is one miniline record data base for each front-end transaction processor; the miniline record provides the mechanism for transferring changes that have occurred in the host to the front end.[6]

Service order history—This data base contains a list of all line records changed during the day. The list is used for constructing miniline records to be sent to the front ends.

1.5 Data base conversion and update

The three modes for processing changes to the host data base are LOAD, Automatic Line Record Update (ALRU), and ON-LINE. The LOAD subsystem is used to initially create the line record data base from existing paper records or from other mechanized sources. The ALRU automatically performs the bulk of day-to-day changes to the records because of service order activity. The ON-LINE subsystem provides a means for manual inspection and/or change of line record information via a CRT; the principal uses of this subsystem are error correction, input of nonstandard service orders, and input of information as a result of plant rearrangements and changes (work orders).

Audits provide for internal consistency between common data items in the various data bases. Accuracy checks usually require data comparison to physical circuits.

1.6 Data base decisions in retrospect

The data base system of LMOS had to accommodate the following major repair functions:

(*i*) *Taking trouble reports*—The operational objective was to display, in five seconds or less, information about a customer's telephone service when the customer contacted the Centralized Repair Service Answering Bureau.

(*ii*) *Tracking open troubles*—The system had to provide a capability for accepting new trouble reports and maintaining status information about the troubles until closed out.

(*iii*) *Maintaining trouble history*—The most recent forty days of closed trouble information had to be maintained in the data base for summary and review purposes. Afterwards, the trouble history data could be transferred to microfilm storage.

(*iv*) *Maintaining up-to-date line record data*—Changes made to the customer's telephone service had to be reflected (typically within 24 hours) in the LMOS data bases.

While the above list is not exhaustive, it does show a requirements pattern for the data base system. Functions (*i*) and (*ii*) require the data base system to provide rapid access to data and to manage volatile trouble report information while the trouble is being processed. Functions (*iii*) and (*iv*) are characterized by long-term storage of large amounts of data that change relatively slowly (i.e., 1/3 to 1/2 percent of the data changes every working day).

It was decided that functions (*i*) and (*ii*) could best be met with small data bases distributed across several front ends. These data bases would contain copies of essential line record data (miniline record) obtained from a large master data base. The master data base (referred to in this paper as the LMOS host data base) would be the focal point for all updating and distribution of line record changes throughout the LMOS system.

Using redundant storage to meet response time requirements somewhat complicates the data base update process, but time constraints on update are much less severe and the penalty was considered worth paying. In addition, the power of a large main frame machine (host machine) could be effectively used to update the master data base and to propagate changed miniline records to the front-end data bases.

Regarding data base conversion, another judgment made early in the program was not to require BOC's to purify records prior to LMOS load. The rationale was twofold. First, the repair operations suffered mostly from lost records as opposed to inaccurate records. With LMOS, the line record would always be available and at a quality level with which the BOC chose to operate. This philosophy significantly reduced data base conversion expense. Secondly, tools were provided in LMOS to permit gradual record quality improvement if desired by the BOC. This basic decision is one of the main reasons that LMOS has gained a rapid market penetration.

1.7 Summary

This overview has summarized the LMOS data base system from the viewpoints of trouble processing flow and data base architecture to support this flow. Advantages being realized by the distributed data base architecture described include the following:

(*i*) Use of inexpensive minicomputers as transaction processors with small data bases while taking advantage of the Information Management System (IMS) data management system for manipulating large data bases on the host.

(*ii*) Availability of several highly reliable transaction processor configurations for real-time customer interaction.

(*iii*) Ability to locate the transaction processor near the RSBs being served to minimize communications costs.

To date, the data base design has served the loop repair process well. At the end of 1980, approximately 50 million customer line records were resident in LMOS installations throughout the Bell System. This huge reservoir of data (60 billion bytes) is now being viewed as a system resource that will undoubtedly be tapped to support other loop operations in addition to repair.

II. DATA BASE ARCHITECTURE OF LMOS

2.1 Evolution of architecture

Architecture of the data base system of LMOS has evolved from the centralized data base design of the prototype system installed in the first trial company in 1972.[1,2] Experiences with that system and additional data needs of the second and third BOC customers forced changes in the data base structure.

The prototype system divided the line record data between two data bases, POTS and SS, to allow use of IMS's fastest access method for the POTS data base. The prototype system installed in December, 1972, contained data that today is kept on the front end. At that time, the line record data bases also contained data about open troubles on the circuit. The trouble history (TH) data base contained both trouble history and history of changes to the line record data bases, called service order history.

During the early months of the first trial company's conversion, projections indicated that a POTS data base for a 2.5-million-line system would span twenty 3330 Model 1 disk packs, making the necessary backup and recovery processes intolerably slow and unmanageable. The two line record data bases were split into seven POTS data bases and three SS data bases, and a "WHICH" table was added to tell which data base contained a line record, given the exchange (NNX) of the line record key.

Data base lockout problems were experienced because, at that time, IMS prevented access to the entire data base while updating a record. To reduce the incidences of lockout, two new data bases were created: one for the open trouble data that resided in the line record data base and one for the service order history data that was in the TH data base.

The open trouble data base was moved to the front-end system with the introduction of the distributed LMOS in the second BOC in 1974. (The TH data base remained on the host because the data base was so large.) Since the lines covered by the second installation included different area codes (NPAS), NPA was added to the line record key and the WHICH table was expanded to include NPA with the NNX.

The structure of the POTS data bases changed again before installation in a third BOC in 1975. This BOC has many NNXS in which the assigned telephone numbers fall predominantly in certain thousands (last 4 digits) groups. For instance, there might be 800–900 numbers of the form 8611xxx, but less than a hundred of the form 8612xxx. Since the data base design at that time allocated space on a switching entity basis (10,000 records), this would have resulted in very large POTS data bases with many records having unassigned numbers. The data base was redesigned to allocate space on one-thousand group entities rather than ten-thousand group entities, thus, reducing wasted storage space.

The principal lesson learned from the introductory experience is that the repair operation environment varies widely from company to company. It is strongly recommended, prior to the introduction of major mechanized systems, that prototype "soaks" in at least two companies having widely different geographic environments be performed.

2.2 *Current architecture*

The LMOS host data base structures are hierarchical. The structure of the line record data base serves as an example. The line record data base contains a root segment for data that is constant in length and almost always present. Examples are the line record key (telephone number or circuit number), central office equipment, listed name, repair route, indicator for special service protection, essential line number, and class of service. Variable length data items are kept in child segments having the following structure names:

LCLOC	Line Card Location—Contains additional listed name, service address, and location information. (The first 55 bytes only are stored in the root segment.)
LCRMKR	Line Card Remarks, Retained—Contains remarks to inform the repair technician about access and equipment information.
LCSE	Line Card Service and Equipment—Contains codes for customer's service and equipment.
LCSEN	Line Card Service and Equipment Narrative—A child segment of LCSE that contains narrative about the service and equipment.
LCCL	Line Card Cable—Contains cables and pairs assigned to the circuit.
LCCLN	Line Card Cable Narrative—A child segment of the LCCL that contains cable narrative, binding post, and terminal address data.
LCISG	Line Card Incoming Service Group—Contains hunting data.

Figure 3 shows the line record structure. Any of the child segments may have multiple occurrences. The customer trouble processing operation frequently results in having to access line record data when the telephone number or circuit number is not available, but, one of the following is:

(*i*) Central office equipment number

(*ii*) Cable pairs

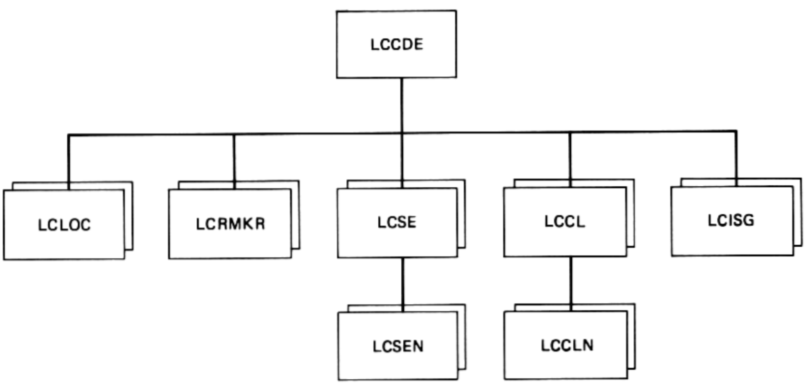

Fig. 3—Line record structure for POTS and SS data bases.

(*iii*) Main telephone number if the circuit is part of a multiline account

(*iv*) Board, position, and jack if the circuit has telephone answering service.

This access capability was implemented by building four inverted data bases rather than using the secondary indexing provided by IMS. Access through the secondary index would have been too slow and data base reorganizations would have been required too frequently. The price for the inverted data bases is that the update programs must consistently update two data bases every time one of the data items is added or deleted; when programs have bugs, inconsistencies between the line record data base and the inverted data bases result. This points to the need for a common data base access routine (which has not yet been implemented).

The four inverted data bases are described below:

(*i*) *Cable (CA)*—The CA data base contains a segment for each 25-pair complement within the cable. Associated with each pair is a pair status, taper code, pair use, and telephone number if the pair is working. Multiple telephone numbers working on the same pair are listed in separate child segments.

(*ii*) *Associated number (AN)*—Large business accounts have a main account telephone number that is used for billing and other central functions. All other telephone numbers assigned to that business are known as associated numbers. The AN data base contains a root segment for a main account telephone number and a child segment for each associated number. A program performing a disconnect of a large business account would use this data base to find all the line records to update.

(*iii*) *Central office equipment (COE)*—The COE data base contains a segment for each piece of COE. Multiple telephone numbers working on the same equipment are kept in a separate child segment, one for each additional number. A separate data base, the COE parameter data base, contains the range of allowable COE numbers. This data was separated from the COE data to reduce the disk space needed for the COE data.

(*iv*) *Telephone answering service (TAS)*—The TAS data base contains a root segment for each telephone answering service board and position number. Two occurrences of a child segment exist to associate the telephone number of TAS customers with their jack numbers, one for jacks 1–49 and one for jacks 50–99. Multiple circuits working off the same jack are kept in a third-level segment.

Brief descriptions of the other LMOS data bases follow.

(*i*) *Miniline card (MLC)*—The MLC data bases provide the mechanism for transferring changes that have occurred in the host data base to the front-end data bases. There are up to 12 MLC data bases in the host, one for each front-end system. At the end of every day, a miniline record is constructed from each line record that was changed during the day. These miniline records are placed in the MLC data bases. During the following day, the front-end system asks for the new miniline records to refresh its miniline record data base, which is used for trouble report processing.

(*ii*) *Service order history (SOH)*—The SOH data base contains a list of line records that were changed. After the miniline records are built and placed in the MLC files, the SOH data base is reinitialized.

(*iii*) *ALRU messages (ALRUM)* and ALRU recovery monitoring *(ARM)*—The Automatic Line Record Update (ALRU) system (described below) uses these two data bases. The ALRUM data base collects error messages during the ALRU run. When ALRU finishes, the messages are sorted and distributed, and the data base is reinitialized. The ARM data base contains data useful for ALRU recovery and monitoring.

(*iv*) *Cable fail (CF)*—The CF data base contains a list of all cables for which a known cable failure exists.

(*v*) *Trouble history (TH)*—The TH data base contains trouble history for all troubles closed during the day. At the end of the day, the front-end system sends trouble history data to the host to populate this data base, which is the primary input to the Trouble Report Evaluation and Analysis Tool (TREAT). The TH data base is reinitialized daily.

(*vi*) *Abbreviated trouble history (ATH)*—The ATH data base contains a subset of the data in the TH, but it keeps, as a minimum, the most recent 40 days of trouble history.

(*vii*) *Pending service order (PSO)*—The PSO data base contains the text of pending service orders by main account telephone number. The BOR checks this data base to warn the repair technician of any pending work on the telephone number. About half of the LMOS companies have implemented this data base since its utility varies from company to company.

(*viii*) *Completed service order (CSO)*—The CSO data base contains the text of completed service orders by main account telephone number. These orders are used primarily for reference when correcting errors generated by ALRU. As above, about half of the LMOS companies have implemented this data base.

2.3 Data base sizing for a typical BOC

For a five-million-working-line system, the LMOS host data bases will contain about six billion bytes of data, and the total of all LMOS front-end data bases will contain about 1.3 billion bytes of data. The "per line" average is shown in Table I.

Table I—Average bytes of data per line record

Host Data Base	Bytes	Front-End Data Base	Bytes
Line record	790	Miniline record	130
Cable	250	Open troubles	30
Office equipment	45	Testing, other	30
Associated number Telephone answering	(negligible)	Index to open troubles and line records	70
Closed troubles	60		
All other	75		
Total (per line)	1220	Total (per line)	260

Note that the front-end data base miniline record contains only 15 percent of the host line record data, since the front end must contain only that data subset required for on-line customer trouble report processing when the host is down.

Figure 4 is a display of a miniline record. The corresponding host line record is shown in Fig. 5. Note the additional information the host line record contains. The line record lists customer service and equipment codes and accompanying narrative (S&E), retained remarks (RMK), which may contain premises access information, the vertical termination of the originating equipment (VT), party position number

```
DMLR  TN- 713 4921000        PG- 1    PRTR- W998    REQ BY- JFH

LN-  JOHN DOE COMPANY                 WKG- YES           UNAS- NO
SA-  101 ANYPLACE                     DISC- NO           TEMP NWKG- NO
LOC-

OE- 010- 05- 81   RPT- 4354A   UNIT- 02000001
SC- 1FH    CS- BUS

CAB1 NPA- 713  WC- 006   CA-       11 PP- 0847
                                      COLR-
CAB2 NPA- 713  WC- 006   CA-     1108 PR- 0454
                                      COLR- BR/W
CAB3 NPA- 713  WC- 006   CA-     1108  PR- 0405
                                      COLR-
CAB4 NPA- 713  WC- 006   CA-     1108 PR- 0407
                                      COLR- BL/W
CAB5 NPA- 318  WC- 006   CA-       11 PR- 0907



CO-                     BSP-               TERM- BUSINESS
FEATURES-
NBR OF RINGERS-
DMLR  TN- 713 4921000            PG- 2  PRTR- W998   REQ BY- JFH


**LINE CONDITIONS**

  TAS- NO        DPA- NO              SEC- NO
  MAIN NBR- NO   HAS A MAIN- YES
DELETE LINE REQ- NO

**MLT INFORMATION**
  ASSOC TEST TN- -000000      DIFFERENT NNX- NO

DIRECTORY RECORD NBR- 0000217168     LRF RECORD NBR- 022348
```

Fig. 4—Miniline record.

```
DLR  DLRL  EC  444  TN  713  4921ØØØ               SEC      DPA      PRTR T998 PAGE
  ORD C966441         CD Ø6-13-75 CUS 78Ø UNIT Ø2ØØØØØ1
  NSTA     3 PUB PUB  SP                                          EN
  MAIN 713 4921ØØØ KS      Ø HTG1 4921ØØØ RT 4354A TSOP           Ø
  OE  Ø1Ø- Ø5- 81 EXK 713 497 CS BUS    SC 1FH    VT 1288 PTY
  SWC               - Ø-    SSN ? TAS N TAC 713/4921111/ 1/ 4
  LCO Ø5-29-81 LCT 122754Ø1Ø
  LN  JOHN DOE COMPANY
  SA  101 ANYPLACE
  RMK ØØ1Ø ACCESS AT BACK
  S&E QTY     1 USOC 1FB    KS     Ø LTD     REF
  S&E QTY     1 USOC 1EC    KS     Ø LTD     REF
  S&E QTY     1 USOC 1EF    KS     Ø LTD     REF
  SNR /PU 1ØØØ,Ø1
  CAB TP F1    CA 11          PR   874 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO
  CAB TP F2    CA 11Ø3        PR   454 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO BR/W
  CAB TP F3    CA 11Ø3        PR   4Ø5 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO
  CAB TP F4    CA 11Ø3        PR   4Ø7 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO BL/W
  CAB
*DISPLAY CONTINUED ON NEXT SCREEN

--------------------------------------------------------------------------------

DLR  DLRL  EC  444  TN  713  4921ØØØ               SEC      DPA      PRTR T998 PAGE
  CAB TP F5    CA 11Ø3        PR   4Ø8 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO
  CAB TP F6    CA 11          PR   9Ø7 NPA 713 WC ØØ6 PRU      TPR          PRS
                                                  CO
  HTG ØØ1Ø 4921ØØØ,4921ØØ1,
  LCO


*END OF DATA
```

Fig. 5—Full line record.

if the customer has party service, and a complete list of other circuits participating in a sequential hunt group (HTG). The example indicates that the customer is a telephone answering customer (TAC) and is connected to a telephone answering service (TAS) board with telephone number 7134921111 at position 1 on jack 4. While the miniline record has a limit of 55 characters for name, address, and location, the host line record can contain up to 823 characters. Finally, the miniline record has a limit of five cable pairs, but the host line record contains the complete cable pair list and any accompanying cable narrative. Considering the total "per line average" storage requirements per customer, the front-end storage space per customer is about 20 percent of the host storage space per customer. Assuming a five-million-line system using five front ends, the storage space per front end is met by two DEC RP06 disc storage units (1200 cylinders). The host storage requirements are met by approximately 30 IBM 3350 direct access storage devices (DASDs).

III. BUILDING THE OPERATIONAL DATA BASES

This section describes the LMOS host procedures to (*i*) initially load the data bases when LMOS is first installed, and

(*ii*) merge additional data into the data bases when repair entities are added.

3.1 *Initial load*

In preparation for data base loading, BOC personnel must assemble the paper records and other data sources currently used in the repair operations and convert these data to machine readable form. Accuracy checks on the data prior to loading LMOS are not required since LMOS provides internal consistency checks and data correction capabilities based on conflicts and errors observed by the field craft.

A total of nineteen jobs must be run to complete the initial host data base load. Figure 6 summarizes the flow of these nineteen steps and partitions the steps into four major loading functions:

(*i*) Build skeleton history and message data bases

(*ii*) Initialize data base to accept only that data falling in specified ranges.

(*iii*) Perform validation checks on line record data and partition data by principal data bases

(*iv*) Load the principal data bases (line record data base and inverted data bases).

After the principal data bases are loaded, audits of data validity and consistency must be performed. Audit programs fall into two categories. The "self check" class of audit programs scan the line card, central office equipment, and cable files independently, looking for load errors, such as two or more telephone numbers connected to the same central office equipment terminal. The "cross-check" class of audits compares common data in the inverted files (AN, COE, TAS, and CA) to the line record files (POTS and SS). These data must be consistent; therefore, if a discrepancy is found, the line record file is assumed to be accurate and the cross-audit program automatically updates the inverted file to agree.

3.2 *Merge load*

The LMOS data base is typically loaded in phases (by RSB) until the entire locality served by the host is populated. For example, customer data for additional switching machine entities or RSBs can be added to the data base by performing steps 7 through 19 (using merge options) of Fig. 6.

IV. KEEPING THE DATA BASE CURRENT

4.1 *Data input sources*

For our purposes, the telephone network can be divided into two

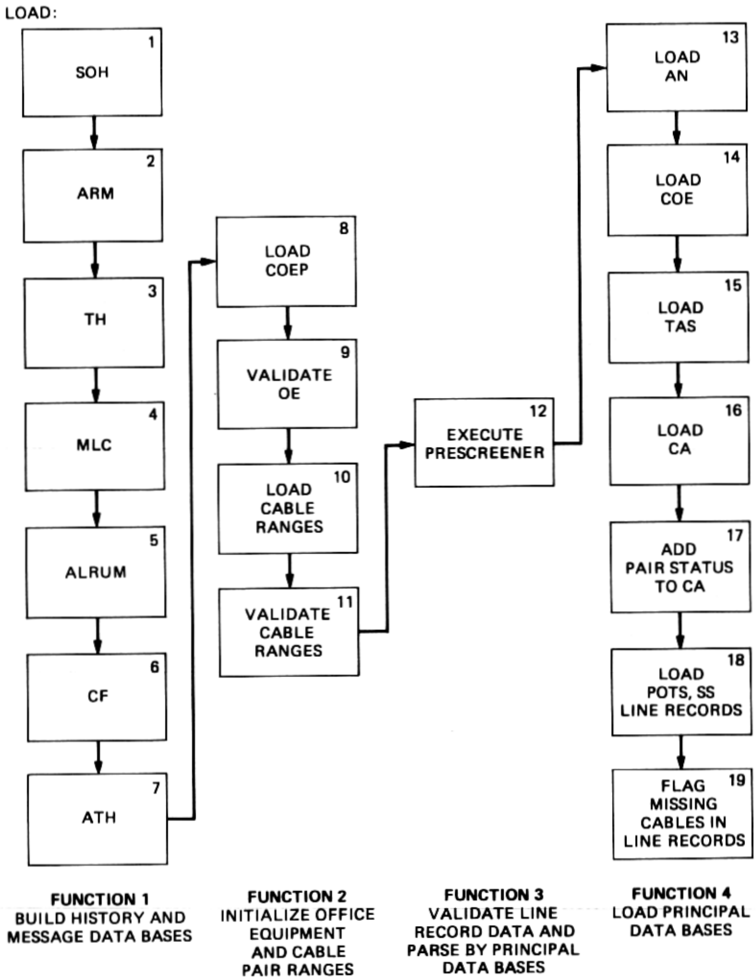

Fig. 6—Steps required for initial LMOS host data base load.

major pieces: the loop portion (i.e., from the end office to customer premises) and the toll portion (the remaining network that interconnects that national long-distance facilities). While the toll portion of the network is relatively stable, the loop portion undergoes constant change because it is the customer interface with the total network.

Since the LMOS data base is customer (and, thus, loop) oriented, these changes must be tracked. Activities that generate data base changes fall into two basic categories: (*i*) *customer* initiated service requests, and (*ii*) *Bell operating company* initiated plant changes. These categories are described below:

4.1.1 Customer initiated service requests

These requests are typified by a customer calling the local Residence Service Center/Business Service Center (RSC/BSC), or stopping by a phone center store, to request telephone service for a newly completed home or business. Other types of requests include rearrangement or addition of station equipment for an existing service, household moves, and changes to class of service.

The fundamental loop network record of these requests, and subsequent changes made to the customer's service and facilities, is the Universal Service Order (USO). Figure 7 provides an example of a completed service order (i.e., all work to implement the customer's request has been completed) for a simple POTS service.

The service order *header* is the only "fielded" portion of the order and contains record identification information, such as the telephone number for the account and service order number.

The *listing section* contains customer's name and location information; the *billing section* is of minor interest to LMOS; the *service and equipment section* identifies service features, quantity, and circuit arrangements for station equipment; and the *assignment section* identifies the central office and outside plant facilities.

Standards for the machine-readable USO are documented by AT&T.

4.1.2 Bell operating company initiated plant changes

The BOC's engineering and construction forces are charged with having adequate facilities in place at the right locations to meet customer service requirements. The requests that stimulate additions and rearrangements to loop plant are called work orders (sometimes called job orders).

Examples of work orders include the following:

(*i*) *Cable throw*—A new cable may be installed to augment an existing cable feeding a high growth area. To achieve desirable cable pair utilization levels (fill level), a range of cable pairs in the old cable can be freed up and reassigned to the new cable. This involves a change to the customer's cable and pair number.

(*ii*) *Area transfer*—It is occasionally necessary to do wire center load balancing for growth. One method is to reassign customers in a geographic serving area from one wire center to another, or to a newly installed central office switch. This usually involves customer feeder cable changes and frequently involves change of customer telephone number.

The above are only two examples of a variety of work orders. The record format and content of completed work order forms depend on the type of order worked.

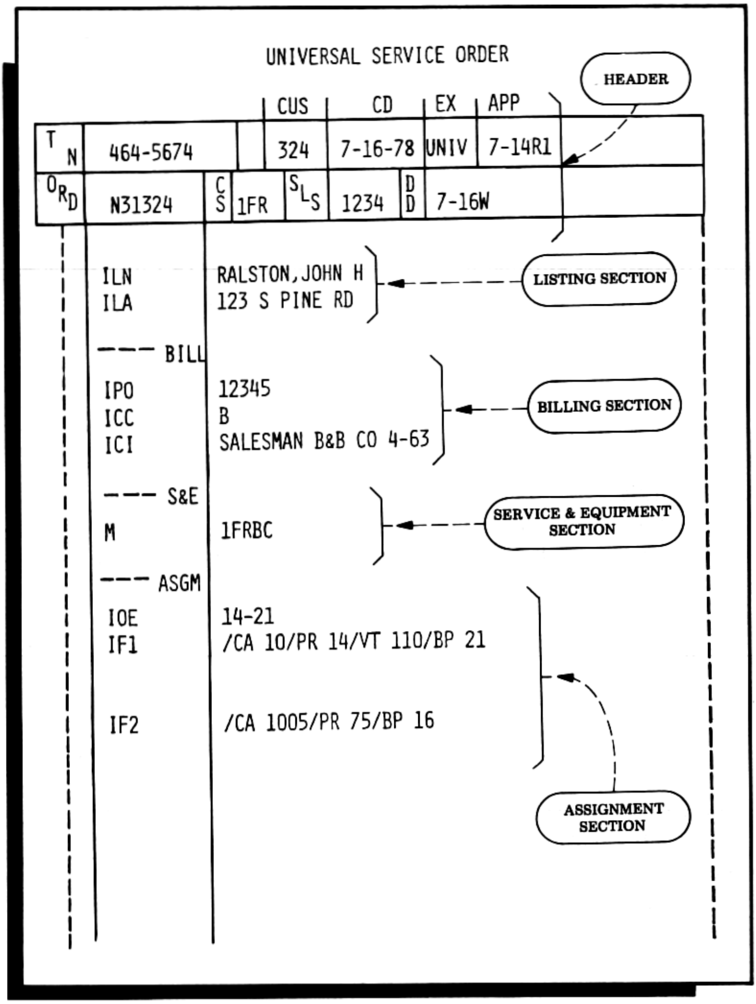

Fig. 7—Example service order.

4.2 Service order processing

Because service orders are written in USO language, they can be processed by machine. Each BOC has a mechanized service order network that produces a daily tape of completed service orders for updating the LMOS host data bases.

Before LMOS programs can read these service orders to update the data bases, the orders must pass through a BOC written interface program to add RSB identifiers (repair unit numbers) needed by LMOS and to translate BOC unique data to the standard USO format.

The LMOS programs that update the data bases from service order input form the ALRU system. The ALRU comprises two program functions, the service order reader and the packet processor. The service order reader parses service orders, extracts data of interest to LMOS, and produces "packets," which are groups of data that correspond to the LMOS data base structure. Among the packets produced from the service order in Fig. 7 would be a packet to

(*i*) create a new line record,
(*ii*) install the listed name and address,
(*iii*) install the service and equipment data on the line record,
(*iv*) install the repair route on the line record,
(*v*) install the office equipment on the line record and update the COE data base,
(*vi*) install the cable data on the line record and update the CA data base,
(*vii*) install COE remarks on the line record, and
(*viii*) install assignment remarks on the line record.

The packet processor reads the packets and updates the data base. The number of packets produced for each service order will vary, depending on service order type and complexity. Based on field experience, a typical LMOS installation may process 20,000 orders, or about 200,000 packets a day.

4.3 Work order processing

Unlike the service order, the work orders today are not written in a uniformly structured language. Hence, the "load" generic and the "on-line" generic are used to input work order data to the LMOS host (see Fig. 2). If the work order involves a bulk change of data, such as throwing 400 pairs from cable 102 to cable 109, the bulk cable throw batch program of the load generic accomplishes this very efficiently. If, on the other hand, only a few pairs are to be "thrown," say five pairs, the enter cable change (ECC) transaction of the on-line generic would be the best choice to use. Changes made to the host data base by using batch programs of the load generic, or by using the various transactions available in the on-line generic, are propagated to the front-end data bases in the same way that service order changes are.

4.4 Data base update summary

Figure 8 provides an encapsulated view of the LMOS data base update processes described in this paper, and how those processes interface with the BOC's service order and work order flow.

First a summary of the service order flow as shown by the solid lines in Fig. 8:

1. The customer requests new or changed telephone service.

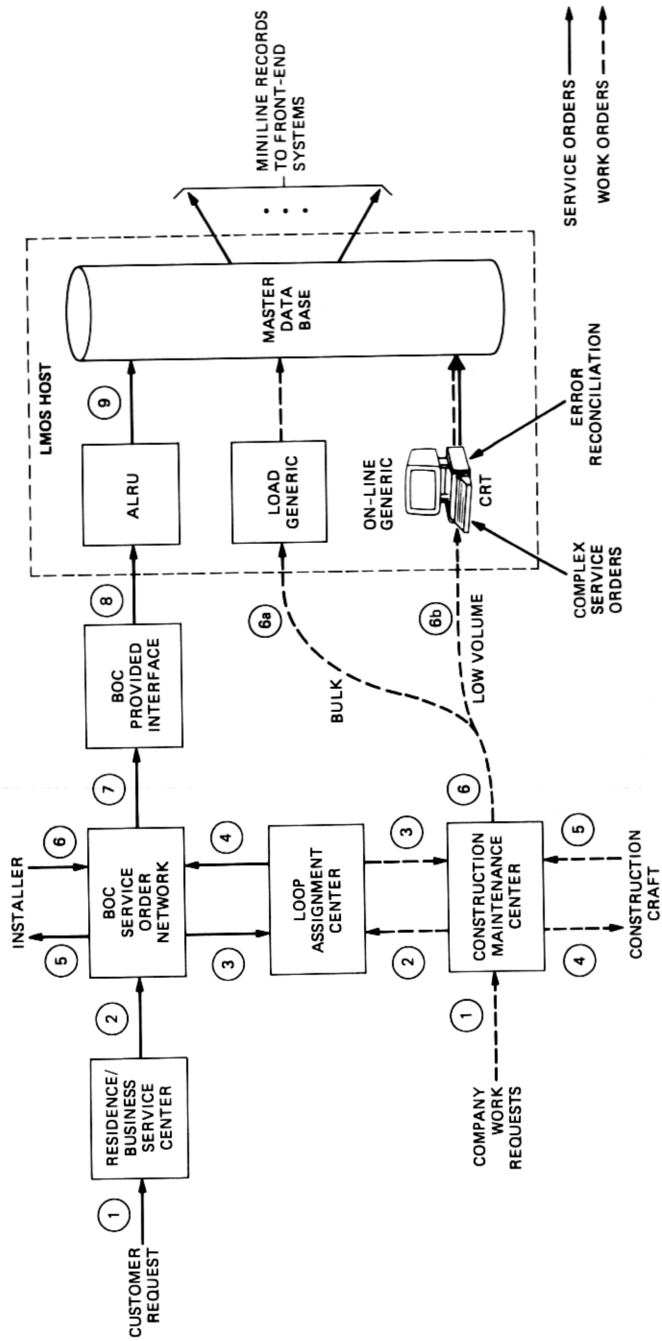

Fig. 8—Flow paths for LMOS data base update.

2. The request is entered into the BOC's service order network to be "worked."

3. A request is made to assign facilities necessary to install or modify the customer service.

4. Facilities are assigned and information is forwarded to the service order network.

5. Service order network forwards information to do work to the installer.

6. Installer completes work, returns notice to service order distribution network that service order has been completed.

7. Completed service order goes to BOC interface program to perform selected data translations for "standard" ALRU input.

8. A day's worth of service orders are accumulated and read into ALRU.

9. Automatic Line Record Update automatically updates the host data base.

On the average, there is one service order processed per line per year. A typical 5-million-line LMOS installation will process about 20,000 service orders per working day.

A summary of the work order flow as shown by the dashed lines of Fig. 8 follows.

1. The Distribution Services Design Center forwards requests for loop facility additions or rearrangements to the Construction Maintenance Center to be worked. In addition, other work centers may request work to be performed. For example, the repair forces may request work to be performed to repair a trouble (maintenance change request).

2. If the request for work involves existing facilities, facility assignment information is requested.

3. Facilities assigned to the work order are forwarded to the Construction Maintenance Center.

4. The construction craft receives the complete work instructions.

5. Work is completed and notices sent to the Construction Maintenance Center.

6. A paper record of the completed work order is distributed to LMOS. Either the load generic or the on-line generic is used to input the data, depending on the magnitude and type of change.

Field experience indicates that, on the average, work order activity accounts for about one-fourth the data base change activity incurred by service orders (in terms of customer lines affected per year).

When service order and work order activities are combined, it is estimated that 20 megabytes of data in the typical LMOS host data base is modified in some way every working day.

V. SUMMARY

The data base system of LMOS has evolved over several years. Among the lessons learned are that it pays to install a working prototype system in more than one BOC and to plan to make revisions based on field experience. An interface with the BOC service order process is a critical interface, and a mechanized work order interface would have been beneficial. In addition, the fixed length data base fields and storage attributes (e.g., packed binary) for selected data items have resulted in a more rigid data base design than we now find desirable. It is suggested that future data base systems be designed with the view that data items can change in format, length, and attributes.

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