

Common Channel Interoffice Signaling:

Peripheral Maintenance and Administration Support System

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Common Channel Interoffice Signaling (CCIS) introduces a new network for routing signaling information, new equipment, and new functions for which performance must be monitored. Reliable, timely (within seconds or minutes in many cases), and readily usable performance reports are required by traffic and maintenance personnel to administer and maintain these new capabilities to provide the high quality of service to which customers are accustomed. The Peripheral Bus Computer (PBC) System provides the maintenance and administration support required by the CCIS signaling network, Signal Transfer Point (STP) offices, and toll crossbar switching offices. This article describes the PBC and the support it provides CCIS.

I. GENERAL

As the demand for long-distance telephone service grows, the capacity, capability, and complexity of the nationwide switched network increases accordingly. Increasing demands for service must be satisfied while maintaining the high quality of service to which customers are accustomed. Thus as the capacity and capability of the nationwide switched network increases, so does the need for and complexity of performance surveillance, maintenance and administration of the switching offices. For example, Common Channel Interoffice Signaling (CCIS) now provides the capability to rapidly exchange information among processor equipped switching systems over a new network of signaling, or data, links. This new signaling network introduces new equipment and many additional functions for which performance must be monitored.

To control, maintain, and engineer switching office equipment, voice path circuits, and CCIS signaling links, operating companies must have traffic and maintenance performance data that are reliable, timely, and readily usable. Rapid detection of irregularities which result in the improper transmission of signaling and address data between switching offices is necessary to reduce internal reattempts and lost calls. These events are generally called retrials and ineffective attempts, respectively, and can be caused by trouble in the near or far end switching office or in the interconnecting signal facility.

The Peripheral Bus Computer System (PBC) is an on-site, small computer adjunct to the No. 4 crossbar toll CCIS Switching Offices (SOs)¹ and Signal Transfer Points (STPs)² that meets these operating company needs by applying real-time computer technology to the surveillance, maintenance, and administration of the switching offices and the signaling network. The PBC collects and processes per call, real-time data and provides threshold triggered exception reports to alert telephone company maintenance and traffic personnel to trouble and potential trouble conditions due to equipment malfunction or traffic congestion. Extensive historical data are accumulated by the PBC for administrative reports which are used by traffic administration and engineering personnel to make decisions about the quantities and configuration of equipment in the toll switching offices and connecting voice paths and signaling link network. In addition, the PBC data are available to centralized telephone company computers over private lines and dial-up switched lines for network management operations,³ and long-term engineering and administrative studies. In summary, the PBC is the current state of the evolution^{4,5} to provide the No. 4 crossbar toll switching system with modern, on-site performance and administrative data collection and processing capabilities and compatible interfaces with the numerous centralized administrative systems now in service.

II. PBC CONFIGURATION

The PBC connects to the No. 4 crossbar equipment, as shown in Fig. 1, via two interfaces which are the paths by which usage and miscellaneous data are collected from the electromechanical circuits. Data collected over a third interface, an interprocessor interface, comes directly from the call processing and signaling link actions being executed by the software resident in the SPC No. 1A system.

2.1 Central processor, memory, and peripherals

Figure 2 shows the three interfaces (two electromechanical frames used to collect usage data are not shown) and the other components which comprise the PBC. The central processor is a general-purpose mini-

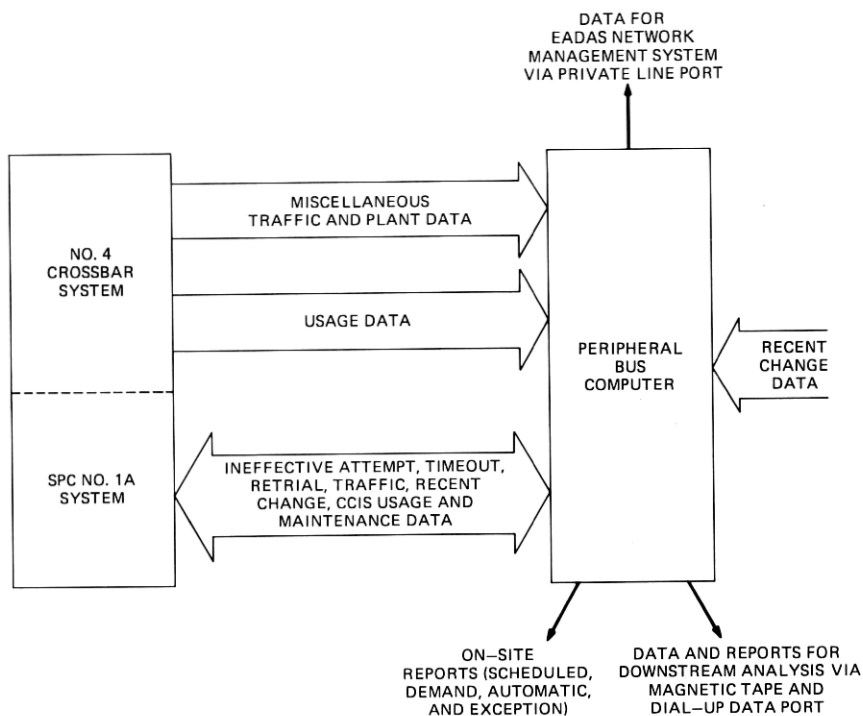


Fig. 1—Functional block diagram.

computer supported by 16-bit core memory (80K words in STP offices and 96K words in switching offices) and one disk controller equipped with two moving head disk cartridge drives containing 1.24 million words each. Associated hardware includes a nine-track industry compatible magnetic tape controller and drive, paper tape reader/punch, and an assortment of I/O interfaces to provide communication with local or remote (equipped with Bell System data sets) *DATASPEED*® 40 terminals and various other remote I/O facilities. The minicomputer central processor, associated memory and peripherals, and data sets are housed in four cabinets. Two interfaces connect with the No. 4 crossbar circuits and an interprocessor interface connects with the SPC No. 1A. These interfaces partially reside in a fifth cabinet (the multicontact relays for multiplexing usage data are mounted on up to two frames located with the switching equipment). The *DATASPEED* 40 terminals and the optional 4210 magnetic tape cartridge terminal shown in Fig. 2 are supplied by Teletype Corp.

The primary human-machine I/O device for the PBC is the *DATA-SPEED* 40 terminal which is equipped with a keyboard, cathode-ray tube (CRT) display, and a high-speed line printer. Three terminals are required for office (dial) administration, network management, and switching maintenance functions. Up to four additional terminals may

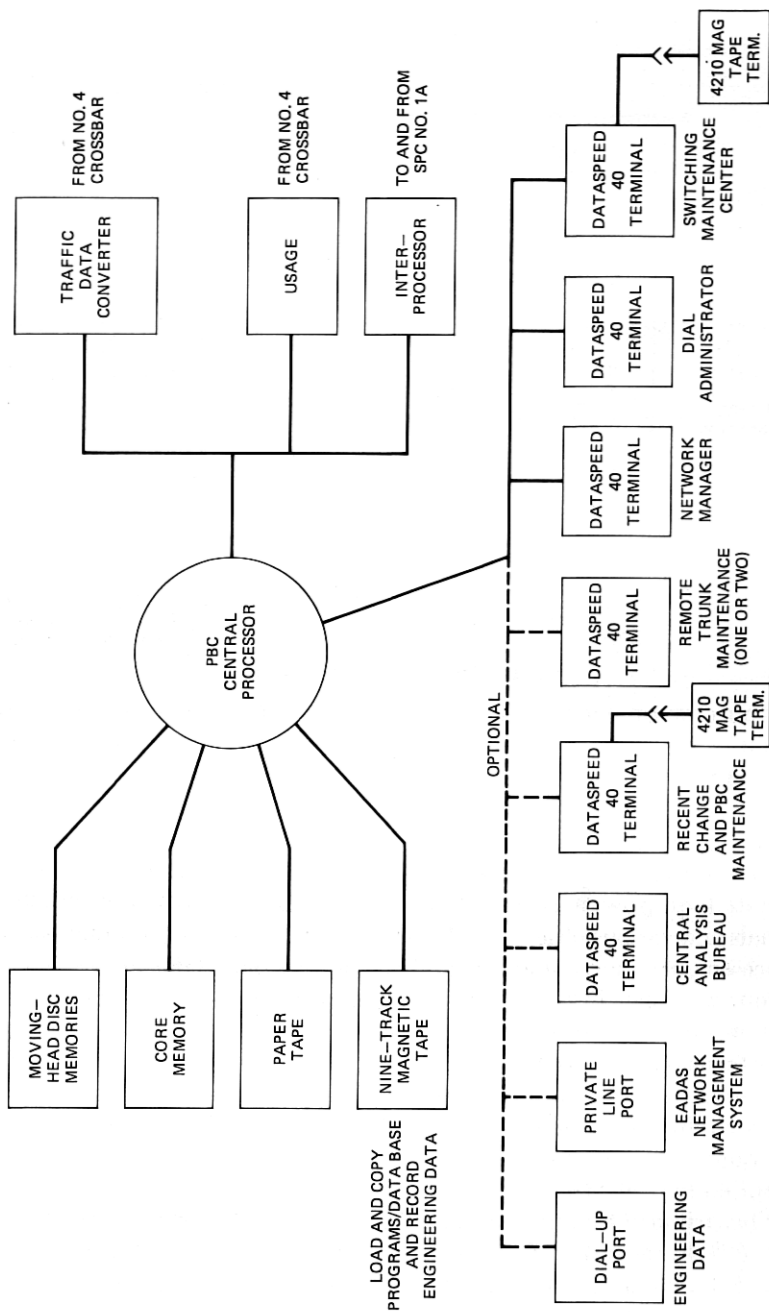


Fig. 2—System configuration.

be optionally provided to send trunk maintenance related exception reports directly to trunk maintenance areas, provide a separate data base management (commonly referred to as recent change) terminal and support centralized trouble analysis operations. Data base management, or recent change, can also be accomplished over the switching maintenance terminal and a 4210 magnetic tape cartridge terminal may be associated with both *DATASPEED* 40s which provide recent change capability.

All on-line software is Bell System designed. The PBC software in No. 4 crossbar offices equipped to perform STP functions for the CCIS signaling network, like the software resident in the SPC No. 1A (Ref. 2), performs two virtually independent jobs. The No. 4 crossbar system with its associated Electronic Translator System (ETS)^{6,7} processes non-CCIS calls practically independent of the STP functions. The STP software is coresident with the ETS software in the SPC No. 1A system. Likewise, the PBC in STP offices collects and processes data in support of both the non-CCIS call processing functions of the ETS (Refs. 4 and 5) and the relatively independent CCIS signaling link operations.

2.2 PBC-SPC No. 1A Interprocessor interface

Of the three interfaces between the PBC and the No. 4 crossbar and SPC No. 1A equipment, the interprocessor interface is the most important because of the quantity and variety of data which are exchanged between the PBC and SPC No. 1A processors. This interface provides a full duplex communication channel between the 16-bit PBC and the 20-bit SPC No. 1A. As shown in Fig. 3, information is transmitted by the SPC No. 1A to the PBC over the Peripheral Unit Address Bus (PUAB) and information is transmitted by the PBC to the SPC No. 1A via the Scanner Answer Bus (SCAB). The bus repeater circuit shown in Fig. 3 serves to "OR" the duplicated PUABs (and the enable and control lines shown in Fig. 4) for compatibility with the unduplicated bus to the PBC bus access circuit. Similarly, the repeater circuit "expands" the unduplicated answer bus from the PBC bus access circuit by driving both SCABs. The repeater circuit is the demarcation circuit between SPC No. 1A frames and the PBC units. When the repeater is out of service the SPC No. 1A and the PBC are isolated from one another. Any trouble with the interface which causes SPC No. 1A controlled diagnostics to fail causes the repeater to be taken out of service. The repeater is constructed with No. 1 ESS type circuit packs and has standard SPC No. 1A frame control keys, fuse alarm, etc.

The bus to bus access circuit (BBAC) to which the repeater connects provides for transmission of data from the SPC No. 1A directly to the minicomputer memory on a direct memory access (DMA) basis and from

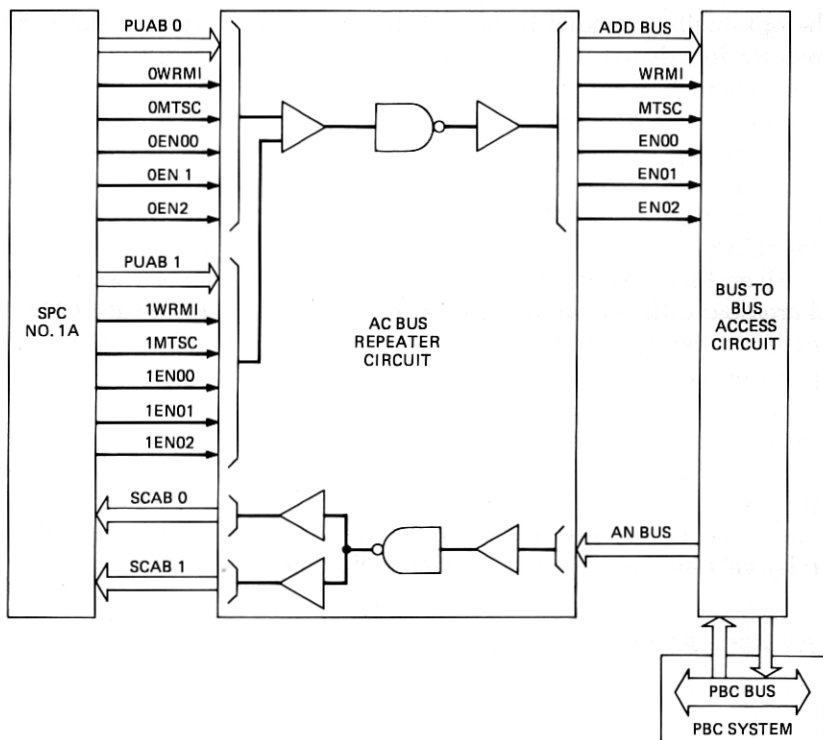


Fig. 3—SPC to PBC interface block diagram.

the minicomputer to the SPC No. 1A on a scan-for-data-present basis. A distribute from the SPC No. 1A using one of the two possible enable signals (EN00 or EN01) sends 21 bits of data to the minicomputer including the 20-bit data field. The distribute (DS) register shown in Fig. 4 holds the distributed data temporarily and the enable is stored in a flip-flop until the DMA control circuitry has gained control of the minicomputer bus. The data are then gated to the minicomputer (PBC) memory as one 16-bit data word and one 5-bit identity code. The DMA address counter determines the addresses of both locations within two 1024 location cyclic buffers. These cyclic buffers are unloaded by PBC software every 20 milliseconds. The PBC can accept data from the SPC No. 1A at a rate up to 80 thousand transfers per second for intervals less than 13 milliseconds without any data loss. The maximum long-term transfer rate is 50 thousand transfers per second to insure no data are lost.

Data are sent to the SPC No. 1A by the PBC writing directly into the control and status (CAS) and scan (SC) registers. The SPC No. 1A periodically reads the CAS register and, upon seeing the scan register full

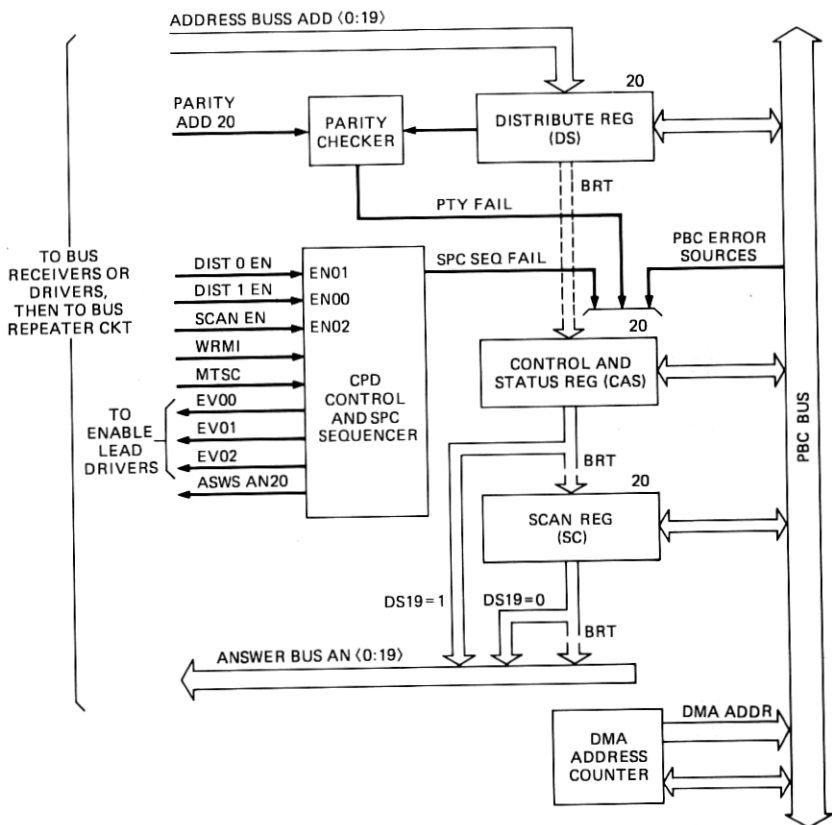


Fig. 4—Block diagram of bus-to-bus access circuit.

(SRF) bit set, causes the 20-bit datum in the SC register and the return identity code and error bits in the CAS register to be gated into the SPC No. 1A by issuing scan instructions to the PBC. The data field of each scan instruction is gated into the distribute (DS) register. If the most significant bit of the scan instruction data field is zero the SC register is read, otherwise the CAS register is gated into the SPC No. 1A. The maximum data transfer rate from the PBC to the SPC No. 1A is about 70 transfers per second and primarily consists of commands to read SPC No. 1A memory and commands and data to change the SPC No. 1A resident call routing and equipment translation data base. This latter function is referred to as recent change.

During the initial setup and signaling preceding the actual data transfer from the SPC No. 1A to the PBC, the CPD control and SPC sequencer circuits shown in Fig. 4 provide the proper signal interchange with the SPC No. 1A and request control of the PBC bus once the data

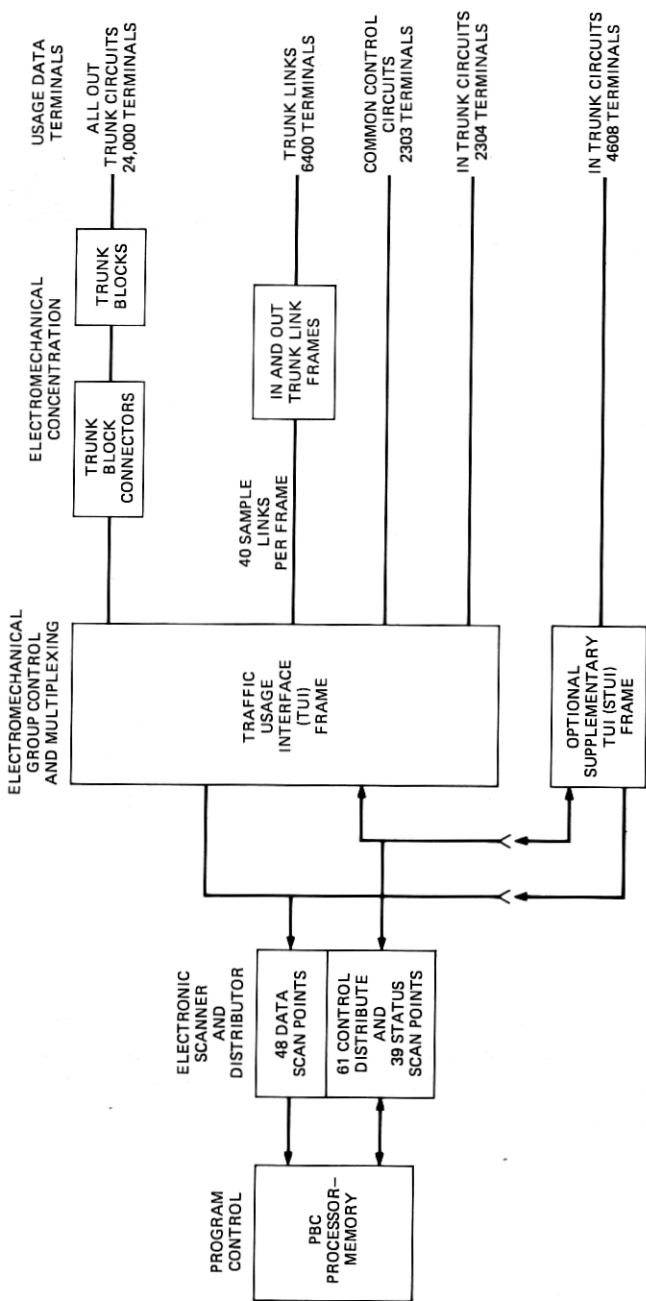


Fig. 5—Usage data collection.

are received. Also, the parity checker circuit computes the parity of the DS register datum and compares it with address parity sent by the SPC No. 1A. A mismatch sets an error bit in the CAS register and inhibits an all-seems-well (ASW) check which interrupts the SPC No. 1A. Other bits in the CAS register are error indications from various sources.

Because the interprocessor interface is the most efficient of the three interfaces, as much of the data required by the PBC as possible is collected from the SPC No. 1A. Only data to which the SPC No. 1A has no access are collected over the other two interfaces between the PBC and the No. 4 crossbar equipment. For example, usage data for CCIS switching office trunk circuits are collected from the SPC No. 1A but non-CCIS trunk usage data are collected over the usage interface shown in Figs. 1 and 2. Furthermore, all data associated with STP functions are collected from the SPC No. 1A.

2.3 Usage interface

Usage data are sampled measurements of traffic load on the various equipment in an office and are accumulated in usage units of one hundred call-seconds (CCS) per hour. Usage data from common control circuits, trunk link frames, and non-CCIS incoming and outgoing trunk circuits are collected over the usage interface. As shown in Fig. 5, this interface is a complex of program-controlled electronic distribute and scan points which direct electromechanical multiplexing and concentration circuits to access specific usage points within the office. Sixty-one distribute control and 39 scanner status points are used to collect usage data from over 39,600 possible usage leads through only 48 scanner data points. The distributor and scanner design provides the capability of isolated single contact relay outputs and individually sensible inputs. The unit is designed to be grown in a modular fashion with either distribute or scanner points. Currently, the distributor and scanner is primarily used to control the usage interface frame(s) and sense results.

A major efficiency in the PBC traffic usage interface (TUI) over conventional usage recording methods is achieved by integrating usage scanning into the switching office architecture. Present usage data collection methods use hardware scanners which require a dedicated lead to each usage terminal to be sensed. Thus conventional usage scanning is expensive in terms of equipment and cabling, administration, maintenance and floor space. The PBC takes advantage of existing switching circuitry to gather outgoing trunk usage. The busy/idle control leads for outgoing non-CCIS trunks (maximum 24,000) are already concentrated in subgroups of up to 40 trunks per outgoing route in trunk block connector circuits. The marker accesses the proper trunk block connector during each call when it is ready to select a trunk to the next switching

office. Therefore, through a modest addition to each trunk block connector circuit, the PBC gains access to the 400 trunk terminations on each connector in subgroups of 40 to gather usage data. A 62-lead control bus, plus a dedicated lead per trunk block connector (60), replaces up to 24,000 trunk usage leads. A similar multiplexing arrangement is employed to gather usage data from the switching network through the incoming and outgoing link frames. However, usage data for incoming trunk and common control equipment is gathered by dedicated leads. Consequently, these latter two usage categories comprise most of the equipment in the TUI frames.

Usage scanning is performed at a 10-second rate for the common control circuits, and at a 100-second rate for all other equipment. Besides the common control circuits, approximately 10 percent of the ultimate quantity of the trunk block connectors, incoming trunks and switching network linkage are also scanned every 10 seconds. Once per day during a nonbusy period, various maintenance checks are performed by the PBC on the traffic usage interface, including an individual lead continuity check to each outgoing trunk and switching network usage terminal. Thus, the integrity of the PBC usage data is more easily administered than were past usage measurement systems.

2.4 Miscellaneous traffic data converter interface

The Traffic Data Converter (TDC) interface between the PBC and the No. 4 crossbar equipment gives the PBC access to miscellaneous peg count data which are not available from the SPC No. 1A resident software. The TDC is a special-purpose autonomous scanner which collects peg count data generated by relay contact closures from up to 1022 sources within an electromechanical switching office. All peg count inputs are scanned at approximately a 20-millisecond rate. The TDC, a common systems unit, was originally designed to collect and transmit peg count data to a centralized data collection computer via data link, and is equipped with several words of memory to buffer peg count data awaiting transmission to the central computer. To adapt the TDC to the PBC application, the internal memory and data link interface were replaced with circuitry to permit the TDC to write peg count data directly into a dedicated area of PBC core memory. Every 100 milliseconds the PBC reads these memory locations and processes any waiting peg count data.

2.5 Maintenance

The PBC and all of its interface circuits provide continuous surveillance of the No. 4 crossbar office. There are a number of maintenance programs which are executed by the PBC for the purpose of fault isolation

in the peripheral circuits. The maintenance programs are designed to provide little or no interference with the data collection functions of the PBC and do not require the PBC to enter a maintenance-only mode. These programs are separated into two basically distinct functions: fault recognition and diagnostics. The fault recognition programs primarily consist of periodic tests which are executed to prove PBC system sanity and identify conditions which may affect the SPC No. 1A. The prime intent upon detection of trouble is to remove the interprocessor interface from service to protect SPC No. 1A call processing capability. In these cases diagnostic resolution is fine enough to identify single faulty circuit packs. Although not designed for diagnostic purposes, the fault recognition programs are also effective for diagnosis of system troubles during the installation and early service of a PBC. If any of the three interfaces develops a problem, maintenance diagnostic software in the PBC or SPC No. 1A will diagnose the trouble and notify maintenance personnel via the switching-maintenance *DATASPEED* 40 channel or an SPC No. 1A teletypewriter. Either an entire interface or a portion of the usage interface can be removed from service to allow the PBC and the other interfaces to continue functioning.

For nontransient problems within the PBC itself, or with the BBAC interprocessor interface, the AC bus repeater circuit is removed from service to isolate the PBC system and protect the SPC No. 1A. However, trouble with either the TDC or usage interfaces, or both, will not result in the PBC system being isolated from the SPC No. 1A. In these cases, valuable data can still be collected from the SPC No. 1A call processing activity even though the other interfaces with the No. 4 crossbar circuits are not in service. Data collected from the SPC No. 1A permit the PBC system to provide the complete analysis and reports of ineffective attempts, sender retrials and other call irregularities for maintenance personnel, about 95 percent of the analysis and reports destined for the network manager and over one-half the data that the dial administrator expects.

III. COLLECTING, PROCESSING, AND REPORTING PERFORMANCE DATA

All data are initially accumulated in "real-time" files in core memory as shown in Fig. 6. From these short-term files longer term files are accumulated in disk memory and real-time reports are generated (primarily for network management and maintenance). All data are accumulated in raw form, i.e., not calculated, formatted or labeled for any particular output report. This conserves memory because the same data is often required for several different reports. The report calculations, labels and format parameters are controlled by report generator programs rather than redundantly stored in the bulk data files. In addition,

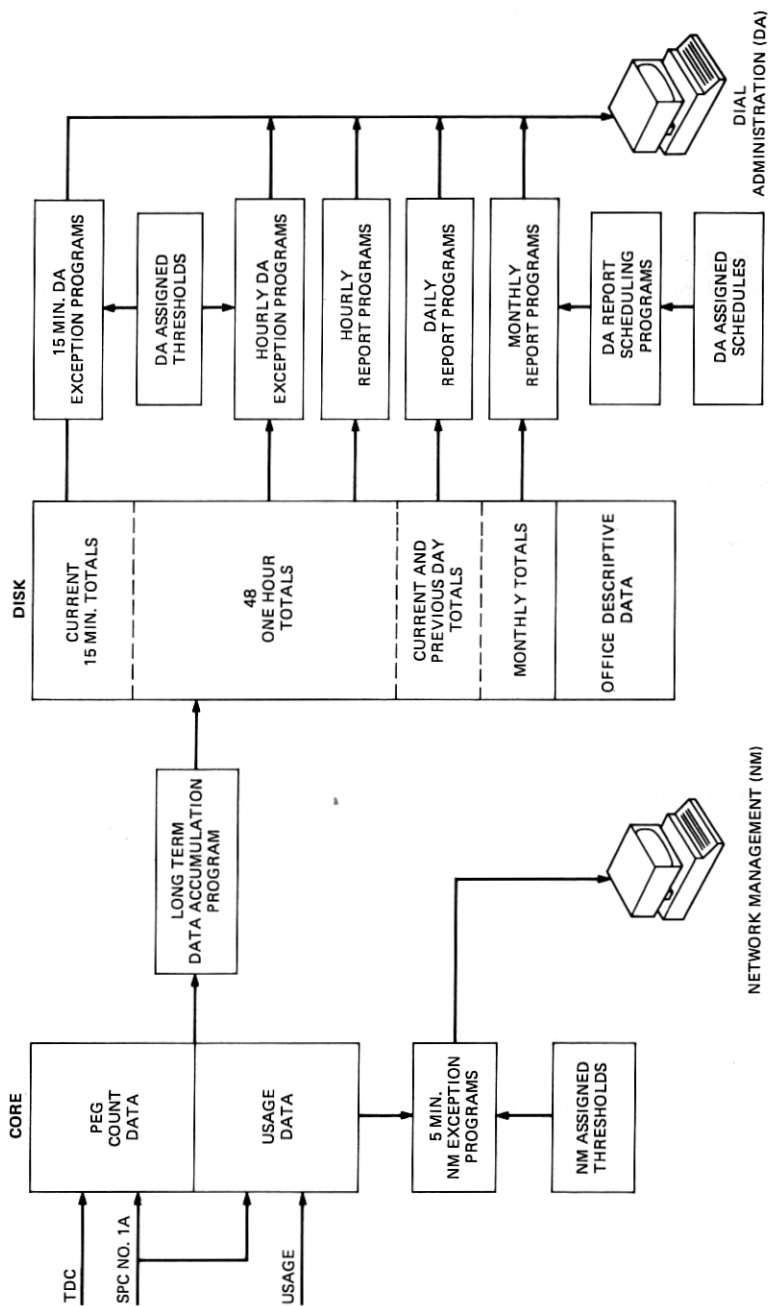


Fig. 6—PBC data accumulation.

raw data entries for many time periods are stored in the bulk data files and output reports, some several pages long, can be demanded for any of these time periods.

Traffic data are collected and analyzed over three intervals of time: (i) short-term or real-time (seconds and minutes), (ii) intermediate-term (hours), and (iii) long-term (days and months) as shown in Fig. 6. Real-time or short-term data are most useful to operating company network managers for monitoring performance during expected peak traffic periods such as occurs on Mother's Day and deciding what temporary network adjustments should be made to handle unexpected traffic generated, for example, by natural disasters. Intermediate-term data are most useful to office (dial) administrators. With this data, they can monitor performance of the switching system components and its associated network, balance the traffic load, ensure quality service, and estimate future needs. This information is also valuable to help network managers plan for future expected high traffic conditions. Long-term data are most useful to equipment and facility engineers in projecting long-term traffic trends and planning for switching office, trunking and signaling link growth.

Maintenance forces must keep the office descriptive data bases (stored in the memories of SPC No. 1A and PBC) up to date with changes to equipment translations, routing patterns and trunk and signaling link assignments. The SPC No. 1A memory contains data that identifies equipment and controls route translation, while the PBC memory contains support data for measurement, analysis and reports. The PBC system also includes the administrative software necessary for managing both the SPC No. 1A and PBC office data bases.

All reports are produced by software report generators which read unprocessed data from the appropriate files, perform any necessary calculations, provide the report labels and align the processed output data with the labels. Reports are generated by four basic stimuli:

(i) Automatic—generated by the PBC in response to a system event (such as an interface failure) or a predefined schedule that is part of the system's generic program and cannot be altered by the user.

(ii) Scheduled—generated as a result of a schedule which has been entered into PBC memory by persons who are using the system.

(iii) Demand—generated immediately in direct response to a request by the persons using the system.

(iv) Exception—generated when a threshold value has been reached or exceeded by the contents of a counter (register) or the results of a calculation in PBC memory. Threshold values are numbers which are entered into PBC memory by persons using the system.

The exception report is a concise report intended to alert personnel to a problem or pending problem. Additional information can then be obtained to supplement the exception report by using demand requests to query the details retained in the memory files.

3.1 Signaling link performance

All data associated with CCIS switching office and STP functions are collected over the interprocessor interface between the PBC and the SPC No. 1A. Included in these data are performance measurements of the CCIS Signaling Links (SLKs), which are each composed of a terminal and modem at each STP or CCIS switching office location connected by a Voice-Frequency Link (VFL). Discussion about signaling link data collection, processing, and reports applies both to CCIS switching offices and STP offices. However, the number of signaling links which can terminate in STP offices are over an order of magnitude greater than the number which terminate in CCIS switching offices.

Table I is a list of the names and abbreviations of the counts which the PBC must accumulate for maintenance and traffic reporting purposes. In addition to keeping these counts, the PBC must calculate signaling link occupancy and error rates. Error rate calculations require knowledge of the actual time period covered by the counts (RACU, SUIE, SACU, and RERQ) used in the calculations. This time period can be less than the collection interval time. The SUIE and RERQ counts are maintained on a per-VFL basis, and, thus, the time each of the VFLs is active must also be retained.

The first ten counts in Table I are scored in the signaling terminals as they occur. Every five minutes when the PBC is about to switch the active/passive status of its five-minute core memory accumulators, a command is transmitted to the SPC No. 1A to read and transmit the counter values to the PBC from each in-service terminal and then zero them. Counts 11 through 19 listed in Table I are recorded in PBC core memory as they occur. Items 20 and 21 (EMR TIME and SLK OOS) are computed by the PBC.

The time in emergency restart (EMR TIME) is determined by internal PBC timing. When the "start of emergency restart" distribution is received by the PBC from the SPC No. 1A, flags are set in the PBC for the signaling link and its mate, if it exists. A one-second timer task causes counters to be incremented for the involved signaling links until the "end of emergency restart" distribution is received by the PBC. Similarly the signaling link automatic or manual maintenance usage (SLK OOS) is determined by setting a flag and starting a one-second timer whenever a signaling link out-of-service condition is received by the PBC. In this case, the one-second timer task increments a counter for the signaling

Table I — Signaling link data accumulated by PBC

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1. Signal Units Transmitted (SU XMT)
 2. Signal Units Received (SU RCD)
 3. IAMs Transmitted (IAM XMT)
 4. IAMs Received (IAM RCD)
 5. ANSs Transmitted (ANS XMT)
 6. ANSs Received (ANS RCD)
 7. Received Repeated ACUs (RACU)
 8. Signal Units in Error per VFL (SUIE)
 9. Received Skipped ACUs (SACU)
 10. Retransmission Requests per VFL (RERQ)
 11. Near-End and Far-End Initiated Automatic Changeovers per VFL (NECO and FECO)
 12. Near-End and Far-End Initiated Manual Changeovers (MANNECO and MANFECO)
 13. Buffer Threshold Exceeded (BFR THRS)
 14. Repeat Buffer Threshold Exceeded (RPT BFR THRS)
 15. Buffer Overflow (BFR OFL)
 16. Emergency Restarts (EMR)
 17. Processor Signaling Congestion Received (PSC RCD)
 18. Processor Outage Received (PRQ RCD)
 19. Failures Longer Than Three Minutes (FLR > 3)
 20. Time in Emergency Restart (EMR TIME)
 21. Automatic and Manual Maintenance Usage (SLK 00S)
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link until a "changeback" distribution is received by the PBC for the link.

Terminal resident counters RACU, SUIE, SACU, and RERQ are initialized to zero values each time an out-of-service signaling link is restored. As mentioned earlier, calculation of error rates requires knowledge of the actual time interval covered by the error counters. Therefore, the time each changeback occurs is recorded and used at the end of the five-minute collection interval to determine the error counter interval for the signaling links affected by changeovers. Signaling links not affected by a changeover during the collection interval use the collection interval (normally five or thirty minutes) to calculate error rates.

3.2 Retrials, ineffective attempts, and miscellaneous CCIS irregularities in switching offices

Internal switching office faults are detected by the switching control circuits and reported to the maintenance force by a perforated trouble record card per event. Because of the detailed trouble history data presented on each card record, identification of the faulty unit is generally possible by pattern analysis of a few trouble records containing similar trouble data.

Such is not the case for the class of faults which result in retrials or ineffective attempts. These faults are associated with the reception or transmission of the called telephone number and may locate in either the near-end or far-end switching office, or the interconnecting transmission facility. Incorrect customer dialing may also cause ineffective

attempts. Consider the reception of an unassigned telephone number at a switching office. Very likely the customer has misdialed. However, the lack of up-to-date route translation information at this office or incorrect translation data in a preceding office can cause the same result. Again, consider a multifrequency (MF) receiver which times out waiting for digit reception. The fault may be located in the MF receiver, the preceding office outpulsing equipment, or the interconnecting transmission path. Inadequate equipment provisioning can also produce call failures.

PBCs in non-CCIS offices analyze a total of 21 retrial and ineffective attempt failure categories to detect persistent problems with up to six received digits and six types of equipment (senders, outgoing trunks, outgoing trunk groups, incoming trunks, incoming trunk groups, and sender link frames). In a CCIS switching office the failure categories to be analyzed are expanded to a total of 46 including the original 21 categories with appropriate modifications required for CCIS. Additional equipment types introduced by CCIS and included in analysis of failures are senders modified to operate as outpulsers (sender-outpulsers), sender-outpulser link controllers, outpulsers, outpulser link controllers, transceivers, and the distributor and scanner (DAS). In addition, the other existing equipment types must also be included in the analysis of CCIS call attempts which fail and include sender link controllers, decoder channels, decoder connectors, markers, and incoming trunk group decode. Finally the number of digits to be analyzed on digit-related failures in CCIS offices is expanded from six to eleven.

Some of the software which accomplishes this analysis resides in the SPC No. 1A memory but most of the associated software resides in the PBC disk memory and is collectively called the Plant Analysis Support System (PASS). The part of PASS in the SPC No. 1A collects all the necessary data for each failure event, identifies the event as one of the failure categories, formats a multiword (number of words depends on the failure category) message, and transmits the message to the PBC. The part of PASS residing in the PBC primarily compares each new failure event with all others already in the specified failure category current analysis file. A customized, separate current analysis file exists for each of the failure categories. When a specific unit of equipment or digit pattern reaches a user set trouble threshold, which can be a unique value per failure category and per each equipment type (consider digits analogous to an equipment type) analyzed within each failure category file, then the PBC outputs an exception report to alert office maintenance personnel of a faulty equipment unit or digit pattern (e.g., vacant national number, incomplete address detected, etc.). Real-time analysis is provided, since each failure event is immediately categorized and sent to the PBC where it is compared against all records in the current analysis

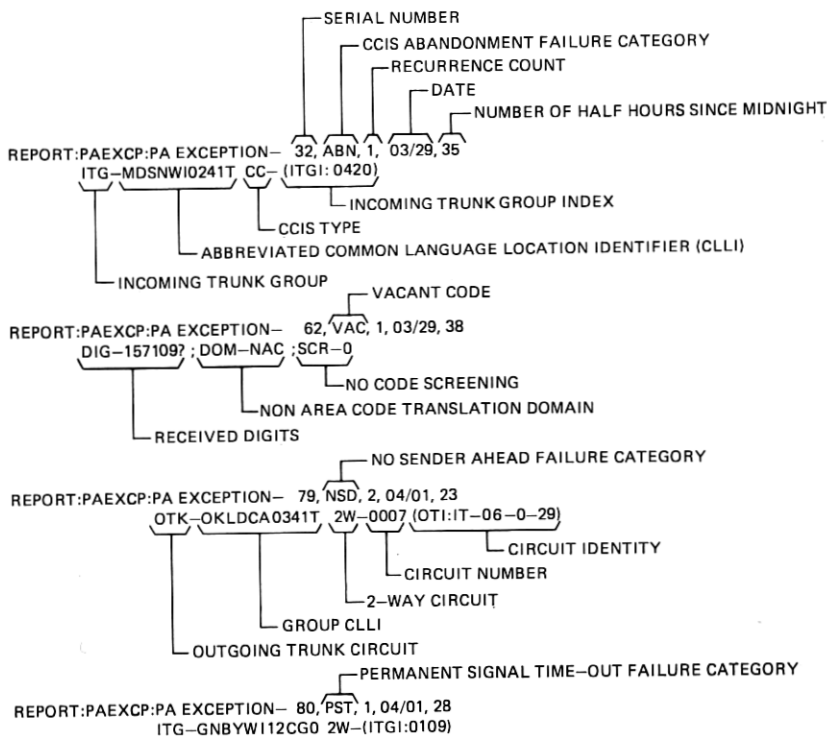


Fig. 7—Plant analysis exception reports.

file for the failure category.

A memory file of exception reports is maintained for between a month and a month and a half depending on the rate exception reports are generated. Several sample exception reports are shown in Fig. 7. Note that trunks are identified with the standard Bell System abbreviated Common Language Location Identifier (CLLI), and overall the reports are relatively easy to understand. All failure event messages contributing to exception reports are maintained for at least 24 hours and as long as space exists in the Pattern Found (PF) file.

If during the day any of the failure category current analysis files overflow, these failure event messages (records) are moved to the No Pattern Found (NPF) file. Also any failure event records remaining in the current analysis files at the end of the day are also moved to the NPF file. The NPF file is then analyzed to produce a daily "worst equipment" report. This is a last effort to identify the worst performing equipment from the data which did not cause exception reports to be triggered.

PASS outputs all reports over the No. 4 crossbar switching maintenance center *DATASPEED* 40 and selected outputs over up to three optional *DATASPEED* 40s. Two of the optional stations are associated

CALL IRREGULARITY AND DISPOSITION SUMMARY

1210 4/ 6/77 TO 0000 04/07/77

TOTAL INEFFECTIVE	479	.16%	DCH 2ND TRIAL	1637	.56%
<u>EM CALL IRREGULARITIES</u>					
INCOMING	PC	PA MSGS	OUTGOING	PC	PAMSGS
PST TOTAL	154	118	IKF	46	55
SDR	154	---	NSD	166	157
REG-NC	0	---	DPD TOTAL	99	93
PDT TOTAL	74	68	DPD	---	2
SDR	74	---	XST	---	91
REG-NC	0	---	UXS	44	42
PE TOTAL	127	121	MRE TOTAL	40	30
PEO	---	7	MOF	---	25
PMS	---	114	MPS	---	5
PMD	41	---	RVT	---	---
<u>CCIS CALL IRREGULARITIES</u>					
INCOMING	PC	PA MSGS	OUTGOING	PC	PAMSGS
ADI DET	1	1	ADC TO	0	0
COT TO	0	0	CON CK FAIL	1	2
IAM IRREG TOTAL	0	---	GLARE	0	0
INVALID	0	---	MISC CC FAIL	2	2
LENGTH CHECK	0	---	COF RCVD	2	---
2ND NON MATCH	0	---	RLG RCVD	0	---
IAM-BLK TRK	0	---	RST+RSB RCVD	0	---
IAM-UNEQ TRK	0	---	BLK RCVD	0	---
ABDN CALL	60	59	SIG NET FAIL	0	---
CONNECTING	PC	PA MSGS	MRF RCVD	0	---
OP-MFOP ABNR RL	1	1	UQL RCVD	0	---
NO CREG INC	0	---	NO SIG PATH	0	---
NO CREG OUT	0	---	ADI RCVD	1	1
NO TCVR INC	0	---	VNN RCVD	14	14
NO TCVR OUT	0	---	IMMEDIATE RAT	0	---
CREG TO	3	3	SDR/OPLS RAT	25	---
CREG TO-IGNOR	1	---	TRK LC RAT	1	---
NO OP/MFOP	0	---	CFL RCVD	0	---
NO FACILITIES	0	0	MISCELLANEOUS	PC	PAMSGS
BAD DAS REPORT	1	1	RSB RCVD	0	---
BAD SV REPORT	5	5	RST RCVD	0	---
			UNSTABLE CALL RST	0	---
			STABLE CALL RST	2	---
			SU RCVD UNEQ LBL	0	---
			UNRSNBL SU RCVD	0	---
			UNDEFINED SU RCVD	2	---
			SYS00 MSGS	6	---
<u>MISCELLANEOUS ITEMS</u>					
PASS TOTALS			TST PA MSGS		1253
TOTAL PA MSGS		3664	ERR PA MSGS		2
PA EXCEPTION REPORTS		162	PA MSGS LOST IN SPC		100
NO TROUBLE FOUND DISPOS		0	PA MSGS LOST IN PBC		0
TROUBLE FOUND DISPOS		0	PA INVALID		0
AUXILIARY TROUBLE RECORDS		27			

Fig. 8—Part of call irregularities and disposition report.

with trunk maintenance areas and one is associated with a central analysis bureau operation.

3.3 Plant (maintenance) reports

The *DATASPEED* 40 terminal located in the No. 4 crossbar switching maintenance center provides I/O capability for data base administration (recent change), maintenance messages and plant reports. The seven

SUIE 5 MINUTE EXCEPTION REPORT						
04/01/77		1121 TO 04/01/77			1126	
NAME	TYPE	SLK	VFL	CTR TIME	SUIE PC	ERR RATE
OMAH NE NW MSP 1	A	0-00	A	300	89	.35
*IPLS IN 01 MSP 1	A	0-01	A	300	40	.16

Fig. 9—Signal units in error, 5-minute exception report.

plant (maintenance) reports provided in non-CCIS offices are described in Refs. 4 and 5. In addition to a variety of smaller changes and additions to six of these plant reports, a CCIS switching office has a Call Irregularity and Disposition Summary (PMCIDS) report, partially shown in Fig. 8, in place of the former Retrial and Ineffective Attempts Summary (PMRIAS) report. The PMCIDS report is divided into the two major parts, non-CCIS (EM) call irregularities and CCIS call irregularities. The PMCIDS report includes, in the EM call irregularities part, all items formerly on the PMRIAS report, and in addition, includes counts of the number of PASS analyzed CCIS failure events by category, CCIS call irregularities, and miscellaneous items moved from the other plant reports. The PMCIDS report can be scheduled and demanded as described for the other plant reports in Ref. 4.

CCIS switching offices and Signal Transfer Point (STP) offices output four additional plant reports which provide signaling link performance data:

- (i) Signal Units in Error Five-Minute Exception (SUEX) report.
- (ii) Signaling Link 30-minute Exception (SLKX) report.
- (iii) Signaling Link Data (SLKD) report which can be scheduled and demanded.
- (iv) Signal Units in Error Summary (SUIE) report which can only be demanded.

3.3.1 Signal Units in Error Five-Minute Exception (SUEX) report

The signal units in error (SUIE) counts and time marks for each signaling link are used at the end of each five-minute measurement interval to calculate the SUIE rate for each link. A signaling link is included in the SUEX report, shown in Fig. 9, if its SUIE rate equals or exceeds the 0.2 percent threshold value. For each link included in this report the abbreviated Common Language Location Identification (CLLI) NAME (identified by the far-end office name), type, Terminal Access Circuit (TAC) and terminal position (SLK), Voice-Frequency Link (VFL), counter time, SUIE count, and SUIE rate are printed.

The SUIE rate of particular links can be tracked over successive five-minute periods by demanding, via an input message, a printout of the

SLK 30 MIN EXCEPTION REPORT
 1100 04/01/77 TO 1130 04/01/77

NAME	T	SLK	VFL A			VFL B			RPT ACU	SKP ACU		
			CTR TIME	SUIE RATE	RERQ RATE	TOT CO	CTR TIME	SUIE RATE			RERQ RATE	TOT CO
OMAH NE NW MSP 1	A	0-00	28.3	.00	.00	0	.0	.00	.00	0	4	1
IPLS IN 01 MSP 1	A	0-01	18.3	.00	.00	2	4.0	.00	.00	1	1	0

Fig. 10—Signaling link 30-minute exception report.

SUEX report over a specified time period even though the link's SUIE rate does not reach the 0.2 percent threshold value. If a signaling link is included in the SUEX report because its error rate reached the threshold, an asterisk (*) is printed after the link's error rate. Signaling links being tracked (demand schedule printout) are identified with an asterisk at the beginning of the line. If no link is being tracked or reaches the SUIE threshold, then no SUEX report is printed.

3.3.2 Signaling Link 30-Minute Exception (SLKX) report

The SLKX report shown in Fig. 10 is triggered by thresholds against five different measurements. If one or more of the following measurements reaches its threshold value within 30-minute intervals ending on clock hours and half hours, the SLKX report is generated:

- (i) Per voice frequency link signal units in error (VFL SUIE) rate equal to or greater than 0.2 percent.
- (ii) Per VFL retransmission requests (RERQ) rate equal to or greater than 0.2 percent.
- (iii) Per VFL failure changeover count equal to or greater than two.
- (iv) Skipped acknowledgment signal unit (SACU) count equal to or greater than three, and
- (v) Repeated acknowledgment signal unit (RACU) count equal to or greater than three.

The NAME of each link reaching one or more thresholds is listed in the report along with the type of link, TAC and terminal position (SLK), counter time, SUIE rate, RERQ rate, failure changeover counts, SACU count and RACU count. An asterisk is printed after items which reach or exceed threshold values.

Signaling links can be tracked over successive 30-minute periods by demanding a printout of the SLKX over a specified time period even though no thresholds may be exceeded. An asterisk at the beginning of a line indicates the link is on a demand schedule printout. If no links are being tracked and no exception occurs, the SLKX report is not generated.

3.3.3 Signaling Link Data (SLKD) report

The SLKD report shown in Fig. 11 is not an exception report and can be scheduled and demanded similar to plant reports discussed in Refs. 4 and 5 but on a half-hour basis rather than hourly. The SLKD report is intended to be the primary signaling link information report for the plant (maintenance) personnel. It has a total office counts section, which is always printed first, and a per-signaling link section. This latter section can be much longer in STP offices than in CCIS switching offices because of the greater number of signaling links possible in STP offices. The total office section includes five Threshold Exceeded Counts (TEC), Changeover Counts (CO), Emergency Restart Data (EMR), and a count of signaling link failures less than three minutes (FLR <3) which is computed from total failures minus the FLR >3 count listed in Table I. The per-signaling link section requires two or three lines per link because of the number of per-signaling link report items and the possibility of the signaling link having redundant voice frequency links (VFLs).

23 REPORT:PMSLKD

SLK DATA REPORT
0000 04/01/77 TO 1100 04/01/77

TOTAL OFFICE COUNTS

TEC					CO		EMR		FLR
SUIE	RERQ	CO	SACU	RACU	FLR	MAN	PC	SEC	<3
0	0	0	0	0	1	1	0	0	1

PER SIGNALING LINK COUNTS

NAME	T	SLK	MATE SLK	VFL	CTR		SUIE	RERQ		FLR CO				
					HR	MI		RATE	TE	RATE	TE	NE	FE	TE
OMAH NE NW MSP 1	A	0-00	0-00	A	7	59	.00	0	.00	0	0	0	0	0
				B	2	55	.00	0	.00	0	1	0	0	0
IPLS IN 01 MSP 1	A	0-01	0-00	A	10	59	.00	0	.00	0	0	0	0	0
				B	0	0	.00	0	.00	0	0	0	0	0

NAME	T	SLK	SACU		RACU		FLR <3	EMR		MAN CO		OOS (SEC)	
			PC	TE	PC	TE		PC	SEC	NE	FE	FLR	MAN
OMAH NE NW MSP 1	A	0-00	12	0	0	0	1	0	0	0	1	19	24
IPLS IN 01 MSP 1	A	0-01	0	0	6	0	0	0	0	0	0	0	0

Fig. 11—Signaling link data report.

3.3.4 Signaling link Signal Units In Error Symmary (SUIE) report

The SUIE report shown in Fig. 12 can only be demanded and provides a 24-hour (most recent) summary by half-hour periods for specified signaling links. If the link type is A, then redundant VFLs may exist (shown in Fig. 12 as VFL A and VFL B).

SLK SUIE DATA REPORT
2300 3/31/77 TO 0400 04/01/77

SLK 00-01:NAME-IPLS IN 01 MSP 1, TYPE-A

TIME PERIOD	VFL A		VFL B		
	CTR TIME	SUIE RATE	CTR TIME	SUIE RATE	
2300 TO 2330	30.0	.00	.0	.0	
2330 TO 0000	30.0	.00	.0	.0	
0000 TO 0030	.0	.00	28.0	.00	← CHANGEOVER TO DUAL VFL
0030 TO 0100	.0	.00	30.0	.00	
0100 TO 0130	.0	.00	30.0	.00	
0130 TO 0200	.0	.00	30.0	.00	
0200 TO 0230	.0	.00	30.0	.00	
0230 TO 0300	.0	.00	30.0	.00	
0300 TO 0330	25.1	.00	.0	.0	← CHANGEBACK TO ORIGINAL VFL
0330 TO 0400	30.0	.00	.0	.0	

Fig. 12—Signaling Link Signal Units in Error (SUIE) summary.

3.4 Network management

One of the three required *DATASPEED* 40 terminals is dedicated to the network management function. Because the network manager primarily uses short-term data for real-time management of the intertoll, toll connecting and tandem networks, the reports, as shown in Fig. 6, are mostly based on 5-minute intervals with the remainder based on 15-minute intervals. References 4 and 5 discuss network management reports in non-CCIS offices. Data collected in non-CCIS offices also must be collected in CCIS offices for the non-CCIS traffic components and for the analogous events produced by CCIS traffic. In addition a considerable number of additional CCIS measurements must be made.

Network managers currently monitor switching offices and trunking networks for trends toward short-term scarcity and overload conditions that can potentially degrade network performance. Overloads and failures in the CCIS signaling network can affect both trunking and switching capacity. For example, trunks can be made inaccessible to new calls for short periods of time when signaling links or STP offices experience heavy traffic overloads. In another example, an overloaded STP may affect the performance of non-CCIS call translation which co-resides in the same SPC No. 1A system. For these reasons the signaling network is monitored by the network manager to observe its effects on trunking and switching performance. However, the network manager does not exercise manual control over the CCIS signaling network but, instead, relies on the automated overload controls described in Ref. 2.

New measurements introduced with CCIS and used by network managers include those associated with signaling links, CCIS common control equipment functions and expanded network management controls. The new measurements are far too numerous to discuss all of them within the scope of this article so only a few of the more interesting ones are described.

NETWORK MANAGEMENT 5 MINUTE EXCEPTION REPORT
 WKSH WI 02 41T 4/01/77 1301

REGISTER	IT PC	TC PC	TOTAL	AVG E-E
MARKER	1304	1218	2522	24.7 MS
ITLF	1245	1153	2398	

REGISTER		PC	%MKR
FST-ATB	IT	0	0.0
FST-ATB	TC	1	0.1*

SENDER	SADR	SADR	%	GROUPS
TYPE	BC	DC	SAD	DC > 0
MF	74	4	5.4	A

CROSS OFFICE	XOD	XOD	%	AVG XOD	CONTRIB GRPS
DELAY	BC	DC	XOD	TIME-SEC	MFO OP
CCIS	35	3	8.6*	0.786	A

	--ANNOUNCEMENT--			-TRUE IMA-	
REGISTER	PC	OFL	%ITLF	PC	%ITLF
ROA	3	0	0.1	3	0.1*
VCA	9	0	0.4	9	0.4*

CCIS SIGNAL COUNTS	--INC CALLS--		-OUTGO CALLS-	
TOTAL CCIS CALLS (IAM)	35	% IAM	30	% IAM
* ANSWERED (ANS)	23	65.7	21	70.0
* TRUNK CONGEST (NTC)	0	0.0	0	0.0
* SWITCH CONGEST (NSC)	0	0.0	0	0.0
NO CALL REG INC	0	0.0		
NO SNDR-OPLS AVAIL	0	0.0		
NO TRANSCEIVER AVAIL	0	0.0	0	0.0

Fig. 13—Network management 5-minute exception report.

3.4.1 Incoming delay measurements

Knowledge about incoming delay in a switching office is important to network managers because delay can propagate congestion to preceding switching offices by increasing the holding time on common control equipment in those offices. In both non-CCIS and CCIS No. 4 crossbar offices Sender Attachment Delay Recorder (SADR) equipment provides a measurement of incoming delay on non-CCIS incoming calls. The SADR has an appearance as an incoming trunk on each sender link frame. When SADR is active it rotates test calls through the sender link frames at the rate of one call every four seconds and transmits to the PBC via the TDC interface the number of test calls placed (base count) and the number encountering delays in sender attachment greater than three seconds (delay count). The PBC then generates exception reports if the percentage of delays exceeding three seconds is greater than a threshold value within a defined time period. The network manager is provided a 5-minute exception report for alerting purposes and a more detailed 15-minute automatic report both of which provide incoming delay measurements. In switching offices which also switch CCIS calls these 5-minute and 15-minute reports, shown in Figs. 13 and 14 respectively,

NETWORK MANAGEMENT 15 MINUTE REPORT
 CITY ST BG ETY 4/01/77 1401

MARKER PEG COUNT

IT 40618 TC 33973 TOTAL 74591

SADR DATA

SENDER TYPE AND SENDER GROUP	SADR		% SAD
	BC	DC	
MF	202	18	8.9
MF -A	22	4	18.2
MF -B	22	2	9.1
MF -C	23	1	4.4
MF -D	22	3	13.6
MF -E	23	2	8.7
MF -F	23	5	21.7
MF -G	23	0	.0
MF -H	22	1	4.6
MF -J	22	0	.0
DP -A	23	3	13.0

CCIS INCOMING DELAY

CROSS OFFICE DELAY	BC	DC	%XOD	AVG XOD
TOTAL	5242	477	9.1	.862
IT TRAIN	2635	242	9.2	.865
TC TRAIN	2607	235	9.0	.859

OPLS (SNDR/OPLS) ATTACHMENT DELAY	BC	DC	%OAD	AVG OAD
OPLS-A	2701	270	10.0	.331
OPLS-B	2541	200	7.9	.301

NON ZERO MC & SQ DATA

REGISTER	PC	CCS	%ACT
MC 1	5	17	1.9
MC 2	1	5	.6
SQL A	43	130	14.4
SQHA	9	10	1.1
SQL B	12	30	3.3
SQHB	11	10	1.1

Fig. 14—Network management 15-minute report.

can also be triggered by outpulser and sender-outpulser (senders modified to also perform CCIS outpulser functions) attachment delay and cross-office delay encountered by CCIS incoming calls.

Excessive outpulser and sender-outpulser attachment delay will be the likely source of incoming CCIS call delay. Possible causes of temporary outpulser and sender-outpulser scarcity which leads to attachment delay can be heavy non-CCIS traffic to sender-outpulser groups and problems with non-CCIS traffic outpulsing to a congested office. In addition, attachment delay measurements alone do not directly monitor all sources of incoming delay. Scarce transceivers (due, possibly, to a facility failure) or processor real-time congestion can also cause incoming CCIS call delay. Measuring the time it takes a call to be connected through the office to an outgoing trunk (cross-office delay) is a measure of incoming delay due to these other factors. Cross-office delay is also

attractive as a measure of the delay experienced by common control equipment in the previous offices switching a call. This is true because the sender in the first CCIS office (non-CCIS incoming and CCIS outgoing call) and call registers in each subsequent CCIS office are held up until the cross-office connections of all CCIS offices switching the call are complete and the address complete signal is returned.

Outpulser (and sender-outpulser) attachment delay and cross-office delay are derived from three timing marks distributed to the PBC on each incoming CCIS call by the SPC No. 1A software and associated with one another in the PBC via the Call Register Index (CRIX). The three timing distributes are sent to the PBC during:

- (i) Processing of the received Initial Address Message (IAM).
- (ii) Processing of the outpulser (or sender) link controller bid.
- (iii) Processing of the marker disposition report.

The interval measured by the first and second distributes approximates the outpulser (or sender-outpulser) attachment delay (OAD). The interval measured by the first and third distributes is the cross-office delay (XOD). The OAD measurement is not exact because the controller bid indicates only that an idle outpulser has been selected and a path to it reserved. However, what is measured constitutes most of the OAD and includes the variable part. The measured OAD is thus adjusted by a constant (one for outpulsers and a slightly larger constant for sender-outpulsers) to project the actual OAD which is used on the output reports shown in Figs. 13 and 14. It is interesting to note that both SADR and OAD measurements are taken on sender-outpulser groups which serve both non-CCIS and CCIS trunks.

3.4.2 Signaling link measurements

Network managers in STP offices and CCIS switching offices are provided the five-minute signaling link exception report shown in Fig. 15. This exception report is triggered by a signaling link reaching or exceeding the outgoing percent occupancy threshold value set by the network manager for the signaling link, simultaneous outages of complement signaling links, or certain CCIS terminal buffer overload control activity. An asterisk behind the percent occupancy value on the report indicates the threshold was reached or exceeded. The only discernable difference between the five-minute signaling link exception report output by an STP office and one output by a switching office is the signaling link TYPE and the associated mate signaling links printed. As shown in Fig. 15, STPs report on A-, B-, and C-type signaling links while switching offices report on A- and F- (associated signaling) type signaling links.

NETWORK MANAGEMENT 5 MINUTE CCIS LINK EXCEPTION REPORT
MDSN WI 02 41T 4/27/77 1335

SIGNALING LINK													TERM BUFR OVLD				
NAME, SUFFIX, TYPE													THR	RPT	CTRL	BFR	
CITY	ST	BG	ETY	S	T	SLK NO.	OUTGO DATA		INC DATA		LINK %OOS	LINK CMPL %OOS	RCVD PSC PRO	PC	PC	%ACT	OFL
IPLS	IN	01	04T	1	A	0-00	10148	43*	10027	43	.0	.0		3	6	26.0	1
OMAH	NE	NW	04T	1	A	0-01	7788	33	7923	34	8.2	.0		0	0	.0	0
IPLS	IN	01	04T	2	A	0-04	7316	31	7491	32	.0	.0		0	0	.0	0
OMAH	NE	NW	04T	2	A	0-05	9440	40*	9490	40	.1	.0		5	2	22.0	0
WKSH	WI	02	41T	1	F	0-08	8260	35*	8157	35	4.2	4.2		0	0	.0	0
WKSH	WI	02	41T	2	F	0-09	7821	33	7803	33	5.6	4.2		0	0	.0	0

NETWORK MANAGEMENT 5 MINUTE CCIS LINK EXCEPTION REPORT
IPLS IN 01 04T 4/27/77 1335

SIGNALING LINK													TERM BUFR OVLD				
NAME, SUFFIX, TYPE													THR	RPT	CTRL	BFR	
CITY	ST	BG	ETY	S	T	SLK NO.	OUTGO DATA		INC DATA		LINK %OOS	LINK CMPL %OOS	RCVD PSC PRO	PC	PC	%ACT	OFL
DLLS	TX	TL	14T	1	B	0-10	19093	81*	18937	80	.1	.0		5	10	43.3	4
OKCY	OK	CE	14T	1	B	1-03	16971	72*	17003	72	.0	.0	C	3	13	44.7	3
OMAH	NE	NW	04T	1	C	0-06	4217	18	4173	18	12.2	.0		1	0	3.3	0
OMAH	NE	NW	04T	2	C	0-07	5173	22	5204	22	.0	.0		0	0	.0	0
MDSN	WI	02	41T	1	A	3-11	8259	35*	8192	35	2.0	1.9	F	0	0	.0	0

Fig. 15—5-minute signaling link exception report for network management in CCIS STP (below) and switching (above) offices.

Monitoring the CCIS signaling links is a function of network managers because of the links' potential effect on telephone traffic. Presently, however, no capability is provided network managers to directly intervene in CCIS signaling network operation. The five-minute signaling link report indicates both outgoing and incoming signaling link occupancy because excessive signaling traffic in either direction may indicate undesirable answer signal delay. The percent of time a signaling link or signaling link complement (SLC) is reported out of service (OOS) includes the time signaling is inhibited for any reason including receipt of processor failed signals from a distant terminal and the signaling link being in the out-of-service, unavailable, or emergency restart states. One signaling link out of service may explain heavy traffic on the mate link. An outage simultaneously affecting complement signaling links (e.g., both A0 links to mate STPs) leaves no signaling path for corresponding bands of trunk groups which will be marked out of service in the associated switching offices. An F printed in the signaling link exception report column labeled RCVD PSC PRO indicates the signaling link outage is due to processor outage (PRO). Links over which processor signaling congestion (PSC) signals have been received from an STP will have a C

printed in this column. CCIS terminal buffer overload control activity which broadcasts group signaling congestion (GSC) signals at an STP or makes trunk groups inaccessible to new call initiations at a switching office will also trigger the signaling link exception report. Note that, again, the CCIS signaling link is identified in terms of the abbreviated (11-character) Common Language Location Identification (CLLI) of the distant office along with two characters which designate suffix and type. Also, mate signaling links are always output together.

3.4.3 Other network management measurements

Besides the delay measurements on the 5-minute and 15-minute reports shown in Figs. 13 and 14, there are sender queue high and low (SQH and SQL), machine congestion levels one and two (MC1 and MC2) and reorder, sender overload, and vacant code announcement (ROA, SOA, VCA) measurements. The SQH and SQL measurements are the same as taken in non-CCIS offices. The MC1 and MC2 congestion states trigger restrictive controls in offices contributing CCIS traffic and the network manager must have knowledge of this activity. Announcements are the end results of ineffective machine attempts (IMA) due to troubles, congestion, or misdialed calls. Announcement measurements details are on the 5-minute exception reports and are therefore not provided on the 15-minute report. It should be noted that equipment reorder, no circuit, and vacant code conditions can cause actual announcement routing to occur in the originating CCIS office and not necessarily in the office detecting the condition. Thus, percent reorder, no circuit and vacant code calculations are based on the counts of detected conditions rather than counts of calls routed to announcements.

The 5-minute and 15-minute trunk group and 5-minute usage exception reports are generated and formatted similarly in non-CCIS and CCIS offices. The CCIS trunk groups are labeled following the abbreviated Common Language Location Identity (CLLI) standard as are the non-CCIS trunk groups. The 5-minute usage exception report shown in Fig. 16 includes outpulser groups, outpulser link controllers, sender-outpulser groups (appropriately labeled), sender link controllers associated with sender-outpulsers (also appropriately labeled) and transceivers.

3.5 Office administration and traffic engineering

One of the three required *DATASPEED* 40 terminals is dedicated to the office (dial) administrator. As shown in Fig. 6, the office administrator uses intermediate- and long-term data to perform the day-to-day and week-to-week office administration functions. Office administration responsibilities include:

NETWORK MANAGEMENT 5 MINUTE USAGE EXCEPTION REPORT
 WKSH WI 02 41T 4/01/77 1306

EQUIPMENT ITEM	AVG # OUT	MAINT CCS	TRAF CCS	TOTAL CCS	% OCC	PC	HT/A
* TRANSCEIVER GROUP 5	0	.0	.1	.1	0	34	.29
* TRANSCEIVER GROUP 1	0	.0	.3	.3	0	41	.73
* TRANSCEIVER GROUP 0	0	.0	.3	.3	3	55	.55
* IT MARKER	0	.1	6.1	6.2	34	1560	.39
* TC MARKER	0	.4	4.5	4.9	27	1443	.31
* DECCDER CHANNEL	0	.0	4.3	4.3	24	3005	.14
* SLC-A (MF -A)	0	.0	2.5	2.5	21	584	.43
* SLC-B (MF -B)	0	.0	3.2	3.2	27	569	.56
* SLC-C (MF -C)	0	.0	2.7	2.7	23	574	.47
* SLC-D (MF -D)	0	.0	2.9	2.9	24	550	.53
* SLC-E (MF -E)	0	.0	1.4	1.4	12	211	.66
* SLC-F (MF -F)	0	.0	1.5	1.5	13	230	.65
* SLC-G (MF -G)	0	.0	1.1	1.1	9	247	.45
* OLC-A (OPLS-A)	0	.0	.0	.0	0	46	.00
* MF -A	0	.4	31.0	31.4	30	575	5.39
* MF -B	0	.4	29.3	29.7	28	567	5.17
* MF -C	0	.6	31.4	32.0	30	554	5.67
* MF -D	0	.8	30.7	31.5	30	543	5.65
* MF -E	0	.8	10.3	11.1	11	207	4.98
* MF -F	0	.5	10.0	10.5	10	228	4.39
* MF -G	0	1.3	10.9	12.2	12	255	4.27
* OPLS-A	0	.0	1.8	1.8	5	46	3.91

Fig. 16—Network management 5-minute usage exception report.

- (i) Ensuring proper functioning of all components of the switching system and associated network.
- (ii) Balancing the load on switching system components.
- (iii) Maintaining a required level of service.
- (iv) Collecting and summarizing valid traffic data for historical analysis and use by traffic engineers to provide the required amount of equipment and facilities.

Although some 15-minute and monthly data are provided to the office administrator, most information is reported on an hourly or daily basis as described in Refs. 4 and 5. Probably the most important and comprehensive administration reports are the Machine Load and Service Summary (MLSS), the Ineffective Machine Attempts (IMA) and the CCIS Summary (DACCIS) reports. Other reports are the incoming trunk group reports, the outgoing trunk group reports, the trunk link frame load balance report and the data integrity status report. Discussion in this article centers on the MLSS, IMA, and DACCIS reports. All three reports can be scheduled to report an hour's worth of data on the hour and the half-hour. Also these reports can be demanded for hourly periods beginning on the hour or half-hour up to and including the past twenty-three hours of data and for the 15-minute period preceding a demand. Finally various items on the reports can have threshold values set to trigger exception versions of the reports. The new CCIS measurements included on the office administration reports are far too numerous to discuss them all and, so, only a few are highlighted.

H 19 REPORT:DACCIS
 DA CCIS SUMMARY REPORT
 OFFICE: WKSH WI 02 41T DATE:03/30/77 PERIOD: 900-1000
 DATA INTEGRITY: ETS=300

SO OFFICE PERFORMANCE

CALL SWITCHED	%	ATTEMPTS	PC	%	BASE	SPC OCCUP	%
CC-EM	988	2.0	INC CC TOTAL	1001		ESTIMATED:	
CC-CC	0	.0	INC NOT SW	13	1.3	CALL PROC	10.2
EM-CC	740	1.6	OUT CC TOTAL	748		CALCULATED:	
EM-EM	45257	95.8	OUT NOT SW	8	1.2	BASE LEVEL	74.0
EM-ANN1	272	.6				TIME TABLE	16.0
CC-ANN1	0	.0	INC CC SW	988	2.1	CALL PROC	10.0
-TOTAL-	47257	100.0	INC EM SW	46269	97.9	TOT SW	100.0
REATTEMPTS						AVG E-E MSEC	20.0
EM-ANN2	0	.0	OUT CC SW	740	1.6	TOT SW	
CC-ANN2	0	.0	OUT EM SW	46517	98.4	TOT SW	

(a)

H 28REPORT:DACCIS
 DA CCIS SUMMARY REPORT
 OFFICE: ANHM CA 01 28T DATE:05/09/77 PERIOD: 900-1000
 DATA INTEGRITY: ETS=300

STP OFFICE PERFORMANCE

CCIS ITEMS	PC	ETS ITEMS	VALUE
OUT SIG UNITS	134358	MARKER PC	53537
INC SIG UNITS	134275		
OUT IAMS	3288	REAL-TIME FOR ETS	14.1%
INC IAMS	3288	REAL-TIME FOR STP	1.9%
OUT ANS SU	2451		
INC ANS SU	2451	AVG E-E TIME	24.5 MSEC
SYSTEM CONGESTION		SPC UTILIZATION	
PSC BROADCASTS	0	BASE LEVEL WORK	68.0%
PSC RECEIVED	0	TIME TABLE WORK	16.0%
SLK OVERLOADS	0	CALL PROCESSING	16.0%
		TOTAL	100.0%

(b)

Fig. 17—(a) Total office part of CCIS summary report for switching offices. (b) Total office part of CCIS summary report for STP offices.

3.5.1 CCIS Summary (DACCIS) report

The DACCIS report provides 15-minute and 60-minute summaries of CCIS activity in the office. The first page of the report provides total office measurements. The remaining pages provide the load and performance data of individual signaling links. Figs. 17 and 18 illustrate the DACCIS report format.

Total office counts of switched calls include CCIS to non-CCIS (EM), EM to CCIS, CCIS to CCIS, and EM to EM calls. In addition, counts of incoming CCIS calls routed to announcement are registered. All counts are made on an actually routed basis as opposed to a first choice basis. If, for example, it becomes necessary to subsequently route to announcement after switching to an outgoing trunk, a count is scored for the

original switched attempt and another for the announcement. Examples of CCIS call irregularities are initial address message (IAM) irregularities, Vacant National Number (VNN), glare detected, no outgoing call register, etc. VNN, for example, is a received backward failure signal for a call routed CCIS outgoing and indicates that a subsequent office has found a vacant code condition for the call.

The STP office performance section includes counts for incoming and outgoing initial address messages (IAMs) and signal units (SUs), PSC

DA CCIS SUMMARY REPORT
OFFICE: IPLS IN 01 04T DATE: 05/19/77 PERIOD: 900-1000
DATA INTEGRITY: ETS=300

SIGNALING LINK LOADS

OFFICE: IPLS IN 01 04T DATE: 05/19/77 PERIOD: 900-1000
DATA INTEGRITY: ETS=300

NAME	T	SLK NO	OUT SU	OUT OCC	INC SU	INC OCC	OUT IAM	INC IAM	OUT ANS	INC ANS	EST %	OUT	OCC
OMAH NE NW MSP 1	C	00-01	63	0	63	0	0	0	0	0	0	0	0
OMAH NE NW MSP 2	C	00-02	84	0	84	0	0	0	0	0	0	0	0
CHCG IL CL 57T 1	A	00-03	2125	1	2070	1	138	216	241	97	1	1	1
DLLS TX TL MSP 1	B	00-04	2484	1	1720	1	439	75	54	298	1	1	1
OKCY OK CE MSP 1	B	00-05	1470	1	1315	0	245	114	50	157	1	0	0
MDSN WI 02 41T 1	A	00-06	5926	2	5810	2	589	616	513	314	2	2	2
WKSH WI 02 41T 1	A	00-07	7166	3	9410	3	385	1483	1032	302	2	3	3

SIGNALING LINK PERFORMANCE

OFFICE: IPLS IN 01 04T DATE: 05/19/77 PERIOD: 900-1000
DATA INTEGRITY: ETS=300

NAME	T	SLK NO	CHANGE OVERS	OOS SEC	—SLK OVERLOADS—			OVER FLOW
					PC	SEC	AVG	
OMAH NE NW MSP 1	C	00-01	0	0	0	0	0	0
OMAH NE NW MSP 2	C	00-02	0	0	0	0	0	0
CHCG IL CL 57T 1	A	00-03	0	0	0	0	0	0
DLLS TX TL MSP 1	B	00-04	0	0	0	0	0	0
OKCY OK CE MSP 1	B	00-05	0	0	0	0	0	0
MDSN WI 02 41T 1	A	00-06	0	0	0	0	0	0
WKSH WI 02 41T 1	A	00-07	0	0	0	0	0	0

NETWORK PERFORMANCE

OFFICE: IPLS IN 01 04T DATE: 05/19/77 PERIOD: 900-1000
DATA INTEGRITY: ETS=300

NAME	T	SLK NO	PSC RCD	CHANGE OVER		EMER PC	RESTART SEC
				NE	FE		
CHCG IL CL 57T 1	A	00-03	0	0	0	0	0
MDSN WI 02 41T 1	A	00-06	0	0	0	0	0
WKSH WI 02 41T 1	A	00-07	0	0	0	0	0
DLLS TX TL MSP 1	B	00-04	0	0	0	0	0
OKCY OK CE MSP 1	B	00-05	0	0	0	0	0
OMAH NE NW MSP 1	C	00-01	0	0	0	0	0
OMAH NE NW MSP 2	C	00-02	0	0	0	0	0

Fig. 18—Signaling link and network part of CCIS summary report (common format for STP and switching offices).

broadcasts, PSCs received, signaling link overloads, marker attempts (non-CCIS switched traffic), and a summary of STP/non-CCIS real-time utilization of the SPC No. 1A. The Traffic Separations (TSEP) report

L DAY

INEFFECTIVE MACHINE ATTEMPTS - TOTAL - LAST REPORT DAY

WKSH WI 0241T

PERIOD= 0000 03/24/77 TO END OF REPORT DAY

INTEGRITY ETS= 7192 TDC= 7194

	IT	TC	TOTAL		BASE	DELAY	% DELAY	AVG AT
MARKER PC	246830	232608	479438	XOD-IT	5409	149	2.75	.782
ITLF PC	240015	224908	464923	XOD-TC	3712	61	1.64	.777
				XOD-TOT	9121	210	2.30*	.780
				OAD-OP	9248	10	.10*	.302
				OAD-MFO	0	0	.00	.000
				SAD-MF	20222	0	.00	
				SAD-MFO	0	0	.00	
				SAD-DP	0	0	.00	
				SAD-CAMA	0	0	.00	
				SAD-ORP	0	0	.00	
	PC	%	BASE		PC	CCS	%OCC	
TOT INEFFECT	744	.15*	TOTINC	SQL (A)	0			
RO DETECTED	682	.14*	TOTINC	SQL (A)	0			
SOA	0	.00	TOTINC	SQL (B)	0			
FRA (-ANN OF)	6	.00	TOTINC	SQL (B)	0			
NC DETECTED	56	.01	TOTINC	MC1	1	.08		
CAMA DP RO	0	.00	TOTINC	MC2	0	.00		
UCA	0	.00	TOT TV					
MCA	0	.00	TOT TV					
VC DETECTED	2395	.51	TOTINC					
LBA	0	.00	TOTINC					
SC RESET	7	.00	TOTINC					
RO INCOMING	556	.11	TOTINC					
PERM SIGNAL	362	.07*	EM INC					
PARTIAL DIAL	86	.01*	EM INC					
PULS ERROR	44	.01*	EM INC					
MUT DIGIT	62	.01*	EM INC					
STUCK REG-NC	0							
ADI DETECTED	2	.11	EM OUT					
IAM-UNEQ TRK		.02	EM OUT	TOTINC	465107			
COT TO	41	.05	EM OUT	EM INCOMING	455736	97.96	TOTINC	
RO OUTGOING	86	.01	EM OUT	CC INCOMING	9371	2.01	TOTINC	
EATR	49	.01	EM OUT	TOTOUT	462161			
	66	.01	EM OUT	EM OUTGOING	454716	98.36	TOTOUT	
				CC OUTGOING	7445	1.61	TOTOUT	
				CC TOTAL	16816	3.61	TOTINC	
				DCH 2T	3836	.82	ITLF	
CCIS REATMPT	1	.01	CC OUT					
RCPT COF-1A	0	.00	CC OUT					
RCPT RLG-1A	0	.00	CC OUT	EM-EM	445580	95.80	TOTINC	
RCPT RST-1A	0	.00	CC OUT	EM-CC	7009	1.50	TOTINC	
RCPT BLK-1A	1	.01	CC OUT	EM-AN1	3147	.67	TOTINC	
RCPT UQL-1A	0	.00	CC OUT	EM-AN2	25	.00	TOTINC	
CON CK FL-1A	0	.00	CC OUT					
GLARE-1A	0	.00	CC OUT	CC-EM	9136	1.96	TOTINC	
CREG TO-REAT	0	.00	CC OUT	CC-CC	0	.00	TOTINC	
				CC-AN1	0	.00	TOTINC	
IAM IRREG	1	.01	CC INC	CC-AN2	0	.00	TOTINC	
INVALID	0	.00	CC INC					
LENGTH CK FL	1	.01	CC INC	TPC TOTAL	461819	99.28	TOTINC	
2ND NO MATCH	0	.00	CC INC	THRU	172738	37.40	TPC TO	
NO CREG OUT	0	.00	EM-CC	INCOMING	83624	18.10	TPC TO	
CALL ABANDON	0	.00	CC TOT	OUTGOING	166952	36.15	TPC TO	
				NON-THRU	38505	8.33	TPC TO	
				IT GOING	339690	73.54	TPC TO	
				TC OUTGOING	122129	26.44	TPC TO	
				SDR CAMA	0	.00	TOTINC	
				CA DPR (ADJ)	0	.00	SDR CA	
				TOT TVTR	0	.00	SDR CA	
ADI	5		2					
NSC	0		0					
CFL	0		2					
SUBTOT	5		4					
VNN	22		36					

Fig. 19—Part of ineffective machine attempts summary report.

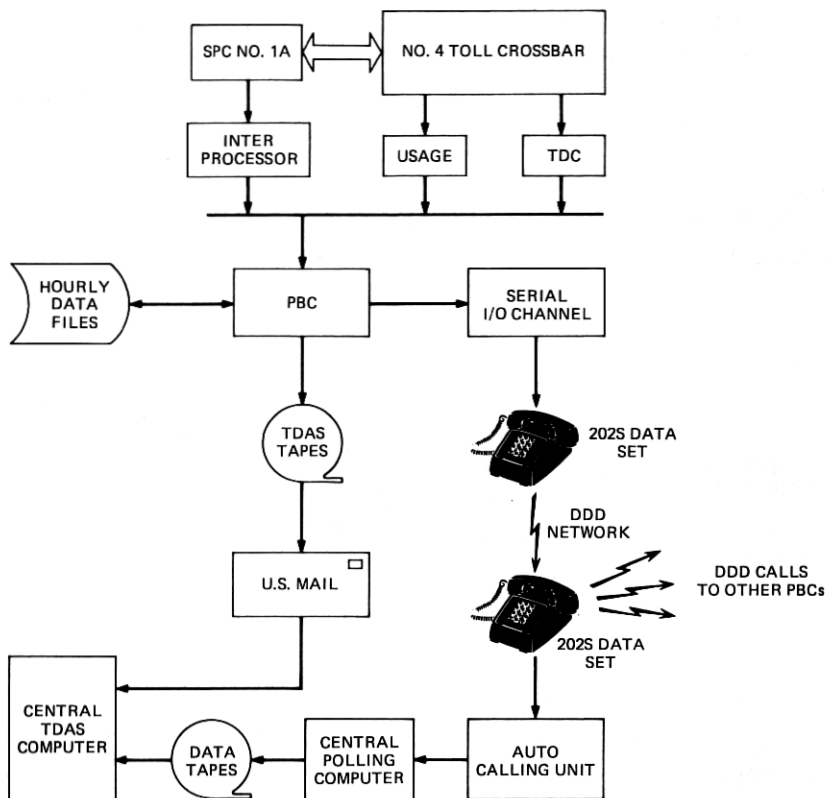


Fig. 20—TDAS interfaces with No. 4 crossbar CCIS offices.

used for division of revenue purposes also provides a real-time utilization summary in STP offices.

3.5.2 Ineffective attempt (IMA) and load service summary (MLSS) reports

The IMA report is partially shown in Fig. 19. Note that SADR (shown as SAD), OAD, and XOD measurements are summarized on the IMA report as are the SQH, SQL, and office congestion states (MC1 and MC2). All CCIS ineffective attempts, retrials, reattempts, time-outs, and miscellaneous other failures are summarized on the IMA report. In addition, CCIS signals sent and received and Voice Path Continuity (VPC) tests are summarized.

The MLSS report described in Refs. 4 and 5 is basically expanded to include occupancy and holding time summaries for the new equipment and groups including outpulsers, sender-outpulsers, outpulser link controllers sender-outpulser link controllers, and transceivers.

3.5.3 Interfacing with other systems

The long-term data required to perform engineering studies of the switching office are provided by two PBC features illustrated in Fig. 20. An optional dial-up data port can be installed which allows hourly traffic separations, trunk group, and common control equipment data files to be transmitted over the switched commercial network to a central polling computer once a day. The central computer forwards the data to a Traffic Data Administration System (TDAS), or equivalent, which enables an operating company to do engineering and division of revenue studies for No. 4 crossbar systems. As an alternative, the PBC provides this data on magnetic tape in a format which can also be processed by TDAS. TDAS enables an operating company to minimize, manage, and control the traffic data collected from a variety of switching offices for engineering use. TDAS tape entries must be made once a day during a study period. The PBC places a "restart" mark on the tape so that a single magnetic tape can be used to accumulate several days' worth of data for long-term engineering studies before it is sent to the operating company's TDAS-equipped computer center.

One additional data port is provided as an option by the PBC system. This port requires a permanent data link and is designed to interface with a centralized network management system which will poll the PBC system every five minutes as discussed in Ref. 3.

IV. MANAGEMENT OF THE OFFICE DATA BASES

As mentioned earlier, the data which describe the office equipment translations and define the routes over which calls are sent reside in the SPC No. 1A memory while the data which provide the proper associations among the raw measurement data and processed, labeled output reports reside in the PBC memory. The data bases are initially generated by Western Electric from completed questionnaires submitted by the telephone company for new installations or major growth additions. The daily, routine management of these two data bases are accomplished via the facilities provided by the PBC. Data base management is composed of three major functions:

- (i) Recent change—the capability to implement real-time data base changes formatted in user language.
- (ii) Verification—the capability to read the data bases by the No. 4 crossbar decoder marker test circuit software for advance verification of pending route changes and by the PBC for output in user language formats which facilitate comparison with office records.
- (iii) Off-line change order generation and storage—the capability to record change orders on a storage medium regardless of the state of the system.

4.1 Recent change

The Recent Change (RC) function is accomplished by software which resides in both the SPC No. 1A (minimal) and the PBC and which can change the SPC No. 1A data base and the PBC core and disk resident data bases. The appropriate RC programs are selected and executed by entering the desired input messages on either the *DATASPEED* 40 terminal associated with the No. 4 crossbar switching maintenance center or a second, optional *DATASPEED* 40 provided for data base management activities. The RC software programs are divided into control and change functions. The control software allocates and releases disk memory storage during the change process, updates status indicators, builds change orders, communicates with the SPC No. 1A via the interprocessor interface and actually writes the new data into memory when the change order is activated. Some control programs are executed by entering control messages while others are executed as subroutines to change programs. The change software translates input change message fields into addresses and data to be used by the control software. Change programs are executed by entering change messages. Change orders are built by entering combinations of control and change messages in the proper order. Control messages are used to begin, end and activate or cancel a change order.

A change order is entered into a PBC disk resident RC order buffer where it is held for verification tests and until the order is either activated or canceled. When a change order includes changes for SPC No. 1A data tables, a control message causes the new data to be transmitted across the interprocessor interface to the SPC No. 1A software which holds it in a temporary buffer for verification tests and until the change order is either activated, canceled or the next change order is transmitted to the SPC No. 1A for verification and activation or cancellation. During the change order transmittal the SPC No. 1A actually transmits a copy back to the PBC to ensure the change data was received error free by the SPC No. 1A. A well-defined handshake protocol and a set of error messages further ensures integrity of the change order.

4.2 Verification

Numerous verification facilities are provided. At the time a change order is first entered into the RC order buffers in disk memory, a response message prints out the data currently in each of the tables in a column beside the actual field label and beside a column containing the new data. Any field which differs between the old and new data columns will blink on the CRT between low and high intensity to attract attention to the changes pending in the change order buffer. The field labels are those used on the office data compiler records.

If call routing data in SPC No. 1A memory are to be changed by a RC order, the change data can be transmitted to the SPC No. 1A and its accuracy verified in advance of change order activation via the decoder marker test circuit keys, lamps and teletypewriter output messages.

A variety of readout verification messages and data table audits are provided which allow both the SPC No. 1A and PBC data bases to be queried over any of the PBC *DATASPEED* 40 terminals (RC order inputs and outputs are restricted to the two terminals identified in paragraph 4.1). The outputs of these verification and audit messages are in labeled formats similar to the office data compiler records for ease of recognition.

One further verification facility is the use of a comparison between the magnetic tape copy of the verified data base made after the last RC orders were activated and the contents of memory before and after the new RC orders are activated.

4.3 Off-line RC order preparation

The optional 4210 Magnetic Tape Terminal shown in Fig. 2 is an alternative to manual *DATASPEED* 40 keyboard entry of RC orders into the PBC disk buffers. Any 4210 terminal associated with any type of compatible keyboard device (teletypewriters, *DATASPEED* 40, etc.) independent of the PBC can be used to record RC order messages on the 4210 magnetic tape cartridges. The recorded cartridges can then be read by the 4210 terminal(s) directly onto the appropriate PBC *DATASPEED* 40 CRT's as an alternative to manual keyboard entry. From this point all other RC operations to verify and activate or cancel the RC orders are independent of the 4210 terminal.

The 4210 cartridges provide a means of long-term, bulk storage of RC orders for backup purposes and off-line, advance recording of future RC orders. Recording RC orders on 4210 magnetic tape is several times faster than punching paper tapes due to more streamlined RC messages, editing features of the *DATASPEED* 40/4210 terminal combination, and the reusable nature of magnetic tape for error correction. Furthermore, entry of RC orders recorded on 4210 cartridges is about ten times faster than entry using paper tape. Considering the increased size and complexity of the data base in a CCIS office, these data base management improvements are needed.

V. ACKNOWLEDGMENTS

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