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Stored Program Controlled Network:

800 Service Using SPC Network Capability—Network Implementation and Administrative Functions

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This paper describes the network elements and administrative functions affected by the implementation of the new method of operation for 800 Service. The new method of operation affected all existing network elements and required significant coordination of the implementation of the necessary modifications to meet the service dates. In addition, a new element being introduced into the network, called a Network Control Point (NCP), required the creation of a complete administrative plan.

I. INTRODUCTION

The 800 Service, which allows a customer to receive calls without charge to the calling party, has specific network and administrative methods of operation. In the previous paper on the 800 Service by Sheinbein and Weber, appearing in this issue of *The Bell System Technical Journal*, the change in the method of operation to use the Stored Program Controlled (SPC) Network and the use of centralized data bases called Network Control Points (NCPS) were discussed. With this new method of operation, the previous network and administrative methods were reviewed, adjusted, or totally changed. The network implementation involved changes in the type and characteristics of the Originating Screening Offices (OSOS), Signal Transfer Points (STPS), NCPS, trunking, routing, and overall coordination. The administrative changes primarily affected service provisioning, but they also had a significant impact on service maintenance, network maintenance, network administration, and network management. Sections II and III of this paper describe these changes.

II. NETWORK IMPLEMENTATION

To structure the network for transition from conventional 800 Service routing to the new common-channel interoffice signaling (CCIS) routing technique utilizing centralized data base translations, a plan with specific guidelines was established. A system letter was issued by AT&T to the Bell Operating Companies (BOCs) describing the CCIS 800 Service operation, equipment requirements for network nodes, network trunking needs, and plans for POTS routing. Specific dates were established for implementation activities and the BOCs were advised to establish project teams to provide overall coordination. The primary members of these teams were the CCIS coordinators for network implementation concerns and the 800 Service product managers for marketing and tariff activities.

2.1 Originating Screening Offices

Earlier sections of this issue of *The Bell System Technical Journal* discussed the SPC network and described the function of an Action Point (ACP). To review, an ACP is a switching office that has the capability to communicate with an NCP. The OSO will perform the ACP functions for 800 Service. Under the previous 800 Service routing arrangement, any switching office equipped with proper translation tables could function as an OSO. However, in the SPC network, CCIS OSOs (800 Service ACPs) are required to have CCIS capability to allow for initiating inquiry messages to a centralized data base for screening and translation. Initially, the only switching systems capable of providing the CCIS 800 function are No. 4 ESS (equipped with Generic 4E4) and No. 4A ETS (equipped with Generic 4XC2). No. 1 ESS and 1A ESS offices will be capable of CCIS OSO operation with Generics 1E7 and 1AE7 planned for 1982 and 1983, respectively.

In addition to updating software with the new generic, the 4A ETS offices required hardware modifications. Upon receiving dialed 800 Service calls, a sender must be able to function as a sender/outpulser. This means that the sender must be able to release and outpulse the terminating customer's DDD-routable number,* which was received from the NCP. This modification was required for all senders at a 4A ETS/CCIS office functioning as an OSO.

Upon establishing the number of CCIS-OSOs, all operating telephone companies planned to establish the trunks that would route dialed 800

* The number returned from the NCP is a network-routable but not a customer-dialable number.

Service traffic to these new OSOs. The prerequisite for a CCIS OSO was established requiring that it must function as a conventional OSO prior to CCIS activation. This requirement forced a reduction from the over 200 available OSOs to approximately 124 that would be equipped for CCIS and CCIS-OSO operation.

2.2 Signal Transfer Point direct-signaling generics

To perform the function of sending inquiry messages via CCIS from ACPs to NCPs, a new feature—direct signaling—was required in the signaling network. This feature necessitated a new generic in all Signal Transfer Points (STPs). The new generic (4XS2 for those STPs that also served as switching systems and 1STP2 for stand-alone STPs) was first available in September 1979. Conversions to the new generic began in September 1979 and completed with all STPs converted in April 1980.

Direct signaling provides the capability for the STP to route messages based on the first six digits of the dialed number. Thus, for 800 Service, inquiry messages will be routed to the appropriate NCP via the CCIS network, based also on the first three digits which are 800 followed by the NXX.

2.3 Network Control Point

Network Control Points (NCPs) are centralized data bases that contain call-handling information to perform the band-screening functions (the determination of whether the call originated from an area subscribed to by the purchaser of the service) and translate the dialed 800 number to a standard ten-digit DDD-routable number of the customer's destination. New features that will be introduced with this new method of operation are based on the ability of further expansion of the translation at the NCP. This expansion will allow different DDD numbers to be returned for routing based on customer's requested routing. The NCP is a 3B2OD processor-based system described in more detail in other sections of this issue. The NCPs are individually duplexed systems that are deployed in 800 Service in mated-pair arrangements. For 800 Service, each pair will contain the data base for a subset of 800-NXX codes. Each member of the pair, a duplexed processor, will perform translations for half of the data as its primary responsibility and will perform translations of the other half of the data only in case of failure of the mate. The mate contains a copy of the same data base information but performs its primary and secondary functions in exactly the mirror images of the mate, i.e., what is the primary data in one processor is secondary in the other. Each processor is traffic-engineered to 50 percent of its capacity during normal operation, which allows for carrying the total traffic (it and its mate) in the event of a mate failure.

The NCPs are connected to the CCIS network via dedicated interprocessor (I) links to an STP. The NCPs are colocated with STPs. For initial service to accommodate all 800 Service data base requirements, seven pairs of NCPs were deployed: two pairs each at the St. Louis, Missouri, Dallas, Texas, and Denver, Colorado regional STPs, and one pair at a new pair of STPs within the Denver region. All NCPs were installed, operated, and maintained by AT&T Long Lines.

Installation of the initial NCPs began during the fourth quarter of 1980 and completed in September 1981. Cutover to service commenced on September 1, 1981 with the first two pairs in the St. Louis region, and completed with the seventh pair in the Denver region on November 1, 1981.

2.4 Trunking plans and POTS routing

One of the major network benefits of CCIS 800 Service is the ability to use DDD-routable translations and routing. As discussed in the Sheinbein and Weber paper, the use of a centralized data base for band screening and translation to a DDD-routable number allows the elimination of the Terminating Screening Office (TSO) function in the network. Since TSOs were located high in the network hierarchy, 800 Service traffic was routed over trunk groups to class 1 or 2 switching offices and, in many cases, utilized final trunk groups. This routing is inefficient since the call must eventually terminate at the class 4 office. Eliminating the TSO function allows traffic to be routed from the OSO over high-usage trunk groups as directly as possible to the serving office, consistent with standard traffic engineering rules.

To effect a transition from conventional to CCIS routing of 800 Service traffic, AT&T Long Lines had to plan additional trunking in the high-usage groups. These were engineered and provided in the 1981 construction program. The removal of TSO trunking is planned for in the 1982 construction program.

Another factor in converting to DDD-routable numbers is the number assignment in the serving office where the customer's 800 Service terminates. In many offices, the line number used in conventional 800 Service routing was assigned from the available numbers in the office NXX code. In these cases, this number is a ten-digit code, routable from anywhere in the network. However, in other locations where line numbers suitable for 800 Service were not available in the central office code, pseudo codes were established and the routing information for this code is only known at the TSO, the serving office, and in some cases the intermediate office. As a result, completion to these numbers is only possible by routing through the TSO. Therefore, the BOCs and independent operating companies (IOCs) had to assign a ten-digit DDD-routable number for these lines. This is now possible since the tens block restriction on line assignments of the 800 Service conventional routing plan is eliminated with the new CCIS/NCP technique.

Conversion to DDD-routable numbers is under the control of the BOCs and IOCs for their respective territories. To effect this DDD routing, the BOC and IOC needed to load the ten-digit number into the data base for translation from the dialed 800 number. For those locations where DDD-routable codes are used in conventional 800 Service routing, this step occurred as soon as the NCPs were activated. At locations where pseudo codes were used, local translation changes and, in some cases, wiring changes were required before the POTS record could be activated at the data base. Therefore, a time period was allocated for BOCs and IOCs to complete conversion to DDD-routable numbers. The beginning of this period was determined by the activation date of the NCP that contained the specific 800 NXX assignments (September 1 to November 1, 1981) and was completed by February 1, 1982. This completion date was set since the 1982 trunking plan assumed that DDD routing was in effect and TSO trunking eliminated.

2.5 Cutover strategy

Since 800 Service is national in scope, cutover to the new CCIS operation without service impairment would be difficult. A plan was needed to allow the orderly activation of 124 OSOs and 14 NCPs. The plan was centered on the ability of an STP, whose NCP is not yet installed, to turn around inquiries, destined to the NCP, back to the CCIS-OSO. The format of the response looks to the CCIS-OSO as if it came from the NCP, except that a DDD-routable number is not yet available. The St. Louis, Dallas, and Denver STPs were initially equipped with the turnaround translation to return the dialed 800 number to the OSO.

As discussed previously, after February 1982, the NCP will contain only DDD-routable numbers. However, during the transition, the NCP or the STP may return an 800 number, and special arrangements to handle such responses were devised. Upon receiving an 800 number as a response to a data base inquiry, the OSOs will revert to conventional 800 Service operation and route the call to the appropriate TSO for completion. Activation of the CCIS-OSO function at OSOs began in May 1980 and continued each weekend until August 1981. All STP locations were equipped with 800-XXX routing information to direct inquiries to the proper STP and, thus, the NCP location. This step was completed in the second quarter of 1980.

The final step in cutover to CCIS 800 Service occurred during the September-November 1981 period with activation of the NCPs. Prior to this time, the normal installation procedures and acceptance testing took place and the operational responsibility of the processor was officially turned over from Bell Laboratories to AT&T Long Lines. Loading to the data base occurred during the two weeks immediately preceding cutover. Service activation of the NCP occurred by activating the I-links to the STP and removing the 800 turnaround feature. All inquiries were then routed to the NCP for data base translation.

2.6 Coordination of implementation activities

The implementation of CCIS 800 Service required the close coordination of activities of a large number of organizations. In addition to the normal first application support activities performed by Bell Laboratories and Western Electric, coordination between AT&T, Long Lines, and the BOCs was vital to an orderly implementation. To provide this coordination, an 800 Service Network Implementation Committee was formed in October 1980. The committee, under the chairmanship of a representative of AT&T Network Design, consisted of representatives from various AT&T Network departments, Long Lines, Bell Laboratories, and Western Electric. This committee, which met monthly, was charged with monitoring the implementation progress of all network activities for CCIS 800 Service. This included identifying critical issues and taking corrective actions, coordinating all network activities, monitoring NCP installation progress, and providing central project control.

III. ADMINISTRATIVE FUNCTIONS

Development of a new 800 Service capability within the network necessitated careful study and definition of the needs of a Bell System operational environment. The operational plan must adequately support both the services that would utilize the capability and the network entities that would provide the capability. The administrative plan for the 800 Service capability encompassed five primary operational functions:

- Service Provision—The process that includes the tasks performed from the time a customer orders service to the time the service has been installed in the network and made available for the customer's use.
- Service Maintenance—The process invoked by a report of impaired service, initiated either by a telephone company (BOC, IOC, AT&T Long Lines) procedure or by a customer report, that covers the tasks of verifying, sectionalizing, and repairing the reported troubles.
- Network Maintenance—The process, peculiar to specific elements in the network, that guides the analysis of a problem, localization of trouble, and repair of that specific element. This process is

either keyed by a self-diagnostic alarm condition of the element or is triggered by service maintenance procedures.

- Network Administration—The set of tasks associated with monitoring the performance of elements in the network to ensure optimizing the load-handling capability of each element.
- Network Management—The process that monitors indications of abnormal network operation and supports the implementation of controls that will minimize total network harm.

Since 800 Service was an existing Bell System offering, there was already in place an operational set of methods, procedures, and tools that covered all of the above functions. The challenge of developing an administrative plan for 800 Service capability was not to create a total set of processes from the ground up but, rather, to identify the unique functional requirements in a manner that would blend with the existing operational environment. With this as an objective, a functional analysis of the total set of administrative needs was conducted. The results of that analysis indicated that the aspects of network maintenance, administration, and management that were related to the ACPs and the STPs could readily be applicable to the work centers and operations systems that were already responsible for those network elements. Since the NCP was being initially introduced into the network, a complete administrative plan covering network maintenance, administration, and management had to be created for this new element.

The functional analysis also indicated that major augmentation of the provision and maintenance processes for 800 Service would be required to accommodate the new methods of call routing that were being introduced by the CCIS-800 Service capability. The remainder of this paper will focus on the administrative plan developed for the NCP and on the new aspects of service provision and maintenance that will apply to the range of services that utilize the CCIS-800 Service capability.

3.1 Service provision process

As described in other papers in this issue of *The Bell System Technical Journal*, the major change in the network architecture was the introduction of the NCP and its related translation data base. The data base contains, for each 800 number, the following specific parameters required to successfully complete a call initiated to the 800 number:

(*i*) Valid originating area codes based on purchased area

(*ii*) POTS number translations for interstate and intrastate calls

(*iii*) Desired translations based on particular time of day or day of week (*iv*) Alternative translations based on busy condition of primary line.

Obviously, the source of this information is the 800 Service customer. The primary new task in the service provision process is to capture that information and condition and place it in an NCP data base (and its mate data base). Procedures existed in each BOC and IOC to generate service orders, institute billing procedures, and ensure that the physical installation of the service took place. A key work group in those procedures was the Dialing Service Administration Center (DSAC), formerly called INWATS coordinators. The role of the DSAC was expanded to include the responsibility of deriving from a service order the information that would have to be provided to the NCP data base for 800 Service. To assure the integrity of that information, transform it to a form usable by the NCP, and deliver it to the proper NCP, a centralized Bell System Operations System was designed by AT&T Long Lines. The system, designated as the Network Support System-800 Service (NSS-800), provides on-line, dedicated access by each DSAC location. The DSAC interacts with the system to obtain and reserve unique 800 numbers. When a service order is issued, the DSAC again interacts with the system to enter required information about the service and a service date. These data are validated as they enter the system. Within NSS-800, a customer profile record is created. Twenty-four hours prior to the service date, NSS-800 will retrieve the customer profile record, format it for the NCP, determine the primary and mated NCPs that are to receive the record, and load the record into the appropriate NCPs. The NSS-800 is connected via dedicated 4800-baud private lines to every NCP in the network. The system will look for an acknowledgment from both NCPs (primary and mate) to ensure that the record was properly distributed. If both acknowledgments are not received, the system will alert the work center responsible for NCP data administration. That work center is the Operations Network Administration Center (ONAC), a Long Lines Network Services work group located in Kansas City, Missouri. The ONAC was created to coordinate the overall flow of service provisioning information from the DSAC organizations, through NSS-800, to the NCPs. The ONAC is responsible for managing that information flow and ensuring that any malfunctions in the flow are promptly repaired. In addition to this role in the service provision process, ONAC provides an important ingredient to the service maintenance process.

3.2 Service maintenance procedures

The placement of translation data bases throughout the network offers the potential for a customer-affecting trouble caused by a data record error. The previously existing maintenance plan for 800 Service was expanded to include procedures that would effectively locate and clear possible data-related problems. Customer trouble-reporting procedures remained unchanged, being handled either by Special Service Centers (SSCs) or Repair Service Bureaus (RSBs). These centers will use existing procedures to verify, sectionalize, and clear physical plant problems. If it is ascertained that the customer reported problem could be data-related, the responsible work center (SSC or RSB) will contact their local DSAC and request their assistance. The DSAC has direct access on the NSS-800, and through on-line inquiry, it can audit customer record content, as well as determine which version of the record is contained in the NCP data base. If discrepancies are discovered, DSAC can transmit immediate corrections to NCPs through NSS-800. The ONAC has access to additional capabilities in NSS and, accordingly, the DSAC may contact ONAC and request their assistance on more difficult troubles.

In addition to serving as the tool that DSAC and ONAC can utilize to respond to trouble reports, NSS-800 is programmed to periodically audit the contents of the NCP data base. The NSS-800 retrieves each record in the primary data base and mate data base and compares them with the current active record entered by DSAC. Any discrepancy discovered in this comparison is reported to ONAC for reconciliation.

3.3 Network management

As mentioned above, NSS-800 is directly linked to each NCP to allow real-time data interactions between the NCPs and ONAC and the DSACs. The NSS-800 also serves to link the NCPs to the Network Operations Center (NOC) in Bedminister, New Jersey, so that the network management aspects of the CCIS-800 Service capability can be monitored and, if necessary, controlled in the case of mass calling to any 800 number. The NCP data base has been designed with automatic control capabilities that monitor attempts to each 800 number, compare those attempts against a threshold value and, when necessary, instruct OSOs to limit the volume of calls directed to that 800 number. When this control is initiated by an NCP, a message is sent to the NOC via the NSS-800. Thus, the NOC is alerted to the calling conditions occurring on the network. The NOC personnel can assess overall network performance and, based on their analysis, can elect to override the controls initiated by the NCP.

As described above, the NSS-800 and the ONAC provide the primary augmentation to the service provision and service maintenance processes to support the CCIS-800 Service capability. In addition, NSS-800 supplies the NOC interface to the NCPs to support the network management process. While the system was developed primarily to satisfy these functions, its role in several adjunct functions was identified.

Since the system became the collector of all 800 Service customer records, it was the logical source of information for the 800 Service Directory Assistance (DA) process. A mechanized interface was developed between NSS-800 and the 800 DA processor in Kansas City, Missouri. Each night, record changes that have been entered into NSS-800 by the DSACs are transmitted to the DA processor where they are conditioned and forwarded to the 800 Service DA centers.

The NSS-800 also provides a mechanized interface to the Centralized Message Distribution System (CMDS) in Kansas City. The information provided is the correlation between an 800 number and the translation that will exist in the network. This correlation is necessary for CMDS to correctly provide source data for the traffic engineering processes that it supports.

3.4 Network Control Point maintenance

The introduction of the NCP as a new network element required the development of a maintenance and administration plan for that entity. The basic design of the NCP, similar to other SPC-based elements, included self-diagnostic and self-repair capabilities. Primary interfaces for local craft personnel and for the No. 2 Switching Control Center System (2-SCCS) were provided. Because of the close relationship between the NCP and the CCIS network, it was desirable to provide NCP performance information to the work centers responsible for CCIS network performance. These centers are the CCIS Electronic Switching System Assistance Center (CESAC) located in Columbus, Ohio, and the zonal CESACs located in San Francisco, California; Denver, Colorado; Chicago, Illinois; and White Plains, New York. The centers are provided access to the data they need via a centralized Bell System Operations System, designed by AT&T Long Lines, called the Network Control Point Administration System (NCPAS). The NCPAS is directly linked to every NCP in the network and collects processor performance data from each NCP. These data are stored and formatted into reports that can be retrieved by CESAC and zonal CESACs. The reports are also received by the local craft personnel at each NCP location. The local craft personnel can be connected to NCPAS through the NCP itself. This arrangement removes the burden of formatting and storing report data from the NCP and provides the users with the flexibility to redefine report structure and content without incurring NCP development cost.

3.5 Network Control Point administration

Administration of the NCP processors encompasses two discrete functional processes. The first of these is definition of the software of each NCP: What service will the NCP be expected to handle (800 Service, Automated Calling Card Service, etc.) and what customer records

(800-NXX, NPA-NXX) will it contain? This software definition is contained in the NCPs "specification file." These decisions are made in an engineering process and provided to a national Long Lines work center, the Engineering Network Administration Center (ENAC). The ENAC uses the NCPAS to structure the specification files for each NCP, format them, and distribute them to the NCPs involved. Once the service specification has been distributed in this manner, there is a second function, the complementary administrative function, to be performed. Since the distribution of services and records among the NCPs is based on a forecast, it is necessary to monitor the actual call attempts that each NCP is handling to ensure that the engineering distribution is correct. The NCPAS is the vehicle used by ENAC to perform the monitoring function. When redistribution is appropriate, ENAC will use NCPAS as described above.

3.6 Traffic measurement collection

Embedded in the design of the NCP software is the capability to measure various attributes of the call attempts handled by each NCP. These data are valuable to the engineering or network provisioning and marketing processes that evaluate various aspects of a service offering. There is also a requirement to capture network usage statistics that will be used in the separations process. Although the NCP collects these types of data, it cannot analyze them. Accordingly, AT&T Long Lines developed a national Bell System Operations Support System called the Network Control Point Data Collection System (NCPDS). This system is linked to each NCP and collects the traffic measurement data generated by the NCPs. Sampling rates for the particular data to be captured by each NCP are set by ONAC and ENAC using NSS-800 and NCPAS, respectively. The NCPDS serves as a centralized data store that can provide the information needed by engineering and marketing processes.

3.7 800 Service record

At the time of implementation of the 800 Service capability using the SPC network, there were almost 200,000 customer lines for 800 Service. Records pertaining to each of these lines had to be verified, expanded to include valid POTS translations, and then loaded into the appropriate NCP data base. The source data for these records was resident in the BOCs and IOCs and existed in various forms and states of accuracy. The transformation of these data to a validated and consistent form that could be loaded into the NCPs represented a substantial task for the Bell System. To effect the necessary controls on the conversion process and to minimize the manual work effort, AT&T Long Lines developed a mechanized process that utilized two existing 800 Service data records, Wide Area Telecommunications Services (WATS) Information System, and 800 Directory Assistance, plus a mechanized record of 800 numbers from those BOCs and IOCs that had one available. These records were compared and used to develop an initial load of the NSS-800 data base. Various reports indicating discrepancies resulting from the comparisons were furnished to each involved BOC and IOC. The NSS-800 was made available in December 1980 to all the BOCs and IOCs to allow them to complete and purify their records. All on-going service-order activity was entered into NSS-800 to build as complete and accurate a data base as possible before actually loading the NCP data base.

3.8 Network Support System-800 characteristics

The NSS-800 is implemented on a large-scale IBM main frame (3032) computer located in Rochelle Park, New Jersey. The machine is dedicated to the NSS-800 application. In addition, a second processor (IBM 3168) is available to sustain the system functions required to interface with the NCPs if there is a failure of the primary processor. In the unlikely event of a catastrophic processor failure at Rochelle Park, full-scale remote site restoral capability is provided in White Plains. The system uses the Information Management System (IMS) data base management/teleprocessing software package from IBM. Each line between NSS-800 and an NCP has a dedicated backup. These lines are all terminated on a COMTEN 3650 front-end National Cash Register processor that has been designed to support the BX.25 level 1, 2, and 3 protocol.

3.9 Network Control Point Data Collection System characteristics

This application has been implemented on the NSS-800 backup processor described above. Data related to 800 Service and its customers is fed indirectly to NCPDS from the NCPS via an IMS EXIT routine in the NSS-800. Processor traffic measurement data are fed from the NCPs directly to NCPDS. The COMTENs terminate simplex lines from NCP. This arrangement efficiently uses the processing power that has been provided at the Rochelle Park site.

3.10 Network Control Point Administration System characteristics

The NCPAS is implemented on two DEC 11/70 processors located in Freehold, New Jersey. Both processors utilize the *UNIX** operating system. One processor acts as a front-end, handling the communications interface to the NCPs (duplex lines) and supporting the BX.25

* Trademark of Bell Laboratories, Inc.

level 1, 2, and 3 protocols. The second processor handles the network administration applications. The ENAC, located in Cincinnati, Ohio, is connected to NCPAS, and the zonal CESACs are provided with dial-up capability.

3.11 Center and system impact

While the introduction of the NCP and its translation data base has a dramatic effect upon the capabilities of the network, the impact on the operational environment required to support those capabilities was minimized. Two new national work centers (ONAC and ENAC) were identified, the role of DSAC was expanded, and three centralized operations systems were developed. The functions of both the centers and systems are intended to be consistent with the network capabilities. While the initial implementations are geared to 800 Service, the design of both the centers and systems is hoped to easily accommodate any new customer services that employ the SPC network capability.

IV. SUMMARY

The technical implementation of the CCIS 800 Service required modifications in all existing call-processing elements, as well as the addition of the new network element, the NCP. The administrative implementation affected service provision, maintenance, network administration, and network management. Clearly, such a new capability impacts how we provide service today and required the coordination of all elements of the Bell System-Bell Laboratories, AT&T, AT&T Long Lines, Western Electric and, most critically, the BOCs, as well as the IOCs. Without their cooperation, such a network capability could not have been implemented.