Recent technological advances have increased the size and number of teleprocessing networks as well as broadened their scope and complexity. This added size and complexity has magnified the need for communications network management. One approach to communications network management is to provide centralized control which is integrated into the Systems Network Architecture user network. This approach is described in this paper by focusing on two program products that provide centralized operator control and problem determination capabilities for a network.

An integrated approach to centralized communications network management

by R. A. Weingarten

In the 1960s, teleprocessing was in its initial stages. Each user had the responsibility, by means of an application program, to manage and control all terminals dedicated to an application. In IBM systems, no standard products were provided that aided the user in communications network management since only a few terminals, both in numbers and types, were in use, and few users required the interconnection of hosts such as the System/360 processors.

In the 1970s this situation changed as technological advances allowed the production of more sophisticated terminals and larger and faster host systems, including models of the System/370 and the 3031, 3032, 3033, 4331, and 4341 computers. This environment was also changed with the introduction of Systems Network Architecture (SNA)[1-4] and a new line control discipline called Synchronous Data Link Control (SDLC)[5] in 1974. With these technological advances, the need to control and manage larger and more sophisticated networks was increased.

Communications network management techniques were required to plan, install, control, and maintain the newer, more complex networks. These new networks differed from the networks of the earlier period because they supported multiple application programs sharing both communication lines and terminals, interconnection of multiple-host systems, and connection of large quantities of varied types of communication terminal equipment.

One approach for the operational control and problem determination aspects of communications network management was to integrate the functions into the user network, providing for centralized communications network management. Having originated with the introduction of SNA, and developed further as the multisystems networking facility capabilities of the Advanced Communications Function[6] were made available, this approach allows a network operator(s) to manage and control the entire network from one or more operator terminals integrated into the network from a centralized location. By being integrated into the network, it is possible to have access to information known by network elements and to utilize the network to transport data back and forth between network resources (e.g., communications network management applications to other applications or terminals, etc.).

This paper will discuss one way in which this approach has been implemented by describing two IBM program products announced in November 1978, with a subsequent release in June 1979. The program products are the Network Communications Control Facility (NCCF)[7] and the Network Problem Determination Application (NPDA Release 1 and 2).[8]

NCCF provides centralized operator control for the Advanced Communications Function access methods and program environment (base) services for communications network management applications. NPDA utilizes the base services of NCCF and allows a centralized NCCF network operator to detect errors and isolate them to specific network components. By allowing communications network management applications (such as NPDA) to operate on the NCCF base, the same network operator can view and correlate data obtained from multiple communications network management applications with the operational aspects of the network.

This paper first provides a description of NCCF and its usage for centralized operator control and as the base facility for communications network management applications. The paper then provides a description of NPDA. After describing the program products, this paper identifies how they can be used together to implement the integrated communications network management approach.

Network operation—an historical look

The operator of a teleprocessing system has always had the responsibility of ensuring that terminals were available for use. The operator had various means to accomplish this task: by displaying the terminal status, activating/deactivating the terminal, or starting and stopping trace routines to determine if data could be sent and received from the terminal.

During the 1960s these functions were provided by IBM software for a single-host environment. Each host node (System/360 or System/370) controlled all its own teleprocessing resources. Most application programs during those years operated in the Basic Telecommunications Access Method (BTAM) environment.

As the number of terminal types and application programs began to increase, it became more difficult to update application programs used for terminal control purposes. To relieve the user of the task of modifying the application program each time a new device was introduced, a new "layer" was developed which fit between the end user application code and the access method (BTAM). This new "layer" contained operator control for its terminals as well as new programming capabilities that relieved the user of device mapping and control. One example of this new "layer" (or subsystem) is the Customer Information Control System (CICS).

Coupled with the introduction of BTAM was the Queued Telecommunications Access Method (QTAM). It functionally isolated the application program from terminals and terminal control.

Separation of operator control from application control was not generally utilized until early in the 1970s when the Telecommunications Access Method (TCAM)[9] was introduced as a replacement for QTAM.

TCAM operator control

TCAM allows the user to specify two types of operator terminals that can control all the terminals connected to a single TCAM host system. The terminals can be designated as either primary or secondary operator terminals. The primary operator terminal function (TCAM terminal, TCAM user-written program, or system console) can issue all TCAM operator control commands as well as receive TCAM operator control command replies and all unsolicited operator control notification messages (link failure notification, etc.). Secondary operator terminal functions are the same as the primary ones with the exception that unsolicited operator control notification messages will not be sent to that terminal. This operator capability was made more flexible by the TCAM message handler capabilities. Operator commands and messages can be modified, logged, or deleted by the utilization of a message handler.

Although TCAM provided operator control facilities for multiple application program use, these facilities were limited to a single TCAM host environment. The introduction of the Telecommunications Control System (TCS)[10] extended the operator capability to a multihost TCAM environment. TCS allowed a TCAM network operator attached to one host to operate TCAM in another host. These two TCAM systems were connected by a transmission control unit (IBM 270X) or a communications controller (IBM 3704-3705/EP, i.e., Emulation Program) via binary synchronous communications (BSC) line control. This capability provided IBM's first standard software centralized network operator control facility. It was limited, however, to a TCAM system connected via BSC line control.

As TCAM was extended in 1977 to incorporate direct support for SNA and the new SDLC protocols, so were the TCAM operator control capabilities. The TCAM operator could control SNA devices connected to a single TCAM host. The same TCAM operator could also control multiple SNA TCAM host systems by utilizing TCS via the BSC interhost TCAM connections. The capability to control multiple SNA TCAM systems connected with the multisystem networking facility via SDLC line protocol became possible with the introduction of the Advanced Communications Function of TCS in 1978. This extension to TCS allowed a single TCAM operator to centrally control a TCAM SNA and/or non-SNA network via either interhost connections by SDLC and/or BSC line protocols. This centralized operator control mechanism was still limited to networks that contained only TCAM-controlled systems.

VTAM operator control

During 1974, a new access method called the Virtual Telecommunications Access Method (VTAM)[11] was introduced by IBM. This access method provided SNA support that included communications network management capabilities defined in the System Services Control Point. VTAM had its own operator control functions that allowed commands to be issued and received via the system operator console. The sharing of the system operator console for VTAM and operating system commands and messages could create operational problems in systems with a large number of attached terminals. To alleviate this problem and separate network operations from systems operation, an interface called the programmed operator interface was made available in VTAM in 1975.

The programmed operator interface allows an application program to issue VTAM operator control commands and receive VTAM operator control responses and all unsolicited operator control notification messages. The first IBM program product that utilized this new interface was the Network Operations Support Program (NOSP)[12] introduced with the announcement of the Advanced Communications Function for multisystem networking of

VTAM in 1976. NOSP allowed a designated operator to issue and receive operator messages, both solicited and unsolicited, from a VTAM system. In a multisystem network environment, an NOSP could communicate with other NOSPs to control the network from either a single central terminal or multiple distributed terminals. This function was similar to the function provided by the Telecommunications Control System of TCAM, with the exception that NOSP was developed for use in the SNA networking environment. NOSP was also limited in that it could execute in a VTAM-only network.

TCAM and VTAM operator control

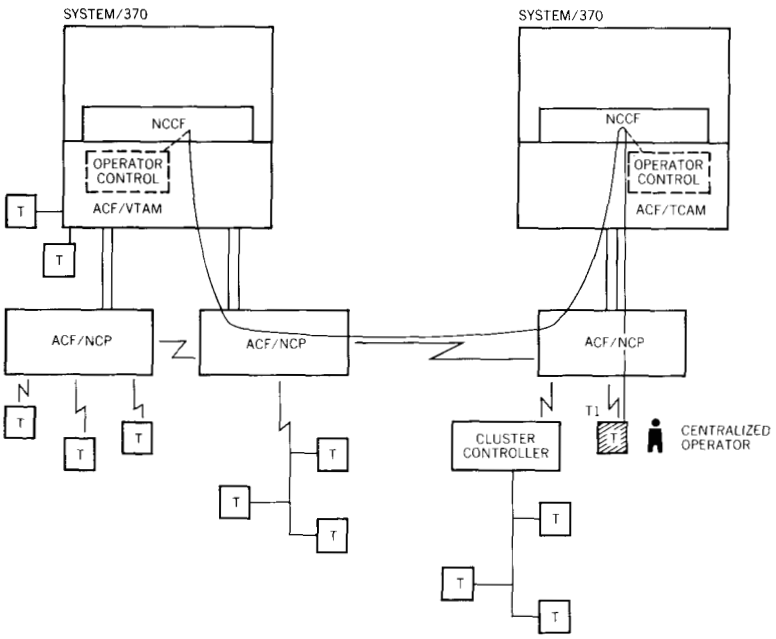
To satisfy the requirement for centralized operator control of multisystem networks with the coexistence of TCAM and VTAM in an SNA environment, NCCF was announced in November 1978. It was an outgrowth of NOSP with extensions for operator control for the TCAM environment and communications network management functions for both TCAM and VTAM.

NCCF allows operator control messages to be issued from a central operator terminal (or multiple distributed operator terminals) to and from either a VTAM[13] or a TCAM[13] host, each of which contains an NCCF. This capability is illustrated in Figure 1 in which two System/370 hosts are connected together in a multisystem SNA network environment. One of the systems contains VTAM with NCCF. In this system, NCCF provides the interface to VTAM for operator control via the programmed operator interface. Note that in this configuration, no terminals are directly connected (in an SNA session) with the VTAM NCCF to either issue or receive VTAM operator control commands.

The other host system contains TCAM with NCCF. In this case, NCCF provides the interface to TCAM for its operator control messages. This NCCF does have a display unit (terminal T1, an IBM 3270 display unit) connected via an SNA session. The display can be used to issue and receive both TCAM and VTAM operator control commands and messages.

If the NCCF operator (at T1) wishes to issue a TCAM operator control command, then the NCCF (in the TCAM system) simply routes this command to the operator control for TCAM. Any responses are passed back to NCCF for forwarding to terminal T1. If the NCCF operator (at T1) wishes to issue a VTAM operator control command, the NCCF (in the TCAM system) will route, upon request of the operator, this command to the NCCF in the VTAM system, which, in turn, will pass the operator control command to VTAM via the programmed operator interface. The reply to this VTAM operator control command, as well as any unsolicited VTAM messages, will be returned to the NCCF in VTAM for forwarding to terminal T1 via the TCAM system NCCF. The commands issued by the NCCF operator must be in the syntax of the target access

Figure 1 Centralized operator control



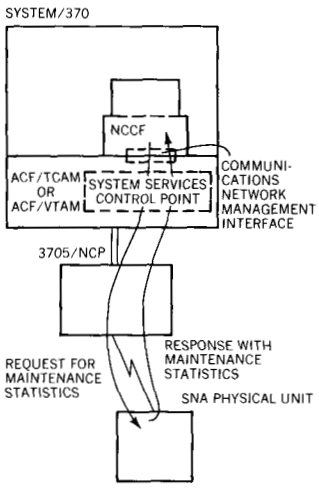
method. The routing mechanism provides for explicit command (operator directed) routing among multiple NCCF-supported systems to either TCAM or VTAM system or implicit command (NCCF directed using the resource network name in the command) routing only between VTAM systems.

NCCF services

In addition to the functions described above, NCCF provides services that were designed specifically for integrated and centralized host control for communications network management. Two services have already been mentioned: the capability to send and receive messages from any NCCF-defined IBM 3270 display unit independent of network location and the capability to issue access method (TCAM and VTAM) operator control commands via a programmed operator interface. A third interface which has been incorporated into TCAM[13] and VTAM[13] is the communications network management interface.

The communications network management interface provides access from a host application program into the network via the System Services Control Point of either TCAM or VTAM to request and obtain communications network management data. This interface allows NCCF to request maintenance data from a specific SNA physical unit (e.g., an SNA IBM 3276 unit or IBM 3770 Data Communications System MLU) and the System Services Control

Figure 2 Communications network management interface



Point to deliver the response back to NCCF (see Figure 2). Two additional communications network management requests have been incorporated into SNA. The interface also allows statistical error data generated by a communications controller operating with NCP/VS (Network Control Program/Virtual System)[14,15] to be delivered by the System Services Control Point to NCCF. The network management request units provide problem determination data that is received by NCCF for processing by NPDA. Since NPDA utilizes these request units for problem determination purposes, their content and usage will be further discussed in the appropriate NPDA section of this paper.

NCCF communications network management base functions

In the introduction, it was mentioned that an approach used for communications network management was centralized network control. NCCF provides capabilities for this centralized approach via its network operator interfaces and its usage of the communications network management interface. To further provide communications network management, NCCF also has program environment base services for user- or IBM-written applications. These services can be used for communications network management applications (for instance, NPDA) or for the user to enhance and/or tailor operator control functions. They can be utilized by writing command processors, command lists, and/or user exits in NCCF.

command processors

A command processor is logically a subroutine of NCCF. It can be used to tailor and enhance operator control functions as well as provide communications network management functions. It is initiated via a user-specified input command from an NCCF operator terminal. The command processor output can be either a command (which could initiate another command processor), a reply message to an NCCF operator, a communications network management interface request, or an access method operator control command. After a command processor has initiated its output request, control is returned to NCCF.

NCCF provides other services for communications network management application usage. The most important services will now be described.

VSAM file support

One of these services is VSAM (Virtual Storage Access Method) file support capability. NCCF provides the physical input/output control and the error recovery mechanisms for the VSAM file access. The user- or IBM-written command processor can request that NCCF either GET, PUT, UPDATE, or ERASE data on the VSAM file. This capability allows multiple communications network

management applications to share and store data about network resources on the same VSAM file.

screen management

NCCF provides the IBM 3270 display screen management which controls the placement of multiple output messages on the operator display screen. These output messages can either be directed to the same or different screens by means of user-defined control. Thus, messages received from the programmed operator interface, command processors (i.e., communications network management applications), or other NCCF operators can be displayed as they are received by NCCF on a single screen or distributed among several screens. Also, there is a capability provided that allows a command processor to display a full screen of contiguous data.

There are other services within NCCF that allow the user to provide both the tailored and/or enhanced operator control functions (e.g., command lists) as well as communications network management applications. These services are provided to the user through defined NCCF interfaces that are independent of access methods (TCAM and VTAM) and operating systems (DOS/VS, OS/VS). Network problem determination is a communications network management application that utilizes this interface.

Network problem determination application

NPDA collects, stores, monitors, and allows the user to display network problem determination data at a centralized or distributed NCCF operator terminal. For example, the operator can access specific problem determination data on a display unit after receiving notification from the access method (via operator control interface) that a network component has failed (i.e., link failure, etc.). NPDA utilizes NCCF services and is itself a set of NCCF command processors.

NPDA objectives

Before describing the centralized communications network management capabilities provided by NPDA, a brief discussion of the objectives of NPDA is presented. NPDA is intended to satisfy four major objectives. They are:

1. To provide a facility to assist the user with network problem determination in an SNA network regardless of what applications, access methods, or operating system are in use, and to provide this facility for both SNA and non-SNA (for migration purposes) devices in the network.
2. To provide the user with a hierarchical data display capability to help the user to isolate a network problem to a failing physical component.

3. To state the error description in user-oriented text (modifiable by installation) and provide a probable cause (defined later) definition that aids the user in determining which network component(s) has failed.
4. To allow the above three facilities to be accessed from a single centralized or multiple distributed network operator terminal(s).

NPDA uses NCCF services to provide an interactive display capability on a display unit that allows a single operator (or multiple operators) to view network problem determination data from a centralized location. It collects, summarizes, displays, monitors, and records the error records received from network components.

NPDA is not the first or only problem determination application available to IBM users. It was preceded by two IBM service aids that are briefly described in this paper. It does have some functions that the others do not have, including:

1. The ability to access network problem determination data from any designated NCCF display unit independent of network location.
2. The capability to provide a "probable cause" definition for errors (SNA and non-SNA network components) by processing of error "bits" obtained from individual error events.
3. Ability to solicit summary error statistics from SNA network nodes.

The above three functions will be discussed further in this paper, but for background, a brief review of the two IBM service aids, which influenced the design of NPDA, is now given.

service aids

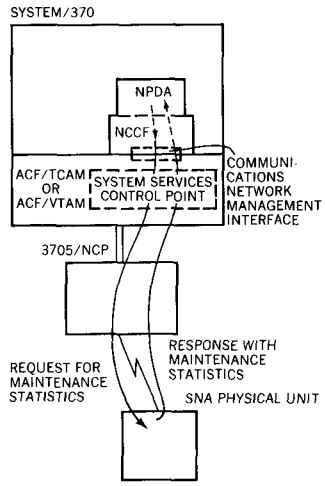
The Facility Error Recognition System (FERS)[16,17] is an IBM Field Engineering service aid that provides on-line displays of terminal and data-link error data in a single CICS host environment. It can be viewed as an extension to the CICS terminal error program since it is activated whenever a CICS-controlled terminal experiences an unrecoverable BTAM error. FERS places on a file the abnormal condition line entry with the terminal's identification for display purposes. Display of the error data is accomplished via a CICS transaction request for the FERS application task. FERS is basically a tool for IBM 3270 error displays and as such contains detailed screens that translate the display unit sense and status bit combinations into text describing the error. It also provides support for a transmission control unit (IBM 270X) and communications controller (IBM 3704-3705/EP) for sense data relating to all attached devices.

The Display Exception Monitoring Facility (DEMF)[17,18] is an IBM system control program service aid. It is functionally richer than FERS. It operates in a single-host OS/VS environment and requires either CICS, IMS (Information Management System), or TCAM. DEMF, like FERS, is basically a tool for error detection for lines and IBM 3270 terminal devices. It translates sense and status data encountered from the attached devices into English text, but obtains the data differently than FERS.

DEMF is a logical extension to the OS/VS error-recording function for hardware errors (LOGREC)[19] and obtains its data via an exit to the OS/VS supervisor call which records the hardware errors. It summarizes certain data elements and records this data on a disk file. These error records and summaries can then be put on a display unit. The error records are displayed with the hardware address of the unit being viewed.

Both FERS and DEMF record error information for components of a non-SNA network. They do not provide similar data for SNA nodes or for centralized viewing of this problem determination data when multiple-host systems are connected as does NPDA. This capability is provided by NPDA with an extensive set of displays for SNA and non-SNA network components. Also, since NPDA is an application that utilizes NCCF services, it allows an operator to view all problem determination data from a centralized NCCF terminal.

Figure 3 NPDA use of the communications network management interface



communications network management interface

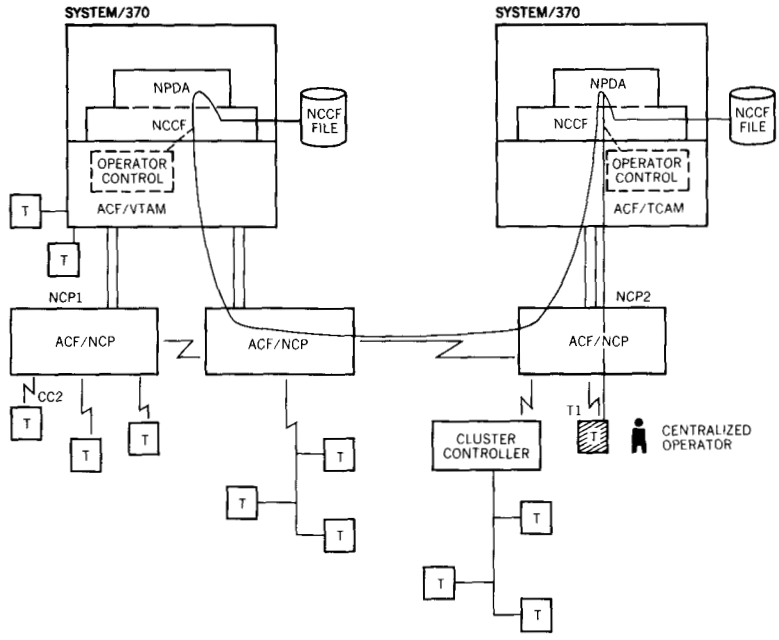
The method used by FERS and DEMF to collect problem determination data was not used to collect data from SNA network nodes. To do this, the communications network management interface was created. The data is obtained via requests that are generated and transported within the SNA network.

As you may recall, the communications network management interface is a recent facility incorporated into both TCAM and VTAM. This interface allows an application program (i.e., NCCF) to establish a session with the System Services Control Point of the access methods. Through this interface, communications network management requests can be issued to network nodes to obtain statistical maintenance data used for problem determination purposes.

Two new requests have been designed to flow across the interface: (1) request maintenance statistics and (2) record formatted maintenance statistics.

Request maintenance statistics is forwarded by the System Services Control Point (Figure 3) to an SNA physical unit upon request of the communications network management interface user—in this case, NCCF. NCCF issues a request when directed by the NPDA command processor. NPDA automatically initiates this sequence

Figure 4 Centralized operator control and problem determination



whenever an NCCF operator requests, via network name, to view the problem determination data for a specific SNA physical unit. This request may be issued from any terminal connected to NCCF.

The System Services Control Point transforms the network name, supplied on the request, to a network address for message routing. This allows the NPDA operator to deal with network names as the TCAM and/or VTAM network operator and terminal operators do, rather than network addresses.

After the request for maintenance statistics is processed by the SNA physical unit, the maintenance data is returned in a record formatted maintenance statistics request. This maintenance data record is sent to the System Services Control Point to be delivered via the communications network management interface to NCCF. NCCF then schedules the NPDA command processor to process the maintenance record data for storage on a VSAM file for current or future NCCF operator display.

The maintenance data item is placed on the VSAM file utilizing network names as an index. The network name is appended to the maintenance record by the System Services Control Point before it is delivered to NCCF. Also appended to the maintenance record is the network name hierarchy to which the node is connected. The hierarchy consists of the network names of the node issuing

the maintenance record up to and including its controlling communications controller operating with NCP/VS. For instance, if a maintenance record was being processed for a terminal attached to a communications controller, then the network name hierarchy would include the terminal, the link name attaching the terminal to the communications controller, and the communications controller. By providing this network name hierarchy, the user does not have to provide NPDA with configuration information to build its file structure.

NPDA will display this maintenance data to the requesting NCCF operator. The physical location of the NCCF operator has no bearing on this data retrieval or display capability. For instance, the terminal T1 (in Figure 4) can obtain problem determination data from SNA network nodes named as communications controllers NCP1 or NCP2 or controller CC2 (an IBM 3276), or other devices that support the communications network management requests.

These new maintenance records provide statistical data on either the enhanced SDLC data link test results, summary product error data (e.g., number of communication checks, etc.) or the communication adapter error counts. It is also possible to obtain the release level data of a physical unit.

The statistical data described above is obtained from specific physical units. This support has been extended in NPDA Release 2[20] to obtain statistical test results from the IBM microprocessor-based modems[21,22] either automatically upon the communications controller detection of a permanent station or link error or via NCCF operator-initiated request. A test request can be initiated by the NCCF operator to a specific communications controller to test a specific set of modems (local/remote pair) as portrayed in Figure 5. There are two test requests. One request queries the local modem status, the remote modem status, and modem self-test results. The other request obtains the status of the interface between a remote modem and the attached station. The results of this status test request are displayed upon receipt by NPDA to the NCCF operator requesting the status.

There is another maintenance statistics record, which flows across the communications network management interface for processing by NPDA. This record is generated by the communications controller and also recorded on the "hardware error recording files" for both OS/VS (LOGREC) and DOS/VS (SYSREC) as a miscellaneous data record (Figure 6).

The data from the maintenance requests received via the communications network management interface provide NPDA with problem determination data for the communications controller-at-

Figure 5 IBM microprocessor-based modem pair

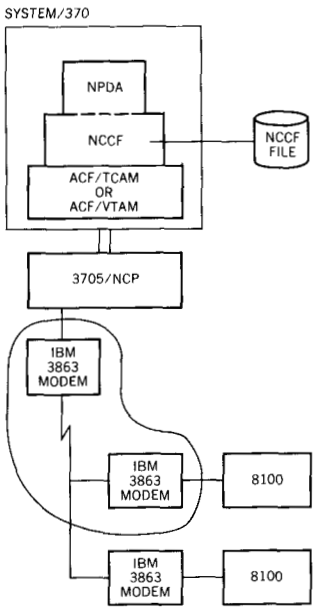
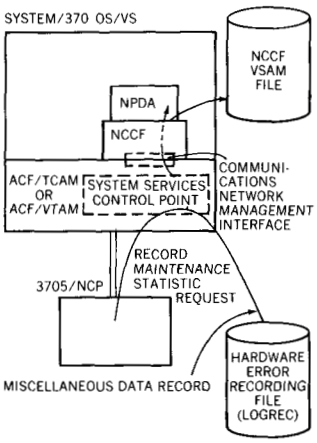


Figure 6 IBM 3705/NCP maintenance data



tached BSC 3270, communications controller (3704-3705/NCP) error data, lines attached to the controller (SDLC, BSC, S/S), IBM microprocessor-based modems (3863, 3864, and 3865), and SNA terminals/controllers attached to a communications controller. The problem determination data is summarized and displayed in a hierarchical manner that is intended to lead a centralized communications network management operator through a logical sequence for network problem detection and isolation.

problem determination methods

NPDA provides the operator with a prompting mechanism to help the NCCF operator locate a failing network component. The NCCF operator can approach problem determination either by specifically requesting data about a named node or by viewing a hierarchical summarization of data about the network nodes attached to a communications controller and then proceeding through increasing levels of detail in search of the specific component causing the problem. Using the first method, the NCCF operator can ask NPDA to collect problem determination data from a specific SNA terminal or controller via its physical unit symbolic network name. This data may or may not be sufficient to determine whether the error occurred in the named node itself or in the route to that node.

To the end user at the terminal a failure appears as a loss of connection to the application. To the NCCF operator the same event could have appeared as a failure of the communications line (i.e., broken cable), a modem (local or remote), a communications controller, a channel, a host application or access method, a terminal, or possibly even an end user (incorrect input). Displaying the node error data for the user's terminal may not be sufficient to locate the component causing the failure.

The NCCF terminal operator may have to view other problem determination data, use operator control functions to display communication node status, or start other specific network tests (line traces, etc.) to locate the failing component. The capability to initiate further tests to locate the error is made possible by the integrated approach to communications network management.

The NCCF operator can also use a second method of problem determination via NPDA. The NCCF operator could begin the search for the cause of the error at the communications controller, then trace through the remaining network components until the problem area has been identified. The hierarchical display can begin at the communications controller, then go to a line, and then to a specific station. This hierarchical method can be used by the NCCF operator whether the operator is attempting to detect a specific error cause or merely scanning the entire network to detect

Table 1 Error display hierarchy

Device	*Screen function*	*Screen contents*
Communications controller + lines	Total error summary	For each network element Date/time Permanent/temporary error counts Traffic count Secondary indicator
Line + stations	Total error summary	For each network element Date/time Permanent/temporary error counts Traffic count
Communications controller, line, station	Most recent errors	A line per error-event with: Date/time Operation at failure* Probable cause* Brief error description
Communications controller, line, station	Selected event	For each selected error event: Date/time Detail operation description Detail error description Probable cause Hexadecimal display of error event

*Probable cause replaces operation at failure for line and station most recent error screens in NPDA Release 2.

possible problem areas before they can degrade the performance of the network. This is done by viewing the traffic and temporary error data.

The screen display hierarchy with the screen contents is presented in Table 1. (Table 1 relates to the NCP mode of operation and not problem determination for locally attached host devices.)

As can be seen from the table, the centralized NCCF operator can display the communications controller plus all its attached lines to get a summary of the total number of permanent errors, temporary errors, and traffic counts.

In addition to the hierarchy that is provided for error analysis, new capabilities have been included in NPDA Release 2 to provide link statistical data for IBM's microprocessor-based modems, other IBM modems (nonmicroprocessor based), or non-IBM modems. The display of this data is initiated within the normal hierarchy, as defined for error information, at the level equivalent to the most recent errors. The data items contained on the most recent statistical data screen are illustrated in Table 2.

Figure 7 Sample configuration

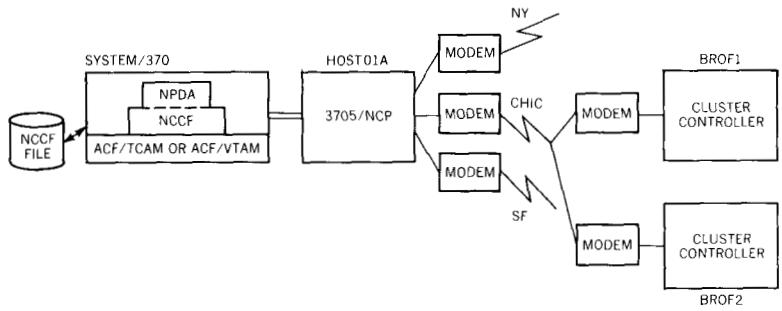


Table 2 Statistical data

		Most recent statistical record
Line by station (BSC, SDLC)	IBM micro-processor modems	A line per error event with: Date/time Traffic count Error alert percent Data rate Local modem status Remote modem status Switched network backup indicator
Line by station (BSC, SDLC, Start-Stop)	IBM nonmicro-processor modems Non-IBM modems	A line per error event with: Date/time Traffic count Error alert percent Traffic error count

For the network configuration illustrated in Figure 7, a sample NPDA display screen is shown in Figure 8. From this screen the NCCF operator can proceed to display a specific line with all its associated stations. The NCCF operator may select the next hierarchy level to be displayed by selecting the line with the most errors per traffic rate over the shortest time period. For instance, from Figure 8 it can be seen that the next component to display is the SDLC line named CHIC. By using the NPDA prompting services, the NCCF operator can select the next level of the hierarchy to the next component that has the highest incidence of errors.

The last screen in the hierarchy is the selected event screen, an example of which is shown in Figure 9. This display contains the representation of a single error event as recorded by NPDA. The screen contains a date/time stamp, a detailed explanation of the

Figure 8 Sample display of total summary errors for 370X/NCP and primary end of attached lines

```
NETWORK COMMUNICATIONS CONTROL FACILITY                          5/17/79 14:30:22
NPDA 370X ALL                    *TOTAL ERRORS*                      NCP MODE
      FOR 370X/NCPS AND PRIMARY END OF ATTACHED LINES

SEL-#
(1) NCP NAME: HOST01A      ERRORS: 05      FROM: 5/17 08:30 TO: 5/17 14:30
  LINENAME      TRAFFIC   PERM-ERRS   TEMP-ERRS      FROM            TO          SEC
(2) NY          034780        2           10       5/15 08:00    5/17 13:30
(3) CHIC        058300       10           40       5/15 12:00    5/17 14:10     Y
(4) SF             400        1            2       5/15 23:00    5/16 13:00

                              — END OF DATA —

TO VIEW ERRORS FROM SECONDARY END OF LINE, ENTER S AFTER SEL-#
ENTER SEL-# OR COMMAND:
```

Figure 9 Sample display of selected event

```
NETWORK COMMUNICATIONS CONTROL FACILITY      5/17/79      14:30:25
NPDA-DETAIL                  *DETAIL OF SELECTED EVENT*          NCP MODE
                                FOR THE SDLC STATION

NCPNAME: HOST01A      LINENAME: CHIC          STATIONNAME: BROF1
DATE/TIME: 5/17 14:10
OPERATION: RUN INITIATES NORMAL SEND/RECEIVE OPERATION ON THE SDLC LINK.
           SDLC I-FORMAT SENT OR SDLC RR SENT.

ERROR DESCRIPTION
PROBABLE CAUSE     COMMUNICATIONS FAILURE
                   FRAME CHECK SEQUENCE ERROR (DATA CHECK)

     0   2   3   4    6   7   8   9    11  12   14  15   17  18   20  21  22
002D 0024 03  05  0006 00  00  30  0000 00  1200 00  1200 00  0021 07  00  0000
     24  25  26  27  28  29  30    32  33  34
     02  00  00  00  02  02  001E  00  02  00
ENTER TO RETURN TO PREVIOUS DISPLAY
ENTER COMMAND:
```

error, the operation description, a hexadecimal display of the error record, and most importantly, the probable cause of the failure.

For this example, the operator is informed that the error occurred while the communications controller was receiving data from station BROF1. The error itself was a data check identified as a "frame check sequence error (data check)." The probable cause for the failure was defined as a communications failure. This means that based on this error event, the failure was most likely to have occurred between the communications controller and the secondary station, possibly within the local modem, the communication medium, or the remote modem. For this particular error, the probable cause can only isolate the problem area to a set of communications components.

If the IBM microprocessor-based modems were used for this link, the probable cause could isolate the error to the local modem, modem interfaces, remote modem, or communication medium. (See Figure 12.)

probable cause

The probable cause definition identifies the most likely network component or group of components that caused a failure. The probable cause is derived from network error data and relieves the user of analyzing the error data, at the bit level, to isolate the error-causing component(s). The probable cause definition should be used as a starting point to perform further tests when it does not specifically identify the failing network component. Three examples of the probable cause definitions are depicted in Figures 10, 11, and 12. From Figure 10 some failures can be isolated to specific nodes (i.e., communications controller hardware or software failures, secondary station failures, etc.), whereas other failures can be isolated only to groups of components (i.e., communications failures). In either case, the integrated communications network management approach makes it possible to resolve the problem further by utilizing the operator control interface to start additional tests. For instance, if the probable cause is a communication failure (for lines which are not connected with the IBM microprocessor modems), the failure may be further isolated (perhaps to a failure in the communication adapter of the secondary node) by issuing the enhanced SDLC link test to either TCAM or VTAM operator control.

The enhanced SDLC data link test can be issued by the same centralized NCCF operator who noted the probable cause. The physical unit symbolic network name appearing on the NPDA screen would be used to initiate the enhanced SDLC data link test command. After the NCCF operator issues this test command and receives the results, the same NCCF operator may resume viewing of the NPDA screen at the same location in hierarchical display sequence.

The definitions of probable causes are portrayed in three diagrams. The first diagram (Figure 10) depicts probable causes as derived from error data received from a communications controller.

The second diagram (Figure 11) depicts probable causes as derived from error data received from a secondary station (in this example an SNA terminal/controller). These probable cause definitions are derived from the record formatted maintenance statistics request received from supporting SNA terminals/controllers. Note that when a secondary station error is analyzed, no distinction can be made for probable cause between a communications controller and a host system. The terminal/controller only notices an error occurring "up the line." But if the NCCF operator cor-

Figure 10 Probable cause for communications controller detected failures

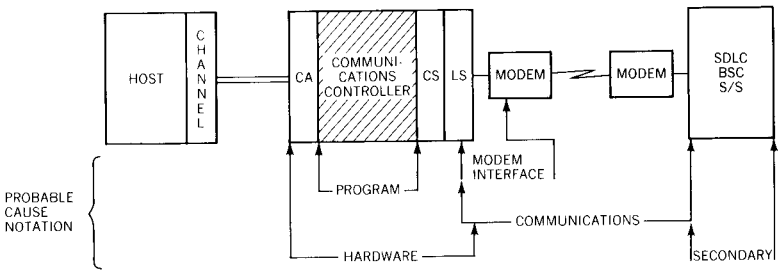


Figure 11 Probable cause for SDLC secondary station detected failures

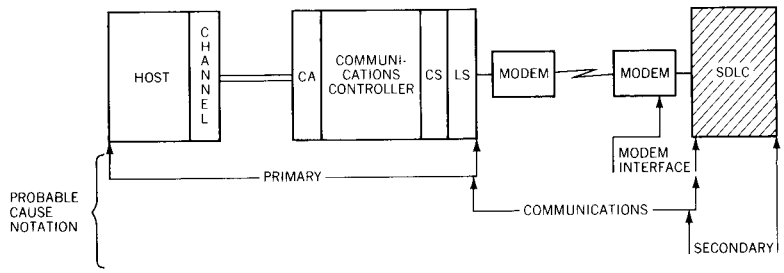
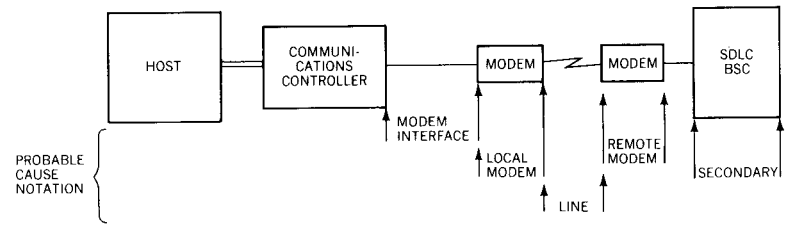


Figure 12 Probable cause for IBM microprocessor-based modems



relates the probable causes defined from the secondary station and the communications controller, then the NCCF operator can often determine where the error actually occurred.

The third diagram (Figure 12) depicts the probable cause as derived from usage of the IBM microprocessor-based modems. These new probable cause definitions, available in NPDA Release

2, make it possible to further isolate error conditions to within the link subsystem. This probable cause provides further isolation to either the local modem interface, the local modem, the line (communication medium), the remote modem, or the secondary station. Without the information provided by these IBM microprocessor-based modems, the probable cause can only isolate the potential error to the modem interface or to a communication failure.

NPDA also provides probable cause definitions that are derived from error data received from network and locally attached products.

monitoring traffic errors

A function included in NPDA Release 2 allows the authorized NCCF network operator to receive advanced warning when a communications controller line connecting a specific station exceeds an error threshold rate on the line. The operator will be alerted if the ratio between the traffic and temporary station errors exceeds operational norms (specified by the user) on a line basis.

As already stated, the NCCF operator can utilize the TCAM and/or VTAM operator control commands (access method syntax dependent) to further investigate a probable cause definition. This capability of issuing operator control commands is an important facility which NCCF provides for all communications network management applications. Various NCCF command processors (communications network management applications or operator control) can be initiated from the same display unit. This allows an NCCF operator to correlate many different data items and react accordingly. For instance, when an NCCF operator determines from the NPDA display screen that a specific cluster controller has been experiencing a large number of temporary errors, the operator can vary that named controller off line so that the repair action can be started. By taking this action, the operator may avoid performance degradation for other cluster controllers attached to the same line.

NPDA on the NCCF base

The implementation of NPDA on the NCCF base is important for two major reasons. As already mentioned, by allowing NPDA to reside on NCCF, the NCCF operator can initiate NPDA requests from the same centralized display console being used for operational control of the network. This allows a single view of all network activity and all problem determination data (provided by NPDA) from a single display unit.

Also, by using NCCF as a base facility, the operator needs to be connected only to NCCF to use the access method operator con-

trol interfaces as well as issue other command processor (i.e., NPDA) requests. The NCCF operator need only be authorized once, via user identification and password, to issue NCCF commands. A separate connection (session) to each command processor is not required.

Another reason for using NCCF as a base facility deals with the current and future capability of correlating logical information with the physical network configuration.

A few words should be said about the logical and physical network as viewed by NCCF/NPDA. In the SNA environment, the NCCF/NPDA operator deals with the logical network via network names. The NCCF operator utilizes the network names for both the operational control and problem determination functions. These network names are converted to assigned network addresses by the System Services Control Point in the access methods for routing purposes within the physical network. The network configuration data used to correlate the logical network to the physical network is not contained within the NCCF/NPDA program products. The user can provide the NCCF operator with access to this information to allow this correlation to occur. Although NCCF/NPDA does not provide this correlation, it does provide a beginning for the correlation process. As previously discussed, the System Services Control Point places hierarchical configuration data on the maintenance error record returned to NCCF. The following discussion provides a description of how the logical-to-physical correlation can be utilized for the SNA environment.

In an SNA system, a terminal operator issues a "LOGON" request to an SNA logical unit (e.g., an application program) by using a specific name. The terminal operator is unaware of the physical location of the application program. The operator is only interested in being able to logically connect to (go into session with) the application program to use its processing capabilities. The operator is also not concerned with the physical route to which the data exchange is assigned as long as the message exchange rate is reasonable. The operator only becomes concerned with the physical network if (a) the connection to the application program cannot be made, (b) the connection between the terminal and the application program fails, or (c) the response time degrades.

For all three of these situations, there is a need to have an understanding, at the network operator level, of the logical-to-physical correlation so that appropriate actions can be accomplished to provide service to the terminal user. For instance, if the terminal cannot "LOGON" to the application program (case a), the terminal user may want to know why the "computer doesn't work." Normally the network operator will be called. The network operator could query either TCAM or VTAM using the NCCF operator

control interface as to the status of the application program. The problem could be that the application program has not been activated, but it may be more complex.

The application program may be in another domain (residing on another host system in the network). The reason that the application program cannot be accessed could involve hardware failures in the route to the other host domain. If the NCCF operator has an understanding of the physical route needed for the connection of the two logical entities (the terminal and the application program), then the operator can use a mixture of operator control status request and NPDA screens to understand where in the route a failure occurred and what type of failure it was. This can be done, at times, with today's understanding of all the physical connectivity of the network and the locations of all the application programs and terminals.

For the case of the failure of the session between the user at the terminal and the application program, the error location may be detectable, again, only at times. For instance, if the NCCF operator understood the physical route on which the session was assigned and a link within that route failed, then the operator could possibly correlate an access method operator message notification of a "link failure" with the session failure. This illustrates a simple case for error detection. In a large network connecting multiple TCAM and VTAM domains, this correlation process usually becomes more difficult.

First, the operator may not know where the various terminals and application programs reside in the network. Second, the failure may not be as obvious as a link failure. It may be a software error in the application program; these are not recorded by either NPDA or NCCF. Third, the network may contain the multiple route[23,24] capability, announced in June 1979, which makes it difficult for the operator to understand to which physical route a session is assigned.

For the case of response time degradation, more effort is required by the network operator to determine why the degradation has occurred. For this problem, considerably more correlation between the logical and physical network is required. In a small system with only one communications controller and a few lines, the operator could scan the communications controller and lines display (via NPDA screens) to see whether the line on which the user terminal is connected has had a large number of temporary errors causing multiple retry operations. In a large network, with multiple routes connecting multiple nodes, without more correlation information the network operator would not know where to begin searching for the network components causing the degraded performance.

From the three cases mentioned, it is apparent that correlation between the logical network (sessions) and the physical network is essential for problem determination. For this correlation, a mechanism is needed to centrally obtain and process various data elements relating to the same network components. NCCF and NPDA provide a beginning for this process.

Summary

The complexity of current and planned teleprocessing networks has made the job of managing them more critical. Communications network management can no longer be done randomly. The integrated approach to communications network management allows a centralized operator on NCCF to control and obtain problem determination data by utilizing resources of the network itself. This approach has been implemented with two new program products.

The Network Communications Control Facility provides the centralized network operator support, the communications network management interface support, and program environment services which allow communications network management applications to be created.

The Network Problem Determination Application is an IBM communications network management application that utilizes the NCCF services to obtain problem determination data on a network-wide basis for display at a centralized NCCF operator display screen.

These two program products provide a beginning to the correlation process for the SNA logical network entities to the physical network for error detection and isolation. This correlation is essential, and in the future, as more communications network management applications are written, it will become the driving factor in providing the user with the ability to perform effective communications network management.

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