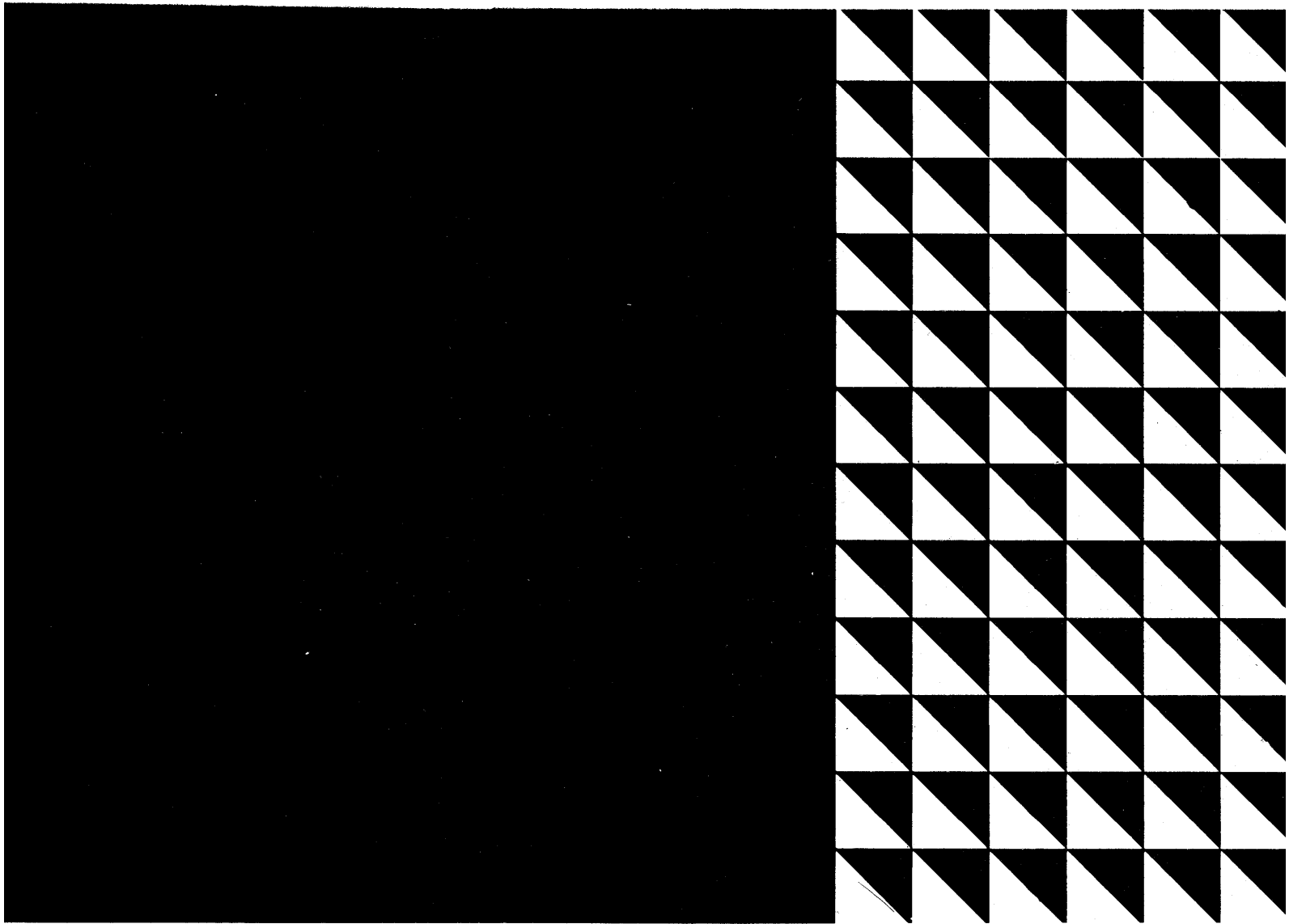


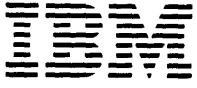


**Concepts of  
IBM 3704 and 3705  
Communications  
Controllers**



**Student Text**





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IBM 3704 and 3705  
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## **Preface**

This publication is a text on the concepts of the IBM 3704 and 3705 Communications Controllers. The material is at an introductory level on the hardware, emulation program, and network control program.

At the end of each major section is a quiz. The answers to the quiz are in Appendix A.

If additional information on a given area is required, additional reference material is identified following each section.

# Contents

Preface . . . . .	i
IBM 3704 and 3705 Communications Controller Hardware Introduction . . . . .	1
Introduction . . . . .	1
Data Flow in a Communications Controller . . . . .	1
Network Configuration with the Communications Controllers . . . . .	2
Program Support For The Controllers . . . . .	4
A Compatible Family . . . . .	5
Advantages of the IBM Communications Controllers . . . . .	5
Communications Controller Hardware Concepts . . . . .	13
IBM 3704 and 3705 Hardware Review . . . . .	23
IBM 3704 and 3705 Hardware Quiz . . . . .	23
Emulation Programming . . . . .	25
Introduction . . . . .	25
Defining the Emulation Program . . . . .	26
Generating the Emulation Program . . . . .	26
Communications Controller Utilities . . . . .	27
Emulation Review . . . . .	28
Emulation Quiz . . . . .	28
Network Control Program Introduction . . . . .	31
Introduction . . . . .	31
Communication Between Controller and Host Processor . . . . .	32
Achieving a Network Control Program . . . . .	36
Obtaining the Contents of Controller Storage . . . . .	37
Network Control Program Review . . . . .	37
Network Control Program Quiz . . . . .	38
Appendix A . . . . .	41
IBM 3704 and 3705 Hardware Quiz . . . . .	41
Emulation Programming Quiz . . . . .	41
Network Control Program Quiz . . . . .	41
Glossary . . . . .	43
Abbreviations . . . . .	43
Index . . . . .	47

# IBM 3704 and 3705 Communications Controller Hardware Introduction

## Introduction

Telecommunication is a growing part of the data processing industry, and telecommunication operations must be flexible to accommodate the increased diversity of products, communications facilities, transmission control units, and other equipment. Furthermore, the extremely time-dependent telecommunication functions put great demands on all the resources of the data processing system. These demands increase as the telecommunication subsystem grows.

The IBM 3704 and 3705 Communications Controllers are compatible, programmed, transmission control units designed to assume many of the line-control and processing functions for the telecommunication subsystem. In many installations, primary control of the communication network is concentrated in the central processing unit (CPU), with a telecommunication access method controlling the flow of data to and from the stations in the network. Sending and receiving data over the communications lines is a function of the transmission control unit, operating in response to commands from the access method. In addition to performing the usual functions of transmission control units, the communications controllers take over many of the functions of an access method. In this way, the controllers remove much of the control of the telecommunication subsystem from the CPU.

## Data Flow in a Communications Controller

The flow of data between the host system and the terminal should be transparent to the user. The purpose of the communications controller hardware and program support is to provide a path for data flow between the host and terminal. The program which emulates earlier data adapters or transmission control units requires the user to provide code definition, translations, connections for switched networks, polling and addressing characters, etc. Any change to the network usually requires a new generation of the host system to reflect the network change.

The network control program allows the host to communicate with any terminal in EBCDIC, without having to consider special line-control disciplines, terminal codes, polling and addressing characters, error recovery, etc. Any changes to the network should be made directly to the network control program, so that a new generation of the host operating system is not needed. While line-control disciplines, terminal codes, etc. are now transparent at the host and terminal, these elements must be provided in hardware and network control program generation specifications.

Data flow of the emulation program requires a connection to a host subchannel for each line. All of the support to establish that connection, transmit or receive the data, and end the communication must be provided by the host programmer - all in the terminal code. The host program sends the appropriate data to a specific subchannel address. The emulation program receives the data for that subchannel and by emulation program definition, sends the unchanged data to a specific line interface on a communications scanner. If the host sent a read request, when the data is received from a specific line interface it is directed by the emulation program to the host over that same

subchannel. In emulation support, the host programmer assumes responsibility for the network connection, data transmission, error recovery, etc., and changes to the network usually require changes in the host generation and/or application programs.

Data flow in network control program mode is also initiated by the host. All communications are sent from the host over a single channel address, regardless of destination. All communications are in EBCDIC, without any requirement for the host to be aware of line type or device codes.

Each transmission is sent to the communications controller with a prefix identifying the destination as a binary number. The network control program receives this data, identifies the destination by the binary number, and schedules the data to be transmitted to the appropriate terminal. Translation, device codes, line scheduling, error retries and recovery are all handled by the network control program. The data is transmitted to the terminal and a response is sent to the host, if a response was requested. The network control program can receive data from a terminal without a host application request and send the data to the host; such data might be a request from the terminal to communicate with a specific host program. (In previous telecommunication networks the host program had to initiate connections with a terminal.)

Data still must flow from the host channel, but it does so on a single channel, is buffered in the communications controller (not the host), and is scheduled for transmission over an appropriate line with required polling or addressing characters in the required line code. If an error occurs during transmission, the 3704/3705 attempts error recovery without host intervention. A response from a terminal is converted (if required) into EBCDIC and sent to the host with the identifying prefix over the single channel address.

This 'transparent' connection between the host and the terminal must be defined and maintained. The 'transparent' connection should allow for changes that may be made to the network (such as adding or deleting lines and/or terminals) without requiring a new generation of the host system or host applications.

### **Network Configuration with the Communications Controllers**

The 3704 and 3705 controllers, though dissimilar in appearance, serve precisely the same purpose in a telecommunication network. The control programs provide identical capabilities. The essential difference between the two controllers is the size of the networks they can accommodate. Figure 1.1 summarizes the differences between the controllers in number of communication lines, maximum line speeds, and available storage capacity. As used throughout this publication the term communication line (or simply line) refers to the path over which information is transmitted from one point in a telecommunication network to another. The path may be any communication facility of the communications common carrier, such as wire, radio, or satellite; or it may be a combination of facilities. SDLC lines are commonly called 'links', and the term link may also be used for a communication facility.



	3704	3705
Maximum number of lines for half-duplex operation	32	352
Maximum line speed (bits per second)	50,000	56,000
Number of communication scanner types available	2	3
Maximum number of communication scanners installable	1	4
Number of channel adapter types available	1	4
Maximum number of channel adapters installable	1	2
Range of storage capacity (bytes)	16K-64K	16K-256K
Size of storage increments	16K	32K

Figure 1.1 Summary of Differences between 3704 and 3705 Controllers

The control program in the 3704 or 3705 communicates with a telecommunication access method in the CPU to which the controller is connected. This CPU is called the host processor.

A controller may be attached directly to a host processor channel via a channel adapter or may be located many miles distant from the host processor. When all stations are directly connected with a controller attached to the host processor channel the controller is called a 'local' controller. If a local controller has a link attachment to a separate controller which is initially program loaded (IPL) from the local controller, the link attached controller is called a 'remote' controller. Using remote controllers in a telecommunication network allows the controller to be placed nearer the stations it serves, thus reducing the aggregate length of the communication lines. This reduction in line mileage can significantly lessen line charges - a major portion of network cost - even though two controllers and a relatively expensive communication line between them are required.

A remote controller must be linked to a local controller by a duplex or half-duplex communication line. This line, called the 'local/remote communication link', carries all the message traffic exchanged between the local controller and stations connected to the remote controller. (In this publication, the term 'duplex communication link' means a link having two independent data paths over which data can be transmitted simultaneously in both directions; a half-duplex communication link is one having a single data path over which data can be transmitted in either direction, but not simultaneously. A duplex communication link may operate in half-duplex mode.)

Only one communication link may exist between a local and a remote controller. However, if this link fails, the controllers may be connected via the switched communications network (with half-duplex data transfer), provided the controllers have the required hardware and program options.

In the discussion of a local/remote link, we considered only a single local and single remote controller. However, multiple remote controllers may be

connected to the same local controller, each by a separate local/remote communications link. (A remote controller cannot be connected to more than one local controller.)

Two local controllers may be connected by a communications link. Each local controller is channel attached to a host. Communications between 'domains' (host and owned local controllers) occurs over the link between the two local controllers.

The 3705 is designed for either (1) attachment to an IBM System/370 selector, byte-multiplexor, or block-multiplexor channel; (2) communication over a duplex or half-duplex local/remote communication link with a local, channel-attached 3704 or 3705; (3) communication over a duplex or half-duplex local/local communication link to a second domain. The 3704 can be attached to a byte-multiplexor channel or attached as a remote controller.

### Program Support For The Controllers

**Network Control Program** Much of the increased capability of the controllers is provided by the network control program (NCP), which is executed in the controller. The network control program provides the flexibility necessary to meet increasing telecommunication demands; at the same time it relieves the CPU of much of the telecommunication responsibility.

Support of one to four channels in NCP mode and local/local links for cross domain communication is available in the Advanced Communication Function (ACF) NCP.

Information on SDLC is in the publication *IBM Synchronous Data Link Control General Information*. (GA27-3093). SDLC link control is not covered in this material as a line-control discipline.

**Emulation Program** IBM provides an emulation program (EP) to run in controllers attached to a host processor channel. This program emulates the functional operation of the IBM 2701 Data Adapter Unit, the IBM 2702 Transmission Control, and the IBM 2703 Transmission Control, and allows many programs written for operation on the 2701, 2702, and 2703 to operate through the controllers without modification.

The emulation program communicates with access methods running in a System/360 or System/370. Two host CPU's can be attached to a single 3705 with two type 4 channel adapters for concurrent emulation support; a given line is under the control of the first host which enables the line interface.

A feature of the network control program, called the partitioned emulation programming (PEP) extension, allows the program to operate some communication lines in network control program mode while operating others in emulation mode. Lines can be defined for both NCP and EP, and switched from one mode to the other by host operator control. An NCP with PEP can be executed only in a local controller. The program communicates with one or more telecommunication access methods in the System/370 host processor. The emulation portion of PEP can be under the control of one or two

CPU's, and emulation can be on one CPU with NCP mode controlled by a second host.

**System Support Programs** In addition to the network control and emulation programs, IBM provides system support programs. These programs, which are executed in a central processing unit, generate control programs, load them into controller storage, and dump controller storage.

*The IBM 3704 and 3705 Control Program Generation and Utilities Guide and Reference Manual (GC30-3008)* provides information on defining network control programs and emulation programs and on using the support programs.

## **A Compatible Family**

The various models of the 3704 and 3705 make up a compatible family of communications controllers that provides a telecommunication entry for every type of installation, from the completely new user to the large user with an existing network. The controllers offer an easy path for conversion from existing systems and for continuing telecommunication growth.

The 3704 is designed primarily for new telecommunication installations and small installations that presently have a few lines attached through IBM 2701, IBM 2702 or equivalent control units. The emulation program simplifies the transition from the 2701 and 2702 to the 3704. The 3704 can support small networks of SDLC devices.

The 3705 is designed for telecommunication installations with medium-to-large networks that require one or more IBM 2701, IBM 2702, IBM 2703 or equivalent control units. In addition, the 3705 offers the smaller user a convenient means of increasing the size of his network. The emulation program and the network control program with PEP allow easy conversion from the 2701, 2702, and 2703 to the 3705. The 3705 supports medium-to-large networks of SDLC links, or mixed networks of SDLC and BSC/SS lines in either emulation or network control program mode.

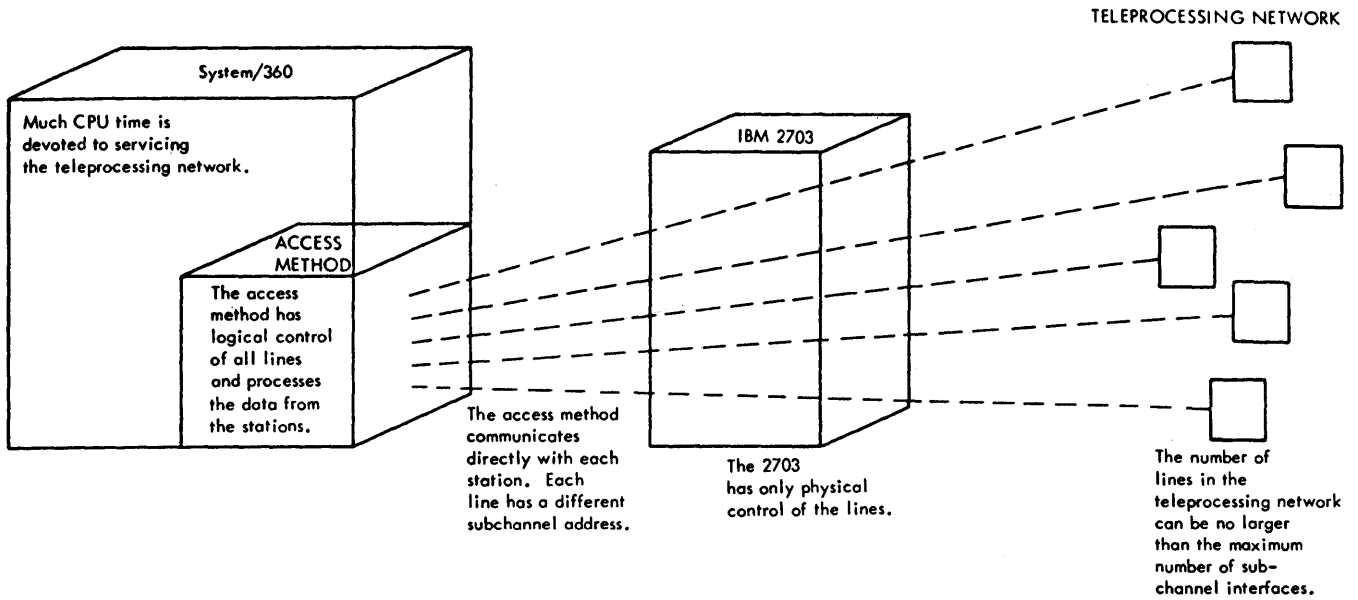
Transition from a 3704 to a 3705 is simplified by the compatibility of the IBM-supplied programming support. A network control program, emulation program, or partitioned emulation program for either the 3704 or the 3705 can be generated from the same library; the same macro language is used. A control program generated for the 3704 can be executed by a 3705 with the same configuration of communication lines and adapter hardware, provided the amount of storage installed is adequate. Conversely, a program generated for the 3705 can be executed by a 3704 if both are equipped with the same types of scanners and channel adapters, and both have sufficient storage. The support programs for the network control and emulation programs are identical for the 3704 and the 3705. Likewise, an access method that communicates with the 3704 will communicate with an identically configured 3705.

## **Advantages of the IBM Communications Controllers**

The IBM 3704 and 3705 Communications Controllers have most of the capabilities and features of the IBM 2701 Data Adapter Unit, the IBM 2702 Transmission Control, and the IBM 2703 Transmission Control. With the additional capabilities provided by the network control program and new features in the design of the hardware, the controllers offer many advantages over these transmission control units.

In the following discussions, the largest of the transmission control units mentioned above (the IBM 2703) is used for comparison to the 3705. Figure 1.2 illustrates some of the advantages that the 3705 with the network control program has over the 2703. These advantages prevail whether the 3705 is a local or a remote controller. The 3704 with the network control program has equivalent advantages.

**A TELEPROCESSING SUBSYSTEM WITH AN IBM 2703**



**A TELEPROCESSING SUBSYSTEM WITH AN IBM 3705**

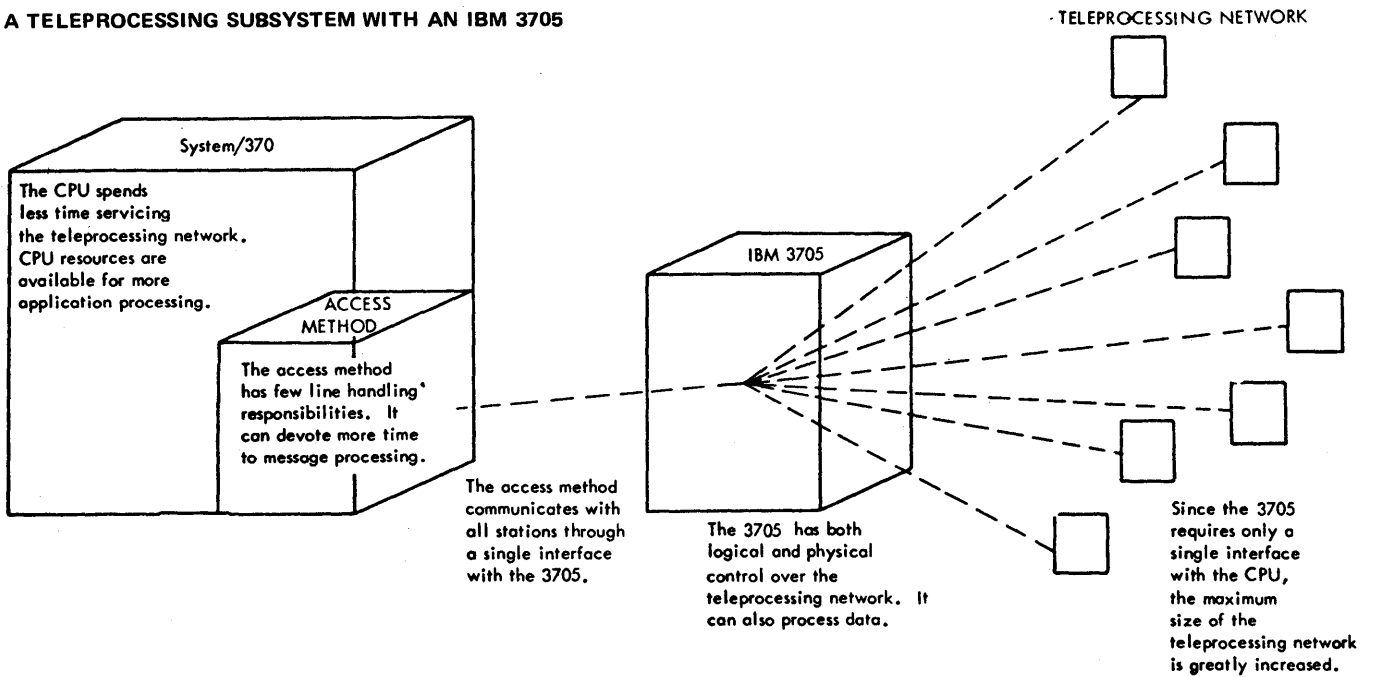


Figure 1.2 Advantages of the IBM 3705 over the IBM 2703

**Flexible Configurations** Flexibility is one of the principal advantages of the 3704 and 3705 controllers. Both the hardware and the network control program are designed to allow a high degree of flexibility in configuring the telecommunication subsystem to meet the particular requirements of most installations.

The 3704 and 3705 can communicate with many types of telecommunication stations using both synchronous and asynchronous line-control disciplines, at line speeds from 45.5 bps to 56,000 bps. The network control program recognizes and translates a variety of transmission codes, including USASCII, EBCDIC, EBCD, BCD, and correspondence code.

A maximum of 32 communication lines for half-duplex operation can be attached to the 3704. A maximum of 352 lines for half-duplex operation can be attached to the largest model of the 3705 (twice as many as for the 2703). These limits include any local/remote or local/local communication links. Each duplex communication link decreases by two, and each half-duplex communication link decreases by one, the number of communication lines available for communicating with stations in the network. The actual number of communication lines that the controllers can support depends upon performance factors and the combination of features chosen.

In addition, the line-attachment hardware provided for the controllers allows many different types of communication lines to be attached through a single line scanner. Lines are available in pairs (and in some cases, singly) rather than in groups of four or eight, as in the 2703. This characteristic allows considerable latitude in the number of line types that can be attached to the controllers. This ability to purchase only the minimum hardware is especially advantageous when an installation requires a few lines of several different types. In many cases, such a network requires only a minimum of line-attachment hardware.

The 3704 and 3705 are connected to a host system channel by a 3704 or 3705 channel adapter. The hardware component in the 3704 and 3705 which interfaces to the lines is called a 'communication scanner'. The 3705 hardware offers additional flexibility in the choice of channel adapters and communication scanners. Depending upon the anticipated throughput and type of system attachment desired, you can choose between four types of channel adapters and three types of communication scanners. Two types of scanners and three types of channel adapters offer high throughput and performance capabilities. The other type of each, which are less expensive but can handle less throughput, are suitable for use with smaller networks. The 3704 is available with the low- and medium-speed scanners of the 3705 and it offers only the low-throughput channel adapter.

Further contributing to the flexibility of the 3704 and 3705 controllers is the network control program, which you can easily adapt to the requirements of your telecommunication installation. The standard functions of the network control program include a wide range of facilities to control the telecommunication subsystem. In addition, a number of optional functions can be performed by the network control program or by the access method or, in some cases, can be omitted entirely.

A high-level macro language is available to describe a network control program tailored to the requirements of your installation. This language gives you control over many of the operating characteristics of the telecommunication subsystem. Some characteristics are controlled by specifying particular values for certain network control program parameters or specific functions to be included in (or excluded from) the program. Other characteristics are controlled indirectly, depending on the network and the options you specify.

Since the scanning mechanism is program-controlled, the controller's scanning hardware need not be rewired for every change in network configuration. When new communication lines are added to the network, the network control program is regenerated to include the new lines and any modifications to the scanning scheme are made automatically.

This characteristic also permits the generation of several different network control programs to handle different subsets of communication lines, all attached to the same controller. The program currently resident in the controller determines which lines are scanned and in which order, depending upon the parameters specified when that program was generated.

Flexibility in the network control program is increased by the ability to change certain network characteristics dynamically -that is, during execution of the program. The access method can issue special commands to the program to make changes such as activating and deactivating communication lines. This flexibility allows you to modify the telecommunication subsystem as the demands of the network change.

A principal advantage of a network control program with the partitioned emulation programming (PEP) extension is the ability it offers to operate the same communication line alternately in network control mode and emulation mode. Changes from one mode to the other are made during program execution by command from the access method. Alternate operation requires that the stations connected to the line be supported in both network control mode and emulation mode. In addition, during program generation you must specify the line is to be operable in either mode.

Much of the flexibility of the controllers comes from the modular design of the hardware and the network control program. Such modularity allows the controllers to grow easily to meet the needs of an expanding telecommunication subsystem.

Both the 3704 and 3705 offer storage in increments that can be ordered according to the needs of the particular installation. Both models also offer a wide range of choices in line-attachment hardware.

The controller is available in different models that allow easy expansion of the telecommunication network. The various models of the 3705 also offer options in the number of channel adapters and communication scanners you can order, in addition to the amount of storage and line-attachment hardware.

Furthermore, the network control program is designed in modules that the user may select according to the requirements of the network. Since no telecommunication subsystem requires all the facilities of the network control program, you can specify through the program generation language just those facilities that your particular installation needs.

**Availability** Many characteristics of the controller hardware and the network control program work together to ensure high availability of the controller to perform its normal telecommunication functions.

For example, the network control program provides error recovery procedures (ERP's) that can recover from many intermittent hardware or transmission errors. In most cases, the controller remains available to the rest of the network while the ERPs are being executed.

Some hardware options also increase the availability of the controllers. For example, three types of channel adapters have a two-channel switch that allows the adapter to be attached to two CPU channels at once. If one channel fails, the channel adapter can be switched manually to the second channel. (This feature does not provide for simultaneous operation over both channels.) Installing two type 4 channel adapters on a 3705 allows concurrent emulation operation of the network, with the first host to request a specific line obtaining the line. The second host cannot use the same line until it is released by the first host. Two to four type 4 channel adapters installed on a 3705 allows concurrent network control operation of the network.

An option that further increases availability in the larger models of the 3705 is their ability, when executing a network control program to support up to four channel adapters (type 4 channel adapters), two in EP mode, and one to four in NCP mode.

If the channel adapters have the two-channel switch, the 3705 can be attached to as many as eight CPUs, making availability even higher. However, only four channel paths at a time can be active for network control program mode. The partitioned emulation program operates over two channel adapters concurrently with network control program mode on the same channel adapters or alternate channel adapters.

The type 3 channel adapter allows the 3705 to be attached to both processing units of a tightly coupled multiprocessor through one channel adapter. The controller appears to each processing unit as the same controller and can be accessed alternately by each processing unit in exactly the same manner. This facility allows the access methods for the controller (TCAM, VTAM, etc.) to run in either CPU, with the path from the 3705 being transparent to the access method. This type of channel adapter can also provide an alternate path when attached to a uniprocessor.

The 3704 can have up to 32 attached communication lines, the 3705 up to 352 lines. The first 3705 communications scanner can have a maximum of 64 lines; each additional scanner can have a maximum of 96 lines. If a scanner fails, only those communication lines attached to it are affected. The rest of the network continues to operate as usual.

**Conservation of Host CPU Resources** When executing a network control program, the controllers can take over many functions that were previously performed by the telecommunication access method. In doing so, the controllers free resources in the host processor to handle more local processing jobs. The advantages to the host processor increase as the size of the telecommunication network increases.



Most of the advantages to the host processor come from the transfer of line-control and buffering functions from the access method to the controller. Much of the line-control information previously maintained in control blocks by the access method is now maintained by the network control program. In addition, the controller buffers data as it arrives from the station and sends it to the host processor in blocks. Consequently, the access method can allocate buffers after an entire block has arrived from a station, and buffer space in host main storage is no longer tied up while data is being transmitted over the communication lines. Buffer requirements for the access method are therefore reduced, especially when input from the network is high.

The network control program can also take over some of the processing functions, such as date and time insertion, previously assigned to the access method. Including these functions in the network control program saves the host processor both the time and the main storage required by the processing programs. This support is provided by user-coded block handlers which are only for SS and BSC devices.

An advantage to the entire data processing installation is that a local controller, when executing a network control program, occupies a single control-unit position on the channel and requires only a single subchannel address to communicate with the host processor. (The IBM 2701, 2702, and 2703 require a separate subchannel address on a byte-multiplexor channel for each communication line in the network.) Therefore, if the controller is attached to a multiplexor channel, many subchannel addresses are still available for the attachment of other peripheral equipment and the channel facilities can be better utilized.

Also because of this characteristic, the 3705 with the network control program can be attached to a System/370 selector channel, regardless of the number of communication lines in the network. This capability is advantageous to a telecommunication subsystem with high-speed communication lines and high throughput requirements.

**Reliability** The controllers are designed so that data is transferred between remote stations and the host processor with maximum reliability and efficiency. The controllers have four interrupt levels, performing those functions that are most critical at the highest priority level. Correspondingly, the network control program has five program levels, the first four paralleling the hardware interrupt levels, the fifth performing the functions that are not critically time-dependent.

As an example of the type of priorities established by the interrupt scheme, the first interrupt level (both hardware and program) handles those situations that require immediate attention -hardware and program checks and requests for IPL (initial program load), among others. If these conditions are not resolved immediately, normal operation of the controller is impossible. Therefore, they receive highest priority.

The most critical of the normal telecommunication functions are handled at the second interrupt level. These are the servicing of the communication lines and the handling of data as it arrives and leaves. The controller hardware and the control program interact very closely at this level to prevent loss of data arriving on a line.

The controllers have four groups of eight general registers. One group is associated with each of the three lower program levels, and the fourth is shared by the first two program levels. This feature eliminates much of the overhead involved in saving and restoring register contents when control is being passed from one level to another. Thus, the controllers can devote more time to the network control functions.

Additional overhead can be eliminated in a local 3705 if one of the high-performance channel adapters is installed. These adapters use 'cycle steal' to transfer data. Cycle steal allows the channel adapter to transfer data to or from storage without interfering with the logic of the control program. Program execution is simply suspended for the length of one machine cycle, during which the data is transferred. Thus the overhead involved in regular program interrupts is eliminated. The 3705 can also have a cycle steal scanner which requires program interruption only on a buffer basis.

**Error Recovery and Diagnostic Facilities** The network control program has a number of error recovery procedures and diagnostic facilities to enhance the reliability and serviceability of the controllers.

Some error recovery procedures (ERP's) are executed automatically by the network control program when a transmission error occurs. If these procedures fail to recover from the error, the program can perform other ERP's. In some cases, the program can notify the access method of the error and allow the access method to try to solve the problem.

The network control program also collects statistics on errors that occur for each line and sends these statistics to the host processor when a given count is reached.

Other diagnostic aids are available to the controllers. Online terminal tests can be executed for the stations in the telecommunication network. In addition, a diagnostic 'wrap' facility enables the controller to test the communication line attachment hardware to determine whether problems are in the controller hardware or in the communication lines. The network control program also provides online tests for testing communication lines.

**Communications  
Controller Hardware  
Concepts**

**3705 Hardware** The 3705 is available in 40 models, based on the amount of storage and physical line-attachment capability. Each model is designated by a letter and a number, such as 'Model G3'. The letter indicates the maximum line-attachment capability; the number indicates the amount of storage. All G-models, for example, can attach up to 256 communication lines for half-duplex operation, and all '3' models with a prefix of E, F, G, or H have storage of 96K. The number of scanners (one to four) are specified as E, F, G, and H; storage is indicated in 32K increments as 1, 2, etc., with the combined letter and number indicating line and storage capacity.

Figure 1.3 shows the storage capacity of each 3705 model and the maximum number of lines for half-duplex operation that can be attached to each. (An SDLC line that operates in duplex mode, data transmitted and received concurrently, counts as two half-duplex lines). The actual number of lines that the control program can support depends on many factors, such as the line speeds required and the throughput capacity of the control program.

**3705-I**

Model	Maximum Number of Half-Duplex Lines	Amount of Storage (Bytes)
A1	64	16K
A2	64	48K
B1	160	16K
B2	160	48K
B3	160	80K
B4	160	112K
C1	256	16K
C2	256	48K
C3	256	80K
C4	256	112K
C5	256	144K
C6	256	176K
D1	352	16K
D2	352	48K
D3	352	80K
D4	352	112K
D5	352	144K
D6	352	176K
D7	352	208K
D8	352	240K

**3705-II**

Model	Amount of Monolithic Storage (Bytes)*
E1-F1-G1-H1	32K
F2-F2-G2-H2	64K
E3-F3-G3-H3	96K
E4-F4-G4-H4	128K
E5-F5-G5-H5	160K
E6-F6-G6-H6	192K
E7-F7-G7-H7	224K
E8-F8-G8-H8	256K

\* Monolithic storage is installed in the base module only.

	Maximum Number of Half-Duplex Lines
E1 to E8	64
F1 to F8	160
G1 to G8	256
H1 to H8	352

Figure 1.3 3705 Storage and Line Capacity

All models of the 3705 contain a central control unit, a control panel, and at least 16K bytes of storage. In addition, all models contain provisions for mounting a channel adapter (or a remote program loader), a two-channel switch, a communication scanner, and line interface bases and line sets to attach up to 64 communication lines for half-duplex operation. As the models increase in size, the available hardware options also increase, allowing the mounting of four channel adapters, four two-channel switches, and the storage and line-attachment capabilities as noted in Figure A.3. (The two-channel switch is not available with a type 3 channel adapter.)

An attachment base is a required feature for support of the 3705 adapters. Two types of attachment bases are available: the type 1 attachment base and the type 2 attachment base. The type 1 attachment base provides common controls to the central control unit for both the type 1 scanner and the type 1 channel adapter. The type 2 attachment base provides common controls to the central control unit and line addressing controls for the type 2 and type 3 scanners. One or both of the attachment bases are required, depending on the type of scanner and channel adapter installed in the 3705.

Models of the 3705 can be upgraded to larger models at the user's installation.

A 3705 hardware configuration can have many combinations of components. The combinations vary based upon the type of 3705 (I or II), channel or line attachment (local or remote), the type of channel adapter(s), communication scanners, storage, etc. A brief description of the functions of each segment of hardware follows.

**3705 Central Control Unit** The central control unit contains the circuits and data-flow paths needed to execute the 3705 instructions and to control 3705 storage and the attached adapters. It also includes a storage protection mechanism. The central control unit operates under the control of the 3705 control program.

The 3705 has a two-byte access path with a cycle time of 1.2 us for the 3705 I, and 1.0 us for the 3705 II.

**3705 Control Panel** The 3705 control panel contains the switches and indicators necessary for manual control of certain 3705 functions. Some of the functions provided by the control panel are:

1. the ability to store and display information in storage and register
2. the control and indication of power
3. indications of controller status
4. operator/controller communication controls
5. diagnostic controls

In many installations a remote 3705 operates largely unattended. Two useful features are available for a remote 3705: unit protection and remote power-off.

The unit protection feature is a lock switch that allows all control panel switches (except Power On/Off) to be disabled. This switch prevents unau-

thorized or inadvertent use of the panel to modify the control program being executed.

The remote power-off feature allows power to be turned off by command from the host processor (via the local controller). This feature eliminates the need to have some one present to turn off power manually at the end of the day's telecommunication operations. Power must be turned on manually, however, at the remote controller's panel.

**3705 Storage** The amount of 3705 storage ranges from 16K or 32K bytes to 256K, in 32K increments. The 3705 model numbers indicate the amount of storage installed, as previously explained.

**3705 Channel Adapters** Four types of channel adapters are available for the 3705. The type 1 CA provides attachment to an IBM System/360 or System/370 byte-multiplexor channel. The type 2, type 3 and type 4 CA's provide attachment to an IBM System/370 selector, byte-multiplexor, or block-multiplexor channel. The type 3 CA enables the 3705 to be attached to System/370 Models 158 and 168 tightly-coupled multiprocessor systems as a symmetrical shared controller and to uniprocessors as a controller with an alternate path capability.

When executing the network control program (NCP) with any type of channel adapter, the 3705 appears as a single control unit on a channel and uses a single subchannel address. The emulation program requires multiple subchannel addresses, just as do the IBM 2701, 2702, and 2703.

#### *Type 1 Channel Adapter*

The type 1 CA can handle only a relatively low volume of throughput and requires intervention from the 3705 control program for each data transfer burst. It is adequate, however, for many small networks and is less expensive than the other channel adapters. The type 1 channel adapter transfers data in four byte bursts, with program intervention required after each transfer. The type 1 CA provides emulation, NCP, or PEP support to a single host. It also can provide emulation support to one host while a second CA provides NCP support to the first or a second host. If a second CA is installed with a type 1 CA it must be either a type 2 or type 3. A two-channel switch allows connection to two host systems.

#### *Type 2 Channel Adapter*

The type 2 CA transfers data by cycle steal, requires less intervention from the 3705 control program than the type 1 CA, and can handle a larger volume of throughput. The type 2 channel adapter requires program intervention at the end of each buffer or at the end of message. The type 2 CA supports NCP mode only; however, it can be installed on the same 3705 with a second CA of the same or different type. A two-channel switch allows connection to two host systems.

#### *Type 3 Channel Adapter*

The type 3 CA provides the same capabilities as the type 2 CA. The type 3 CA provides a dual interface to tightly coupled multiprocessors allowing a single NCP to be addressed from either processor. The type 3 CA can be attached to two CPU channels. These two channel interfaces can be simulta-

neously enabled, and alternate (though not simultaneous) operation over the two interfaces is permitted. When a channel input or output operation over one channel interface is being executed, an attempt to initiate operation by the second channel (attached through the type 3 CA's second interface) causes a 'busy' status to be presented over that interface. Having given a 'busy' status, the adapter generates an asynchronous Device End (DE) when the operation causing the busy state has been completed on the opposite channel interface.

The type 3 CA can be enabled to either interface or to both at the same time. Enabling and disabling of the channel interfaces are controlled by manual switches located on the 3705 control panel. A pair of enable/disable switches exists for each type 3 CA (one for each channel interface). The type 3 CA supports NCP mode only, however it can be installed on the same 3705 with a second CA of the same or different type. The two-channel switch is not available on the type 3 CA.

#### *Type 4 Channel Adapter*

The type 4 channel adapter has two modes of operation. Programming can initialize the channel to operate either in cycle steal mode or data transfers of four, eight, sixteen, or thirty two bytes. The cycle steal mode is only supported by NCP advanced communications function (ACF). Emulation programming will normally use a transfer of thirty two bytes. NCP release 5 uses a four-byte data transfer.

The type 4 channel adapter operates in cycle steal mode for the length of an NCP buffer. Up to four type 4 channel adapters can operate concurrently in NCP mode.

Up to two type 4 channel adapters can operate concurrently in EP or PEP mode. Each host may use a portion of the EP lines; the first host which sends an enable to a line obtains the line until it is disabled. Emulation mode lines to a type 3 scanner require a type 4 channel adapter.

Two type 4 channel adapters can be installed in the 3705 I. Up to four type 4 channel adapters can be installed in the 3705 II. When a type 2 or type 3 is installed with a type 4 only two channel adapters are allowed.

Each type 4 channel adapter has a two-channel switch, allowing attachment to two host systems.

#### *Attachment of Multiple Channel Adapters*

Up to four channel adapters can be installed in the 3705. The model's combinations available are as follows:

1. One CA of any type; only one type 1 CA is allowed per 3705.
2. One type 1 CA with one type 2 or type 3 CA.
3. Two type 2 CA's, two type 3 CA's, or one type 2 CA and one type 3 CA.
4. One type 4 CA with one type 2 or one type 3 CA.
5. One or two type 4 CA's on the 3705 I; one, two, three or four type 4 CA's on the 3705 II.

The multiple CA's can be attached to the same or different host systems. Two type 4 CA's may be operational at the same time in emulation mode, and up to four type 4 CA's may be operational in NCP mode.

#### *3705 Network Control Program Support for the Channel Adapters*

The network control program (NCP) can support all channel types. However, a network control program can contain the NCP code for support of one CA type only (type 2 and 3 CA are identical). Multiple concurrent NCP support is only available with the Advanced Communications Function. If the 3705 is equipped with multiple type 2, type 3, or type 4 channel adapters with NCP 5 or without Advanced Communications Function, the nonsupported channel adapter should be disabled when operating in network control mode.

Support of a type 1 or type 4 channel adapter for emulation mode and a type 1, type 2, type 3 or type 4 channel adapter for network control program mode is covered the section Partitioned Emulation Support for the Channel Adapters which follows.

#### *3705 Emulation Program Support for the Channel Adapters*

The emulation program can operate only with the type 1 or 4 channel adapters. Therefore, when the 3705 with a type 2 or 3 channel adapter is operating with the standalone version of the emulation program, the type 2 CA or type 3 CA should be disabled.

If two type 4 channel adapters are available and connected to two host systems, both hosts can share a single 3705 for emulation mode lines. Either host has access to any emulation line. The first host which initiates line activity (enable) obtains the line. When the line is released (disable), the alternate host can initiate a connection on that same line.

#### *Partitioned Emulation Support for the Channel Adapters*

A network control program with the PEP extension can contain the code to support cycle steal channel adapter and emulation mode channel adapter. (Operation in emulation mode is possible only with the type 1 or 4 channel adapter.) If the the 3705 is equipped with a type 1 or type 4 CA and a type 2 or type 3 CA, the type 1 or type 4 adapter handles data interchanges for communication lines in emulation mode, and the type 2 or type 3 adapter handles data interchanges for the lines in network control mode. A type 1 or type 4 channel adapter can support both emulation and network control mode concurrently without a type 2 or type 3 CA. If multiple type 4 channel adapters are installed, one or two may operate in EP mode concurrently with one to four in NCP mode.

#### *3705 Two-Channel Switch Feature*

The type 1, type 2, and type 4 channel adapters offer an optional two-channel switch which allows the 3705 to be attached to two channels through one channel adapter. (The channels can be attached to the same CPU or two different CPU's.) Only one of the channels, however, can be enabled for operation at a time. The channel to be enabled is selected by means of a manual switch on the 3705 control panel.

**Remote Program Loader** A 3705 used as a remote controller requires a remote



program loader. The remote program loader makes it possible to load a network control program from the host processor via the local controller and the local/remote communication link. The remote program loader includes a small auxiliary storage device and a read-only storage unit. The auxiliary storage device contains loading, dumping, and diagnostic routines.

A 3705 I equipped with a remote program loader cannot have a channel adapter. The 3705 II with Advanced Communications Function may have up to three channel adapters and the remote program loader. This allows a 3705 II to be channel attached on one to three host systems and, if required, available to be IPL'ed as a remote. If a 3705 is IPL'ed as a remote, all channel adapters must be disabled and remain disabled.

**3705 Communication Scanners** The communication scanners provide the connection between the communication-line attachment hardware (line interface bases) and the central control unit. The primary function of the scanners is to monitor the communication lines for service requests.

The normal transmission on communication links is serial by bit. The purpose of the communications scanners is to receive or transmit bits on the link. The communications scanner may also receive bits serially from the line to build characters and deserialize characters for bit transmission on the line. The scanner may also provide character transfer into or from program buffers by cycle steal. The level of control is divided between programming and hardware. Depending upon the amount of hardware support, the programming may provide or receive from the hardware a single bit, a single byte, or an entire program buffer.

There are three communication scanners available on the 3705. The type 1 communications scanner requires a program interrupt for each bit sent or received on a line. The type 2 scanner requires program service for each byte sent or received on a line. The type 3 scanner uses cycle steal and requires interrupts only at the end of a buffer or end of message.

Up to four scanners can be installed per 3705. The number and mix of scanner types and lines per scanner are listed under each scanner type.

#### *Type 1 Scanner*

The type 1 scanner requires a program interrupt on each bit sent or received. The program assembles and disassembles characters. The maximum speed of line for a one-line type 1 scanner is 7200 bps. Sixty four lines of less than 300 bps each are the maximum line configuration for a type 1 scanner. One type 1 scanner is the maximum per 3705. Type 1 scanners cannot be installed with any other type of scanners.

#### *Type 2 Scanner*

The type 2 scanner requires program intervention for each character sent or received. A maximum of two 50,000 bps lines is available on the 3705. The first of four possible type 2 scanners can have up to 64 lines; each additional type 2 scanner may have up to 96 lines for a total of 352 lines, with a maximum speed of 600 bps per line.

Type 2 scanners may be installed with type 3 scanners in any combination.

#### *Type 3 Scanner*

The type 3 scanner is a cycle-steal scanner requiring program intervention at the end of each buffer or end of message. The type 3 scanner supports BSC or SDLC, not SS. BSC is supported for either ASCII or EBCDIC. The first scanner position supports up to 48 lines; the other three scanner positions can support up to 64 lines each. Eight 56,000 bps lines is the maximum speed of type 3 scanner support. If emulation support is defined for this type of scanner, the type 4 channel adapter is required; type 1 CA is not supported with the type 3 CS.

#### *Line Interface Bases and Line Sets*

Communication lines are attached to the 3704 and 3705 through line interface bases (LIB's). Several LIB types are available to handle requirements for different types of line terminations. Depending upon the type of line termination, as many as sixteen communication lines can be attached through one LIB. The A and E models of the 3705 can have a maximum of four LIB's; the B and F models, a maximum of 10; the C and G models, up to 16; D and H models, as many as 22 LIBs.

Communication lines are attached to LIB's through line sets. A single line set may provide the interface for one or two communication lines, depending upon the type of interface.

**3705 Extended Environment Feature (Remote 3705 Only)** A 3705 equipped with the remote program loader may have the extended environment feature, which allows the controller to operate in a location without air conditioning. The minimum ambient temperature is 50 degrees F (10 degrees C); the maximum is 100 degrees F (38 degrees C). Without the extended environment feature, the allowable temperature range is 60 degrees F (15.5 degrees C) to 90 degrees F (32.2 degrees C).

**3705 Internal Air-circulation Features (Remote 3705 Only)** A remote 3705 I, if equipped with the extended environment feature, also requires the internal air-circulation feature for each storage block in the controller. The internal air-circulation features provide improved air cooling of the controller storage. A separate internal air-circulation feature is required for each storage block in the controller. A 3705 I having 80K bytes of storage, for example, requires three internal air-circulation features: one for the first 16K storage block and one for each of the two 32K blocks.

**3704 Hardware** The 3704 consists of a single module that contains the central control unit; the control panel; storage ranging from 16K bytes to 64K bytes in 16K increments; a communication scanner; the line-attachment hardware necessary to connect as many as 32 communication lines for half-duplex operation; and either (1) one type 1 channel adapter for attachment to an IBM System/360 or System/370 channel, or (2) a remote program loader.

The 3704 does not require an attachment base and therefore is not specified in the following material.

**3704 Central Control Unit** The central control unit contains the circuits and data-flow paths needed to execute the 3704 instructions and to control 3704 storage and the attached adapters. The unit also includes a storage protection mechanism. The central control unit operates under the control of the program resident in the 3704.

The 3704 has a one-byte access path with a cycle time of .6 us.

**3704 Control Panel** The 3704 control panel contains the switches and indicators necessary for manual control of certain 3704 functions. Some of the functions provided by the control panel are:

1. the ability to store and display information in the 3704 storage and register.
2. the power control and indications.
3. indicators of controller status.
4. operator/control communication controls.
5. diagnostic controls.

Like the 3705, the unit protection lock switch and remote power-off features are available for remote 3704 controllers.

**3704 Storage** Storage in the 3704 is available in 16K increments up to 64K bytes. The base machine includes 16K bytes of storage. To install storage above 16K, an expansion feature is required.

The amount of storage in the 3704 is designated by 3704 models. Figure A.4 shows the model names and amount of storage in each.

3704		
Model	Maximum Number of Half-Duplex Lines	Amount of Storage (Bytes)
A1	32	16K
A2	32	32K
A3	32	48K
A4	32	64K

Figure 1.4 Storage and Line Capacity

**3704 Channel Adapter (Local 3704 Only)** The 3704 provides a single channel adapter (type 1) for attachment to an IBM System/360 or System/370 byte-multiplexor channel. This channel adapter is identical to the type 1 channel adapter for the 3705.

The channel adapter can have the two-channel switch feature, which allows the 3704 to be attached to two channels. The channels can be attached to the same CPU or to two different CPU's. However, only one of the channels can be enabled for operation at a time. The channel to be enabled is selected by means of a manual switch on the 3704 control panel.

**3704 Remote Program Loader (Remote 3704 Only)** A 3704 used as a remote controller requires a remote program loader instead of a channel adapter. The remote program loader makes it possible to load a network control program from the host processor, via the local controller and the local/remote communication link. The remote program loader includes a small auxiliary storage device and a read-only storage unit. The auxiliary storage device contains loading, dumping, and diagnostic routines.

A 3704 equipped with a remote program loader cannot have a channel adapter.

**3704 Communications Scanners** The 3704 can be equipped with either a type 1 or type 2 communication scanner.

#### *Type 1 Scanner*

The type 1 scanner interrupts the control program for each bit that arrives or leaves over a communication line. The program assembles and disassembles characters. The type 1 scanner can have up to 32 lines. A limit of one line of 4800 bps is the maximum for a type 1 scanner.

#### *Type 2 Scanner*

The type 2 scanner interrupts the program only when an entire character has been received from or transmitted onto the communication line. The scanner hardware assembles and disassembles characters. A maximum of 26 lines is available with the type 2 scanner. The maximum line speed is two 50,000 bps lines on a type 2 scanner.

*Line Interface Bases and Line Sets*

Communication lines are attached to the 3704 through line interface bases (LIB's). One or two LIB's can be installed in the 3704. Depending upon the type of line termination, as many as 16 communication lines can be attached through one LIB.

Communication lines are attached to a LIB through line sets. A single line set may provide the interface for one or two communication lines, depending upon the type of interface.

**3704 Extended Environment Feature (Remote 3704 Only)** A 3704 equipped with the remote program loader may have the extended environment feature, which allows the controller to operate in a location without air conditioning. The minimum ambient temperature is 50 degrees F (10 degrees C); the maximum is 100 degrees F (38 degrees C). Without the extended environment feature, the allowable temperature range is 60 degrees F (15.5 degrees C) to 90 degrees F (32.2 degrees C).

**IBM 3704 and 3705  
Hardware Review**

The 3705 allows for more lines at higher speeds and more storage than the 3704. The 3704 and 3705 can be attached locally to a host channel or attached remotely by communication lines to a remote communications controller. The 3705 II can be attached locally via one, two, or three channel adapters and have a remote program loader. If the 3705 II is IPLed via the remote program loader the channel adapters must be disabled. Each of the controllers is individually configured to meet the needs of a specific network, so a knowledge of the components is necessary to select the appropriate options properly.

**IBM 3704 and 3705  
Hardware Quiz**

In the following quiz you are testing yourself. You should try to answer the questions without referring to the reading assignment materials or the answers in Appendix A.

True or false:

1. The 3704 and 3705 communications controllers do not perform the same functions.
2. The 3705 remote communications controller never has a channel adapter.
3. The 3704 maximum transmission rate for one line is less than the 3705 one-line maximum rate.

Completion:

4. The maximum storage for a 3704 is \_\_\_\_\_.
5. The maximum storage for a 3705 is \_\_\_\_\_.
6. The maximum number of lines on a 3704 is \_\_\_\_\_.
7. The maximum number of lines on a 3705 is \_\_\_\_\_.

Criterion:

If you missed more than two questions or had to refer to the text for more than two answers, you should review the reading assignment.

For additional information on this topic refer to *IBM 3704 and 3705 Communications Controller Hardware* (SR20-4544)

# Emulation Programming

**Introduction** The IBM 3704 and 3705 Communications Controllers are programmed transmission control units that communicate with a variety of terminals, transmission control units, and computers. The programming can accommodate many different telecommunication applications and operational requirements.

The emulation program resides in the IBM 3704 and 3705 Communications Controllers and allows either controller to perform most functions of an IBM 2701 Data Adapter Unit, IBM 2702 Transmission Control unit, IBM 2703 Transmission Control Unit, or any combination of the three. The emulation program allows many programs written for support of the 2701, 2702, and 2703 to operate without modification with either communications controller. Such programs include IBM Type I access methods that support the 2701, 2702, and 2703, as well as IBM Type II and Type III programs and user-written programs that interface in a manner equivalent to IBM Type I access method programs. Programs that involve timing dependencies and support of certain special and custom features may have to be changed.

The emulation program requires that a type 1 or type 4 channel adapter be installed in the controller for attachment to a System/360 or System/370 byte-multiplexor channel. All models of the 3704 and the 3705 have enough storage to accommodate small emulation program configurations, but larger configurations require more than the minimum amount of storage (16K).

The emulation program in conjunction with the type 1 or type 4 channel adapter not only permits the use of the same control sequences and data transfers as the 2701, 2702, and 2703, but also provides most of the standard functions of these control units. Not supported are the parallel data adapter, synchronous data adapter type 1, the programmable two-processor switch, two-channel attachment (except by two type 4 channel adapters), six-bit transcode, 230,400 bps synchronous speed, selector channel attachment, direct attachment of the IBM 1032 Digital Time Unit, and the IBM 2712 Remote Multiplexor attachment features.

In addition to the standard 2701, 2702, and 2703 functions, the emulation program also supports certain RPQ's (request for price quotation) for these control units.

In emulation mode, the 3705 with one channel adapter can attach up to 255 communication lines for half-duplex operation at speeds from 45.5 bps to 56,000 bps; with two type 4 channel adapters up to 352 communication lines are supported. The 3704 can attach up to 32 communication lines at speeds from 45.5 bps to 50,000 bps. The actual number of lines that can be attached depends upon the specific configuration of the telecommunications subsystem.

Each line attached to the controller in emulation mode requires a nonshared subchannel address on the byte-multiplexor channel. A line may be switched between subchannel addresses using the multiple subchannel line access (MSLA) facility. MSLA defines multiple subchannel definitions to one line

address. The first subchannel to enable the line gains control of the line until reset by a disable.

Appendix B contains a complete list of the types of stations supported by the communications controller when executing an emulation program.

The emulation program is generated according to the network configuration of each installation. To begin the generation procedure, the user codes a series of macro instruction source statements that define the telecommunication network. The source statements are then generated by a compilation process into an emulation program load module, which is loaded into the communications controller. By dumping the communications controller storage, the user may examine the contents of controller storage as an aid to error diagnostics.

This publication explains how to define, generate, load and dump an emulation program.

### Defining the Emulation Program

Achieving an operating emulation program is a three-step process. The first step, defining the control program, is the most involved. Many different variables and options must be considered in preparing a control program to meet the requirements of a particular network configuration and application.

An emulation program is defined in the form of a source program consisting entirely of macro instructions. These macro instructions include:

1. System macros which provide information pertaining to the entire controller -- hardware features, certain control program options, and program generation information such as data set names.
2. Configuration macros which provide the information necessary to construct tables needed by the emulation program. Such tables are used to control the flow of data between the controller and the telecommunication network and between the host processor and the communications controller.
3. A generation delimiter macro that ends the control program generation input stream.

When punched into cards and preceded by the appropriate job control statements, the source program forms the input to the next step: the generation procedure.

### Generating the Emulation Program

After definition in the form of a source program containing emulation program macro instructions, the emulation program is ready to be generated. The primary output of the generation procedure is an emulation program load module ready for loading into the communications controller.

**Generating the Emulation Program Under VS1, VS2, and MVS** The emulation program generation procedure under the control of VS1, VS2, and MVS is a two-stage process.

In the first stage of the generation procedure, the emulation program generation macros which have been coded are assembled by the communications controller assembler or a host operating system assembler. The output from the assembler is a job stream containing the data and control statements necessary to create the desired emulation program. The job stream is a



sequential data set that can be directed to cards, tape, or a direct access storage unit.

Operator intervention is required between the stages of program generation. Diagnostic messages produced at the end of stage 1 indicate any errors that have occurred. If the errors are serious, no job stream is produced; the source statements must be corrected and stage 1 reexecuted. If the errors are not serious, the operator initiates the second stage, specifying as input the stage 1 output.

Using the controller assembler, the second stage of the generation procedure assembles the control tables that are required by the emulation program being generated. Then the linkage editor is executed to combine the appropriate modules into an emulation program load module, which is loaded from the host processor into the communications controller.

**Generating the Emulation Program Under DOS/VS** The emulation program generation procedure under the control of DOS/VS is a two-stage process.

In the first stage of the generation procedure, the macros which were coded are assembled by the communications controller assembler. The output from the assembler is an object deck and a printed listing.

Operator intervention is required between the stages of program generation. Diagnostic messages are printed in the stage 1 output listing, indicating any errors that have occurred. If there are no serious errors, an object deck is produced.

Stage 2 of the generation procedure is made up of two substeps. First, the operator catalogs the object deck in a library together with IBM-supplied emulation modules. Second, there is a linkage editing of the modules according to the INCLUDE cards on the stage 1 output listing. The result is an emulation program load module that is located in the core image library.

### **Communications Controller Utilities**

The loader, dump, and dynamic dump programs are utilities used with the communications controller. Each utility is initiated by the appropriate job control statements and control cards. Each utility is described briefly below.

**The Loader Utility** The final step in achieving an operating emulation program consists of loading the control program load module from the host processor into the communications controller. This step is accomplished through the use of a loader utility program that is executed in the host processor, with the controller online to the processor.

The loader utility is supplied as one of the emulation program system support programs.

**The Dump Utility** The dump utility program allows all or part of the contents of controller storage to be transferred from the controller to the host processor, which then prints the contents in hexadecimal format. You can request a formatted dump or an unformatted dump of controller storage. The unformatted storage dump prints with EBCDIC equivalents on the right side of the page. The formatted storage dump prints the mnemonic operation codes with the instructions.

Executing the dump utility stops operation of the emulation program. After the dumping process is completed, the emulation program must be reloaded into the controller before telecommunication operations can resume.

**Dynamic Dump Utility** The dynamic dump is an optional utility program that allows the contents of controller storage to be transferred from the controller to the host processor without stopping the operation of the emulation program. A full storage dump or a dump of the trace table can be obtained. In addition, portions of storage can be displayed on the operator's console at the host processor. The utility also can activate or deactivate the emulation program line-trace function and allows the selection of two program levels to be traced.

### Emulation Review

Macros define the emulation program for each network configuration. The macros are assembled in a generation process to create the control blocks for the configuration. The linkage editor combines the control blocks with preassembled modules to produce the emulation program load module.

A loader utility is initiated by job control and utility control statements to transfer the load module to the communications controller. The loader utility is one of the IBM-supplied emulation program system support programs.

A dump of the emulation program may be obtained by either of two methods. A dump utility, initiated by job control and utility control cards, transfers the contents of storage to the host processor for listing. If the dump utility is used, the emulation program is ended and must be reloaded. The dynamic dump utility does not end normal emulation program execution, but allows concurrent emulation and dumping. The dynamic dump can dump storage, trace entries, or trace two program levels.

### Emulation Quiz

The following quiz is provided to enable you to check yourself on this subject matter. The answers are given in Appendix A.

True or False:

1. The emulation program is generated by assembling macros which define the configuration.
2. The dump utility allows the contents of storage to be dumped while the emulation program continues to execute.
3. The loader utility is initiated by job control in the host.
4. The emulation program can operate over a type 1, 2, 3, or 4 channel adapter of a communications controller.
5. The emulation program requires a host connection to a host byte-multiplexor channel.

6. The emulation program emulates the IBM 2701 Data Adapter Unit, IBM 2702 Transmission Control Unit, IBM 2703 Transmission Control Unit, or any combination of the three.

Completion:

7. A communications controller with one type 1 or one type 4 channel adapter and the emulation program can support a maximum of \_\_\_\_\_ lines.
8. Two host systems can share emulation lines (not concurrently) if the communications controller is equipped with two channel adapters. Both channel adapters must be type \_\_\_\_\_?

Criterion

If you missed more than two questions, you should review this section.

For additional information on this topic refer to *IBM 3704 and 3705 Emulation Programming* (SR20-4546)

For information on emulation program data flow and control blocks refer to *IBM 3704 and 3705 Emulation Data Flow* (SR20-4547)



# Network Control Program Introduction

**Introduction** The IBM 3704 and 3705 Communications Controllers are programmed transmission control units which communicate with a variety of terminals, transmission control units, and computers. The programming for these controllers can accommodate many different telecommunication applications and operational requirements.

The network control program first is defined in the form of macro instruction source statements, then generated by a compilation process, and finally loaded into the communications controller.

The network control program controls the transmission of data between the host processor and the remote stations in the telecommunication network connected to the communications controller. The host processor is the central processing unit in which resides the access method that interacts with the network control program.

A network control program can execute two broad categories of functions:

- Network control program functions
- Emulation program functions (except in NCP release 1)

**Network Control Functions** Network control functions cover the wide range of capabilities for which the 3704 and 3705 controllers are principally designed.

The network control program recognizes and fulfills requests by the telecommunication access method to transmit data to or receive data from the network. In so doing, the program performs whatever operations are needed to establish communication with stations. These operations include polling, addressing, dialing, and answering, as appropriate for the type of station and type of communication line linking the station and the controller. The program receives message data in buffers, inserts and deletes transmission control characters as required, and translates message data from processing code (EBCDIC) into transmission code, (or vice versa). Finally, the network control program transmits data from the buffers to the access method or to the stations in the network.

The network control program also governs many aspects of communication between the network and the host processor, such as the amount of data to be accepted from a station once connection is established, the number of devices on a multipoint line with which the access method can communicate at one time, and the exchange of identification sequences with stations on switched lines.

Network control functions also include:

- Automatic error recovery and statistical recording
- Diagnosis of controller, line, and station malfunctions
- Changes to operating parameters during program execution upon request from the host processor

**Emulation Functions** Emulation functions comprise a more restricted range of services, equivalent to those provided by the IBM 2701, 2702, and 2703. (These three units are collectively referred to in this book as 'transmission control units'). When a 3704 or 3705 replaces one or more transmission control units, the emulation functions permit most user application programs to operate unchanged.

According to the needs of your telecommunication installation, you may generate a network control program that performs only network control functions or both network control functions and emulation functions (except in NCP release 1). A program capable of both categories of functions is called 'a network control program with the partitioned emulation program (PEP) extension'. When generating a program having the PEP extension, you must specify, for each BSC or SS line in the network, whether that line is to operate in network control mode or emulation mode or both. Operation in network control mode means that all of the network control functions apply to data transmission over that line. Operation in emulation mode means that only the emulation functions apply to that line. These emulation functions are equivalent to the services performed by the 2701, 2702, or 2703. Because the functions offered by the three types of transmission control units differ in some respects, you must specify for each line which of these units is to be emulated.

If your network has BSC and SS lines and if you specify operation in NCP and emulation modes, operation can be changed from one mode to the other whenever you wish, by command from the host access method.

An SDLC line operates in network control mode only. There is no emulation support for SDLC links for the 2701, 2702, or 2703. Only BSC and SS lines can operate in alternate modes of network control or emulation.

### **Communication between Controller and Host Processor**

The network control program interacts with one or more access methods executing in the host processor. The access method and any associated application programs must be designed to interact with the network control program in the manner appropriate to the mode in which the lines served by the access method are to operate: network control program mode, emulation mode, or both.

Communication in network control mode between the network control program and the access method generally consists of an exchange of requests issued by the access method and responses returned by the network control program. Each request and each response contains the control information necessary to identify the telecommunication resource to which it applies, the operation required (for example, Read or Write), and status information pertaining to that operation. Requests and responses also contain the text of messages to be passed between the access method and the network. Some responses from the network control program are unsolicited; that is, the response is not returned in answer to a request. Unsolicited responses report error conditions and status information that may develop during operations of the controller.

All requests and all responses for lines operating in the network control mode pass between controller and host processor over the network control subchannel. Each channel adapter of the communications controller has a network

control subchannel (NSC). If the controller is to perform only network control program functions, the NSC is the only subchannel required. Load module data sent by the access method loader or independent loader and the contents of controller storage during a dump performed by the standard dump utility also passes over the network control subchannel. (The dynamic dump utility uses an emulation subchannel not assigned to a line).

Communication in emulation mode between the access method and the network control program is essentially the same as communication between the access method and the transmission control unit being emulated. As with transmission control units, each communication line operated in emulation mode requires its own host subchannel address. The subchannels associated with lines operated in this mode are called 'emulation subchannels'. In defining a network control program that performs emulation functions, you permanently associate each communication line with an emulation subchannel address. This association cannot be changed during program execution; only reassembly of the program can make a change. reassembly of the program can make a change. There are two exceptions, however:

- The dual communications interface facility of an IBM 2701 is associated by command.
- A line definition can be associated with two subchannel addresses of type 4 channel adapters.

A program that performs both network control and emulation functions requires a single network control subchannel (NSC), plus an emulation subchannel (ESC) for each line to be operated in emulation mode (even if such a line sometimes operates in network control mode in a PEP program).





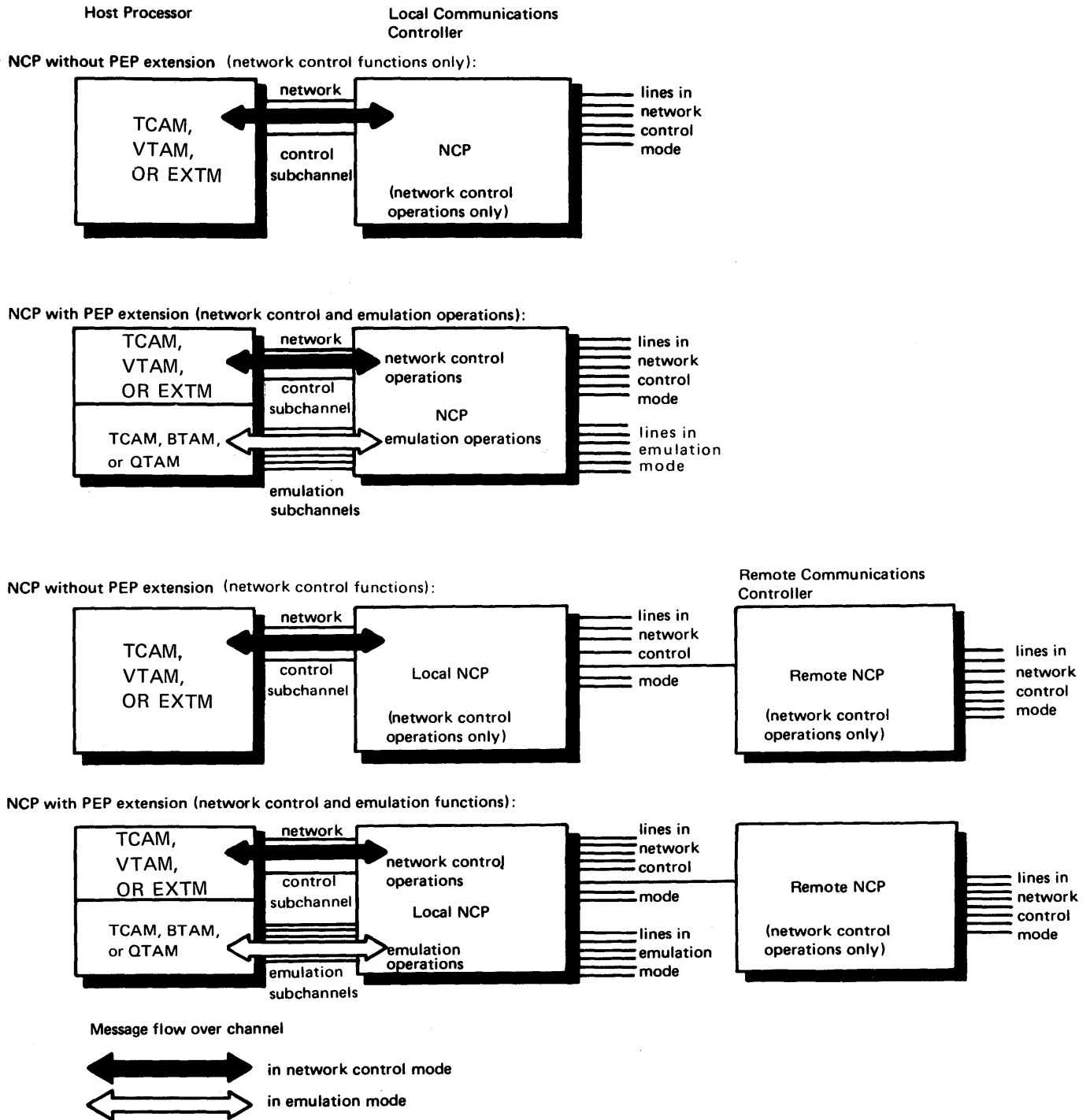


Figure 3.1 Host Processor/Communications Controller Data Flow Relationships

Figure 3.1 illustrates the host processor/communications controller data flow relationships. The examples illustrate the valid combinations of host, channel adapters, and modes of operation.

## Achieving a Network Control Program

An operating network control program is achieved in three steps:

1. Definition
2. Generation
3. Loading

The first step -- definition -- is the most complex. Many different variables and options must be considered in preparing a program to meet the requirements of a particular network configuration and application.

**Definition of the Network Control Program** A network control program is defined in the form of a source program consisting entirely of macro instructions called 'network control program generation macro instructions'. These instructions include configuration macros for specifying the elements of the telecommunication network, such as the definitions of lines and devices. The source program, with appropriate job control statements, forms the input to the second step, the generation procedure.

Many of the operands of the generation macros require information on the physical features of the host buffers, data lengths, and features of the communications controller and terminals. You will need to obtain such information before you can complete your coding.

**Generation** After the network control program is defined in the form of a source program containing network control program generation macro statements, the program is ready to be generated. Generation is a compilation procedure consisting of assembly and link-editing steps. The procedure is executed in a host processor. The primary input is your macro statements and a library of NCP macro statements.

The first phase of generation output is a job stream of assembly steps and link-editor steps. If there are coding errors, there may be diagnostics instead of a job stream.

The second phase of generation is the execution of the job stream created in the first phase. The output of phase 2 is a network control program load module ready for loading into the communications controller. DOS/VS requires the load module be moved to a sequential file using the CSERV utility.

**Loading** The final phase in achieving an operating network control program consists of loading the program load module into the communications controller. For a local communications controller, this phase requires execution of a loader utility program in the host processor, with the controller online to the processor. For a remote communications controller, loading requires execution of a network control program in the local controller to which the remote controller is connected. Apart from transferring load module data between the host processor and the remote controller, the program in the local controller does not participate in the loading process.

The loader utility program executed in the host processor may be a part of the host access method (as in VTAM) or may be an independent utility program provided by IBM as part of the system support programs. The independent utility may be used only for loading a local controller. The host access method loader *must* be used for loading a remote communications controller and may be used for loading a local communications controller.

### Obtaining the Contents of Controller Storage

A utility dump program allows the contents of controller storage to be transferred from the controller to the host processor, which then prints the contents in hexadecimal format. Like the loader program, the dump program may be a host access method facility or an independent program supplied as part of the system support programs. The local controller dump uses two modules, one of which the host processor transfers to the communications controller before the dumping process begins. The two modules interact to transfer the contents of controller storage to the host processor; the host processor module then formats and prints the contents of storage. The remote controller dump uses a module which resides on disk in the remote controller for the resident portion of the dump. When a host access method dump utility requests a dump, the module is read from disk into remote controller storage and is executed. The dump data is transferred through the local controller to the host for formatting and printing. The storage contents of a remote controller can be obtained only with the host access method facility, not the independent utility.

Executing the dump utility stops operation of the network control program. After the dumping process is completed, a network control program must be reloaded into the controller before telecommunication operations can resume. A network control program with the PEP extension can define the *dynamic* dump facility which allows full storage dumps without stopping or changing controller storage.

### Network Control Program Review

The IBM 3704 and 3705 Communications Controllers with the network control program supports SDLC, BSC, and SS devices. With the partition emulation program (PEP) extension, BSC and SS devices may be supported in network control mode or emulation mode, and may be switched between emulation mode and network control mode.

The network control program performs polling, addressing, dialing, answering, and data transfer as appropriate for the type of station and communication link, but only at the request of the host program. The host sends requests to the network control program; the network control program responds to the requests. The functions also include automatic error recovery and statistical recording, diagnosis of controller, line, and station malfunctions, and changes to operating parameters upon request from the host.

The network control program is defined by the user with network control program generation macros. The macros are compiled on a host processor to create a job stream of assembles and link-editor steps. This job stream creates the network control program load module.

The network control program is loaded or dumped using a host access method utility or an independent load utility. Either utility program may be used on a local (channel-attached) communications controller. The host access method

utilities are required to load or dump a remote, line-attached, communications controller through a local controller.

### Network Control Program Quiz

Answer the following questions, then check your answers in Appendix A of this book.

*True or False:*

1. The network control program may be loaded and executed in either the 3704 or 3705 communications controller.
2. The network control program supports SDLC, BSC, and SS lines in network control program mode.
3. The network control program supports SDLC lines in network control program mode, but requires BSC and SS lines to be in emulation mode, using the partitioned emulation program (PEP) extension.
4. The network control program supports SDLC lines in network control program mode, and BSC and SS lines can be switched from network control mode to emulation mode (or from emulation mode to network control mode) under host system control.
5. The generation process of the network control program requires an assembly of network control program macros to create a job stream which, in turn, creates the load module.
6. The independent loader utility or the host access method loader can be used to load the network control program into local or remote controllers.

#### Criterion

If you missed more than one question, you should review this topic.

For additional information refer to *IBM 3704 and 3705 Communications Controllers NCP Programming* (SR20-4568)

The following is a list of the generation manuals for each NCP release level:

#### NCP 1:

*IBM 3704 and 3705 Communications Controllers Network Control Program Generation and Utilities Guide and Reference Manual (for OS/MFT and OS/MVT TCAM Users)* (GC30-3000)

#### NCP 2:

*IBM 3704 and 3705 Control Program Generation and Utilities Guide and Reference Manual* (GC30-3007)

#### NCP 3, 4, and 5:

*IBM 3704 and 3705 Control Program Generation and Utilities Guide and Reference Manual* (GC30-3008)

#### Advanced Communications Function NCP:

*IBM 3705 Advanced Communications Function for Network Control Program/VS Generation and Utilities Reference Manual (SC30-3116)*

NCP releases 1 and 2 are supported in the host by TCAM release 5 or 6 for BSC and SS devices only. This support was released prior to SNA support for SDLC devices.

NCP releases 3, 4, and 5 support BSC, SS, and SDLC devices with host systems of EXTM, VTAM, and TCAM.

ACF/NCP/VS release support BSC, SS, and SDLC devices with host systems of EXTM, VTAM, ACF/VTAM, TCAM, and ACF/TCAM.



## Appendix A:

### Quiz Answer Key

#### IBM 3704 and 3705 Hardware Quiz

1. false
2. false
3. true
4. 64K
5. 256K
6. 32
7. 352

#### Emulation Programming Quiz

1. true
2. false, only the dynadump facility allows concurrent dumping and continued emulation program execution.
3. true
4. false, emulation programming may only use the type 1 or type 4.
5. true
6. true
7. 255
8. 4

#### Network Control Program Quiz

1. true
2. true
3. false - BSC and/or SS may be in either NCP or EP mode.
4. true
5. true
6. false - The independent utility can only be used to load a local (channel attached) controller. The host access method loader utility through a local controller is required to load a remote controller.





# Glossary

## Abbreviations

ABAR	Attachment base address register
ACB	Adapter control block
APPL	Application
ASCII	American standard code information interchange
AT & T	American telephone and telegraph
BCC	Block check character
BCD	Binary coded decimal
BCU	Block control unit
BNN	Boundary network node
BSC	Binary synchronous
BTAM	Basic telecommunications access method
CA	Channel adapter
CCITT	Comite consultatif international telegraphique et telephonique (Consultative committee on international telegraphy and telephony)
CDS	Configuration data set
CE	Channel end
CPM	Connection point manager
CPU	Central processing unit
CS	Communication scanner
EBCDIC	Extended binary coded decimal interchange code
EP	Emulation program
ESC	Emulation subchannel( Address)
FID	Format identification
FM	Function Management
FME	Function Management End
IAR	Instruction Address Register
ICE	Initial Command Execution
IPL	Initial program load
LIB	Line interface base
LU	Logical unit
MSLA	Multiple subchannel line access
MTA	Multiple terminal access
NCP	Network control program
NSC	Native subchannel (address)
PEP	Partitioned emulation program
PIU	Path information unit
RH	Request/response header
RU	Request/response unit
RPQ	Request for price quotation
SDLC	Synchronous data link control

## Glossary

SS	Start-stop
SSCP	System services control point
TH	Transmission header
VTAM	Virtual telecommunication access method
X	Hexadecimal

**Access method:** A data management technique for transferring data between main storage and input/output units.

**Addressing:** The means whereby the originator or control unit selects the teleprocessing device to which it is going to send a message.

**Attachment base:** An attachment base is a required feature for support of the 3705 adapters. The type 1 attachment base provides common controls to the central control unit for both the type 1 scanner and the type 1 channel adapter. The type 2 attachment base provides common controls to the central control unit and line addressing controls for the type 2 and type 3 scanners.

**Bit service:** The process of character assembly or disassembly.

**Buffer:** A temporary storage area for data.

**Central control unit:** The controller hardware unit that contains the circuits and data flow paths needed to execute the instruction set and to control controller storage and the attached adapters.

**Channel adapter (CA):** A controller hardware unit that provides attachment of the controller to a System/360 or System/370 Channel.

**Character assembly:** The process by which bits are put together to form characters as the bits arrive on a communication line. In the controller, character assembly is performed either by the control program or by the communication scanner, depending on the type of scanner installed.

**Character disassembly:** The process by which characters are broken down into bits for transmission over a communication line. In the controllers, character disassembly is performed either by the control program or by the communication scanner, depending on the type of scanner installed.

**Character service:** The process by which a character is moved to a buffer from the storage area where it was assembled.

**Communication line:** The means of connecting one location to another for the purpose of transmitting and receiving data. In this publication, the term refers to any communication facility of the communications common carrier, whether it is actually a wire or some other means of communication, such as radio or satellite.

**Communication scanner (CS):** A controller hardware unit that provides the interface between line interface bases and the central control unit. The communication scanner monitors the communication lines for service requests.

**Cycle steal:** The process by which a type 2 or a type 3 channel adapter, or a type 3 communications scanner, acquires machine cycles from the 3705 control program for data transfer.

**Duplex line:** A communication line having two independent data paths over which data can be transmitted in both directions simultaneously. (Also called a full-duplex line).

**Emulation program:** A control program for the controllers which provides for the emulation of the 2701 Data Adapter Unit, the IBM 2702 Transmission Control, and 2703 Transmission Control, by the user from a library of IBM-supplied modules.

**Generation delimiter macro:** The macro that marks the end of the control program generation input stream (GENEND Macro).

**Half-duplex line:** A communication line having a single data path over which data can be transmitted in either direction, but not simultaneously. Contrast with duplex line.

**Host processor:** The central processing unit to which the controller is attached by a channel and that executes the teleprocessing access method that supports the controller.

**Initial text routine:** A diagnostic program executed in the controller before the control program is loaded. The initial test routine tests the controller hardware for conditions that might cause failure after operation begins.

**Interrupt:** A break in the normal sequence of instruction execution. It causes an automatic transfer to a preset storage location where appropriate action is taken.

**Line adapter:** An IBM modem that is feature of a particular product. Some communica-

tions controller line sets include line adapters; others require external modems. See also Modem.

**Line control character:** A special character that controls transmission of data over a communication line. For example, line control characters are used to start or end a transmission, to cause transmission error checking to be performed, and to indicate whether a station has data to send or is ready to receive data.

**Line group:** A group of communication lines by which stations supported by the same line-control discipline are connected to the controller.

**Line interface base (LIB):** A controller hardware unit that provides for the attachment of communication lines to the controller.

**Line set:** A controller hardware unit that provides for the attachment of communication lines to the controller.

**Load module:** A program in a format suitable for loading into storage for execution.

**Local communications controller:** A communications controller attached to a host processor by a channel adapter.

**Modem:** (Modulator-DEModulator) A device that modulates and demodulates signals transmitted over communication facilities. See also Line Adapter.

**Multiple terminal access:** A support for dial-in calls using start-stop terminals of different line speeds, codes, and terminal types over a single dial port

**Multiprocessor:** A computer employing two or more processing units under integrated control. A tightly-coupled multiprocessor is a computer employing two or more processing units that are controlled by the same operating system and share all main storage and most of auxiliary storage.

**Network control program:** A control program for the controllers, generated by the user from a library of IBM-supplied modules.

**Partitioned emulation program (PEP):** A control program which provides the functions of both the Emulation Program and Network Control Program, generated by the user from a library of IBM-supplied modules.

**Remote communication controller:** A communication controller that communicates over a communication line with a local communications controller, instead of being attached directly to the host processor by a channel adapter.

**System macro:** One of the control program generation macros that provide information pertaining to the entire controller.

**Transmission code:** A character code for sending information over communication lines.

**Two-channel switch:** A hardware feature that allows the controller to be attached to two CPU channels through a single type 1, type 2, or type 4 channel adapter.

**SDLC link:** A communications line over which communications are conducted using the synchronous data link control (SDLC) scheme.

**Uniprocessor:** A computer employing one processing unit.

# INDEX

- Attachment base 15
- Availability 10
- CA (See Channel Adapters)
- Central control unit
  - 3705 15
  - 3704 20
- Channel adapters 16
  - Type 1 16, 22
  - Type 2 16
  - Type 3 16
  - Type 4 17
- Communications controller
  - Introduction 1
  - 3705 13
  - 3704 20
- Communications scanners 19, 22
  - Type 1 19, 22
  - Type 2 19, 22
  - Type 3 19
- Configurations 2
- Control panel
  - 3705 15
  - 3704 21
- CS (See communications scanners)
- Data flow 1
- Diagnostics 12
- Dump utility 27, 37
- Dynamic dump utility 28, 37
- EP (see Emulation program)
- Emulation program (EP) 25
- EP functions 25, 32
- Error recovery 12
- Extended environment feature
  - 3705 20
  - 3704 23
- Generation
  - Emulation 26
    - OS/VS 26
    - DOS/VS 27

- NCP 36
- Host processor 3
- LIB (see Line interface base)
- Line interface base (LIB) 20, 23
- Line sets 20, 23
- Loader Utility 27, 36
- Multiple channel support
  - NCP 18
  - EP 18
  - PEP 18
- NCP (See Network control program)
- Network control program (NCP) 31
- NCP functions 31
- Partitioned emulation program (PEP) 4
- Program support for controllers
  - Network control program 4
  - Emulation program 4
- Reliability 11
- Remote controller 3
- Remote program loader 19, 22
- SDLC 4
- Storage
  - 3705 16
  - 3704 22
- Synchronous data link control (see SDLC)
- System support programs 5, 27
- Two channel switch 18, 22





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