Notes on
THE NETWORK

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FUNDAMENTAL NETWORK PLANNING SECTION

NOTES ON THE NETWORK

FOREWORD

Notes on the Network supersedes the publication ***Notes on Distance Dialing.*** It is issued to reflect changes in technology and to amplify and clarify material published in the previous publications. The primary purpose of ***Notes on the Network*** is to outline the technical requirements and fundamental operating principles of the Bell and Independent Network.

The Network is a system of integrated parts consisting of transmission and switching facilities, a control and signaling process, and associated operational support systems. It is engineered, installed, owned, and managed by a partnership of American Telephone and Telegraph Company (AT&T) Long Lines, Bell System Operating Telephone Companies, and Independent Operating Telephone Companies. Its boundary is the location where the Network tariffed channel terminates on the customer's premises or where carriers other than those comprising the Bell-Independent partnership are provided local access. Its principal function is to provide, on demand, a communication channel connecting any two communications terminal devices for the exchange of information in a variety of forms.

Notes on the Network is confined to matters bearing directly on services and communications paths through the Network to its boundary as defined above. In addition to technical data required by engineering personnel, descriptions are included covering in some detail the Numbering Plan, the Switching Plan, Equipment, Signaling, Network Management, Transmission and Maintenance Considerations, etc, which should be of value to operating and maintenance personnel. For those interested in the overall plan rather than technical details, Section 1 outlines the contents and scope of the other sections in nontechnical terms and discusses some of the fundamentals that are considered when preparing to incorporate facilities and switching systems into the Network.

In many instances, it has been necessary to specify certain requirements or design objectives without including a discussion of the factors underlying their selection. Also, there are many concerns in the Comptrollers, Marketing, Public Relations, and Network Services areas that relate to the Network but are beyond the scope of ***Notes on the Network.*** Nevertheless, ***Notes*** does furnish much of the information needed by the telecommunications industry for the successful coordination of efforts between operating companies in maintaining and expanding the Network.

It should be emphasized that an orderly program should exist to coordinate the introduction of new technological advances into the Network. While ***Notes on the Network*** describes the Network as visualized today, details will necessarily change as new developments and technology are introduced. Decisions in the technical areas should be based on the results of fundamental planning studies with the ultimate plan selected on the basis that it is of most value to the entire set of users of the Network.

A document of such general nature as ***Notes on the Network*** cannot cover all the detailed technical requirements of the Network. To care for questions concerning technical matters not discussed in ***Notes on the Network,*** continued contact at the local or state level between the Independent and Bell segments of the telephone industry is encouraged.

With customer needs and serving arrangements becoming more complex, the planning effort for the Network will continue to involve all Independent and Bell Company partners. In this connection, information relative to ***Notes on the Network*** reflects the combined efforts of the United States Independent Telephone Association (USITA) Engineering Subcommittee on Network Planning and AT&T. The importance of continuous joint planning by Independent and Bell Companies cannot be overemphasized since the plans of all are interdependent and influence the determination of the most economical industry solution.

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SECTION 1

GENERAL INFORMATION

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1. GENERAL

1.01 The Network is an integrated system of transmission and switching facilities, control and signaling processes, and associated operational support systems. It is designed to provide the capability for interconnecting virtually any household and/or office in the country with any other household or office on a direct connection basis.

1.02 These interconnections are established over the Network by an originating customer or operator dialing a unique address code for a specific terminating line without any assistance from intermediate operators. Centralized Automatic Message Accounting (CAMA), Traffic Service Position (TSP), or Traffic Service Position System (TSPS) operators who may enter on the connection for momentary assistance are not considered intermediate operators. The term, "network dialing," is used to describe calls dialed by customers to points outside their local or extended service area. When calls are dialed by an operator, the term, "operator network dialing," is sometimes used. Network dialing methods provide for fast, accurate, and dependable communications services and at the same time result in overall operating economies.

1.03 ***Notes on the Network*** is intended to serve as a general reference and guide for the telecommunications industry on the principles employed in the Network. It describes minimum requirements and is not intended to provide detailed engineering information. Since the basic network plan is designed for both operator and customer dialing, no distinction is made between the two except in instances where requirements differ. A detailed description of circuit operation has been avoided, and the requirements for switching systems are covered only to the extent that they affect network considerations.

1.04 Generally, ***Notes on the Network*** describes the requirements that apply when network methodology has been fully realized and does not cover interim arrangements which may be both expedient and appropriate during transitional periods. Many things dictated by local conditions must be considered before the methods and equipment arrangements for a given office can be properly determined.

1.05 Some references are made to equipment of Bell System manufacture; however, appropriate equipment of other manufacturers with the necessary operating features can be employed.

1.06 The Network is in the early stages of an evolution toward an Integrated Services Digital Network (ISDN) which will provide end-to-end digital connectivity for a variety of services over the Network. Although the time frames for implementation of an ISDN and the services to be provided are not known at this time, it is clear that through extensive deployment of T Carrier, fiberguide, digital radio, and digital subscriber carrier systems along with time division No. 4 Electronic Switching System (ESS) switches, the Bell-Independent partnership is building the foundation of an ISDN for the future. In addition, the partnership has started deployment of time division digital local switches and the first major long-haul digital transmission system (an optical fiber system between Washington and Boston) has been announced. Future issues of ***Notes on the Network*** will address ISDN in depth as the information and deployment strategy concerning ISDN become available.

2. DESCRIPTION OF SECTIONS

NUMBERING PLAN AND DIALING PROCEDURES (SECTION 2)

2.01 A primary concern of any network dialing plan is the creation of a numbering or address system that uniquely identifies each station. A viable numbering plan should reflect uniformity, be convenient to use, and be compatible with existing local and extended area dialing arrangements.

2.02 The numbering system developed over the years for the Network utilizes the principle of destination code routing. Destination code routing is a combination of digits that provides a complete address to reach a specific terminal in the Network. Telephone numbers for the North American Network Numbering Plan consist of two basic parts:

(a) A 3-digit Numbering Plan Area (NPA) code identifying a geographical area

(b) A 7-digit telephone number consisting of a 3-digit central office code and a 4-digit station number.

2.03 As the demand for telephone service increases and more switching systems are added, care must be taken in assigning NPA and central office codes for optimum use of the remaining unassigned code combinations. Parts 4 and 5 discuss relief plans for these codes. Economical utilization of these codes can be accomplished by careful planning and coordination.

2.04 Numbering plan arrangements and dialing procedures for the North American Network Numbering Plan are discussed in Section 2. International numbering arrangements are discussed in Section 10.

THE SWITCHING PLAN (SECTION 3)

2.05 In order that traffic may be routed to its destination in an orderly and economical manner, a switching plan must be defined. This need is met by switching and trunking arrangements that adhere to the rules of a hierarchical network.

2.06 The switching plan takes full advantage of the overall economies offered by alternate routing within the limits of an orderly discipline. With automatic alternate routing, a call which encounters an "all trunks busy" condition on the first route tested is automatically "route advanced" and offered in sequence to one or more alternate routes for completion. Section 3 describes the switching plan in detail.

EQUIPMENT AND SYSTEM REQUIREMENTS (SECTION 4)

2.07 There are several miscellaneous equipment requirements in addition to the signaling requirements detailed in Section 5. Section 4 summarizes these requirements and includes brief discussions of the demands of the Network on station equipment, switching systems, operator systems, automatic equipment for recording message billing data, and miscellaneous central office and network administrative facilities.

2.08 Section 4 includes those specific central office equipment arrangements which interconnect an office with the Network and which provide an interfacing between various operator systems such as the TSPS, Directory Assistance and Intercept, and the Network. The type of equipment employed is not important from the standpoint of the Network as long as the minimum requirements outlined in this section, Section 5 (Signaling), and Section 7 (Transmission Considerations) are met. For this reason, Section 4 covers a number of fundamental considerations regarding miscellaneous and somewhat unrelated items.

SIGNALING (SECTION 5)

2.09 The Network consists of many diverse types of equipment. To ensure that these diverse units function as an integrated entity, detailed information on the interacting signaling and control processes is required. With automatic switching, a complex system of signals is needed to pass information over the Network. These signals include address information for station or terminal identification, information for performing various network control and alerting functions, and supervisory states. They must be designed to actuate and be recognized by switching systems of different types and manufacture and must be capable of being carried accurately and rapidly over many types of transmission facilities.

2.10 Section 5 discusses the address and information signals required for network dialing. Considerable technical information is included to illustrate the nature of the signals themselves as well as typical equipment arrangements required for their generation and detection. Where necessary, the signaling capabilities and requirements of several types of switching and transmission systems are shown for informational background. A number of illustrations and schematic diagrams showing signaling fundamentals are also included. Since basic signaling requirements are essentially the same for both operator- and customer-dialed traffic, no distinction has been made between the two except where necessary.

COMMON CHANNEL INTEROFFICE SIGNALING (SECTION 6)

2.11 Common Channel Interoffice Signaling (CCIS) is a method of signaling between processor-equipped switching systems for which the voice and signaling portions of a call are separated. Essentially, CCIS provides 2-way signaling between switching systems independent of the transmission path of the message circuits.

2.12 Section 6 details the format and information content of CCIS. It also gives details on the advantages, potential, operation, administration, and maintenance of the CCIS system.

TRANSMISSION CONSIDERATIONS (SECTION 7)

2.13 The switching plan contemplates that most calls are to be completed on either direct circuits or over two or three intertoll trunks switched together in tandem. In some instances, a small portion of the calls may encounter as many as seven intertoll trunks within the United States or Canada. To ensure customer satisfaction for all calls and to minimize noticeable differences from one call to another, careful transmission design, as well as concentrated effort in maintaining transmission values close to design objectives, is required.

2.14 Design parameters and objectives for loop and trunk plant are covered in some detail in Section 7. The section is organized by transmission parameters. Within each part, a brief description is made of the parameter, its effect on service, and its control in terms of performance and maintenance objectives.

MAINTENANCE REQUIREMENTS (SECTION 8)

2.15 The objective of an effective overall maintenance plan is to provide a high quality of service at a reasonable cost. This is best accomplished by the use of automatic test and fault recording devices so that troubles may be promptly detected and corrected before they have extensive impact on service. With the expansion and increasing sophistication of the Network, trouble conditions in one part of the Network can have an adverse effect upon other parts. Unless adequate steps are taken to keep trouble conditions within reasonable limits, they not only react unfavorably on the customers, who may be the first to detect them, but also result in inefficient use of the Network.

2.16 Means have been developed for the automatic detection and recording of troubles so that most trunk and equipment troubles may be cleared before they can cause extensive service reactions.

Section 8 describes automatic testing equipment, test lines, and various other testing facilities suited to the needs of the Network together with suggestions for their application.

WIDE AREA TELECOMMUNICATIONS SERVICES (SECTION 9)

2.17 Outward Wide Area Telecommunications Service (Outward WATS) and 800 Service (Inward WATS) are telephone services designed to meet the needs of customers who make or receive substantial volumes of long distance calls. Both Outward WATS and 800 Service are discussed separately since their operations are different.

2.18 Section 9 describes in some detail the line numbering, administrative considerations, and routing considerations for both interstate and intrastate Outward WATS and 800 Service.

INTERNATIONAL DIALING (SECTION 10)

2.19 International Direct Distance Dialing (IDDD) was first introduced in March 1970. At present, IDDD from the United States offers access to 74 countries. This section discusses the worldwide numbering plan which provides each telephone subscriber with a unique telephone number consisting of a country code followed by the national number. It also discusses the routing of traffic between the domestic telephone network and points beyond the North American numbering zone.

2.20 Section 10 describes the International Switching Centers, the International Operating Centers, and the International Originating Toll Centers and how they interface between the domestic network and international dialing.

NETWORK MANAGEMENT (SECTION 11)

2.21 To provide a satisfactory grade of service, an effective network management arrangement is required. Network management encompasses the techniques and organization to ensure optimum use of available facilities under normal load conditions as well as under abnormal load conditions or equipment and facility failure.

2.22 Section 11 gives a conceptual description of network management responsibilities and organization. It also describes the functions and responsibilities of the Engineering and Administration Data Acquisition System/Network Management which collects data on the network performance on a real-time basis.

2.23 Network management actions such as cancellation of alternate routing, line load control, rerouting, and dynamic overload control are also discussed.

SYNCHRONIZATION OF THE DIGITAL NETWORK (SECTION 12)

2.24 The expanding application of digital technologies in the design of facilities and switching systems which are becoming an integral part of the telecommunications network requires that the clock rates between switching systems be synchronized. This section describes the need for synchronization and the hierarchical synchronization network which distributes the synchronizing signal from the Bell System Reference Frequency standard located in Hillsboro, Missouri.

BIBLIOGRAPHY (SECTION 13)

2.25 As mentioned previously, ***Notes on the Network*** is intended to describe the minimum requirements to be met in order to connect with the Network. For further details regarding subjects related to the Network, the Bibliography (Section 13) is furnished for reference.

3. FUNDAMENTAL LONG-RANGE PLANNING

3.01 As customer needs and serving arrangements grow in scope and complexity year by year, the need for thorough planning assumes a higher order of significance in ensuring good service. In addition to the subjects covered in detail in Sections 2 through 12, it may be worthwhile to consider briefly the fundamental plans which are the keystones to the inclusion of any office or service, large or small, in the Network.

3.02 Large sums of money are often required to provide for growth and service innovations tailored to customer needs. Effective planning is the key to ensuring that all network components (switchboards, buildings, trunk facilities, switching systems, and the like) fit together in an efficient and economically sound system.

3.03 Service-oriented planners must acknowledge and answer questions such as: "Where are we going?" (Strategic Planning) and "How do we get there?" (Long-Range and Implementation Planning). A thorough job must be done in assessing the future and determining possible courses of action. There should be an adequate appraisal of the impact on serving arrangements of new services, of modernized services, and of technological innovations. The best course of action should be chosen to implement selected plans and to do so in harmony with a universe of other plans and without impairment of service.

3.04 Planning objectives may be summarized in these terms:

(a) To provide guidance for systematic, orderly growth of the business and maintenance of the planned quality of service

(b) To provide a summation of current and proposed industry objectives so that current operations will have direction and decisions can include considerations of the future as well as present needs

(c) To provide an indication of plant (facilities and equipment), people, and capital required to achieve objectives.

3.05 Fundamental planning includes the following broad fields:

(a) Forecast and analysis of basic traffic data and methods

(b) Plans for equipment to automatically record and process message billing data for direct customer-dialed traffic

(c) Plans and programs for local central offices and customer loops including local numbering

(d) Plans and programs for plant including types of transmission facilities, signaling conditions, and switching equipment

(e) Plans and programs to maximize the use of digital technology in providing facilities and switching systems to evolve toward the ISDN.

3.06 Traffic analysis is an early step in fundamental planning and includes the determination of such items as:

(a) Future routings under the switching plan for the Network

(b) Estimates of future traffic volumes and possible changes in the characteristics of traffic including:

(1) The portion of traffic that can be dialed by customers

(2) The potential for eliminating cordboard handled traffic

(3) The portion of traffic to be handled from and by special service and other networks

(4) The use of the Network for nonvoice traffic.

3.07 Because service improvements and operating economies can be obtained from direct dialing of extra-charge traffic, systems for automatically recording and processing message billing data usually receive early and detailed consideration in fundamental planning. Factors pertaining to this phase of planning include:

(a) The type of station identification to be used

(b) Whether individual recording systems at each local office or one centralized system to serve several offices should be provided

(c) Whether recording systems for person, credit card, and coin traffic should be provided

(d) Traffic volumes to be dialed and the relative proportions of traffic to be detailed or bulk billed

(e) Operating economies which result.

3.08 Fundamental planning for a local exchange to be connected to the Network includes provision for:

(a) A unique 3-digit central office code

(b) A uniform 10-digit telephone number for each station

(c) Segregation of coin boxes (public or semipublic telephones) in certain recommended thousand series to the extent possible

(d) Adequate interception of nonworking station numbers and vacant central office codes

(e) Signaling requirements (as outlined in Section 5)

(f) Customer loop design (as described in Section 7) which will establish the lowest loop loss consistent with economy

(g) Automatic number identification whenever feasible.

3.09 Fundamental planning for switching equipment, outside plant, and terminal facilities takes the following into account:

(a) All plants should be equipped with or arranged for the addition of the features needed to meet the minimum requirements outlined in ***Notes on the Network.***

(b) The most economical transmission facilities which will meet transmission objectives (eg, carrier, radio, voice frequency, etc) should be selected for relief on existing routes and on new routes that may be established. This involves such factors as:

(1) Current and future traffic volumes and trunking requirements for the message network plus requirements for special services

(2) Transmission design objectives under the switching plan with consideration for future integration of transmission and switching facilities

(3) Establishment of an approximate but realistic timetable for the programming of the various phases of mechanization for all dialed traffic

(4) Provision of new routes separated from present routes for protection of service.

3.10 Because the sums invested are large and the service life of most plant involves many years, it is important that fundamental plans be made well in advance of any actual change. This will help smooth the transition to mechanized operation and the introduction of new services. New plant and equipment can be provided in an orderly manner without incurring unwise or unnecessary expenditures. Flexible plans fitted to conditions at a given location can be developed which will permit adjustments as necessary to meet changed conditions and advances in technology. Fundamental plans need frequent review to reflect such changes and advances as they occur in order to be kept current.

4. TOTAL NETWORK OPERATIONS PLAN

4.01 Total Network Operations Plan (TNOP) is used to refer both to a project and a plan. The project is concerned with integrating the efforts of the many organizations at AT&T and Bell Laboratories that are preparing tools to facilitate future operating company operations. This plan is the vehicle used to present the current view of future integrated operations.

4.02 Operations centers are basic elements of the TNOP. An operations center is a group of people reporting to a common manager performing a set of related job functions for a specified geographic area.

4.03 Operations centers are supported by operating methods and, where cost-effective, by mechanization called operations systems. These are computer based systems that are not directly involved in providing telecommunications services to customers, but rather support network operations personnel in the performance of their assigned duties.

4.04 To facilitate planning, the set of network operations centers varies from those that support the local operation to those which are nationwide in scope.

4.05 Some centers have direct responsibility for the actual installation, maintenance, and administration of the Network. Other centers perform their functions in support of line operations for an entire company. In addition, some centers are intercompany. These are typically shared by AT&T Long Lines and operating companies.

4.06 When composite centers are feasible in an operating company environment, the basic centers should be collocated because of operational considerations. In some composite centers, certain job functions may be integrated unless job definitions and work loads dictate otherwise. In addition, there is a greater opportunity for sharing information among the basic centers.

4.07 The TNOP centers are an example of those that provide an operations structure which will permit the Bell System Companies to meet customer and market needs while at the same time maximize the payoff from mechanization of telephone company operations using computer technology. A key aspect is to construct a single, common basis for the planning, development, deployment, and use of operations systems throughout the telephone system for network operations.

4.08 Some specific objectives of the TNOP are as follows:

(a) To formulate a standard industry network operations plan for use by AT&T, the operating companies, and Bell Laboratories

(b) To guide AT&T, Bell Laboratories, and other industry partners planning and development

(c) To guide operating company operations through:

(1) Identification of a set of operations centers which will be supported by detailed methods planning

(2) Definition of the mode of operation for which the operations systems will be configured and designed

(3) Identification of the respective roles of and the evolutionary plans for the set of operations systems as a basis for deployment planning

(4) Definition of the information flows among the operations centers and systems and description of plans for mechanized intercommunications among these centers and systems.

(d) To provide perspective on the expected impact upon expense, capital, and service for the network segment.

4.09 Following are descriptions of centers already implemented that are applicable to the Network:

(a) ***CCIS Network Administration Center (CNAC):*** The CNAC has the responsibility for coordinating the establishment, administration, and operation of the intertoll CCIS network. The CNAC consists of four operating groups with basic responsibilities: Network Planning, Assignment/Administration, Cutover/Conversion, and CCIS 800 Service. To accomplish these responsibilities, the CNAC makes use of several support systems such as Planning and Analysis, Schedule Office Conversion and Cutover, Trunk Forecast, Signal Path Assignment Record Keeping System, and CCIS Network Total Administration System. The CNAC is also responsible for the services dependent on the CCIS network. The CNAC is located in Cincinnati, Ohio, and is staffed by AT&T Long Lines.

(b) ***Circuit Administration Center (CAC):*** The CAC has the basic responsibility of administering the trunk network. This involves the trunk servicing function of determining trunk requirements (demand and busy season) and issuing message trunk orders. Trunk forecasting for 1 to 5 years is also a CAC function. The CAC performs the network routing function which involves administering network routes and issuing Network Routing Orders. The CAC also performs record/schedule base management, data validation, and information exchange functions.

(c) ***Electronic Systems Assistance Center—No. 4 ESS (ESAC-4E):*** The ESAC-4E is a national staff support center that provides technical guidance for the No. 4 ESS operations. It is staffed by technical experts who consult on a complex trouble resolution and on the procedures for complex or new installation and software updates. If necessary, requests for trouble assistance are escalated to the Western Electric Regional Diagnostic Center or the national Western Electric Product and Engineering Control Center. Also included in the ESAC-4E is representation from the Maintenance Engineering organization. In general, the ESAC-4E can access the No. 4 ESS machine and the Switching Control Center System only after obtaining approval from the appropriate Switching Management Control Center.

(d) ***Machine Administration Center (MAC):*** The MAC is responsible for monitoring No. 4 ESS translations, performance, and equipment utilization through surveillance to ensure adequate service levels. The MAC is also responsible for traffic data and circuit order administration for the No. 4 ESS.

(e) ***Switching Control Center-Stored Program Control System (SCC-SPCS):*** The SCC-SPCS is responsible for the installation and maintenance of switching, message trunks, carrier, frame, special services, power, and billing equipment in Stored Program Control (SPC) central offices. It is also responsible for administration of all central office forces unless there is a separate Frame Control Center or Trunk Facility Control Center.

5. NEW SERVICES

5.01 As SPC and CCIS expand, their inherent power and flexibility make many new and innovative network capabilities possible. These capabilities are known collectively as Direct Services Dialing Capabilities (DSDC) and are based on the CCIS direct signaling capabilities described in Section 6. Currently, two major DSDC programs are planned for introduction in the early 1980s:

(a) ***Auto Bill Calling:*** One application, currently under development, is Auto Bill Calling (ABC). This capability allows a caller at a TOUCH-TONE® telephone to dial 0 plus the number being called. A tone or prompting announcement is heard whereupon the caller dials a billing number and a Personal Identification Number (PIN) associated with it. Such a call is routed to a TSPS or an equivalent system which uses CCIS to query a special billing data base to verify the billing information. If the billing information is valid, the call is allowed to proceed with no operator required. This can be thought of as automating credit card service which presently uses an operator.

Another version of ABC can be used when the billing number is the same as the called number, ie, when the call is collect. In this case, the caller dials 0 plus the called number and, after the prompt, simply dials the PIN associated with the called number. This automation of collect calls is useful in situations where the subscriber is expecting the collect call and "preauthorizes" it by disclosing their PIN to the caller.

(b) ***800 Service:*** Another application which is currently under development is an improved 800 Service. 800 Service is very popular and heavily used. However, it utilizes relatively inflexible routing techniques so that a different 800 number must be used for interstate and intrastate calls, and customers must change their 800 number if they wish to move their answering point to a different location within the country. In the improved version, on each 800 number call, a specially assigned telephone number will be obtained from a central data base using CCIS and the call will be routed to this number the same as any normal call. For each 800 number, the special telephone number can be a function of the originating area code, the time of day, and/or the day of the week. Later, when CCIS capability is available at the terminating central office, the routing can be based on the busy/idle status of the destination. Moreover, if all the lines at the destination are busy, the busy tone can be applied at the originating end of the call, thereby, effecting significant facility savings.

5.02 Besides 800 Service and ABC, which are scheduled for introduction, a large number of other new capabilities which utilize the SPC network have been proposed. Although no firm decisions have been made, it is expected that some of these capabilities may be introduced in the mid 1980s. Some future capabilities that CCIS could provide are:

- Using a single nationwide number to reach a ***function*** (not a location), such as the nearest hospital, poison control center, or the nearest local outlet of a specific retailer, real estate franchiser, or government agency
- Using a telephone number to reach a ***person*** (not a telephone) wherever he/she may be in the country
- Using the Network to track the location of people traveling throughout the country, such as vacationers or truck drivers
- Forwarding information about the call, such as the calling number to the terminating end, in order to selectively apply Call Waiting tones, make the phone ring distinctively on certain calls, or provide other uses.

NOTES ON THE NETWORK

SECTION 2

NUMBERING PLAN AND DIALING PROCEDURES

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Figures

1. GENERAL

1.01 An essential element of network dialing is a numbering system wherein each main station has a unique address which is convenient to use, readily understandable, and identical in its format to those of all other main stations connected to the network. With such a numbering system, operators or customers, wherever located, may use this address or an unambiguous shortened form to reach the desired telephone through the network. This is called "destination code" routing and is described more fully in Section 3.

1.02 The routing codes for network dialing within the North American Numbering Plan consist of two basic parts:

(a) A 3-digit area or Numbering Plan Area (NPA) code

(b) A 7-digit telephone number made up of a 3-digit Central Office (CO) code plus a 4-digit station number.

1.03 Together, these ten digits comprise the network "address" or "destination code" for each telephone. This arrangement is shown below as it was used at the end of 1973 prior to the introduction of "interchangeable central office codes" discussed in Part 4 of this section.

AREA CODE	TELEPHONE NUMBER
N 0/1 X†	NNX-XXXX

Where N = Digits from 2 through 9

0/1 = The digit 0 (zero) or 1

X = Digits from 0 through 9

† Excludes N11 codes

1.04 When the network dialing plan was first envisioned in the 1940s, a numbering plan was designed whereby any telephone within the area encompassed by the North American Numbering Plan would be identified by a unique 10-digit address slightly different from that shown previously. While the 3-digit area code was identical, the 7-digit telephone number was in 2 letter-5 digit (2L-5D) form. The two letters used were usually the first two of the serving exchange or building name. This initial arrangement provided 152 area codes, each with a capacity of 540 CO codes.

1.05 The growth in telephones experienced in the 1950s was sufficient to indicate that the life of many area codes would be unsatisfactorily short if the 2L-5D arrangement was perpetuated. As a result, All Number Calling (ANC) was introduced, and all companies providing service within the North American Network were requested not only to avoid the use of any new 2L-5D numbers but also to convert all such existing numbers to ANC as soon as practical. The latter task has been completed in 1980 with 100 percent of the telephones assigned ANC numbers. With ANC, the CO code universe was expanded from 540 to 640. The increase resulted from the added availability of number combinations previously obviated by the lack of names that could be structured from the letters associated with the digit combinations 55, 57, 95, and 97 together with the addition of the originally reserved NN0 code group.

1.06 It has been apparent for many years that additional code relief would be required to extend the life of the North American Numbering Plan to the end of the twentieth century. The relief plan adopted requires that codes previously reserved for only NPA code assignment be used as CO codes also and vice versa. This arrangement, called "interchangeable codes" necessitates certain special equipment arrangements and dialing procedures that are discussed in this section.

2. AREA CODES

2.01 The entire United States and Canada, certain Caribbean Islands, and parts of Mexico have been divided geographically into NPAs and assigned NPA codes. In addition, a few NPA codes have been assigned for special purposes and are known as Special Area Codes (SACs). These special purposes include 800 Service, TWX service, and DIAL-IT services. Figures 1 and 2 list the NPA codes assigned through 1979 numerically and alphabetically by areas served, respectively. Figures 3 and 4 show the geographic boundaries of NPAs in the United States and Canada as of the end of 1979, respectively. The assignment of area codes is controlled by the AT&T Assistant Vice President—Network Planning.

2.02 The initial group of 152 codes reserved for NPA use was in the N 0/1 X format, whereas CO codes were in the NNX format. These two groups of codes were completely nonambiguous in that the second digit of an NPA code was always either "0" or "1" and the second digit of a CO code was always within the digit series "2" through "9". This arrangement made it possible in common control systems to distinguish between NPA and CO codes by examination of the second digit dialed, for switching equipment to advance a call only on a 10-digit basis if a "0" or "1" was in the second position, and to advance the call on a 7-digit basis in all other cases. (In the special case of N11 codes, screening of the third digit received for the digit "1" permits call advance after receiving only three digits.) Equipment economies are achieved by this simple screening process when Home NPA (HNPA) calls are completed on a 7-digit basis and Foreign NPA (FNPA) calls on a 10-digit basis in all but exceptional cases.

2.03 Some time after 1995, it is estimated that the 21 NPA codes still unassigned (end of 1979) will have been used and that it will be necessary to start using NNX-type codes as NPA codes. In the interest of minimizing ambiguity, it is planned to assign the NN0 codes first in accordance with the sequence shown in Fig. 5. (The NN0 codes have been designated as the last to be assigned as CO codes; a sequence that is the reverse of that for NPA code assignment is recommended.) Ultimately, it will become necessary to assign the remaining NNX codes for NPA code purposes.

2.04 NPAs have been created in accordance with principles that tend to maximize customer understanding while minimizing both dialing effort and telephone plant cost. Boundaries are established to last for long periods of time and their locations are based on estimates of future requirements at the time they are drawn. Reevaluation of boundaries created many years in the past sometimes suggests that better ones could have been selected. However, making changes after the passage of time would often cause both massive customer disruption, numerous number changes, and expensive plant rearrangements. Principles to be considered in planning NPA boundary changes resulting from either the creation of new NPAs or the realignment of existing ones are as follows:

(a) Boundaries ***must not*** extend across state lines.

(b) Boundaries should coincide with other political subdivision boundaries where practical.

(c) When (b) above is impractical, boundaries should follow recognizable physical geographic features or structures, ie, rivers, large lakes, mountain ranges, and major highways.

(d) Boundaries should be drawn so as to minimize the splitting of communities of interest or recognized metropolitan areas looking both at the present and the future.

(e) All of the tributaries of a toll center or toll point should be within the same NPA.

(f) Network planning should recognize the economics of alternative boundary alignments. Since the network costs of introducing interchangeable codes for NPA designation are substantial, boundary alignment studies should acknowledge the differences between plans in future network costs.

(g) Any customers affected by a boundary realignment should not be affected by any subsequent realignment for at least 10 years.

2.05 The 152 N 0/1 X codes originally designated for NPA use will have to be supplemented with NNX codes to meet NPA requirements. This will require the introduction of interchangeable code arrangements throughout the North American Numbering Plan in accordance with paragraph 4.03. Since equipment arrangements are fundamentally the same for either interchangeable CO codes or interchangeable NPA codes, minimal changes will be required when the latter are introduced in those NPAs where interchangeable CO codes have already been implemented.

3. CENTRAL OFFICE CODES

3.01 The universe of NNX codes available for CO code use (prior to the introduction of interchangeable codes) numbers 640. However, within the universe, there are seven codes that have been reserved on a network-wide basis for special uses as follows:

Toll Directory Assistance	555
Future New Services	950
DIAL-IT Services	976
Plant Test	958 and 959
Time	844
Weather	936

Since time and weather services are expected to be included in DIAL-IT services, codes 844 and 936 will eventually become available for CO code use.

3.02 Inasmuch as the provision of CO code relief for any NPA involves substantial expenditures for both plant rearrangements and additions, it is essential that CO codes not be utilized when such use is either for convenience alone or for minor or temporary economic advantage. Further, CO codes already in use often can be recaptured for better use. Failure to utilize CO codes carefully and fully would advance the exhaust dates of individual NPAs and require the premature assignment of the remaining spare codes designated for NPA use. The consequence of such assignments would be advancement of the date when major expenditures would be incurred throughout the North American Network for the introduction of NNX type codes as NPA codes. Following is a list of CO code conservation measures recommended for CO code administration:

(a) The establishment of new wire centers is often predicated on economics to be achieved in outside plant construction. It should be recognized that each new wire center requires a CO code which also has a significant cost, though a future one, that must be considered in economic evaluations of alternative plans.

(b) The use of multiple CO codes in the same wire center for rate discrimination purposes is discouraged unless reasonably full use of the codes is anticipated within the expected life of the CO code universe of the NPA involved. Typical situations where this problem arises include the provision of foreign exchange service from a wire center other than the one serving the foreign exchange, the consolidation of small exchanges served by multiple wire centers into a single wire center without the merging of exchanges, and the provision of 2-way optional extended area service.

(c) With the continuing reduction of multiparty service, terminal-per-line equipment in step-by-step offices is inefficient in its use of telephone numbers and CO codes. Plans for new CO units and replacement units should be based on terminal-per-station equipment with its larger number fill potential.

(d) Code protection is an arrangement wherein a CO code assigned in one NPA is excluded from assignment in an adjacent NPA in order to permit 7-digit dialing across the common boundary. This is a permissible arrangement and has advantages where a community of interest bridges the boundary in question but is acceptable only as long as it can be continued without causing the exhaustion of the CO code universe in the NPA protecting the code. Before undertaking a code protection arrangement, the problems of undoing it should be thoroughly evaluated.

(e) CO codes should not be dedicated to individual Direct Inward Dialing (DID) customers, but shared with other DID or non-DID customers. The single exception would be a DID customer whose anticipated number requirement will approach the administrative maximum number fill for a CO code. This can be accomplished by the use of a combination of 5-digit, intra-PBX dialing and 2-digit access codes for tielines, dial dictation, paging services, attendant, etc.

(f) The multiline hunting feature provided in newer type central office equipment eliminates the necessity of assigning individual consecutive telephone numbers to each line in a hunting line group. (Of course, customer functions identified by number, including night connections, may still require individual line numbers.) The replacement of step-by-step and panel systems offers number conservation opportunities through this feature.

(g) As common control offices utilizing multiple CO codes diminish in station capacity due to limited call carrying capacity, it is often possible through careful number administration to recapture a code for reuse in another entity.

(h) The CO codes reserved for growth in specific areas of step-by-step oriented NPAs should be reviewed frequently for possible recapture by virtue of either changes in the forecasted growth patterns or a reduction in routing restrictions resulting from the replacement of step-by-step equipment with common control units.

(i) CO code sharing may be used if the entities involved are within the same toll rate exchange area and there are economic benefits to be gained. Code sharing is the assignment of the same CO code to two or more entities, thereby gaining increased utilization of station numbers in low fill offices. The offices are differentiated by the thousands, or "D" digit, of the station number. Code sharing is limited because of the costs associated with providing "D" digit translation, additional trunking, redesign of automatic rating equipment and coin raters, modification of AMA equipment, and modification of the billing system.

It should be noted that Measured Service will tend to reduce the opportunities for code sharing because of the shrinking of "free-calling" areas and the need to identify new rate zones for billing purposes.

(j) Special CO codes dedicated for miscellaneous purposes such as customer instruction, special billing, mass calling announcement services, etc, should be kept to a minimum.

(k) The CO codes dedicated for plant test and official communication purposes should be minimized. While certain types of older common control central office equipment require as many as 20 dedicated codes and certain coexisting combinations as many as 21, it is expected that, by the late 1980s, this number will be reduced to five codes of the CO code type including 958 and 959.

4. CODE RELIEF

4.01 It has been necessary in recent years to augment the supply of CO codes for some NPAs and this activity will continue as long as telephone number growth continues. Once the CO code conservation measures discussed in paragraph 3.02 have been exploited, the alternatives available to achieve CO code relief are:

(a) Realign NPA boundaries (applies only to multi-NPA states)

(b) Introduce interchangeable CO codes within NPA requiring relief

(c) Split existing NPA and introduce a new area code.

4.02 Basic economic consideration and design in the initial switching machines have made it possible for the equipment to readily distinguish between NPA codes and CO codes. However, since the introduction of interchangeable codes precludes the ability of central office equipment to determine whether to expect a 7- or 10-digit call based on the presence of a "0" or "1" in the "B" or second-digit position, a new methodology is required to distinguish 7-digit calls. Two basic means of accomplishing this have been known for many years.

(a) The ***"timing method"*** requires that central office equipment be arranged to wait for a period of 3 to 5 seconds after receiving seven digits (excluding the prefix digit "0" or "1") to distinguish between 7- and 10-digit toll calls before routing a call on a 7-digit basis. If one or more additional digits are received within this critical 3- to 5-second "time-out" interval, the equipment expects a 10-digit call. With the use of pretranslation, however, timing will be restricted to only those calls having code ambiguity and will preclude timing on all local station calls.

(b) The preferred arrangement, which is called the "***prefix method***," utilizes the presence of either a "1" or "0" prefix to identify the call being dialed as having a 10-digit format. This arrangement has disadvantages in that it requires all customer-dialed, operator-assisted traffic to be dialed on a "0" + 10-digit basis and that, in areas with step-by-step equipment, HNPA station toll calls would have to be dialed on a "1" + 10-digit basis until the equipment is replaced. On the other hand, there are the advantages that the larger cost of providing for timing and customer irritation arising from both increased post-dialing delay and reaching wrong numbers due to inadvertent time-out are precluded.

4.03 It is recommended that the prefix method be used to solve the 7-digit/10-digit ambiguity problem. Extensive studies conducted by Bell Laboratories indicate that, on an individual call basis, customers prefer to dial three additional digits rather than waiting for a call to time out. Bell Laboratories also points out that the advantages of new technology in decreasing post-dialing delay are more readily achieved under the prefix method. In areas without step-by-step equipment, the prefix method imposes the incremental 3-digit dialing requirement on only "0+" HNPA traffic; but in areas with step-by-step equipment, the additional three digits also would be required for all HNPA station toll traffic. On the other hand, the timing method, which utilizes pretranslation capability to limit timing to only those calls involving an ambiguous code in the first three digits dialed, will be relatively innocuous when first introduced but will become increasingly noticeable as code ambiguity expands.

4.04 The customer irritation that would occur as a result of the introduction of either method within an NPA is difficult to quantify because it is not solely attributable to irritation associated with a particular type of call multiplied by the frequency of that type of call. It is complicated by the diversity of call placing experiences. Unusual experiences, such as waiting occasionally for time-out, can overshadow numerous experiences where time-out does not occur. In the long term, step-by-step equipment will be replaced with electronic equipment and only "0+" HNPA traffic, a very small portion of all traffic, will be affected by either method. Evidence indicates that the prefix method will unquestionably be preferable in that time frame.

4.05 The standard customer dialing procedures recommended for the long term when step-by-step is replaced are as follows:

- HNPA—7 digits

- FNPA—1 + 10 digits

- Operator-assisted HNPA and FNPA—0 + 10 digits.

The interim recommendations for customer dialing procedures are shown in Fig. 6.

5. TERMINATING TOLL CENTER AND OPERATOR CODES

5.01 A Terminating Toll Center (TTC) code is normally assigned to each Control Switching Point (CSP) and toll center whether it be class 1, 2, 3, or 4C as defined in Section 3. One switching office per NPA, usually the principal city, is identifiable without a TTC code from points external to the NPA. The principal use of these codes is to enable outward operators to reach inward, directory assistance, "leave word," and other specific operators in distant city toll centers. A secondary use is by maintenance personnel to reach test equipment in distant offices. All code assignments for TTCs are within the "0XX" series.

5.02 Operator Codes (OpCs) are used exclusively by outward operators to designate specific operator groups associated with toll centers. Most OpCs are 3-digit only, eg, "121" for inward and "131" for directory assistance. "Leave word" codes are either four or five digits and are in the "11XX" or "11XXX" series. Switching offices with nationally published TTCs operate with 11XX leave word codes. All toll centers without a discrete TTC code assigned, usually principal city offices, must use 11XXX leave word codes.

5.03 Outward operator dialing procedures are typified by the following examples of calls placed to inward operators:

ORIGINATING LOCATION	TERMINATING LOCATION	CODES DIALED	DIGITS DIALED (EXAMPLE)
FNPA	Nonprincipal City	NPA+TTC+OpC	216+046+121
FNPA	Principal City	NPA+OpC	216+121
HNPA	Nonprincipal City	TTC+OpC	046+121
HNPA	Principal City	OpC	121 or a locally assigned 0XX+121

5.04 In order to prevent customers from dialing directly to special groups of operators and as a protection against fraudulent use of the service, it is necessary to arrange the equipment in all recording offices to block all customer-dialed calls with a "0" or "1" in the fourth-digit position of 10-digit calls as well as calls with a "0" or "1" in the first-digit position.

5.05 Special use of 3-digit codes in the "0XX" and "1XX" series is made within the network on a machine-generated basis for discrete routing purposes such as 800 Service and international services.

6. CUSTOMER DIALING PROCEDURES

6.01 The long-range standard dialing format assumes all switching systems throughout the North American Network to be electronic and use the prefix method described in Part 4 for machine identification of interchangeable codes as follows:

(a) Seven digits for all local calls, including those to an FNPA where there is code protection, and toll calls within the HNPA

(b) 1 + 10 digits for all FNPA customer-dialed station toll calls

(c) 0 + 10 digits for all HNPA and FNPA customer-dialed toll calls requiring operator assistance.

6.02 A long-term network objective is to standardize the dialing procedure for each type of call in all areas. This, however, is unlikely as long as the capabilities of the switching equipment in use differ. It is expected that multiple dialing procedures will be a practical necessity for many years to come because of the variety of equipment expected to be in use. Figures 6 and 7 outline recommendations for the dialing procedures for all types of direct dialed calls placed within the network except for those utilizing N11 codes. Figure 6 shows dialing procedures for areas ***with step-by-step*** equipment while Fig. 7 shows dialing procedures for areas ***without step-by-step*** equipment. It is urged that the recommendations outlined be followed in the interest of minimizing customer confusion and that any necessary changes in working toward the ultimate arrangement be made as early as practical.

6.03 For several years, some of the Bell Operating Companies have used the "611" code for access to Repair Service and the "811" code for access to the Business Office. The universal adoption of these previously recommended procedures has been impractical because of the high costs involved in activating these codes in some areas. Recently, the Bell Operating Companies have been expanding their use of different Business Offices for different classes of service and Repair Service Centers have been similarly divided in some locations. While additional N11 codes could probably be assigned to accommodate these changes, the expenditures required for modifying the switching equipment would be excessive in most areas. The resulting long-term impracticality of making N11 codes universal for these purposes suggests the use of 7-digit numbers for any future splintering of these services and the gradual phasing out of "811" as opportunities present. However, with the advent of the Centralized Repair Service Attendant Bureau (CRSAB) concept for both the residence and business market segments, the use of "611" and/or 7-digit numbers has been recommended. In addition, it has been recommended that the long-range CRSAB access arrangement involves the use of 800 Service numbers when Common Channel Interoffice Signaling (CCIS) is implemented in the network. In the interim, the use of these N11 codes should be considered as optional, but their use should be uniform within metropolitan or directory serving areas.

6.04 All N11 codes, exclusive of "411" and "911", should be kept available for future special services but may be used as temporary test codes, provided that such use can be stopped on short notice. Public emergency service should always be dialed as "911". The use of a "1" prefix is unacceptable.

6.05 International Direct Distance Dialing (IDDD) was first introduced in 1970 and is being expanded to many locations in the network. The prefixes "011" for station calls and "01" for operator-assisted calls are now widely (but not universally) applied. Code "010" dialed without subsequent digits is reserved for possible use in connection with overseas assistance. See Section 10 for details on international dialing.

6.06 The dialing code for operator assistance is "0" (zero).

6.07 Directory assistance calls should be dialed in accordance with the procedures outlined in Fig. 8.

6.08 In areas where optional Extended Area Service (EAS) is offered, calls to certain points are local (not detailed billed) for customers who select the optional EAS plan; whereas, they are toll for the remaining customers. In these areas, the dialing procedures for ***all*** customers should be identical because of the gross awkwardness and impracticality of instructing customers to use differing procedures. In addition, the equipment and trunking arrangements would in many instances be inordinately costly. The single group of dialing procedures used in these areas must be those that favor the limited service offering rather than the EAS offering.

6.09 Local equipment arrangements in some locations permit the dialing of local calls on less than a 7-digit basis. However, all telephone numbers must actually be formatted in accordance with paragraph 1.03 in order to be directly dialable from other network points. Thus, with regular 10-digit numbers assigned to telephones in these locations, recommended dialing procedures as shown in Fig. 6 must be adopted even though less than 7-digit dialing of local calls is possible due to the use of "digit-absorbing" selectors or equivalent equipment.

6.10 The standard network uses of the TOUCH-TONE® telephone symbols * (star) and # (number sign or square) are as follows:

> * ***used as a prefix***—Currently being planned as the dialing arrangement for central office vertical services in No. 1/1A ESS offices. The symbol * plus a 2- or 3-digit access code will be dialed by a customer wishing to access a central office

vertical service. The digits 11 are the rotary dial equivalent of the * symbol.

* ***used as a suffix***—Reserved for future services.

used as a prefix—Future wideband data services.

used as a suffix—IDDD and custom calling services to cancel timing.

7. CENTRAL OFFICES SERVING SEVERAL NPAs

7.01 A central office location near the boundary of an NPA may furnish service to customers in one or more adjacent NPAs. In such cases, it is necessary to assign separate and different CO codes to the groups of customers within each NPA and to arrange the central office equipment so as to route all calls properly and record appropriately for billing. The dialing procedures to be used must be selected on the basis of whether or not code protection exists.

8. NUMBERING OF COIN STATIONS

8.01 Coin stations (public or semipublic telephones) should be numbered in the 9000 series, eg, 225-9XXX. The present operating practices provide for checking coin telephones on collect calls in the 9000 series only. Use of other numbers for coin stations should be avoided. On collect calls, the outward or originating operator must determine whether or not a coin station is being called. If the called telephone number is in the 9000 series, the operator will determine either from a switchboard bulletin or directory assistance operator if the called central office has coin stations.

8.02 The larger Bell and Independent exchanges, for the most part, have their coin numbers segregated in the 9000 series. In small exchanges employing digit-absorbing selectors, such segregation may make certain CO codes unusable or may require another stage of selectors. Nevertheless, segregation of coin stations in all exchanges is desirable to gain overall operating efficiency by reducing operator work time on collect calls.

ASSIGNED NUMBERING PLAN AREAS AND CODES BY AREA OR SPECIAL AREA CODE IN NUMERICAL ORDER

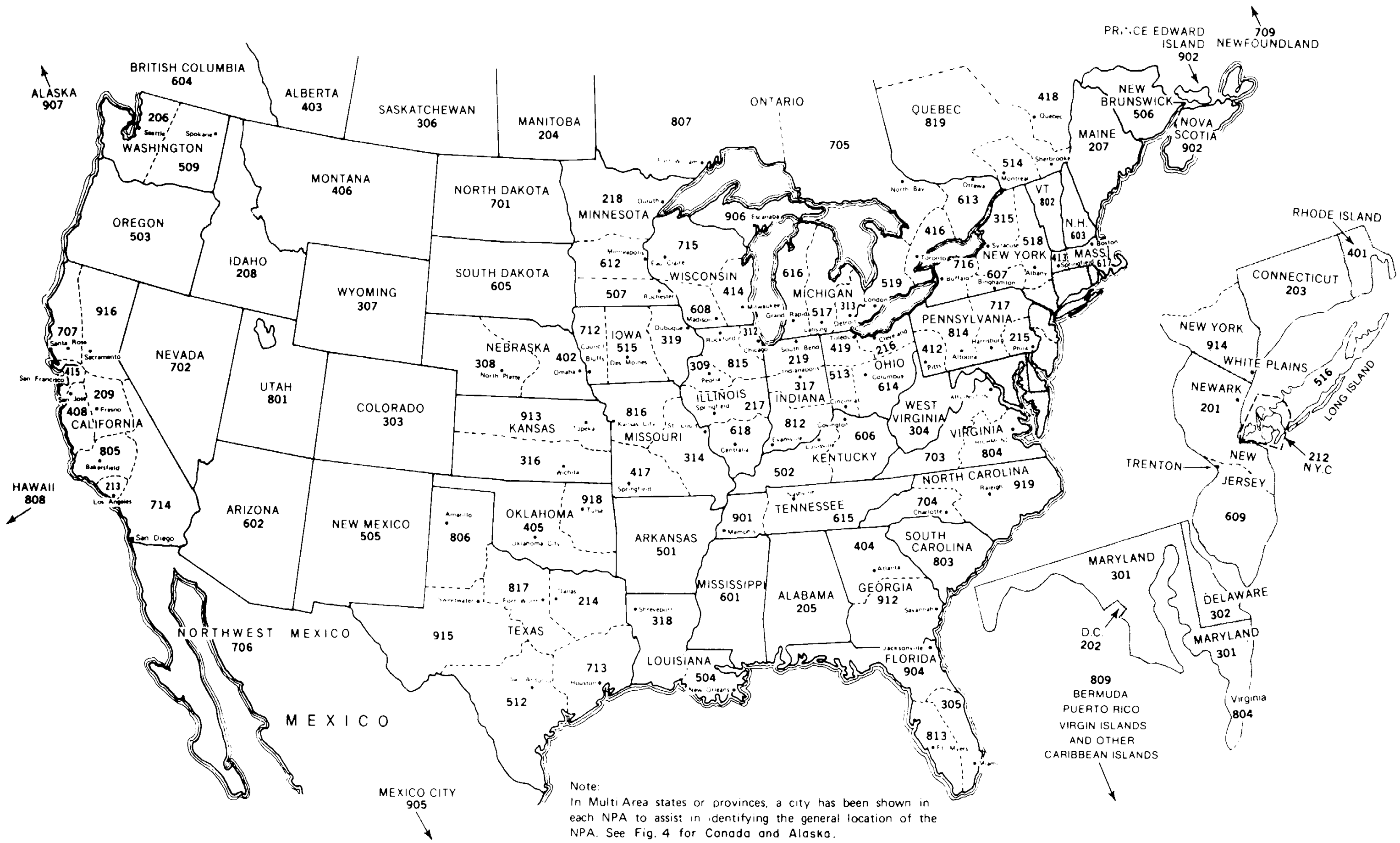
AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE	STATE/PROVINCE OR OTHER SPECIAL USE
201	New Jersey	417	Missouri	710	TWX (United States)
202	District of Columbia	418	Quebec	712	Iowa
203	Connecticut	419	Ohio	713	Texas
204	Manitoba			714	California
205	Alabama	501	Arkansas	715	Wisconsin
206	Washington	502	Kentucky	716	New York
207	Maine	503	Oregon	717	Pennsylvania
208	Idaho	504	Louisiana		
209	California	505	New Mexico	800	800 Service
212	New York	506	New Brunswick	801	Utah
213	California	507	Minnesota	802	Vermont
214	Texas	509	Washington	803	South Carolina
215	Pennsylvania	510	TWX (United States)	804	Virginia
216	Ohio	512	Texas	805	California
217	Illinois	513	Ohio	806	Texas
218	Minnesota	514	Quebec	807	Ontario
219	Indiana	515	Iowa	808	Hawaii
		516	New York	809	Bermuda, Puerto Rico, Virgin Islands of the United States, and other Caribbean Islands
301	Maryland	517	Michigan		
302	Delaware	518	New York		
303	Colorado	519	Ontario		
304	West Virginia			810	TWX (United States)
305	Florida	601	Mississippi	812	Indiana
306	Saskatchewan	602	Arizona	813	Florida
307	Wyoming	603	New Hampshire	814	Pennsylvania
308	Nebraska	604	British Columbia	815	Illinois
309	Illinois	605	South Dakota	816	Missouri
312	Illinois	606	Kentucky	817	Texas
313	Michigan	607	New York	819	Quebec
314	Missouri	608	Wisconsin		
315	New York	609	New Jersey	900	DIAL-IT Services
316	Kansas	610	TWX (Canada)	901	Tennessee
317	Indiana	612	Minnesota	902	Nova Scotia and Prince Edward Island
318	Louisiana	613	Ontario		
319	Iowa	614	Ohio	904	Florida
		615	Tennessee	905	Mexico City
401	Rhode Island	616	Michigan	906	Michigan
402	Nebraska	617	Massachusetts	907	Alaska
403	Alberta	618	Illinois	910	TWX (United States)
404	Georgia			912	Georgia
405	Oklahoma	701	North Dakota	913	Kansas
406	Montana	702	Nevada	914	New York
408	California	703	Virginia	915	Texas
412	Pennsylvania	704	North Carolina	916	California
413	Massachusetts	705	Ontario	918	Oklahoma
414	Wisconsin	706	Northwest Mexico	919	North Carolina
415	California	707	California		
416	Ontario	709	Newfoundland		

Fig. 1—Numeric List of NPAs Assigned at End of 1979

ASSIGNED NUMBERING PLAN AREAS AND CODES BY GEOGRAPHICAL LOCATION OR SPECIALIZED USE IN ALPHABETICAL ORDER

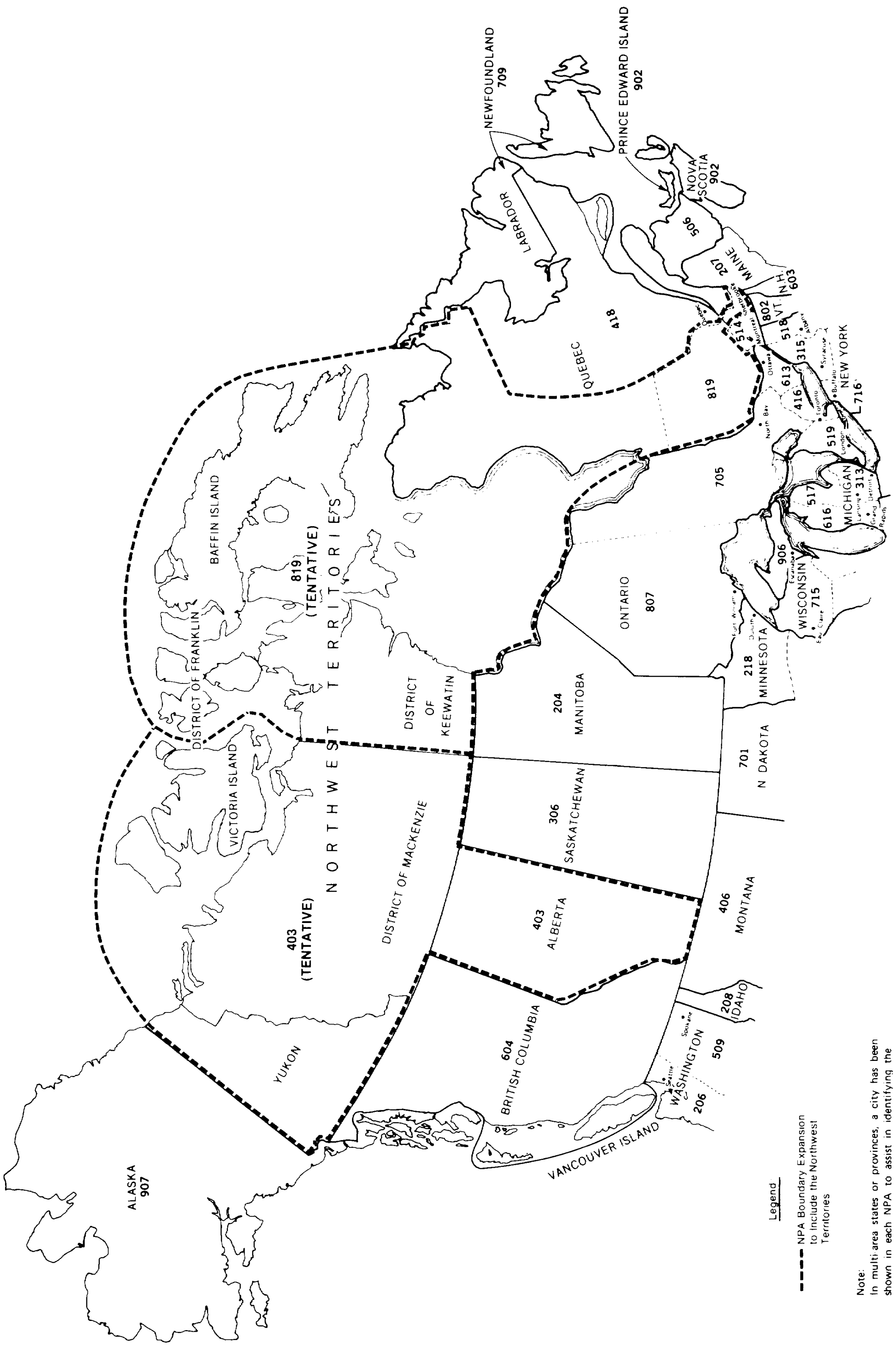
STATE/PROVINCE OR OTHER SPECIAL USE	AREA CODE
Alabama	205
Alaska	907
Arizona	602
Arkansas	501
Bermuda, Puerto	809
Rico, Virgin Islands	809
of the United States,	809
and other Carribbean	
Islands	809
California	209
California	213
California	408
California	415
California	707
California	714
California	805
California	916
Canada:	
Alberta	403
British Columbia	604
Manitoba	204
New Brunswick	506
Newfoundland	709
Nova Scotia and	902
Prince Edward Island	902
Ontario	416
Ontario	519
Ontario	613
Ontario	705
Ontario	807
Quebec	418
Quebec	514
Quebec	819
Saskatchewan	306
Colorado	303
Connecticut	203
Delaware	302
DIAL-IT Services	900
District of Columbia	202
Florida	305
Florida	813
Florida	904
Georgia	404
Georgia	912
Hawaii	808
Idaho	208
Illinois	217
Illinois	309
Illinois	312
Illinois	618
Illinois	815
Indiana	219
Indiana	317
Indiana	812
800 Service	800
Iowa	319
Iowa	515
Iowa	712
Kansas	316
Kansas	913
Kentucky	502
Kentucky	606
Louisiana	318
Louisiana	504
Maine	207
Maryland	301
Massachusetts	413
Massachusetts	617
Mexico:	
Mexico City	905
Northwest Mexico	706
Michigan	313
Michigan	517
Michigan	616
Michigan	906
Minnesota	218
Minnesota	507
Minnesota	612
Mississippi	601
Missouri	314
Missouri	417
Missouri	816
Montana	406
Nebraska	308
Nebraska	402
Nevada	702
New Hampshire	603
New Jersey	201
New Jersey	609
New Mexico	505
New York	212
New York	315
New York	516
New York	518
New York	607
New York	716
New York	914
North Carolina	704
North Carolina	919
North Dakota	701
Ohio	216
Ohio	419
Ohio	513
Ohio	614
Oklahoma	405
Oklahoma	918
Oregon	503
Pennsylvania	215
Pennsylvania	412
Pennsylvania	717
Pennsylvania	814
Rhode Island	401
South Carolina	803
South Dakota	605
Tennessee	615
Tennessee	901
Texas	214
Texas	512
Texas	713
Texas	806
Texas	817
Texas	915
TWX:	
Canada	610
United States	510
United States	710
United States	810
United States	910
Utah	801
Vermont	802
Virginia	703
Virginia	804
Washington	206
Washington	509
West Virginia	304
Wisconsin	414
Wisconsin	608
Wisconsin	715
Wyoming	307

Fig. 2—Geographical Areas Served by NPAs Assigned at End of 1979



Note:
In Multi Area states or provinces, a city has been shown in each NPA to assist in identifying the general location of the NPA. See Fig. 4 for Canada and Alaska.

Fig. 3—NPA Map of Continental United States



Legend

▬ ▬ ▬ NPA Boundary Expansion to Include the Northwest Territories

Note:
In multi area states or provinces, a city has been shown in each NPA to assist in identifying the general location of the NPA.

Fig. 4—NPA Map of Canada and Alaska

ASSIGNMENT OF THE 63† NNO CODES

There are 36 NN0 codes which should be assigned as CO codes, to the extent practical, in the following sequence:

SEQUENCE NUMBER	NNO CODE	SEQUENCE NUMBER	NNO CODE
1	530	19	640
2	420	20	280
3	870	21	790
4	780	22	370
5	440	23	320
6	360	24	890
7	920	25	770
8	830	26	690
9	620	27	840
10	390	28	820
11	340	29	540
12	330	30	350
13	560	31	970‡
14	670	32	990
15	630	33	960
16	430	34	860
17	270	35	980
18	750	36	460

When these 36 NN0 codes are used, the remaining 27 NN0 codes should be assigned, to the extent practical, as CO codes in the following sequence:

SEQUENCE NUMBER	NNO CODE	SEQUENCE NUMBER	NNO CODE
37	380	51	850
38	570	52	730
39	880	53	720
40	760	54	680
41	450	55	660
42	930	56	490
43	740	57	250
44	580	58	220
45	550	59	650
46	470	60	590
47	290	61	520
48	240	62	480
49	230	63	260
50	940		

When the supply of the 152 N 0/1 X codes is exhausted, the above codes will be assigned, to the extent feasible, as area codes in the reverse sequence from that shown; namely, 260 first, 480 second, 520 third, etc, with 530 last.

† The sixty-fourth NN0 code (950) is reserved for future use.

‡ This code is temporarily used network-wide as a plant test code.

Fig. 5—NNO Code Assignment Sequence List

TYPE OF CALL	WITHOUT INTERCHANGEABLE CO CODES					WITH INTERCHANGEABLE CO CODES†				
	PREFIX	AREA CODE	CO CODE	STA NO.	USE	PREFIX	AREA CODE	CO CODE	STA NO.	USE
LOCAL – DIRECT-DIALED:										
HNPA			NNX-	XXXX	R			NXX-	XXXX	R
	1+		NNX-	XXXX	NR	1+		NXX-	XXXX	NR
		N 0/1 X +	NNX-	XXXX	NR		N 0/1 X +	NXX-	XXXX	NR
	1+	N 0/1 X +	NNX-	XXXX	P	1+	N 0/1 X +	NXX-	XXXX	P
FNPA (Protected Codes)			NNX-	XXXX	R			NXX-	XXXX	R
	1+		NNX-	XXXX	NR	1+		NXX-	XXXX	NR
		N 0/1 X +	NNX-	XXXX	NR		N 0/1 X +	NXX-	XXXX	NR
	1+	N 0/1 X +	NNX-	XXXX	P	1+	N 0/1 X +	NXX-	XXXX	P
FNPA (Nonprotected Codes)		N 0/1 X +	NNX-	XXXX	NR		N 0/1 X +	NXX-	XXXX	NR
	1+	N 0/1 X +	NNX-	XXXX	R	1+	N 0/1 X +	NXX-	XXXX	R
TOLL – DIRECT-DIALED:										
HNPA			NNX-	XXXX	NR			NXX-	XXXX	NR
	1+		NNX-	XXXX	R	1+		NXX-	XXXX	NR
		N 0/1 X +	NNX-	XXXX	NR		N 0/1 X +	NXX-	XXXX	NR
	1+	N 0/1 X +	NNX-	XXXX	P	1+	N 0/1 X +	NXX-	XXXX	R
FNPA		N 0/1 X +	NNX-	XXXX	NR		N 0/1 X +	NXX-	XXXX	NR
	1+	N 0/1 X +	NNX-	XXXX	R	1+	N 0/1 X +	NXX-	XXXX	R
ALL – OPERATOR-ASSISTED:										
HNPA	0+		NNX-	XXXX	R	0+		NXX-	XXXX	NR
	0+	N 0/1 X +	NNX-	XXXX	P	0+	N 0/1 X +	NXX-	XXXX	R
FNPA (Protected Codes)	0+		NNX-	XXXX	R	0+		NXX-	XXXX	NR
	0+	N 0/1 X +	NNX-	XXXX	P	0+	N 0/1 X +	NXX-	XXXX	R
FNPA (Nonprotected Codes)	0+	N 0/1 X +	NNX-	XXXX	R	0+	N 0/1 X +	NXX-	XXXX	R

Legend:

N — Any digit 2 through 9
0/1 — Digit 0 or 1
X — Any digit 0 through 9
R — Recommended procedure
NR — Procedure not recommended
P — Permissive procedure. May be permitted in addition to recommended procedure.

† These dialing procedures also will be applicable for interchangeable area codes. In that case, the area code format will become NXX also.

Fig. 6—Recommended Customer Dialing Procedures for Areas With Step-by-Step Equipment

TYPE OF CALL	WITHOUT INTERCHANGEABLE CO CODES					WITH INTERCHANGEABLE CO CODES†				
	PRE-FIX	AREA CODE	CO CODE	STA NO.	USE	PRE-FIX	AREA CODE	CO CODE	STA NO.	USE
LOCAL – DIRECT-DIALED:										
HNPA			NNX-XXXX		R			NXX-XXXX		R ‡
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA (Protected Codes)			NNX-XXXX		R			NXX-XXXX		R
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA (Nonprotected Codes)		N 0/1 X +	NNX-XXXX		R		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		R ‡
TOLL – DIRECT-DIALED:										
HNPA			NNX-XXXX		R			NXX-XXXX		R
	1+		NNX-XXXX		NR	1+		NXX-XXXX		NR
		N 0/1 X +	NNX-XXXX		NR		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX-XXXX		P	1+	N 0/1 X +	NXX-XXXX		P
FNPA		N 0/1 X +	NNX-XXXX		R		N 0/1 X +	NXX-XXXX		NR
	1+	N 0/1 X +	NNX- XXXX		P	1+	N 0/1 X +	NXX-XXXX		R ‡
ALL – OPERATOR-ASSISTED:										
HNPA	0+		NNX-XXXX		R	0+		NXX-XXXX		NR
	0+	N 0/1 X +	NNX-XXXX		P	0+	N 0/1 X +	NXX-XXXX		R ‡
FNPA (Protected Codes)	0+		NNX-XXXX		R	0+		NXX-XXXX		NR
	0+	N 0/1 X +	NNX-XXXX		P	0+	N 0/1 X +	NXX-XXXX		R
FNPA (Nonprotected Codes)	0+	N 0/1 X +	NNX-XXXX		R	0+	N 0/1 X +	NXX-XXXX		R ‡

Legend:

N — Any digit 2 through 9
0/1 — Digit 0 or 1
X — Any digit 0 through 9
R — Recommended procedure
NR — Procedure not recommended
P — Permissive procedure. May be permitted in addition to recommended procedure.

† These dialing procedures also will be applicable for interchangeable area codes. In that case, the area code format will become NXX also.

‡ These are the recommended long-term procedures to be applicable after step-by-step equipment and protected codes are obsolete.

Fig. 7—Recommended Customer Dialing Procedures for Areas Without Step-by-Step Equipment

SERVICE PROVIDED	PREFIX	SERVICE CODE	AREA CODE	CO CODE	TERM. DIGITS	NOTES
HNPA-Local	—	411	—	—	—	1
	1	411	—	—	—	2, 3
HNPA-Toll	—	—	—	555	1212	4
	1	—	—	555	1212	5
	—	—	N 0/1 X	555	1212	6, 10
	1	—	N 0/1 X	555	1212	7, 10
FNPA-Local	—	411	—	—	—	1, 9
	1	411	—	—	—	2, 3, 9
FNPA-Toll	—	—	N 0/1 X	555	1212	8, 10
	1	—	N 0/1 X	555	1212	10, 11

Notes:

1. Standard for all areas.
2. Acceptable alternative for small step-by-step offices.
3. Acceptable alternative in areas with step-by-step equipment where it is necessary to record directory assistance calls at centralized automatic message accounting tandems.
4. Standard for areas without step-by-step equipment.
5. Standard for areas with step-by-step equipment.
6. Deny procedure.
7. Permit in addition to standard or acceptable alternative procedure.
8. Standard for areas without step-by-step equipment prior to interchangeable codes.
9. The number of practical applications should be minimized.
10. Area codes will be in NXX form rather than N 0/1 X after interchangeable area codes are introduced.
11. Standard for areas with step-by-step equipment prior to interchangeable codes and for all areas thereafter.

Fig. 8—Directory Assistance Dialing Procedures

NOTES ON THE NETWORK

SECTION 3

THE SWITCHING PLAN

CONTENTS PAGE

1. GENERAL

1.01 The telephone systems in the United States and Canada handle almost 600,000,000 telephone messages a day. These are routed over a comprehensive network of intercity trunks which interconnect over 1,800 toll switching systems. This network serves, with few exceptions, all of the telephones in the two countries and provides for establishing connections to most other parts of the world as described in Section 10.

1.02 Large volumes of traffic between any two points are generally routed most economically over direct trunks. When the volume of traffic between the two points is small, however, the use of direct trunks is usually not economical. In these cases, the traffic is handled by connecting together two or more trunks in tandem to build up the required connection. The locations where the connections are made are generally known as "switching centers" and the process of connecting trunks in tandem is referred to as a "switch." "Built-up" connections may involve several switching centers if the originating and terminating points are a great distance apart. It is important that telephone plant be designed to provide adequate service levels for this multiswitch traffic as well as the large volumes of traffic handled by the less complex direct- and single-switch connections.

1.03 The basic routing arrangements of the switching plan make possible systematic and efficient handling of customer-dialed and operator-serviced traffic. These arrangements are discussed in this section.

1.04 The basic principles of the switching plan evolved from the earlier plan for "ringdown" traffic in which the switching was performed manually by operators. The experience gained in handling large traffic volumes on a dialed basis between many separate central offices within metropolitan exchange areas also was applied to the automatic switching of intercity traffic.

1.05 The basic elements of the switching plan are as follows:

(a) A numbering plan (discussed in Section 2)

(b) A switching plan (discussed in Parts 3, 4, and 5 of this section)

(c) Destination code routing (discussed in Parts 6 and 7 of this section)

(d) A transmission plan (discussed in Section 7)

(e) Standard signaling for the called telephone number and for supervisory information (discussed in Section 5).

1.06 The needs of the switching plan are met by switching and trunking arrangements that employ a hierarchical network configuration and the principle of automatic alternate routing to provide rapid and accurate connections while making efficient use of the telephone plant. The hierarchical network configuration provides for the collection and distribution of traffic and permits complete interconnectability of all points. With the automatic alternate routing principle, a call which encounters an "all trunks busy" condition on the first route tested is automatically "route advanced" and offered in sequence to one or more alternate routes for completion. Appendix 1 of this section, entitled "Alternate Routing," discusses this principle.

1.07 Trends in the telephone industry are toward increasing traffic volumes and the use of mechanized switching and billing systems employing Stored Program Control (SPC) techniques. Operator service locations are trending toward more centralization as well as SPC mechanization with service and assistance functions being provided at greater distances from the switching location. For the most economical arrangement, traffic should route as directly as possible from the point where billing details are recorded to the called destination. Concentration at various switching centers is justified only if overall network economies can be realized. Two-way trunk groups achieve economies through the meshing of noncoincident busy hour loads and improved trunk group efficiencies.

2. DEFINITIONS

2.01 Under the switching plan, each switching system is classified and designated according to the highest switching function performed, its interrelationship with other switching centers, and its transmission requirements. The hierarchical ranking (and associated class number) given to each switching center in the network determines the routing pattern. The standard classification and homing arrangements for two routing chains (sometimes called a routing ladder) are shown in Fig. 1. Possible groupings of various classes of switching centers are shown in Fig. 2. The classification of switching centers, their switching functions, and the switching areas they serve are described in the following paragraphs.

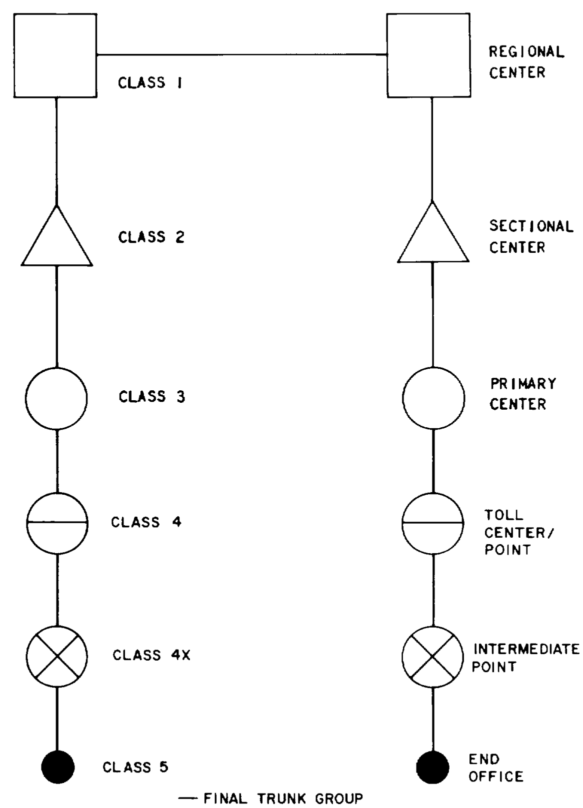


Fig. 1—Switching System Classification and Homing Arrangements

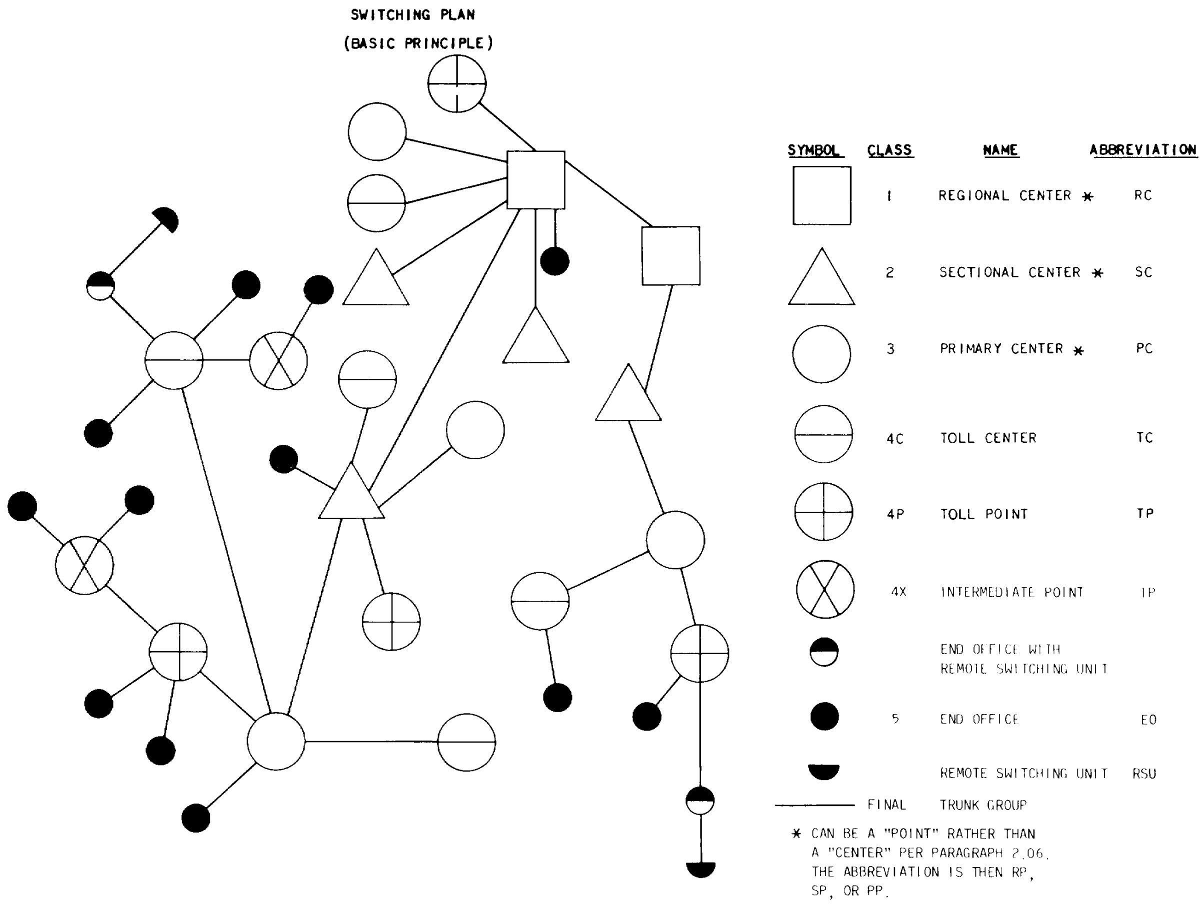


Fig. 2—Typical Switching System Groupings

2.02 The central office trunking entities where telephone loops are terminated for purposes of interconnection to each other and to the network are called "end offices" and are designated as class 5 offices. A trunking entity is that grouping of central office equipment at which a central office code or a group of central office codes are trunked in common for network access. A trunking entity may be those step-by-step units served by the same mainframe, a No. 5 crossbar marker group, a stored program controlled electronic central office, or any equivalent arrangement.

2.03 The switching centers which provide the first stage of concentration for network traffic originating at end offices and the final stage of distribution for traffic terminating at end offices are called "toll centers" or "toll points" and are designated as class 4C or class 4P switching systems, respectively. The class 4 switching function connects a grouping of end offices to each other and to the network. A toll center (class 4C) is a location at which operator assistance in completing incoming calls is provided. A toll point (class 4P) is a location at which operators handle or service only outward calls or where switching is performed without provision for operator functions. The class 4P designation is also assigned to such switching systems as outward and terminating toll tandems and some systems with Centralized Automatic Message Accounting (CAMA). The class 4X intermediate point is similar to the class 4P, but its application is constrained by the requirements discussed in Appendix 4.

2.04 Operator service locations are designated as "traffic toll centers" if inward assistance operator service code functions are provided. This generic designation is applicable regardless of the classification of the location in the hierarchical configuration. Those end offices which are served by operator service locations without inward assistance operator functions must be provided this service by a toll center or higher class switching system. Appropriate listings in conformance with these basic considerations will appear in routing documents such as: (1) the Operating Rate and Route Guide, (2) the Traffic Routing Guide, and (3) the Distance Dialing Reference Guide.

2.05 Certain switching systems, in addition to connecting a group of end offices to each other and to the network, are selected to serve additional switching functions on the basis of overall network economies, thus providing additional hierarchical levels of concentration. These levels are: Primary Centers designated class 3, Sectional Centers designated class 2, and Regional Centers designated class 1. Collectively, the class 1, 2, and 3 switching systems constitute the Control Switching Points (CSPs) of the switching plan. It is important to note that higher class switching systems can also perform lower switching functions. Where multiple switching functions are performed, the switching system is designated by the highest switching function present as shown in Table A.

2.06 In some of the larger metropolitan areas which have two or more toll switching systems, the inward assistance operator function may be served from one of the lower class switching systems instead of the highest class system in the area. In these cases, the lower class switching system should have direct (nonswitched) access to the end offices served. The term "point" instead of "center" is applied to the switching system which does not directly serve the inward assistance operator function, eg, Regional Point, Sectional Point, Primary Point. There are no distinguishing symbols attached to these classifications.

2.07 A CSP is a switching system at which intertoll trunks are connected to other intertoll trunks. There must be at least one switching system of the next lower class homing on a CSP; eg, a class 2 switching system must have at least one class 3 switching system homing on it.

2.08 The backbone hierarchical network of "final" trunk groups, or the final route chain interconnecting the six classes of switching systems, is shown in Fig. 1. A final trunk group is always provided from each switching system to another switching system of higher class. That higher

TABLE A

SWITCHING SYSTEM DESIGNATION BY SWITCHING FUNCTION

SWITCHING SYSTEM RANK	DESIGNATED CLASS NUMBER	SWITCHING FUNCTIONS PERFORMED
Regional Center	1	1, 2, 3, and 4
Sectional Center	2	2, 3, and 4
Primary Center	3	3, 4, and sometimes 5
Toll Center/Point	4	4 and sometimes 5
Intermediate Point	4X	4X and sometimes 5
End Office	5	5

Note: Not all toll centers perform a class 5 switching function; eg, many primary centers perform a class 5 switching function. Sectional centers and regional centers are of such large size that the switching system used generally does not provide a class 5 switching function.

class switching system to which a given switching system is connected over a final trunk group is called its "home." Final groups to more than one higher class switch may be provided if it is necessary to have separate homing by class of service. The lower class or dependent switching system is referred to as homing on the higher class switch. The one exception to this principle is the complete interconnection of all regional centers with final trunk groups, each with all of the others.

2.09 In determining classification and homing arrangements, designations are always assigned to end offices first based on the results of wire centering studies. In succession, based on overall network economics, designations are made for classes 4X, 4, 3, 2, and 1. The network hierarchy is thus established from the bottom up, each switching system being assigned the lowest possible class. Additional discussion of network design and switching system classification is contained in Part 4 of this section.

2.10 The systematic grouping of switching centers results in a similar grouping of the areas they serve. Each Regional Center (RC) serves a large area known as a Region. (There are ten regional areas in the United States and two in Canada.) Each region is subdivided into smaller areas known as Sections; the principal switching system in the section is the Sectional Center (SC). The section is still rather large and it too is further divided into smaller parts known as Primary areas, each of which is served by a Primary Center (PC). The remaining centers that do not fall into these categories are the Toll Centers (TCs), Toll Points, Intermediate Points (IPs), and End Offices (EOs).

2.11 Each separate switching system must be assigned its own classification within the hierarchical routing plan. This separate classification is applicable even when more than one system is located in a single building. The one exception is that cord switchboards in the same building with, and handling traffic exclusively for, a single toll switching system are classified as a part of that system. The cord switchboard and its trunks must also meet Via Net Loss (VNL) transmission requirements as covered in Section 7. When a cord switchboard location is not in the same building as the toll switching system, the cord switchboard is treated as a separate switching system and assigned a class 4P classification.

3. HOMING ARRANGEMENTS AND THE INTERCONNECTING NETWORK

3.01 It is not necessary that class 5, 4 (except 4X), or 3 offices always home on the next higher class (next lower number as shown in Fig. 1) switching system. For example, class 5 offices may be served directly from any higher class switch. Class 4X offices will exist only where interposed between a class 4 and its subtending class 5 offices. Possible homing arrangements for each class of switching system are shown in Table B and are illustrated in Fig. 2.

3.02 Each final trunk group in the network is engineered individually to a low probability of blocking so that, on the average, no more than a small fraction of the calls offered to such a trunk group in the busy hour will encounter a No Circuit (NC) condition. Current service objectives for final trunk groups call for an average of not more

TABLE B

HOMING ARRANGEMENTS

RANK	CLASS OF OFFICE	MAY HOME AT OFFICES OF THE FOLLOWING CLASSES
End Office	5	Class 4, 3, 2, or 1
Intermediate Point	4X	Class 4
Toll Center	4	Class 3, 2, or 1
Primary Center	3	Class 2 or 1
Sectional Center	2	Class 1
Regional Center	1	All regional centers mutually interconnected

than one call in 100 being blocked by an NC condition in the average time consistent busy hour in the busy season.

3.03 In addition to the final route network, High-Usage (HU) trunk groups are provided between switching systems of any class wherever the volume of traffic and economics warrant and automatic alternate routing equipment features are available. HU trunk groups carry most but not all of the offered traffic in the busy hour. As discussed in Appendix 1, overflow traffic is offered to an alternate route. The proportion of the offered traffic that is carried on an HU trunk group ordinarily is determined, in part, by the relative costs of the direct route and the alternate route (including the additional switching costs on the alternate route). HU trunk groups are provided when they are shown to be economically desirable. Due to service considerations, trunk groups which would normally be in the HU category may in some instances be engineered on a no-overflow basis with the same service objective as a final trunk group. This does not change homing arrangements; these trunk groups are called "special finals." Special finals effectively eliminate further alternate routing and truncate or limit the hierarchical final route chain for the items of traffic offered to them. Special finals can seldom be justified on the basis of economic considerations alone.

3.04 In general, both HU and final trunk groups between toll centers, intermediate points, and higher class switching systems are operated 2-way. Within the normal range of traffic load characteristics, 2-way trunk groups present opportunities for meshing of noncoincident traffic in either direction as well as improvement of trunk group occupancy relative to 1-way trunk groups. Where there is a significant cost differential between 1-way and 2-way trunk terminations on switching systems, there may be opportunities to trade off trunk termination savings against the lower occupancy of 1-way trunk groups. This usually is possible with electromechanical switching systems. A large 2-way trunk group may be subgrouped into two 1-way segments (for each direction) and one 2-way segment to which the 1-way subgroups would overflow. (In metropolitan local networks, large trunk groups are often provided as 1-way only in either direction with no 2-way subgroup.) Where direct distance dialing is not provided, the final trunk groups between a small Community Dial Office (CDO) and its toll center are sometimes consolidated on a 2-way basis and designated as 2-way operator office trunk groups. For larger end offices and CDOs, it is common practice to provide 1-way trunk groups to and from the home toll center.

3.05 Parallel Protective High Usage (PPHU) groups are sometimes used as a service protection measure for traffic which might otherwise be first routed on a final trunk group in excessive competition with alternate routed traffic. The PPHU groups are engineered in a manner comparable to HU trunk groups and are for exclusive use of first routed traffic loads which overflow to the final trunk group. The PPHU groups are engineered for high occupancy to assure adequate utilization.

3.06 The "routing pattern" for a call between any two points is established by the final route path (or final route chain) between the originating and terminating locations. Where two or more trunks must be connected to complete traffic, the intermediate switching systems establishing such a connection must be on the final route path. One or more intermediate switching systems on a final route path may be bypassed by an HU trunk group as long as the traffic thus routed always progresses in the direction toward its destination subject to the constraints of the one-level limit rule discussed in Appendix 3. Referring to Fig. 1 and 2, a call originating in one final route chain must progress up that chain until an idle HU trunk to the second chain is found. On entering the second chain (eg, at the class 2 switching system), the call must progress down the second chain through class 3 and class 4 switching systems if necessary to the class 5 destination. Any routing path which involves three final route chains is not permissible since standard routing involves only two chains.

3.07 Appendix 2 illustrates typical standard routing patterns within the switching plan. It should be noted that the maximum number of trunks connected in the final route chains from a class 4 location in tandem to another class 4 location cannot exceed seven. These, plus the trunk to the class 5 office at each end, result in a maximum of nine trunks in tandem. If a class 4X office is interposed between the class 4 and class 5 office as described in Appendix 4, one additional link is installed in the chain. The probability of a call traversing all of the final route links in two complete routing chains is estimated to be only a few calls out of millions. Calls between high-volume points are completed on a single trunk, regardless of distance; relatively few encounter multiple switching systems. Multiple switching is the rule, however, between infrequently called locations.

4. SELECTION OF CONTROL SWITCHING POINTS

4.01 The use of intermediate switching (CSPs) can sometimes increase the efficiency of trunk plant. For example, in Fig. 3, Plan II will effect savings in transmission facilities as compared to Plan I. However, a CSP must be provided with additional capacity for the increased switched traffic load along with features which are not ordinarily required if the switching center serves only a class 4 switching function. This tends to offset, and in some cases will exceed, the transmission facility savings. It is necessary, therefore, to carefully evaluate these plus other related factors to determine the location, class, and number of CSPs which will result in the most economical overall network configuration over a reasonably long time span.

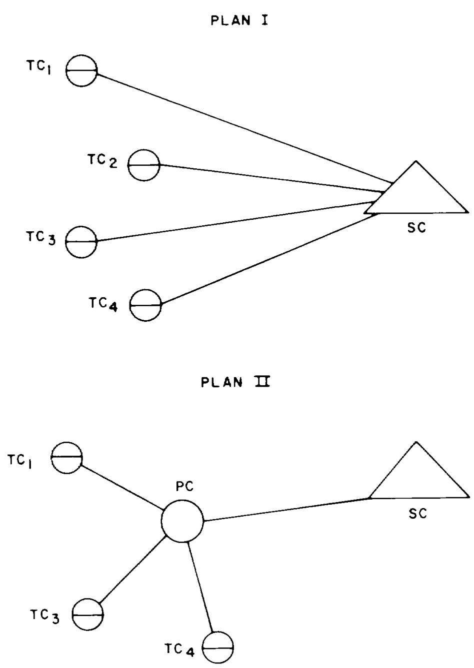


Fig. 3—Effect of Establishing a CSP

4.02 CSP location studies have been made by the Bell System and Independent Operating Companies and must be reviewed from time to time as required by changing conditions. Studies currently being made often indicate the need for fewer CSPs. Such studies reflect the relative costs of transmission facilities and switching equipment suitable for the CSP functions. They recognize the changes in traffic flow occasioned by growth. They include the effect of more common control and SPC switching systems at lower levels in the hierarchy which permit additional HU trunking to develop with the passage of time. The combined effects of these influences reduce the need for CSP switching functions and are expected to lower the hierarchical class of some existing switching systems.

SWITCHING SYSTEM REQUIREMENTS FOR A CSP

4.03 The requirements for switching systems serving as CSPs are as follows:

(a) Storing of digits

(b) Variable spilling—Deletion of certain digits when not required for outpulsing

(c) Prefixing of digits when required

(d) Code conversion—A combination of digit deletion and prefixing (also termed substitution)

(e) Translation of three or six digits (also translation of four or five digits for WH calls, ie, calls to operators coded 11XX or 11XXX)

(f) Automatic alternate routing.

4.04 The switching requirements delineated in paragraph 4.03 can be provided only with common control equipment. Any class 3 step-by-step installation not provided with common control features is, therefore, deficient in these equipment capabilities. It follows that only equipment with the common control capabilities listed can be permitted to route traffic items through a noncommon control step-by-step switching system providing a class 3 switching function. The transmission requirements provided in paragraph 4.05 can be met where step-by-step switching equipment is employed.

TRANSMISSION REQUIREMENTS FOR A CSP

4.05 The requirements for analog transmission are as follows:

(a) VNL operation of intertoll trunks.

(b) VNL plus 2.5-dB operation of toll connecting trunks.

(c) Terminal balance objectives must be met by actual measurement on all toll connecting trunks.

(d) Through balance requirements must be met at 2-wire switches between intertoll trunks for through switched traffic. Any CSP which does not meet through balance requirements is classified as deficient.

4.06 Network objectives for digital transmission are covered in Section 7.

5. TRAFFIC ROUTING REQUIREMENTS

5.01 Alternate routing permits a more efficient (lower cost per carried CCS) network than would be obtained if the trunk groups were all engineered to objective service levels with no overflow. Most growth in an alternate routing network is accommodated by adding new HU trunk groups or by adding trunks to existing HU trunk groups. Final trunk groups thus tend to grow at a lower rate than the overall growth rate for the total area involved. Appendix 1 provides more detail on the principles of alternate routing.

5.02 It is essential that these concepts be considered when planning and engineering plant additions. By so doing, the most economical network may be obtained and, at the same time, the needs during transition periods can be cared for adequately.

5.03 The final trunk group between any switching system and its home switching system should be engineered for low probability of blocking. (See Part 3.)

5.04 Switching systems of different classifications may be located in the same building. If they are physically different entities, each switching system retains its own classification according to the function(s) it performs in accordance with Table A.

5.05 Customer-dialed station sent paid traffic must be provided with automatic recording of call billing details at the originating local office (Local Automatic Message Accounting [LAMA]) or at a centralized point (CAMA). With centralized operation, each end office must be connected directly to the centralized recording system which serves it. See Appendix 4 for explanation of class 4X CAMA applications.

5.06 Customer-dialed, operator-serviced or -handled traffic (dial 0+ or 0–) likewise must be routed over direct trunks from each end office to the Traffic Service Position System (TSPS) or cord switchboard ***without*** any intermediate switch or concentration as stipulated in Appendixes 3 and 4.

6. DESTINATION CODE ROUTING

6.01 By providing flexibility and logic in switching systems and by following the numbering plan described in Section 2, whereby every telephone connected to the network is identified by a unique 10-digit number, a call can be routed from any point on the network to any other point using the 3-digit Numbering Plan Area (NPA) code and the 3-digit central office code of the called telephone. For a specific called destination, the same address is employed, regardless of where a given call may originate and enter the network. This is called "destination code routing."

6.02 When a call is to be set up between two telephones in the same NPA, the 3-digit central office code plus the 4-digit station number are sufficient for completing the connection. The absence of an NPA code is the indication that the call either originates and terminates within the same NPA (home NPA) or that it has arrived from another NPA at a switching system which is capable of completing the connection within the home NPA of the called destination. The connection is completed over a trunk group to the end office which serves the called telephone number. This will require four, five, six, or seven digits as dictated by the capabilities of the central office equipment and local numbering arrangements which are discussed in Section 2.

6.03 It may be necessary to switch a call at one or more intermediate switching systems within the NPA of the called destination before the trunk group to the desired end office is reached. This is always done within the standard hierarchical routing chain, the intermediate switching systems being of successively lower class (ie, 1, 2, 3, 4, 4X) until the final trunk group to the terminating end office is reached. Of course, HU trunk groups will be used, where provided, to bypass one or more intermediate switching systems as discussed in Part 3. (Also see Appendixes 2, 3, and 4.)

6.04 Connections between switching systems for calls between different NPAs are handled similarly using the full 10-digit destination code. Both originating and intermediate switching systems make use of the 3-digit NPA code to route each call over its particular first choice or alternate route to or toward the called NPA. The entire ten digits are sent forward if the next switching system in the routing ladder cannot complete the connection within the NPA of the called destination. Only seven digits are needed if the trunk route used terminates in the called NPA. Once a call reaches the called NPA, only the last seven digits are needed to advance the call to its destination.

6.05 To complete calls to customers where the end office is served by a toll switching system across an NPA boundary, the NPA dialed must be the same as the NPA in which the end office is physically located. Similarly, where customers are served by an end office across an NPA boundary, the NPA dialed is the NPA in which the customers are located and they are assigned a theoretical office code within that NPA. Standard dialing procedures should be established at each individual end office in accordance with the procedures discussed in Section 2 for maintaining uniformity for the NPA and the entire network.

6.06 The code received by a switching system must contain sufficient information to advance the call to or toward its destination. In many instances, a 10-digit call for a distant NPA can be routed at a switching system from the translation of the NPA code alone; this is "3-digit translation." In other instances, involving calls to a distant NPA, the first three digits (NPA code) may not provide sufficient information. When this occurs, the switching system obtains the additional information it requires by also translating the 3-digit central office code, thus using the first six digits to properly advance the call; this is "6-digit translation."

6.07 If from a particular switching system there is one first choice route to reach some end offices in a given distant NPA and a different first choice route to reach other end offices in that same distant NPA, the switching system must 6-digit translate to determine which route to select to reach the desired end office for the call destination.

6.08 For each NPA, there is a switching system (usually a CSP) which is designated as the "Principal NPA Tandem" for that NPA. A CSP may be designated as the Principal NPA Tandem for more than one NPA. A Principal NPA Tandem is defined as that lowest class switching system which can complete to every end office within an NPA on a final route basis, direct or switched. The Principal NPA Tandem accommodates those distant locations which cannot provide 6-digit translation to or toward a given NPA. A call from such a location is routed over the network on the 3-digit NPA code to the Principal NPA Tandem. If the Principal NPA Tandem is within the NPA, the call is completed with the 7-digit destination code. If the Principal NPA Tandem is outside the NPA, it performs the necessary 6-digit translation for completion of the call.

6.09 The routing digits sent forward to a given switching system depend upon the requirements of the distant point to which it connects. For example, extra digits, dialed by an operator or prefixed and sent forward by a preceding switching system, may be required to switch calls through a direct control switching system. Paragraphs 4.03 through 4.05 outline digit prefixing, code conversion, and other features required at CSPs for destination code routing. The digit and translation capabilities of various types of switching systems used in the Bell System are discussed in Section 4.

7. ROUTING CHANGES

7.01 From time to time, new HU trunk groups and new switching systems must be added to the network to provide for growth. These additions usually require routing changes to be put into effect in many existing switching systems. In order to minimize the frequency of reproducing switchboard bulletins and first reference lists, routing changes are combined for implementation on specified dates. The scheduled time and dates for network switching system cutovers and routing changes are 2 PM Eastern time, generally on the first and third Saturdays of each month. Exceptions occur when the tentative "cutover" weekend includes a heavy traffic day such as Easter, Mother's Day, or Father's Day. To avoid these heavy traffic days, the scheduled date is either advanced or deferred one week. The "after midnight hours" are not precluded when the changes involve rearrangements such as local office replacement or wire center boundary changes and can be controlled between the end office and the switching system on which it homes.

APPENDIX 1

ALTERNATE ROUTING

1. GENERAL

1.01 The successful completion of traffic dialed by operators and customers depends upon a trunking network in which No Circuit (NC) conditions are rarely encountered under engineered conditions. Alternate routing is one of the techniques that makes this possible with reasonable trunk efficiency. It is the purpose of this appendix to explain alternate routing and why it is employed.

1.02 Definitions of terms used in this appendix are listed below:

(a) ***Alternate Routing:*** The feature of a switching system by which a call, after encountering NC in the first choice route, is offered another route to or toward its destination.

(b) ***Multialternate Routing:*** Alternate routing with provision for advancing a call to more than one alternate route tested in sequence within the hierarchical routing discipline.

(c) ***High-Usage (HU) Trunk Group:*** A group of trunks for which an engineered alternate route is provided.

(d) ***Final Trunk Group:*** A group of trunks to the next office on the final route and in which the number of trunks is engineered to result in a low probability of blocking. A final trunk group provides the last choice route for all traffic using it, including traffic from HU groups overflowing to it.

(e) ***Special Final Trunk Group:*** A group of trunks which ordinarily would be an HU group but is engineered like a final trunk group with low probability of blocking for the traffic offered to it. The normal alternate routing capability is not employed for this traffic. A special final trunk group may receive overflow traffic but is not permitted to overflow to an alternate route.

2. THEORY OF ALTERNATE ROUTING

2.01 The principle of alternate routing is applied to telephone traffic by providing a first choice (HU) route for a given item of traffic and a second choice (alternate) route when the call fails to find an idle trunk on the first choice route. Additional alternate routes may be provided subject to certain routing restrictions discussed in Appendixes 3 and 4.

FUNDAMENTALS

2.02 Alternate routing is advantageous because it provides the opportunity to minimize the cost per unit of carried traffic. With alternate routing, the load is allocated to HU and final routes in the most economical manner as discussed below. Alternate routing permits the meshing of traffic streams which have differing peak periods (busy hours or seasons).

MINIMIZING THE COST PER CARRIED HUNDRED CALL SECONDS (CCS)

2.03 Figure 1 depicts an alternate routing arrangement.

2.04 Figure 1 illustrates an HU trunk group connecting Toll Centers A and B with an alternate (final) route via a Primary Center C. In general, the direct or HU route is shorter and less expensive than the alternate route path. However, because each leg of the alternate route is used by other calls, a number of traffic items can be combined for improved efficiency on that route.

2.05 The basic engineering problem is to minimize the cost of carrying the offered load. (How much of the offered load should be carried on the direct route and how much on the alternate route?)

2.06 Figure 2 shows the relationships involved. The graph shows, as a function of the number of trunks in the HU trunk group, the cost of the direct route, the cost of the alternate route, and total cost for serving the given offered load.

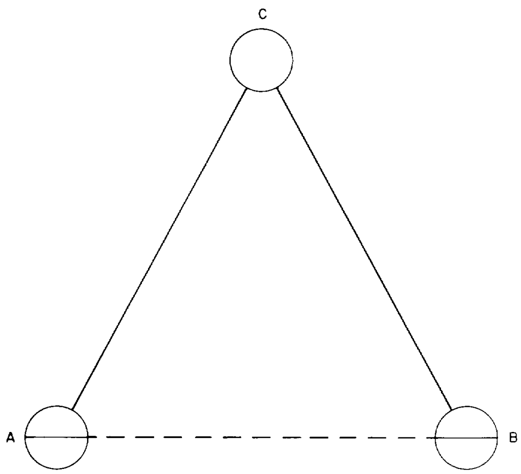


Fig. 1—Alternate Routing Arrangement

The HU trunk group cost, of course, increases in direct proportion to the number of HU trunks.

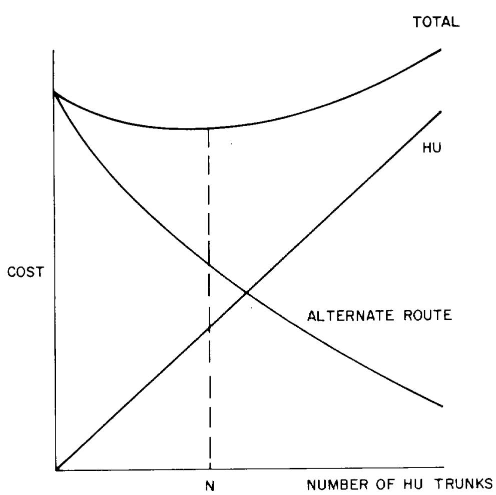


Fig. 2—Relationships Involved in Alternate Routing Arrangement

If there are no HU trunks, all of the offered traffic must be carried on the alternate route so that the incremental alternate route cost is high. As trunks are added to the HU trunk group, less of the offered traffic is overflowed to the alternate route so that the incremental alternate route cost decreases. This cost decreases very rapidly as the first trunks are added to the HU trunk group since each of these trunks is very efficient, thereby relieving the alternate route of a substantial amount of load. As more HU trunks are added, each successive HU trunk carries less traffic* while each alternate route trunk continues to carry a significant amount of traffic and eventually it becomes undesirable to add any more HU trunks. The point at which this threshold occurs is where the total cost (the sum of the two curves) is minimized. This point is designated as N in Fig. 2.

*This principle may be illustrated by assuming the case of a step-by-step switching system offering a call to a group of ten 1-way outgoing trunks. Tested in order, trunk No. 1 will be selected first, reselected when idle, and thus be kept busy most of the time; trunk No. 2 will be slightly less busy; and trunk No. 3 will be used less than No. 2 and so on to the tenth trunk which is called into use only when all prior trunks are busy.

2.07 A method commonly used to determine N is called Economic CCS (ECCS) engineering. This method determines the maximum number of HU trunks for which the cost per CCS carried on the "last" trunk of the HU trunk group is less than or equal to the cost per CCS on an additional alternate route trunk.

2.08 This relationship can be expressed in the following equation which is the basis of ECCS engineering.

$$\frac{\text{CALT}}{\text{CHU}} = \frac{28}{\text{ECCS}}$$

Where: CALT = Cost of a path on the alternate route

CHU = Cost of a trunk on the HU route

28 = Capacity in CCS added to the alternate route by the addition of an incremental trunk (path)

The equation is solved for the ECCS which is the load to be carried by the "last" or least efficient trunk in the HU trunk group. Given the ECCS and the offered load, standard trunking tables can be entered to determine the number of trunks required which is the largest number of trunks for which the load carried on the last trunk is not less than the ECCS.

2.09 Since the equation is solved for the ECCS, the other elements of the equation must be known. The left portion of the equation $\left[\frac{CALT}{CHU}\right]$ is the cost ratio or the relationship of the cost of a path on the alternate route to the cost of a trunk on the direct route. Cost ratios used for alternate route engineering are always greater than unity (1).

2.10 The "28" shown in the equation is the incremental capacity of the alternate route (that capacity which would be added to the alternate route by the addition of one path). This value is usually assumed to be a constant of 28 CCS, thereby permitting calculation of the ECCS as a function of a single variable, the cost ratio.

2.11 Thus it can be seen that with low cost ratios, the ECCS will be high and fewer HU trunks will be provided. Conversely, a low ECCS would result from a high cost ratio and a greater number of HU trunks will be provided. Simply, the more expensive the alternate route relative to the HU trunk group, the less traffic will be overflowed to it.

2.12 It will be noted in Fig. 2 that the total cost curve has a rather broad minimum. As a result, errors in ECCS which might result from minor cost ratio or incremental CCS errors will not have a significant impact on network costs.

EFFECT OF LOAD VARIABILITY

2.13 The number of HU trunks to be provided in a group depends not only on the ECCS and offered load but on the variability of the offered load as well. This variability can be either within the hour, usually peakedness, or day to day. Such variability can be the result of traffic patterns as in the case of day-to-day variations or it may be system induced as is usually the case with peakedness. In either event, the effect of such variability is a reduction of the capacity of a group of trunks. Where such variability is present, equivalent random engineering techniques are required and Neal-Wilkinson capacity tables are used to size grade-of-service engineered trunk groups.

NONCOINCIDENT BUSY HOURS

2.14 Traffic volumes reach peaks during certain hours. Trunks are usually provided to care for average time consistent busy hour loads in the busy season of the year.

2.15 Where only one outlet (trunk group) is available, trunks must be provided for the group busy hour load. If two routes (a direct and an alternate route) are available, however, the busy hours on each of the two routes frequently will be different. Where this is the case, trunks need only be provided in the direct route to care for that portion of its busy hour offered load which cannot be carried on idle trunks in the alternate route which is sized for a different busy hour and thus is not fully loaded in the busy hour of the direct route.

ALTERNATE ROUTE SELECTION

2.16 Often there are two or more potential alternate routes for an HU trunk group. The selection of alternate routes may be based on a routing discipline if overall cost differences are not significant or the choice may be based on the economics of each individual case, ie, selection of the least expensive alternate route. In general, overall network economics are not highly sensitive to variation in alternate routes.

MINIMUM TRUNK GROUP SIZE CONSIDERATIONS

2.17 New HU trunk groups are ordinarily established when offered loads are large enough to justify them. Cost ratio techniques alone will prove in groups with as few as one trunk. Other factors, however, such as administrative costs and traffic measurement variability, usually preclude establishing these groups until at least three trunks can be efficiently loaded. With the longer intertoll groups, the administrative costs are higher and larger minimum group sizes may be necessary. There can also be cases where the cost of certain central office equipment should be considered.

3. APPLICATION OF ALTERNATE ROUTING

LOCAL DIALING (COMMON CONTROL OFFICES ONLY)

3.01 In large multioffice cities, direct trunks are provided from each local office to every other local office where there is sufficient traffic to economically justify such trunks. Also, each local office has trunks to and from one or more common tandem points. Calls between offices not directly connected are completed through a tandem center. Since every local office is connected to a tandem, the tandem network may be used to provide an alternate route for each of the direct groups. Therefore, fewer direct trunks are needed. Furthermore, with the ability to alternate route through a tandem, it generally becomes economical to accommodate growth by establishing new direct groups of small size between offices not previously served by direct groups and thus reduce requirements for tandem switching.

3.02 Because alternate routing can be done automatically, it is used extensively to provide economies and service advantages. Calls may be offered in succession to a series of alternate routes via one or more tandem centers.

3.03 In an emergency situation of limited impact and extent such as a cable failure, the ability to use an alternate route provides a measure of protection to service. However, if there is a heavy surge of traffic over an entire area (as in a major disaster such as a hurricane), there is little margin to absorb surges in load and the service may not be as good as it would be with a nonalternate route network.

NETWORK DIALING—AUTOMATIC SELECTION OF ALTERNATE ROUTE

3.04 The principle of alternate routing is basic in the design of the network. Switching equipment automatically seeks out the alternate routes. The field of application in long-haul networks is more extensive than in short-haul since a call may be subject to routing through more switching systems if long-haul.

3.05 At each switching system, all of the trunk groups to which a call may be offered, except the last, are kept very busy (high usage) with a portion of the traffic overflowing to other routes. The final trunk groups are fewer in number and are low blocking groups so that the engineered level of service is good. The overall chance of completing a call is improved by the fact that it can be offered to more than one trunk group. The switching equipment operates rapidly and there is no significant change in speed of service between the selection of direct and alternate routes.

3.06 In addition to the final trunk groups which connect switching systems to their home switching centers, HU trunk groups to other switching systems are provided wherever it is economical to do so. However, there are no direct routes for calls to many low-volume points. The first route for such calls is a switched route over two or more trunk groups of the network in tandem in accordance with the standard routing pattern.

3.07 Since the 50 states, Canada, and the Caribbean area are integrated into the switching plan the employment of an alternate routing network on such a large scale requires an orderly and prearranged routing plan. The routing plan is described in Part 3, Section 3. Appendix 2, entitled "Routing Patterns Under the Switching Plan," describes how alternate routing is used.

APPENDIX 2

ROUTING PATTERNS UNDER THE SWITCHING PLAN

1. GENERAL

1.01 This appendix discusses routing patterns that are permissible within the framework of the switching plan. Economic and other considerations determine various individual patterns. Examples are included.

1.02 Figure 1 illustrates many (although not all) permissible High-Usage (HU) trunking patterns within the framework of the standard routing plan. It should be understood that the traffic items permitted to justify HU trunk groups between switching systems which are not the same class or which have more than one class difference are limited by the one-level limit rule discussed in Appendix 3.

2. TYPICAL ROUTING PATTERNS

2.01 Figure 2 and the following discussion illustrate a particular routing pattern that might be involved in completing a call that appears at End Office A served from Toll Center B destined for End Office P served from Toll Center Q. In this example, B has trunks to C only; hence, the call must be routed to that primary center.

2.02 At C, the call would be offered first to the HU trunk group to R. Finding a trunk in this group idle, the call would be routed to R where the switching system would look for an idle trunk in the final trunk group to Q. At this toll center, the call would be completed to the called customer served from P over an idle trunk in the final trunk group to P.

2.03 If, however, all of the trunks in the first choice HU trunk group (between C and R) were busy, the call would next be offered to the HU trunk group between C and S assuming C - S - R is the alternate route. At S, the call would have a choice of two routings: (1) via the direct HU trunk group to Q or, if all trunks in this group were busy, (2) over the final route chain S - R - Q.

2.04 In the event that all trunks in the group between C and S are busy, the call should next be offered to the final trunk group to D. At D, all HU trunk groups shown are permissible routes.

2.05 The routing described above is for one set of assumed conditions and could be different in actual practice to the extent that economics and plant layout offer different configurations of HU trunk groups.

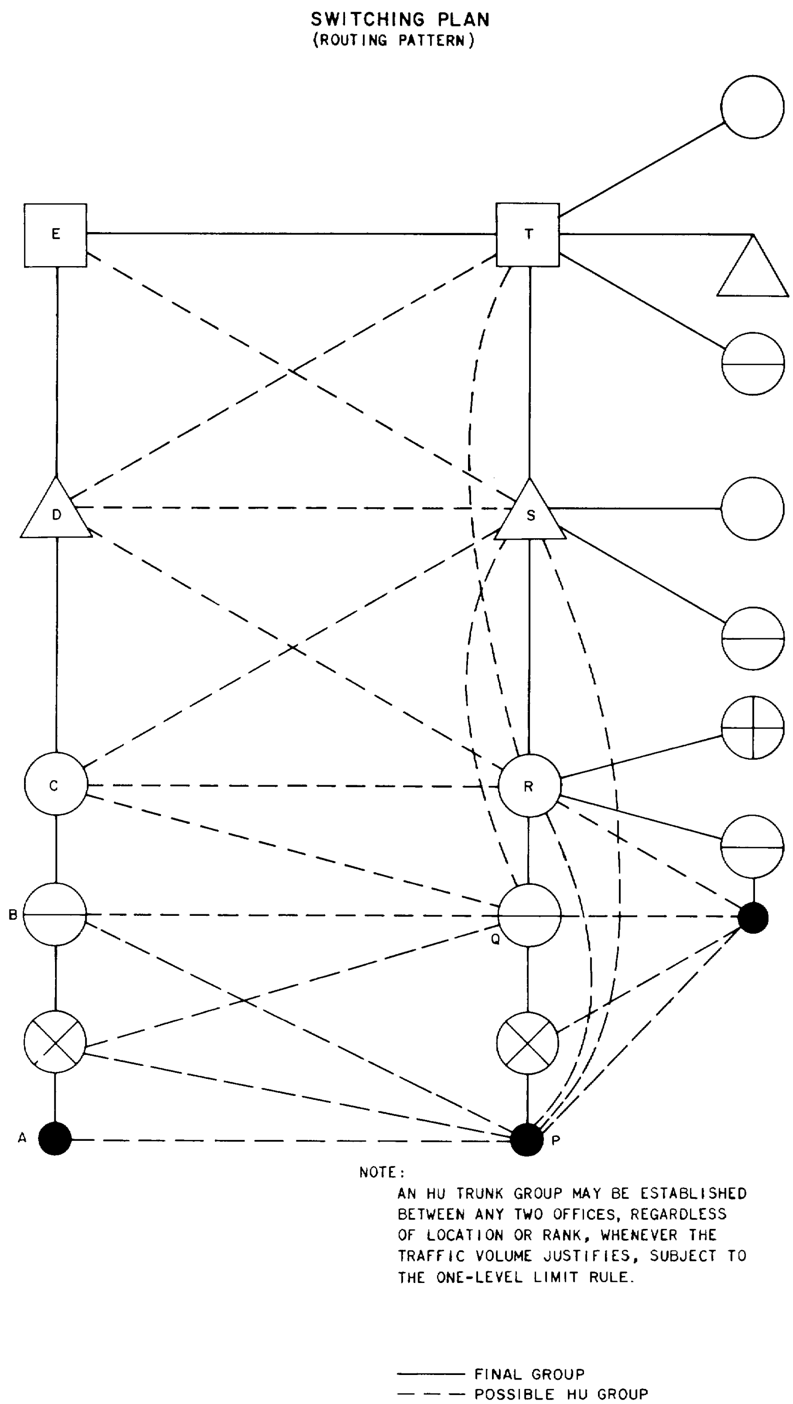


Fig. 1—Standard Routing Plan High-Usage Trunking Patterns

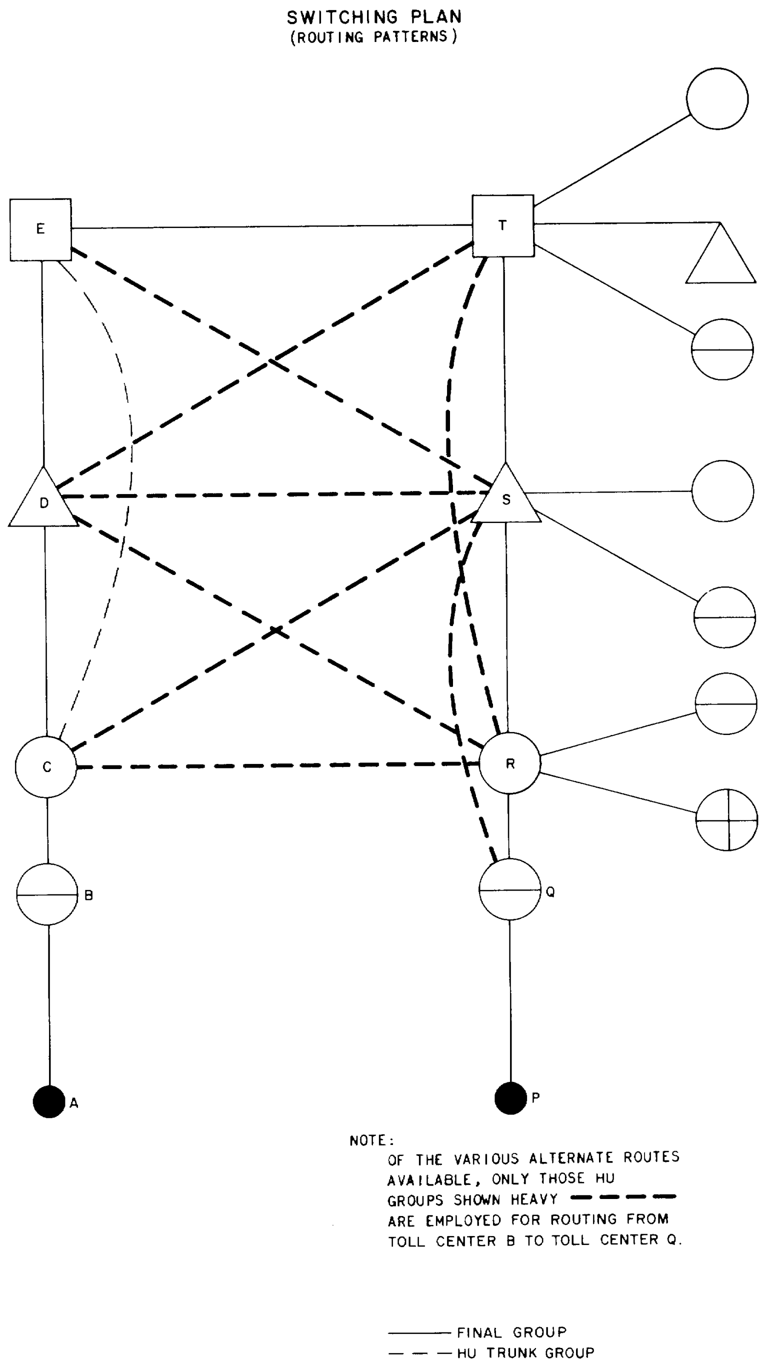


Fig. 2—Typical Routing Pattern

APPENDIX 3

ONE-LEVEL LIMIT RULE

1. GENERAL

1.01 In general, a High-Usage (HU) trunk group may be established between any two offices if the volume of the traffic items permitted to route over it, and the economics, justify it. High-usage trunking should be developed to the maximum economical extent to reduce the requirements of intermediate switching and thereby route traffic at as low a level in the hierarchy as possible. To accomplish the objective of keeping the traffic as low as possible in the hierarchy on an equitable basis, the "one-level limit rule" has been established.

2. DEFINITION

2.01 The basic purpose of the one-level limit rule is to avoid the use of a high class switching system in a distant final route chain as a concentrating point for traffic to locations below it in its final route chain. Such use has the disadvantage of forcing more switching at a higher level in the switching hierarchy than is necessary. Under the one-level limit rule, an HU trunk group can only be justified by those first route traffic items for which the switching functions performed at each end of the trunk group differ by no more than one level. Once justified, other items may also route over the group as discussed in paragraph 3.05. The group must, of course, be sized for all traffic offered to it. Illustrations of proper application are provided in subsequent paragraphs.

3. SPECIFIC APPLICATIONS

3.01 The following are specific applications of the one-level limit rule. In Fig. 1, Toll Center B (class 4 switching function) may have HU trunk groups justified by first routed traffic to:

(a) Toll Center Q (class 4 switching function ***same*** as B)

(b) End Office P (class 5 switching function—one ***class number*** of switching function greater than B)

(c) Primary Center R (class 3 switching function—one ***class number*** of switching function less than B).

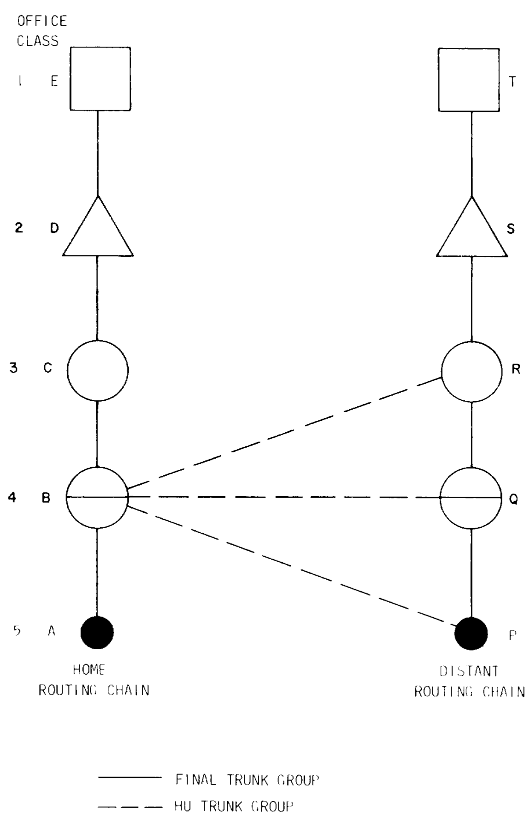


Fig. 1—Application of One-Level Limit Rule to Trunk Groups Out of a Class 4 Office

3.02 If trunk groups from Toll Center B to P, Q, or R cannot be justified because of insufficient traffic loads, these traffic items are routed to the home Primary Center C. Since this primary center more than likely serves as a concentrating point for other class 4 offices in addition to B, trunk groups can probably be justified between C and Q or R. Should this not be the case, a C - S trunk group may be established utilizing the class 2 switching function at S. In no case does the one-level limit rule permit an HU trunk group between B and S to be established for the class 2 switching function of Sectional Center S.

3.03 Another application of the one-level limit rule is shown in Fig. 2. In this case, the B - S trunk group is justified by the traffic load utilizing the class 3 and class 4 switching functions of Sectional Center S. In this illustration, there is insufficient traffic to justify HU trunk groups from either B or C to Q or R. Therefore, B and C traffic to the sectional area served at S must switch at S. Under these conditions, it is permissible and desirable to route traffic between B and P, Q, and R over the B - S trunk group. In like manner, calls arriving at S for completion within its final route chain will use the most direct route available to the call destination. It is most important to note, however, that this "skip-level" routing imposes an obligation to establish the "missing" direct HU trunk groups at lower hierarchical levels as soon as traffic volumes and costs can justify them.

3.04 As an illustration of an unusual case, a trunk group may be established between an end office (class 5 switching function) and a distant regional center, but only if justified by the class 4 switching function performed by that regional center switching system (Fig. 3), ie, the switching function by which end offices are connected to each other and to the network via an intermediate switch. A regional center acts as an ordinary toll center for the end offices homed on it. It should be noted that, if the trunk group A - T is arranged for 2-way traffic, items of traffic from anywhere in the T routing chain destined for A will use this trunk group. This follows the principle of utilizing the most direct HU trunk group when no trunk group can be justified at lower levels in the routing chain to the terminating location.

3.05 The one-level limit rule applies also to the home routing chain in a manner similar to that for a distant routing chain. In Fig. 4, for example, an HU trunk group may be established between End Office A and Sectional Center D, but only for the end offices homed on D for which it

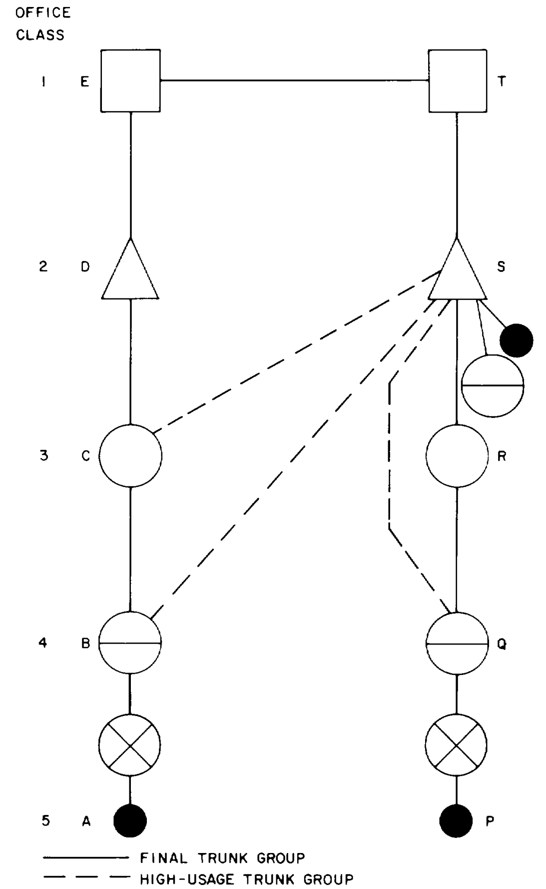


Fig. 2—Application of One-Level Limit Rule to B - S Trunk Group

performs a class 4 switching function. Similar HU routes can be established for the various classes of switching systems and switching functions within the home routing chain. Traffic from End Office A to distant routing chains may use the A - D high-usage trunk group to bypass intermediate hierarchical levels in the home routing chain to the extent that trunk groups cannot be justified to any distant routing chain at these lower levels.

3.06 Figure 5 illustrates the application of the one-level limit rule to the trunk groups out of a class 4X office. The switching function performed by the class 4X switching system is intermediate between 5 and 4. Therefore, in accordance with the rule, trunk groups can be justified by traffic items for which the switching function performed at the distant end of the group is either 5, 4X, or 4. Trunk groups from B′ to P, Q′, or Q are therefore permissible. Trunk groups to R, S, or T can be justified only by the switching function 4 loads at those switching systems, ie, for the end offices homed directly on R, S, or T.

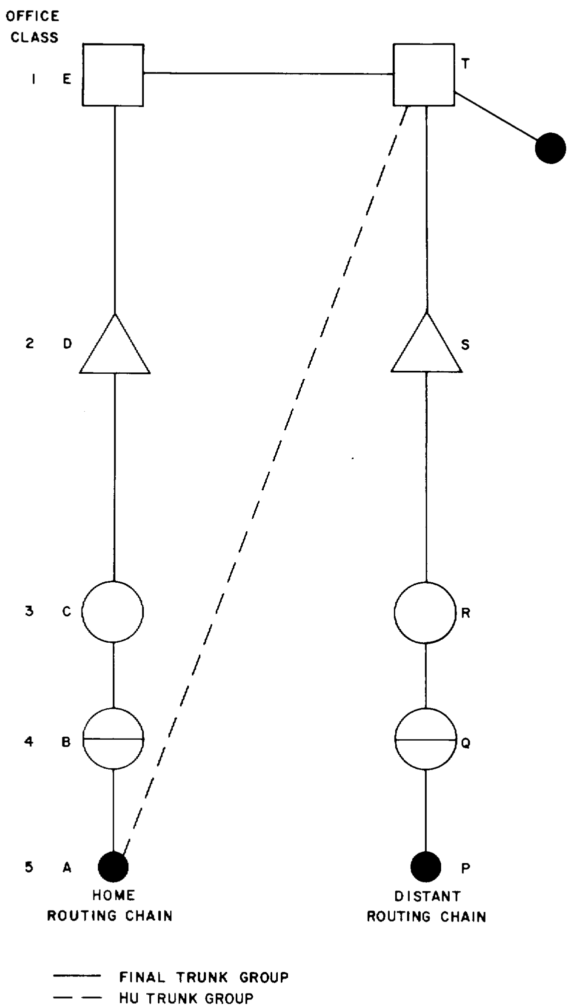


Fig. 3—Application of One-Level Limit Rule to Establish a Trunk Group Between an End Office and a Distant Regional Center

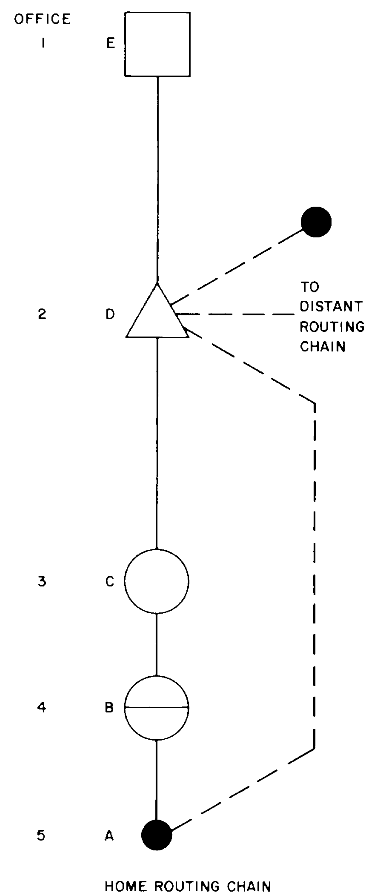


Fig. 4—Application of One-Level Limit Rule to Establish a Trunk Group Between an End Office and a Sectional Center

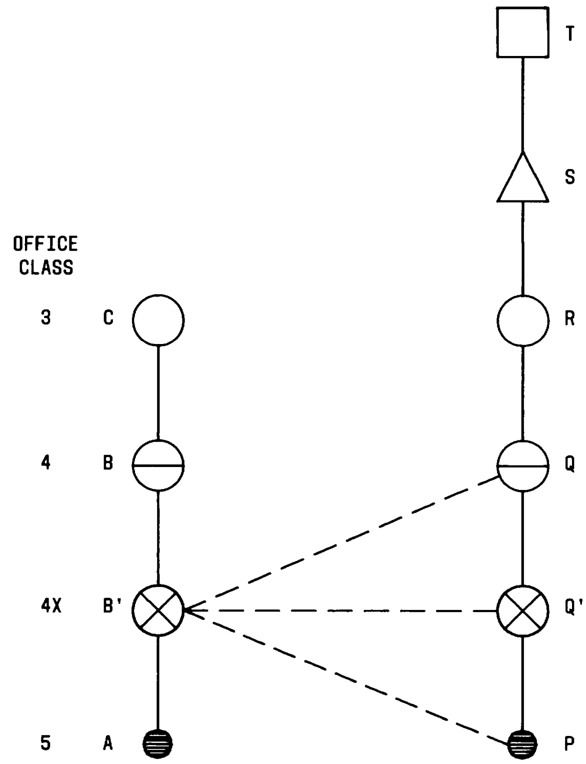


Fig. 5—Application of One-Level Limit Rule to Trunk Groups Out of Class 4X Office

APPENDIX 4

CLASS 4X OFFICE AND REMOTE SWITCHING UNITS

1. GENERAL

A. Introduction

1.01 The availability of digital Stored Program Control (SPC) switching systems with Remote Switching Unit (RSU) capabilities affects the provision of Centralized Automatic Message Accounting (CAMA) for class 5 offices, the acceptability of certain Traffic Service Position System (TSPS) routing and incoming tandem trunk configurations, and the specification of RSU/host office hierarchical classifications. Therefore, clarification of current guidelines for office classification and homing arrangements is needed as this modern technology is introduced in the network.

1.02 This appendix provides that clarification. It reviews newly sanctioned trunking and routing arrangements and discusses associated switching, signaling, trunking, transmission, maintenance, and network management requirements. In particular, emphasis is placed upon the post-dialing signaling delay as affected by deployment of some of these new arrangements.

1.03 The impetus for these changes has come from the introduction of local digital SPC switching systems in the network. In a number of locations, the addition of local digital SPC offices for modernization purposes will offer the opportunity to provide CAMA recording capabilities at small incremental costs. These local offices will often serve as host for RSUs and may also provide recording for nearby electromechanical class 5 offices. Since these SPC offices are frequently located on a main facility route or are natural facility hubs, the opportunities for performing not only recording but other concentration functions (including the tandeming of incoming traffic) are enhanced.

B. Planning

1.04 Planning for the evolving network should be a joint Bell-Independent Telephone Company effort since the plans of one likely affect the plans of others and influence the determination of the most economical industry solution. Proper classification of switching systems in the network hierarchy is essential to the trunk provisioning and design process, to assure an adequate grade of service to all customers, and to minimize degradation of voice and data transmission on calls regardless of length or number of links.

1.05 The switching plan for distance dialing was formulated to meet the requirements for a plan that would route traffic automatically, economically, and rapidly to its destination. The plan incorporates switching and trunking arrangements that adhere to the rules of a hierarchical network. It contemplates that most calls will be completed on direct intertoll trunks or over two or three intertoll trunks switched in tandem. Still, a small portion of the total number of calls may currently encounter as many as seven intertandem trunks plus the usual two tandem connecting links to end offices. This possibility imposes a need for careful transmission, signaling, and switching system design as well as diligent maintenance effort.

2. NEW OFFICE CLASSIFICATIONS, TRUNKING, AND HOMING ARRANGEMENTS

A. Host Office Classifications

2.01 ***Classifications and Settlements:*** An RSU shares the class 5 designation of its host office. Furthermore, pure RSU/host configurations should always carry class 5 designations. New symbols have been established to identify the RSU and the RSU host office. (See Fig. 1 and 2.)

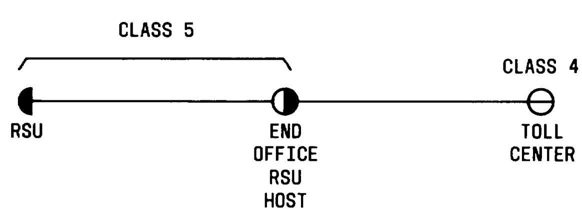
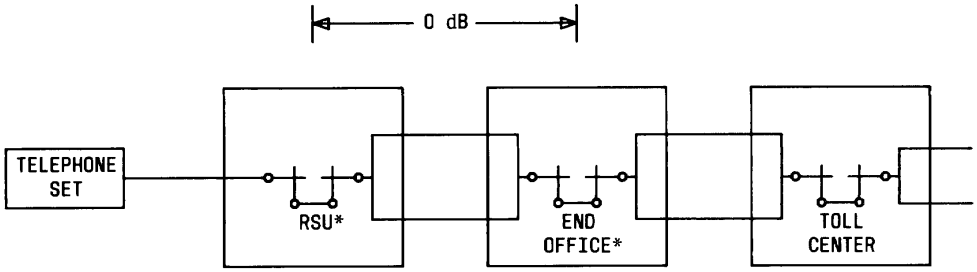


Fig. 1—Standard RSU/Host Office Classification and Homing Arrangements



* MAY BE 2- OR 4-WIRE SWITCH

Fig. 2—Transmission Path

2.02 ***Pair Gain Applications:*** An RSU may also be deployed in pair gain applications. Some applications are planned, implemented, and administered as part of a particular subscriber feeder route. Although potentially large in size (several hundred lines or more), such installations do not possess such distinguishing wire center features as a well-defined area boundary, a service order access point for all customer facilities within the area, and other technical and administrative characteristics of a wire center location.

B. 4X (Intermediate Point) Function

2.03 To effect implementation of newly sanctioned CAMA, TSPS, and incoming tandem arrangements, a new class of office, 4X, has been established to describe an office that is interposed between a class 5 office and a conventional class 4 office in the network dialing hierarchy. In order to qualify for a 4X designation, the digital SPC switching system should be essentially "transparent" to the network, ie, maintain the same service levels between normal class 5 offices and class 4 offices as designated elsewhere in the ***Notes on the Network.*** However, this is not entirely possible because the class 4X office introduces additional post-dialing delay in the network. (See paragraphs 3.07 and 3.08.) The class 4X function is similar to the normal class 4 function in that it connects end offices to each other over grade-of-service trunk groups and to the network for originating and terminating traffic. In addition, the class 4X function may also perform a class 5 function by connecting subscriber lines to each other and to the network for originating and terminating traffic. However, the class 4X function is limited by the routing, homing, signaling, transmission, trunking, and blocking considerations discussed herein.

2.04 The constraints on the class 4X function are more clearly defined in subsequent paragraphs of this appendix. The new class 4X office function has been designated an Intermediate Point (IP) in the hierarchy and a new symbol has been devised. (See Fig. 3.) A revised routing ladder illustrating the position of the class 4X IP office in the network hierarchy is shown in Fig. 4.

SYMBOL	CLASS	NAME	ABBREVIATION
⊗	4X	INTERMEDIATE POINT	IP

Fig. 3—Class 4X Function Designation

2.05 ***Provision of CAMA for Class 5 Offices:*** CAMA is normally provided only at class 4 or higher offices. Consequently, where recording capability is provided in a class 5 office and that office is used to provide recording for other class 5 offices, the office has automatically assumed a class 4 designation in the switching plan and must be homed on a class 3 or higher office. (A current standard CAMA arrangement is shown in Fig. 5.)

2.06 Changes in this arrangement are now possible with the advent of the class 4X office, provided that the CAMA location is transparent to the subscriber and to the network. The exception to the signaling transparency requirement is discussed in Part 3 of this appendix. The class 4X

CAMA location ***must*** meet all the appropriate constraints listed in Part 3. (A possible class 4X office CAMA arrangement is shown in Fig. 6.)

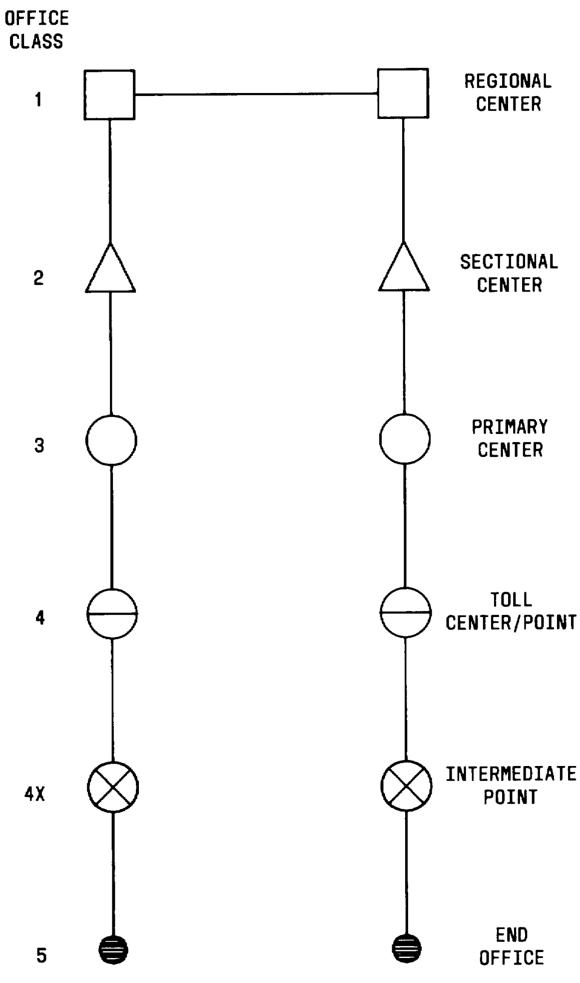


Fig. 4—Routing Ladder

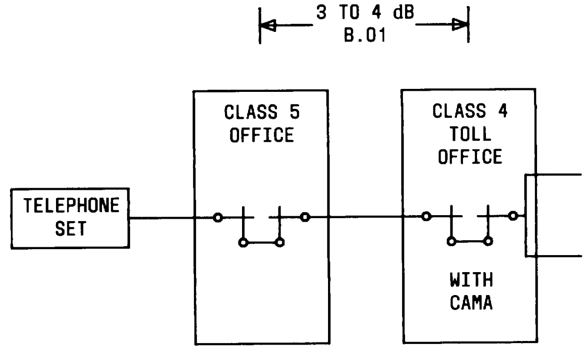


Fig. 5—Current Standard CAMA Arrangement

2.07 ***TSPS Trunk Concentration and Routing:*** TSPS trunk concentration at a class 4X office is ***not*** recommended at the present time. However, switching is permissible if the class 4X office is arranged to associate each individual incoming TSPS trunk with a predetermined outgoing TSPS trunk on a one-to-one basis. This dedication will assure that each call from a class 5 office to a class 4 office is always connected over a fixed path and thereby provides individual trunk control from the TSPS or Remote Trunk Arrangement (RTA) location.

2.08 The relationship of end offices (class 5) and toll switching offices (class 4) are well-defined in Section 3, Part 2. The class 4 office function currently provides the first step of concentration for network traffic originating at end offices and the final stage of distribution for traffic terminating at end offices. (See Fig. 7 for a current standard TSPS/RTA arrangement.)

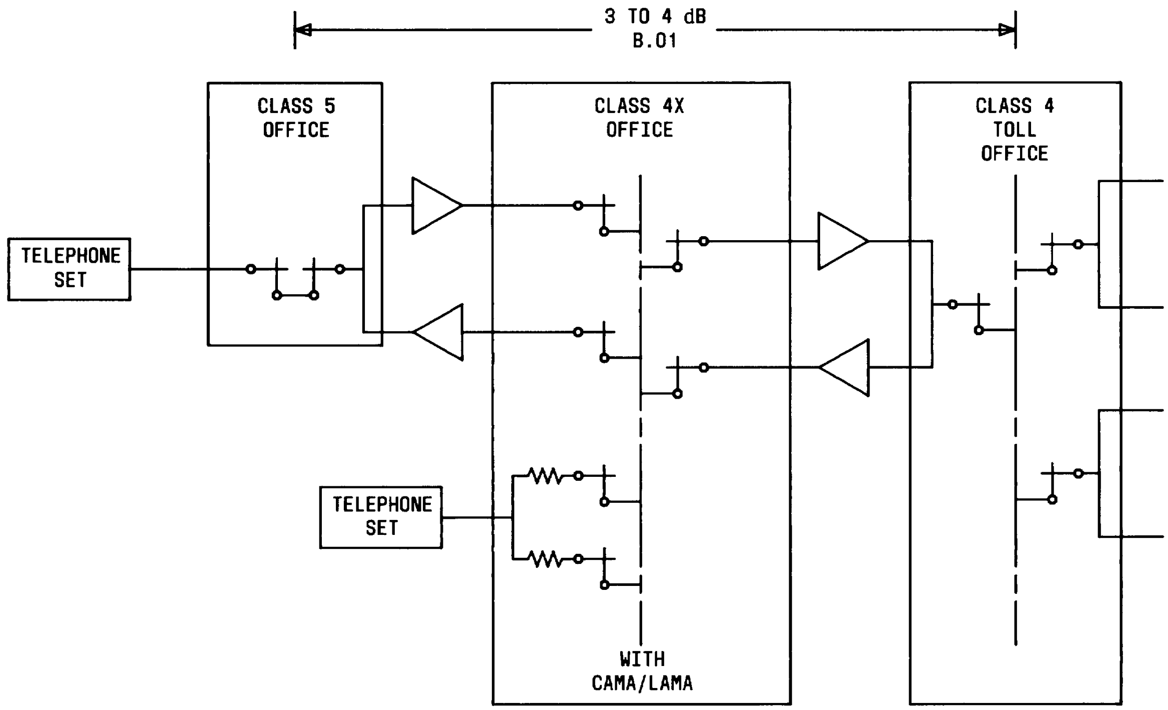


Fig. 6—Class 4X Office CAMA Arrangement

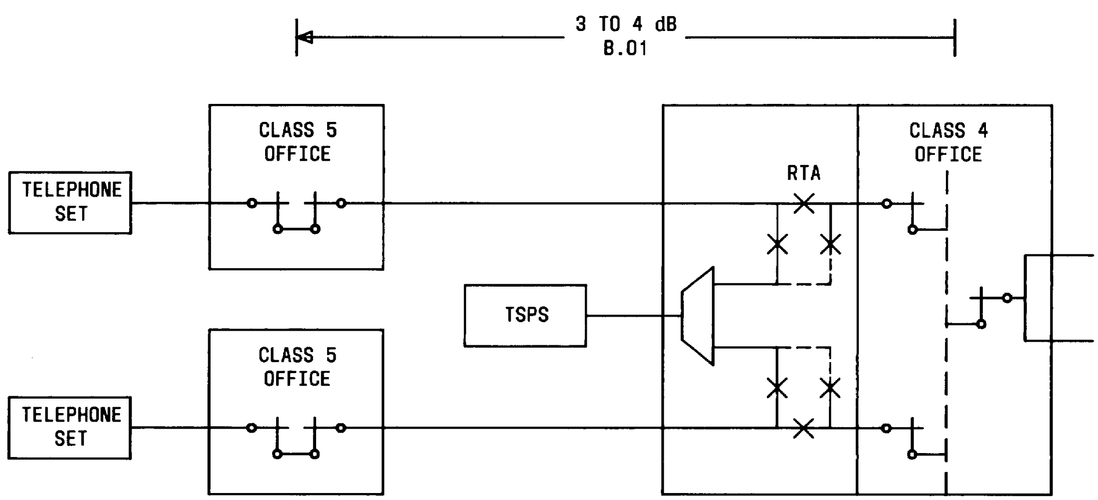


Fig. 7—Current Standard TSPS/RTA Arrangement

2.09 Any arrangement that seeks to interpose a switching office, ie, class 4X office, between the class 5 and the class 4 office for TSPS routing must provide the same grade of service designated by the prescribed switching plan. (See Fig. 8 for one possible class 4X office TSPS/RTA arrangement.) In addition, constraints discussed in Part 3 of this appendix must be met.

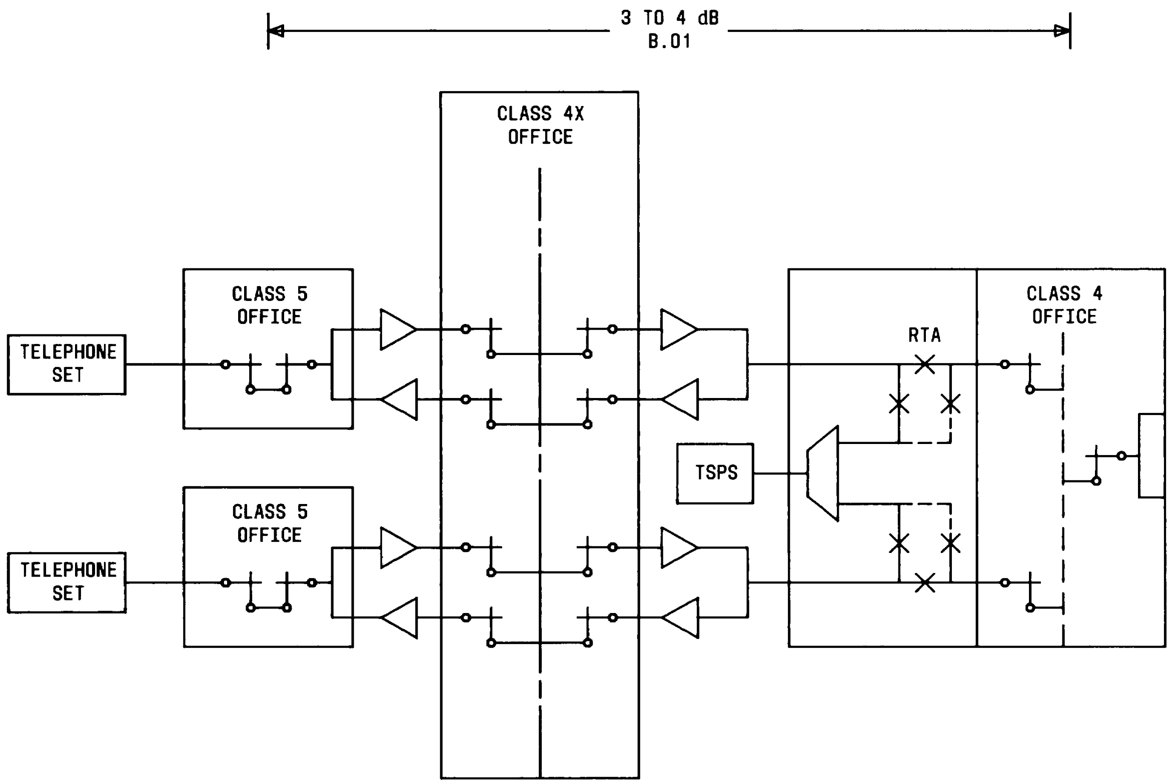


Fig. 8—Class 4X Office TSPS/RTA Arrangement

2.10 ***Incoming Tandem Arrangement for Terminating Traffic:*** Switching systems proposed for use as a class 5 office should normally have direct trunks from the class 4 office. (See Fig. 9 for the current standard arrangement for terminating traffic.) Exceptions to this arrangement are possible with the class 4X office, provided that the constraints in Part 3 of this appendix are met and that the class 4X office performs the incoming tandem function. No tandem or through switching will be permitted at the conventional electromechanical class 5 office. (See Fig. 10 for one possible class 4X office incoming tandem arrangement for terminating traffic.)

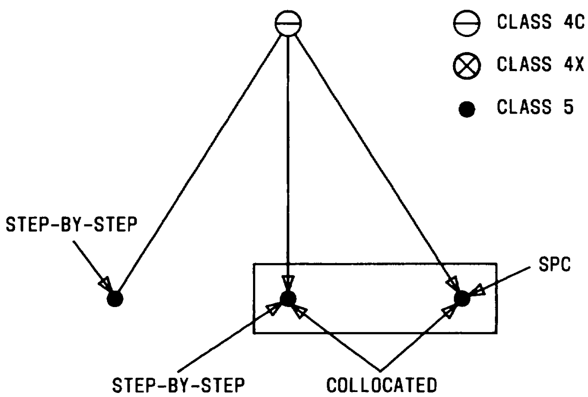


Fig. 9—Current Standard Arrangement for Terminating Traffic

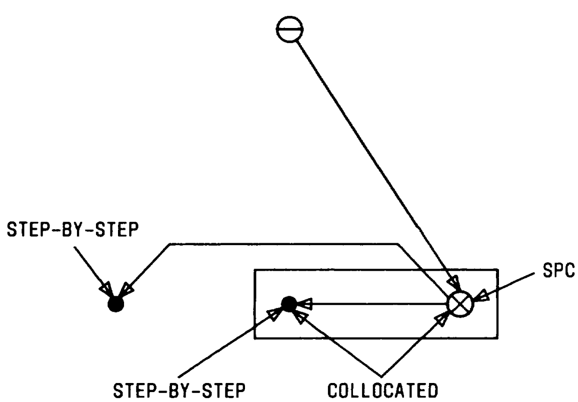


Fig. 10—Class 4X Office Incoming Tandem Arrangement for Terminating Traffic

3. CONSTRAINTS ON THE CLASS 4X FUNCTION

A. Introduction

3.01 The following paragraphs discuss the constraints which must be satisfied in order to deploy class 4X office arrangements in the network. Each application should be analyzed and evaluated on its own merits considering the anticipated benefits and possible risks, especially in view of the post-dialing delay effect discussed in paragraphs 3.07 and 3.08.

B. High-Usage Trunking

3.02 High-Usage (HU) trunking is permitted at a class 4X office but not at subtending class 5 offices. This constraint is necessary to preclude overflow on the 5-4X group which is sized using procedures which assume Poisson-distributed traffic. Also, this constraint is necessary to maintain the integrity of existing software support systems, which assume a 5-level hierarchy, including trunk forecasting, trunk servicing, network planning, and network maintenance systems.

3.03 Only-route groups which do not overflow are permitted at class 5 offices subtending the class 4X office and to connect subtending offices to the class 4X office for access to and from the toll network. These only-route trunk groups out of the subtending class 5 offices to other than the class 4X office should be sized for B.01 blocking using normal procedures.

C. One-Level Limit Rule

3.04 Under the one-level limit rule, the switching function performed for the first-routed traffic by the switching system at either end of the HU trunk group may be of the same class number of switching function or may differ by only one class number of switching function. In the case of the class 4X office, one class level above is class 4 and one class level below is class 5.

D. Switching

3.05 The class 4X office should be an essentially nonblocking switching system with appropriate synchronization arrangements.

3.06 Trunk concentration arrangements must have an overall probability of blocking that is no greater than that of current arrangements. Refer to paragraphs 3.15 and 3.16 for further details on the blocking service objective and its allocation.

E. Signaling

3.07 The class 4X office should not cause any loss of signaling information. However, it will impart additional signaling delay on calls through the switching system. In order to prevent the addition of unacceptable dial pulse signaling delay to the connect time (ie, end of dialing to start of ringing) of a call, the class 4X office may not home on a step-by-step class 4 office. In the case of other class 4 switching systems (ie, electromechanical or SPC), the additional signaling delay should not exceed an average of 2.5 seconds. This can be accomplished by utilizing either multifrequency signaling or common channel interoffice signaling capability. Further, the class 4X office must provide for proper reaction to supervisory signals and appropriate call seizure and disconnect timing. In this regard, answer supervision timing across the class 4X office of approximately 22 ms must be provided (ie, similar to the requirement for other toll offices in the network).

3.08 For class 4X TSPS/RTA arrangements, additional signaling requirements include provision of Automatic Number Identification (ANI), trunk group and originating office identity information, coin control and ringback capabilities, and TSPS control features (eg, ANI/Operator Number Identification [ONI], release guard, TSPS hold, distant end make-busy, overload control, etc).

F. Transmission

3.09 There should be no perceptible transmission impairment introduced by any class 4X office configuration. In order to avoid potential degradation in transmission performance, it is a requirement that the class 4X office be a 4-wire digital SPC switching system. In addition, 4-wire facilities are required on the 4X-4 links and are preferred on the 4X-5 links. Transmission quality will be impaired least when both 4-wire trunking and switching are utilized. Refer to paragraphs 3.15 and 3.16 for additional information on transmission objectives and allocations.

3.10 At this time, concentration of TSPS trunks at an intermediate switching point is ***not*** recommended. Therefore, the normal TSPS trunk design rules and maintenance plan are in effect from the end office to the TSPS bridging point. If the transmission path of TSPS trunks is through an intermediate digital switching system (eg, 4X), treatment is the same as for a digital carrier system.

G. Maintenance and Testing

3.11 The class 4X office should have make-busy features and trouble diagnostic, testing, and service restoral capabilities equivalent to current arrangements.

3.12 The class 4X office will be responsible for toll connecting trunk (ie, 5-4X link) terminal balance testing into the subtending class 5 offices, since the upstream class 4 toll office can no longer select those trunks.

H. Network Management

3.13 The class 4X office should have adequate network management capabilities where applicable, eg, traffic data, routing control, and overload control.

I. Economic Studies

3.14 Appropriate economic studies must be performed prior to implementation of these new arrangements; applications will frequently involve Bell-Independent Telephone Company joint studies. Wherever a study includes a 4X alternative, an evaluation should also be made of the more common class 5—class 4—class 3 hierarchical arrangement to ensure deployment of the most economically effective network. It should be made clear that the 5-level hierarchical arrangements are preferred for service reasons because the 4X arrangements introduce additional post-dialing delay in the network.

J. Blocking and Transmission Service Objectives

3.15 The blocking requirements between the class 5 and class 4 offices remain unchanged, ie, B.01. However, when a class 4X office is interposed between the class 5 and class 4 offices, blocking on the two links, ie, 5-4X and 4X-4, must be allocated to achieve B.01 overall. It is recommended that the 4X-4 link be sized to B.01 using normal procedures and the 5-4X link be sized so it is essentially nonblocking as is done with RSU/host links. This procedure involves converting the average busy season time consistent busy hour load, which would normally be used for sizing, to an equivalent 20-day Return Period Load (RPL) and then entering the Wilkinson B capacity tables with the RPL to determine trunk requirements.

3.16 Existing transmission requirements for tandem connecting and intertandem trunk design other than balance apply to the class 5 to class 4X and class 4X to class 4 office links, respectively. These requirements and allocations are applicable only to class 4X office arrangements for CAMA and terminating traffic as exemplified in Fig. 6 and 10. Balance requirements for these arrangements must ensure performance at the class 4 office equivalent to that which currently exists with a single tandem connecting trunk.

K. RSU/Host/4X Tandem Connections

3.17 At this time, a class 5 office may not host an RSU and still subtend the class 4X office; ie, RSU to host to class 4X connections are not permitted in tandem in the same final route chain. This is necessary to avoid the potential violation of transparency and signaling requirements referenced in this appendix.

4. SUMMARY

4.01 In evaluating the possible application of any "4X office arrangement" described in this appendix, it is imperative that all aspects of originating and terminating traffic be thoroughly analyzed for each case. Particular attention should be given to signaling delay, TSPS traffic, maintenance arrangements, and failure modes. Any arrangement that has a deleterious effect on service objectives, transmission levels, and especially signaling delay should be carefully considered before being implemented.

4.02 It should be emphasized that an orderly program is necessary to coordinate the introduction of new technological advances in the Message Network. Decisions in the technical area should be based on fundamental planning studies which consider all practical alternatives (with the ultimate plan selected on the basis that is least costly) and which consider service implications.