TRUNK NETWORK DESIGN—FIRST ROUTE AND ALTERNATE ROUTE SELECTION—CONCEPTS AND PRINCIPLES

TRUNK ENGINEERING

NETWORK OPERATIONS METHODS

1. GENERAL

1.01 This section face sheet is issued to assign its 9-digit number to Traffic Facilities Practices

Division G, Section 3-e(1), September 1976.

This is part of the conversion of all Traffic Facilities Practices (TFPs) to the 9-digit Bell System Practices (BSPs) series as described in GL-77-05-262 and GL-77-11-200.

1.02 When this section is reissued, all references to TFP numbers will be changed to the appropriate 9-digit BSP numbers.

1.03 Recommendations for changes, additions, or deletions to this section should be forwarded on Form E-3973 as specified in Section 000-010-015.

1.04 TFP to BSP cross-reference information can be found in GL-77-11-200 and in Section 780-400-005.

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TRUNK FACILITIES
TRUNK NETWORK DESIGN
FIRST ROUTE AND ALTERNATE ROUTE SELECTION
CONCEPTS AND PRINCIPLES

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Figure

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TRUNK FACILITIES

TRUNK NETWORK DESIGN

FIRST ROUTE AND ALTERNATE ROUTE SELECTION

CONCEPTS AND PRINCIPLES

1. GENERAL

1.01 This section is the first of a series of sections in Division G which discuss the routing of traffic in hierarchical networks. Specifically, this section discusses the concepts and principles underlying a routing discipline which has been developed to assist with the network design functions of first route and alternate route selection.

1.02 This series of sections replaces Division G, Section 2-a(2) dated September 1968 (Part 3 only), Section 2-a(5) dated August 1968 (Parts 2 and 3), Section 2-c(4) dated June 1965 (entire section) and Section 2-d(2) dated September 1968 (Parts 3 and 8). Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 References in this section to methods, planning, data requirements, service levels, and equipment quantities are based on American Telephone and Telegraph Company recommendations.

1.04 The title for each figure includes a number(s) in parentheses which identifies the paragraph(s) in which the figure is referenced.

1.05 The other sections in this series are:

3-e(2) - First Route and Alternate Route Selection - Rules

3e(3) - First Route and Alternate Route Selection - Load Accumulation - Candidate Trunk Group Identification

3-e(4) First Route and Alternate Route Selection - Network Route Selection Mode

3-e(5) First Route and Alternate Route Selection - Other Considerations

The subject matter discussed in these sections is organized in this manner as an aid to understanding the evolution and application of the routing discipline, and to permit the reader to more easily locate that portion of the subject matter of immediate interest.

1.06 The rules of routing discussed in this practice relate to network design, but they are also applicable to the administration of the network. The procedures for implementing routing, however, are discussed in Section 11 and in the various switching system translation guides.

1.07 The reasons for issuing this series of sections are:

(1) Previous information was divided among several sections of this division.

(2) Clarification of previous guidelines had not been incorporated into the practices.

(3) Previous disciplines did not reflect current thinking related to switching by functional level or to directional routing and alternate routing.

(4) Different guidelines were provided for "local" and "toll".

(5) Procedures were not specified for incorporating routing rules into a network design process.

(6) The development of mechanized routing systems necessitated the development of specific procedures for routing traffic.

1.08 In order to understand the discussion of the routing discipline which follows, it is helpful to know how first and alternate route selection impact the network design function. The overall network design process for hierarchical networks involves six basic steps:

(1) Selecting a network configuration

(2) Establishing a homing arrangement

(3) Determining traffic volumes

(4) Identifying candidate high-usage trunk groups

(5) Selecting first and alternate routes

(6) Sizing trunk groups

1.09 The routing discipline described in this 3-e series of sections relates to basic steps 4 and 5, i.e., the identification of candidate high-usage trunk groups and the selection of first and alternate routes. A brief discussion of the 6-step process is provided in 2.01 through 2.08 and detailed information on the routing discipline itself begins in 3.01.

2. THE 6-STEP NETWORK DESIGN PROCESS

2.01 Several network configurations are commonly used in the Bell System message network. These include the 2-level Originating Sector, Terminating Sector, and Combined Sector Tandem networks commonly used in metropolitan areas; and the 5-level North American network for longer haul traffic. Some of these configurations are shown in Fig. 1. They are described in greater detail in Division G, Section 3-b. A given end office will frequently appear in more than one network for different traffic items.

2.02 All of the configurations assume a hierarchy of switching systems, therefore, a homing arrangement as discussed in Division G, Section 3-a(2) must be established to indicate which switching systems are subordinate to each higher class switching system. Each switching system performs a grouping or concentration function for the switching systems that subtend it. Switching systems in each homing arrangement of the hierarchy are connected by final trunk groups which form the backbone of the network. The choice of network configuration and homing arrangement is normally made as a result of a long range planning study. The trunk engineer will frequently be involved in developing those planning studies and also in developing modifications when specific constraints, such as the deferral of a planned switching system, do not permit implementation of the basic plan.

2.03 In established, stable networks, i.e., those in-service networks in which no new switching systems or trunk groups are to be established and no rerouting is to occur during the time frame under consideration, load data derived from trunk group measurements can be used directly as the base from which to develop trunk group sizes. Where new trunk groups are to be established, however, or traffic is to be rerouted for switching system load-balance purposes, or because of rehoming or new switching systems, trunk group loads must be developed from point-to-point data. The degree to which a network will be engineered, using a point-to-point data base, will ordinarily be a function of traffic growth rates and growth patterns, with the more rapidly evolving networks requiring greater use of point-to-point data. Point-to-point data must include loads for all hours and seasons that are significant to the network sizing process, as is the case with trunk group measurement derived loads. Point-to-point load information may come from a variety of sources such as CMDS, Point-to-Point Attempt Analyzers, or from trunk basing procedures. Section 2 of Division G discusses the determination of point-to-point data. In the development of network requirements for future periods, a representation of future traffic volumes is, of course, required.

2.04 Given a network configuration, homing arrangements, and point-to-point loads, the routing discipline discussed here can be used to identify candidate high-usage trunk groups, to assign the appropriate traffic to those trunk groups, and to determine alternate routes for all high-usage trunk groups. High-usage trunk groups identified as candidates by this process, and which subsequently are justified by the sizing process, supplement the backbone final trunk groups which were specified when the homing arrangement was determined.

2.05 The identification of candidate high-usage trunk groups is accomplished by evaluating point-to-point loads to see if they are of sufficient volume to meet a predetermined threshold level, at which direct trunking should be considered. The threshold level will ordinarily be a function of last trunk loading requirements as discussed in Section 3-c, and the overflow loads to be added to the first route load in the sizing process as discussed in Section 8. The threshold level may vary, group by group, or it may be a fixed value for certain combinations of trunk groups. This value will ordinarily have to be determined experimentally. Where the point-to-point loads do not meet the threshold value, they are assigned to a first choice switched route where they are accumulated with other first route loads. The accumulated loads are then examined to see if they meet the candidate trunk group threshold. The routing rules and procedures related to this process are discussed in detail in Section 3-e(2) and 3-e(3).

2.06 Ideally, trunk quantities and overflow volumes could be computed in this load summation process. To do so, however, would require a complex series of iterations because of trunk group and network interdependencies. Therefore, in these procedures, only first route loads are involved in the summation process. Since the routing procedures indicate that candidate trunk groups should be provided to insure a one-switch alternate route for each high-usage trunk group, those trunk groups dependent upon overflow to meet minimum size will be considered. Specific overflow loads which are not known at this point are added in the trunk group sizing process discussed in Section 8.

2.07 After all candidate trunk groups are identified, and first and alternate routes selected, they enter the last step of network design - sizing. The actual ***justification*** of trunk groups is done in that sizing process. The sizing must take into account not only the first route loads developed through application of the routing discipline, but also the overflow loads developed as a part of the sizing procedure, and the characteristics of the traffic, e.g., its peakedness.

2.08 It must be recognized that this 6-step process is seldom used in its entirety during any one cycle of determining network requirements. For example, network configurations once selected tend to be unchanged for a number of years. Similarly, much of the network required in future years is already in service. As a result, the use of the 6-step process will most frequently be to care for growth and evolution through the addition of new high-usage trunk groups and the resizing of existing ones.

3. THE ROUTING DISCIPLINE

3.01 In order to accomplish the routing function of identifying candidate high-usage trunk groups and selecting first and alternate routes, orderly rules and procedures are necessary, and they must be uniformly applied. The requirements for these rules and procedures, which comprise the routing discipline, are explained in the following paragraphs.

3.02 The telephone system is a combination of many interconnected switching systems and trunk groups. The high degree of interrelationship and interdependence among all of the individual network piece parts require that they be interconnected in a way which assures the proper functioning of the entire network. Further, this interconnection plan must be compatible with engineering and administrative techniques, it must provide for the orderly evolution of the network as traffic volumes, profiles, and characteristics change, and it must meet service objectives. While the need for a discipline may be more obvious in the North American network where trunk groups are often long-haul and inter-Company in nature, the principles apply equally to smaller networks where violations, on the surface at least, might appear to have little impact. It must be realized that while any one departure from the standard routing discipline can possibly be tolerated without significant impact on the network, this departure may appear to justify another and, at some point, the discipline would cease to exist in any effective form.

3.03 The massive size of the message network, both in the geographical area covered and in the number of trunk groups and switching systems involved, requires that it be subdivided into various segments for administration and engineering. With the complex interconnecting routing and trunking arrangements of the network and with its management subdivided, it is imperative that network records, interchanged data, etc., appear in a standard format. The standards imposed by the routing discipline facilitate this by using common routing definitions, sequential procedures for routing traffic, and routing rules designed to be used with standard administrative and engineering practices. Some of the benefits to be derived from the use of standard routing rules are discussed below:

- Uniform Call Routing—The standard routing discipline will provide uniform treatment for calls offered to the network. Engineering and administrative techniques can be established such that transmission and service objectives can be achieved throughout the network.

- Mechanized and Modernized Methods—The routing discipline will enable computer programs to be developed which can provide routing, engineering, and planning information faster and more accurately than is possible today. With the growing complexity of the network, it is becoming imperative that mechanized and modernized methods be developed to aid in network engineering, documentation of call routing, and growth planning.

- Economic Engineering—Engineering criteria are based on a network constructed, and handling traffic, in conformance with the standard routing discipline. When routing rules are followed, economic call handling will result.

- Information Exchange—The routing discipline provides standards which permit routing information to be exchanged rapidly and accurately.

- Data Interpretation—A prime requirement in evaluating basic trunk group load and service data is to know what traffic is being offered to each trunk group. When the network is operating in conformance with the routing discipline, accurate interpretation of the available data is possible.

- Simplified Route Determination—Complete route identification can be determined from a minimum of data by use of the routing discipline. The only data required to determine traffic routing is the homing arrangement of the switching systems by class of service (e.g., DDD, OPR, CAMA, etc.) and the trunk groups provided.

- Simplified Training Methods—Following the routing discipline will reduce or eliminate exceptions and variations in the handling of traffic on the network. Rules are easier to learn and to apply where the exceptions are minimal.

3.04 With the assurance that the network is operating in conformance with routing standards, the trunk administrator or engineer can proceed with the accumulation, verification, interpretation, and projection of load data for the present and future network trunking arrangements, and the detailed computation involved in determining the number of trunks required in each trunk group. The planned changes in the network can be accommodated and the loads can be accumulated as required to build new trunk groups. The routing discipline has been developed to provide an optimum relationship between obtaining the desired service level and meeting the economic considerations of constructing the network, consistent with engineering and administrative requirements.

3.05 The following are some of the specific criteria that guided the development of this routing discipline:

- It should provide for an economic network provision.

- It should facilitate the management and administration of the network.

- It should enable an orderly provision of facilities and equipment and be equitable in its effect on other construction programs.

- It should be adaptable to changing traffic volumes, distributions, and characteristics.

- It should minimize routing and translation problems in switching systems and eliminate unusual traffic patterns.

- It should facilitate publishing and distributing routing information.

3.06 There must be an understanding and acceptance of an "industry point-of-view" by every person involved in the routing process, in order to avoid causing situations which could have an adverse effect on the service and/or costs in other parts of the network for which other persons are responsible. This, basically, involves planning for and establishing only standard routing and trunking arrangements. Non-standard arrangements may appear to be advantageous, when viewed in the light of one's own conditions, but they could create problems for others. Standard routing procedures are oriented to overall industry considerations and requirements. The use of non-standard arrangements in special situations must have a sound economic or service basis. Because of the system-wide increase in engineering and administrative effort required to handle a special routing arrangement, any such deviation from standards should be reviewed by the "AT&T Headquarters Staff" and approved before incorporating the arrangement into the network.

3.07 It can be seen from the above discussion that the routing discipline itself has two main functions; it provides a standard way of routing traffic and, with traffic so routed, it provides a way of analyzing network loads to determine what new trunk groups are justified. It also permits ready identification of rerouted loads which result from rehoming, new switching systems, etc.

3.08 The routing discipline has two distinct modes of application.

(1) A Load Accumulation mode, in which trunk group candidates for later sizing are identified, based upon accumulated point-to-point loads routed in accordance with the discipline. This mode is usually considered to be a part of the trunk forecasting process and leads to the generation of a General Trunk Forecast.

(2) A Network Route Selection mode, in which a given network is utilized to route point-to-point traffic in accordance with the discipline. This mode can be utilized by trunk forecasters and routing engineers to determine how traffic should route in a given network. It can also be used by network management people to determine how traffic is routed without having to make reference to engineering records.

3.09 The Load Accumulation mode consists, essentially, of evaluating point-to-point loads to see if they are of sufficient volume to warrant direct trunking. If not, a first choice switched route is determined where loads are summed to see if their total is of sufficient volume to warrant direct trunking. This process is followed, in a given sequence, until all groups have been considered and all first route loads have been assigned to a specific route.

3.10 The Network Route Selection mode consists, essentially, of selecting the preferred route for a given point-to-point traffic item when all available routes are known.

4. USES OF THE ROUTING DISCIPLINE

4.01 As noted previously, the basic rules which underlie the discipline are discussed in Section 3-e(2), the identification of candidate trunk groups is discussed in Section 3-e(3), and routing in a given network is discussed in Section 3-e(4). The routines being incorporated in the BIS developed routing programs are in accordance with this discipline.

4.02 In identifying candidate trunk groups for a complete network, the assumption is made that homing arrangements (and hence final trunk groups) are known, and that point-to-point traffic data are available to identify high-usage trunk group candidates. It is necessary to know all the point-to-point loads which may in themselves justify direct trunking. The routing discipline is then applied as outlined in Section 3-e(3) and candidate trunk groups identified. The process identifies candidate trunk groups between equal switching functions in the hierarchy first, and then moves sequentially through the hierarchy until all switching functions are examined.

4.03 Detailed knowledge of insignificant items is not needed. For example, analysis of data over several years could indicate essentially no probability of justifying 5-5, 5-4, 4-4, or 4-3 trunk groups between the Spokane, Washington and Chipley, Florida class 3 areas. It is not necessary, therefore, to examine individually any of the traffic items which make up the total load between the two class 3 areas. Only that total load need be evaluated for a potential trunk group between Spokane and Chipley. Accumulation of loads in this way considerably reduces the number of trunk groups to be considered.

4.04 It is expected that a complete network load accumulation will seldom be required. The design responsibilities for the total network are divided among the several Telephone Companies. For the North American network, no one Company has all the basic information needed for a complete network evaluation. Even in the case of those Metropolitan networks which involve only one Company, the usual case involves the assumption of certain trunk groups being in service.

4.05 The more usual application is that of a partial network evaluation. This application may take several different forms, some of which are shown below.

(1) A multicompany evaluation of a multicompany network.

(2) A full evaluation of a network segment.

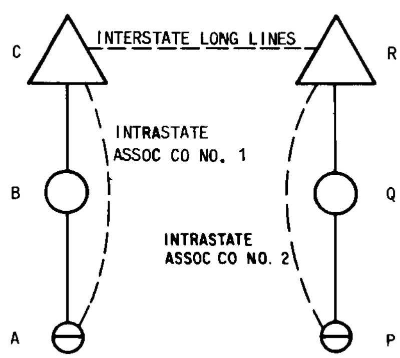
(3) A partial evaluation of an entire network.

(4) A partial evaluation of a network segment.

These options are discussed in broad general terms below. The intent is not to rigidly define specific options, but rather to show the versatility of the routing discipline in accommodating the variety of tasks normal to the network design process. An understanding of the specific discipline, as discussed in Section 3-e(2) through 3-e(5), is necessary for a full appreciation of these applications.

MULTICOMPANY DESIGN OF A MULTICOMPANY NETWORK

4.06 One example of this situation in the North American network, where several Companies are involved, is illustrated in the following sketch.



Sketch 1

4.07 The design coordination between companies is provided for through the use of preestablished trunk groups and prerouted traffic. A preestablished trunk group is one that is assumed to be in service and does not require repeated justification by load developed by the discipline. Prerouted traffic is traffic which follows a user specified route, ordinarily developed using the load accumulation process of the discipline in a previous year or by another company. If Long Lines is developing requirements for its portion of the North American network, it must know which Associated Company trunk groups are available for handling that interstate traffic. For example, Long Lines must be aware of the Associated Company group A-C shown in the sketch in order to properly route interstate traffic from A to R. In like manner, if an Associated Company is developing requirements for its portion of the North American network, it must know which Long Lines trunk groups and loads will impact that part of the network. For example, the Associated Companies forecasting the A-C and P-R trunk groups must know the amount of interstate load routed over those trunk groups by Long Lines. A significant data interchange is required.

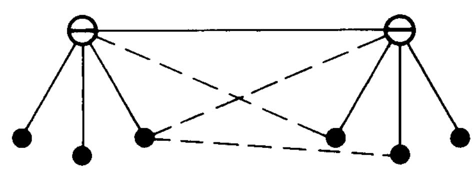
COMPLETE DESIGN OF A NETWORK SEGMENT

4.08 In some instances it may be desirable to develop a trunk network between two specific switching system areas, such as between two class 3 areas.

4.09 The routing discipline will handle this situation by developing all candidate trunk groups ***between*** the two class 3 areas, provided the homing arrangements and point-to-point loads are given for all the switching systems. It is not necessary to know the homing arrangement or loads for the remaining part of the network. If there is sufficient load for ***any*** trunking between the class 3 areas, the discipline will specify that a trunk group be provided between the class 3 switching systems. No higher class switching system will then be involved in handling the first routed traffic between the two class 3 areas.

PARTIAL DESIGN OF AN ENTIRE NETWORK

4.10 It is frequently desirable to determine the effect of growth in a network while maintaining a stable network trunking configuration. For example, the trunk groups sketched below may represent a stable base network configuration which will be retained throughout a study period, when it is desired to determine which, if any, additional trunk groups are justified.



Sketch 2

4.11 The trunk groups shown can be treated as preestablished trunk groups. The discipline, then, provides procedures for routing the appropriate traffic over them and for analyzing the remainder of the point-to-point traffic to determine the additional trunk groups justified. This feature is expected to be of major significance in the development of a General Trunk Forecast as most trunk groups in the forecast are clearly justified year after year, and there is no reason to identify these trunk groups as new candidates each year.

PARTIAL DESIGN OF A NETWORK SEGMENT

4.12 In paragraphs 4.08 and 4.09 the complete design of a network segment was discussed. In addition, it is frequently desirable to determine the effect of growth in a network segment. This is accomplished in the segment along the same line as described in 4.10 and 4.11 for the entire network.

ROUTING TRAFFIC OVER A GIVEN NETWORK

4.13 There are several situations where it is desirable to be able to determine the preferred route for selected items of traffic when the trunk groups are specified. Among these situations are the following:

(1) The route transfer of the appropriate traffic when placing new trunk groups in service.

(2) The route transfer of traffic when discontinuing trunk groups.

(3) The elimination of mis-routes.

(4) The identification of traffic affected by facility problems or trunk outages.

(5) The identification of traffic affected by network management controls.

The specific procedures for identifying the preferred route for selected traffic over a given network are discussed in Section 3-e(4).

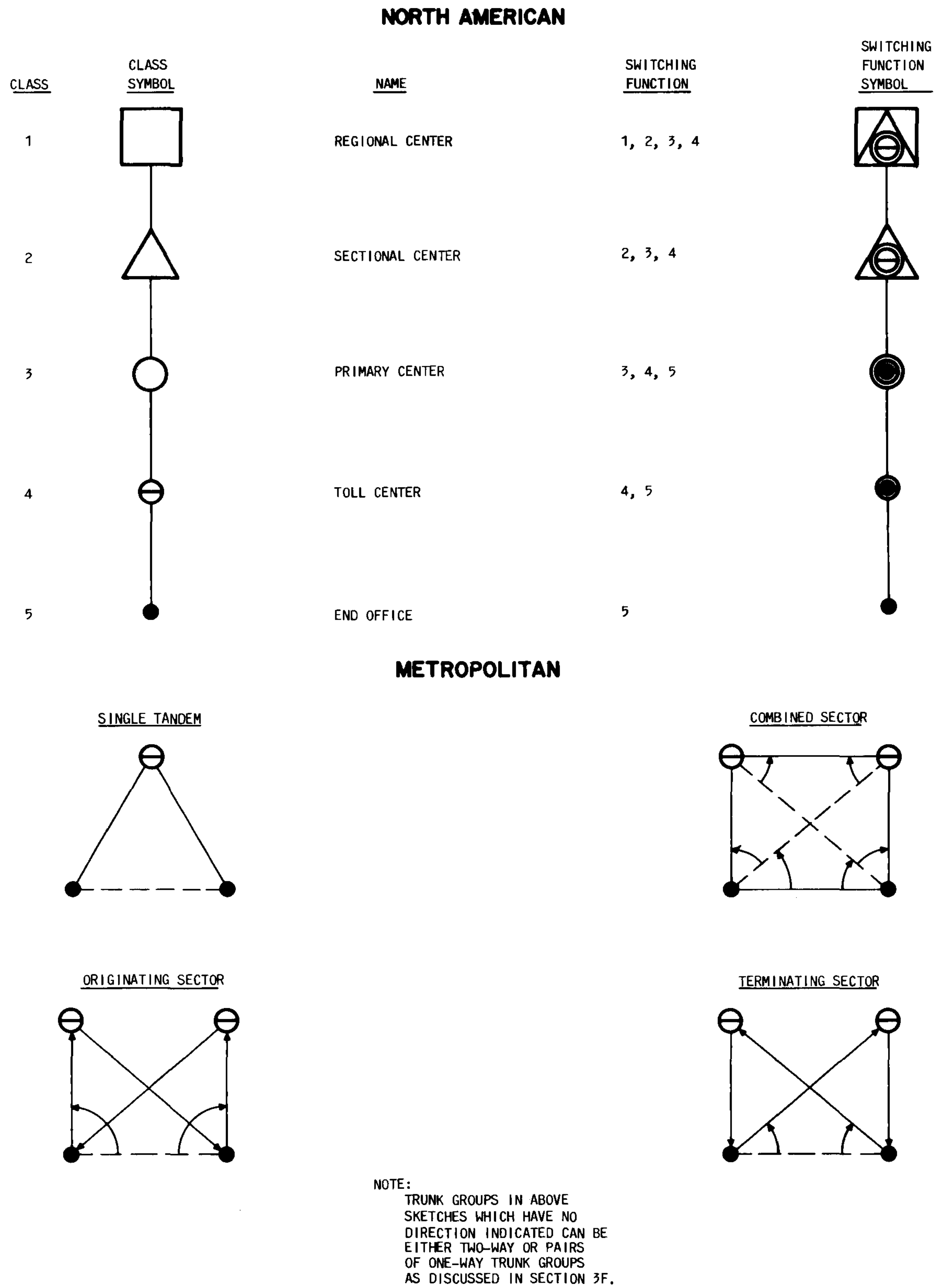


Fig. 1—Network Hierarchical Arrangements (2.01)