TRUNK NETWORK DESIGN—MESSAGE NETWORK CONFIGURATIONS
TRUNK ENGINEERING
NETWORK OPERATIONS METHODS

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1. GENERAL

1.01 The trunk groups and switching systems in the message network are interconnected into various arrangements or configurations. The commonly used configurations are described in this section along with their unique features and characteristics.

1.02 Whenever this section is reissued, the reason for reissue will be stated in this paragraph.

1.03 The North American Network which serves the United States, Canada, Bermuda, and the Caribbean area, except Cuba, basically is configured such that any customer in this geographic area can be connected to any other customer in this area. However, many metropolitan, non-metropolitan, and inter-metropolitan networks, because of economic considerations, traffic volumes, switching system types, or tariff arrangements, utilize other network configurations. As a result, individual trunk groups and switching systems may be used in common for two or more configurations.

1.04 Unique features of the various configurations are covered in this section. The North American Network is discussed first since, conceptually, it can serve all traffic in the geographic area it serves. However, many other network configurations exist, the effect of which is to keep loads on the North American portion of the network lower than they would be otherwise. These other configurations are discussed subsequently in this section. It will be recognized that many of these other configurations, particularly in metropolitan areas, evolved before the North American Network.

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

1.06 For the standard meaning of terms and definitions used in this section, see Section 780-400-305, "Glossary of Trunk Facilities Terms and Definitions".

2. NORTH AMERICAN NETWORK

A. General

2.01 The North American Network is, basically, a 5-level configuration as shown in Fig. 1. The backbone of this network is the last-choice route chain which interconnects the five levels in a hierarchical arrangement. High-usage trunk groups are established when loads reach threshold levels between switching systems not connected by grade-of-service trunk groups. Loads for proving-in high-usage trunk groups are accumulated in accordance with a discipline described in Sections 780-402-130 through 780-402-150. Section 780-402-120 provides information on high-usage trunk group sizing criteria. Automatic alternate routing is employed and, for the most part, both high-usage and grade-of-service trunk groups operate two way. Alternate routes also are selected in accordance with a discipline discussed in Sections 780-402-130 through 780-402-150.

2.02 Each switching system in the network has a "class" as determined by its location in the hierarchy (where two or more switching systems are collocated in the same building, their class will be determined individually).

2.03 The end offices, where customer lines are terminated for purposes of interconnection to each other and to the network, are the first level of the five levels of switching systems and they are designated as Class 5.

2.04 All other switching systems in the network are tandems, ie, switching systems which can establish trunk-to-trunk connections. The tandem switching systems 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, perform a "Toll Center" or "Toll Point" function. Where these tandem switching systems perform only the function of the second of five levels, they are designated as Class 4C or Class 4P tandem switching systems. "Centers" are locations at which operator assistance in completing incoming calls is provided. "Points" are locations at which operators handle or service only outward calls, or where tandem switching is performed without provision for operator functions.

2.05 Certain switching systems, in addition to connecting a group of end offices to each other and to the network, are selected on the basis of overall network economies to provide additional levels of concentration. These switching systems, which are referred to as control switching points, are: Primary Centers or Points designated Class 3 (third level), Sectional Centers or Points designated Class 2 (fourth level), and Regional Centers or Points designated Class 1 (fifth level).

2.06 One final or only-route trunk group is always provided from each switching system to another switching system of higher class. The one exception to this principle is that all regional switching systems are connected to each other by final trunk groups. That higher class switching system to which a given switching system is connected, via a final trunk group, is called its "home". The lower class or dependent switching system is spoken of as "homing" on the higher class switching system. The switching system standard classifications and symbols and the backbone homing arrangement of the North American Network are shown in Fig. 1. A given homing arrangement provides the last-choice route for all traffic to be handled within that homing arrangement. Overlapping homing arrangements also exist where a given switching system will have final routes to and from more than one home. For example, operator-handled traffic may be routed differently, traffic may route to a specific switching system for Automatic Message Accounting (AMA) recording, or , certain traffic items may be selectively routed such as with the Selective Routing Tandem (SRT).

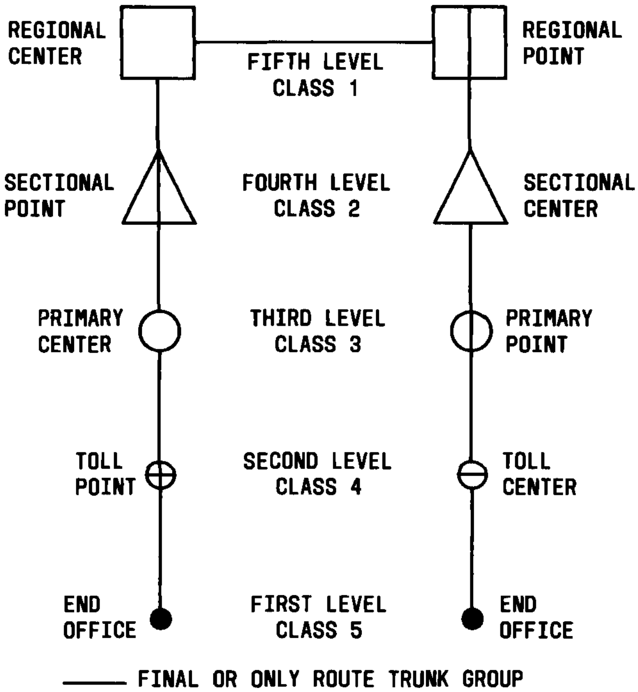


Fig. 1—North American Network

2.07 It is not necessary that Class 5, 4, or 3 switching systems always home on the next higher class (lower number) switching system. For example, an end office may be homed directly on any higher class switching system. Possible homing arrangements are shown as follows:

POSSIBLE HOMING ARRANGEMENTS

SWITCHING SYSTEM NAME	CLASS	MAY HOME AT FOLLOWING SWITCHING SYSTEM CLASSES
Regional Center or Point	1	All Regional Centers or Points interconnected
Sectional Center or Point	2	Class 1
Primary Center or Point	3	Class 2 or 1
Toll Center or Point	4	Class 3,2 or 1
End Office	5	Class 4,3,2 or 1

2.08 Where homing is not direct to the ***next*** higher class, the higher class switching system performs multiple switching functions. For example, if a Toll Center (Class 4) homes directly on a Regional Center, the Class 1 switching system also performs as a Primary Center (switching function 3) and a Sectional Center (switching function 2). Where multiple switching functions are performed, the class of the switching system is designated by the highest switching function performed, as follows:

MULTIPLE SWITCHING FUNCTION

SWITCHING SYSTEM NAME	CLASS	SWITCHING FUNCTION PERFORMED
Regional Center or Point	1	1,2,3, and 4
Sectional Center or Point	2	2,3, and 4
Primary Center or Point	3	3,4, and sometimes 5
Toll Center	4	4 and sometimes 5
End Office	5	5

2.09 The requirements for the various classes of switching systems in the hierarchy are determined first for the lowest, the end office. This switching system location is determined by study to provide the most economic location for serving its customer lines. A group of end offices is then homed on a tandem which provides a Toll Center or Toll Point function, usually located at one of the end office locations. A grouping of Toll Centers and/or Toll Points is homed on a tandem which provides a Primary Center or Primary Point function. Primary Centers and/or Primary Points are homed on a tandem which provides a Sectional Center or Sectional Point function and Sectional Centers or Sectional Points are homed on a Regional Center or Regional Point. Each switching system assigned a class number must have at least one switching system of next lower class homing on it.

2.10 In some of the larger metropolitan areas, two or more tandem switching systems in a sectored arrangement (as discussed beginning in paragraph 2.11) may be required. In these metropolitan areas, the inward assistance operator function may be provided at one of the lower class switching systems instead of the highest class switching system in the area. In these cases, as previously discussed, the lower class switching system is the Center and the higher class switching system is called a Point. Further discussion of the effects of operator traffic on the network is included in Part 5.

B. Sector Tandem Network Arrangements

2.11 When originally introduced, the North American Network required only one tandem switching system in each toll center area. Some very large toll center areas grew to the point where they required more tandem capacity than one switching system could provide and a second tandem was needed. Continued traffic volume growth may force the addition of more tandem switching systems in many other toll center and metropolitan areas. Even with the introduction of new larger capacity switching systems, an arrangement to handle traffic for multiswitching system areas is required.

2.12 Ordinarily, when the second tandem is to be placed in service, the toll center area is divided into "sectors" each of which is served by a "sector tandem". The sectors are made up of end offices from adjacent wire centers or a selection of end offices to make a "traffic" sector. Traffic sectoring usually involves the selection of end offices to achieve a traffic balance or special traffic load characteristic desired in the sector tandem. Loading arrangements to be considered in sectoring include the balancing of the A.M. and P.M. busy-hour traffic load and balancing the distribution of business and residence customers.

2.13 The example in Fig. 2 shows a metropolitan area with three sectors. The end ofices in each sector are homed via final trunk groups on the sector tandem. One sector tandem in the metropolitan area is of higher class than the others and all the other sector tandems home on it to conform to the standard hierarchical routing pattern. The higher class switching system is called the Principal Sector Tandem and it serves also as an ordinary sector tandem for those end offices within its sector. The Principal Sector Tandem is defined as that tandem switching system of lowest class in a metropolitan area, through which all end offices in that area can be reached on a final route basis.

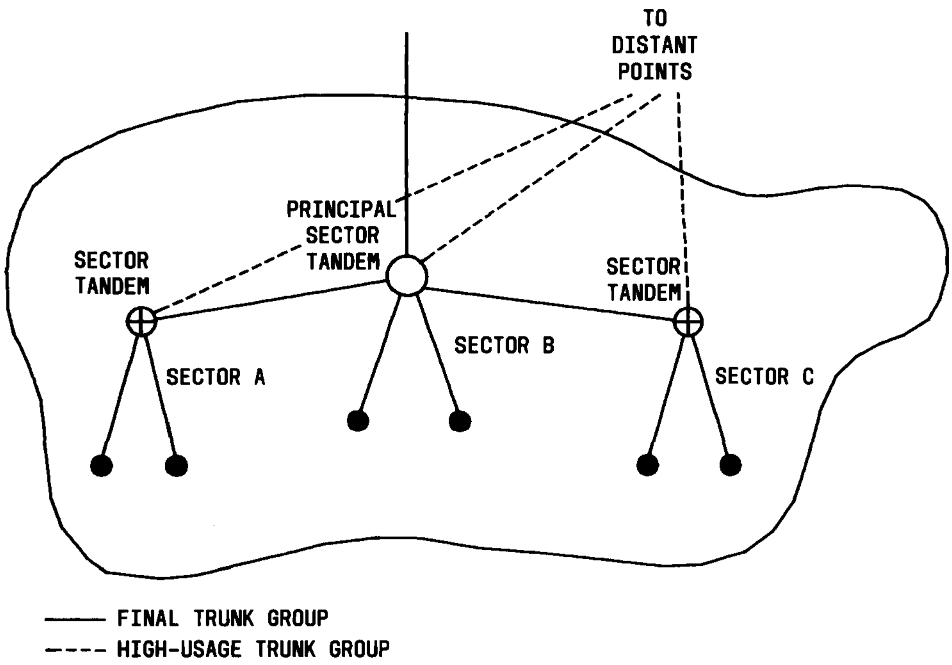


Fig. 2—Sectored Metropolitan Area

2.14 Figure 2 also shows that there could be development of high-usage trunking to the world from each sector tandem, as justified by the traffic volumes to and from that sector.

2.15 There will be some items of traffic which do not justify direct high-usage trunk groups from the sector tandems. These items may be routed to the Principal Sector Tandem for further routing. Where the combined traffic volume of all such items is large enough, high-usage trunk groups may be established between end offices and the Principal Sector Tandem as shown in Fig. 3. This arrangement bypasses the sector tandem, reducing intermediate switching requirements. Specific guidelines for sizing high-usage trunk group candidates can be found in Section 780-402-120.

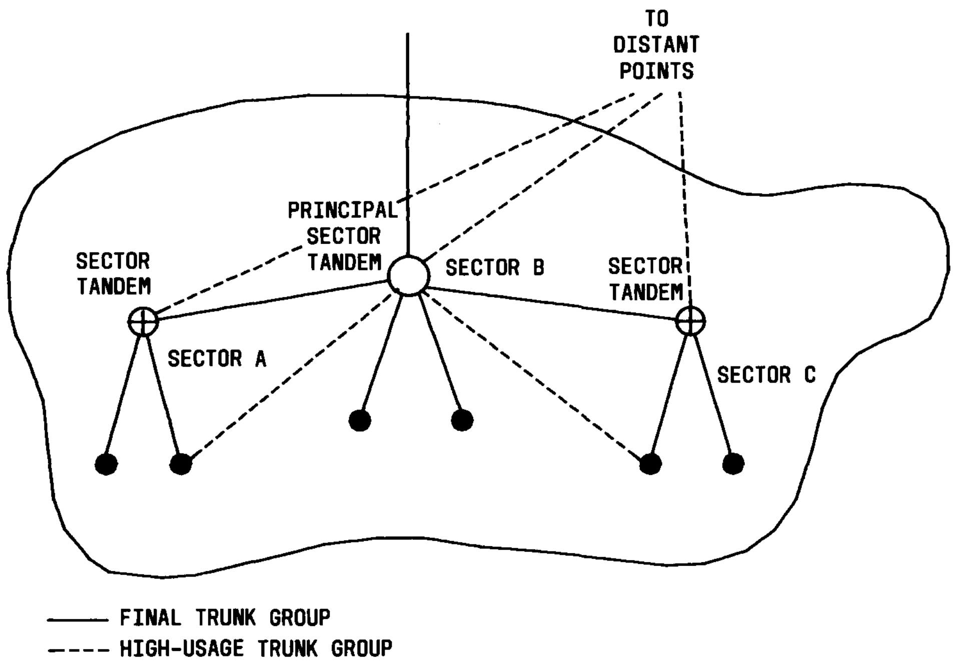


Fig. 3—High-Usage Trunking to Principal Sector Tandem from End Offices

C. Selective Routing Tandem Arrangements

2.16 As traffic volumes in an area increase, additional sector tandems may be required. The addition of a sector causes splintering of the traffic to each distant point among several trunk groups, resulting in less efficient interarea trunking. (Load splintering is discussed further in Section 780-402-120.) Additional double switching of traffic results and end-offices must be rehomed in order to achieve a balance of load among sectors.

2.17 One network configuration which may be employed to reduce this splintering of interarea trunk groups is the Selective Routing Tandem (SRT) configuration. This arrangement reduces interarea trunk group splintering by concentrating specific items of traffic for all of the end offices in a sectored area at only one switching system—the SRT. An example which utilizes an SRT is shown in Fig. 4. For simplicity of presentation, no end office to SRT trunk groups are shown. Selectively routed traffic items usually consist of the total traffic between two metropolitan areas, between a metropolitan area and distant NPA, or between NPAs.

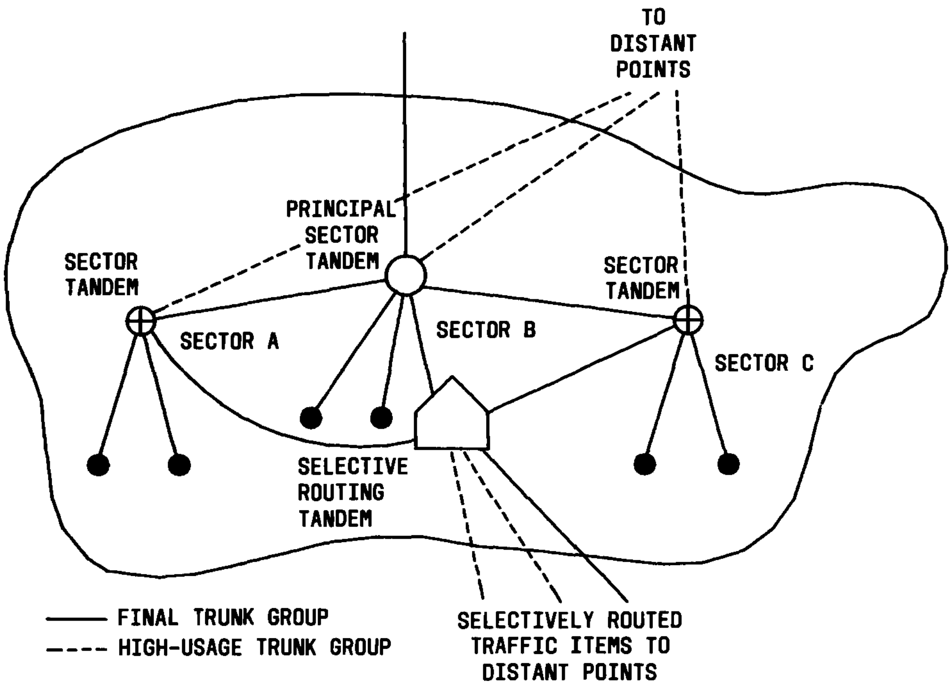


Fig. 4—Sectored Metropolitan Area with Selective Routing Tandem

2.18 A sectored metropolitan area or toll center area with a selective routing tandem may appear to a specific distant switching system as a location with a single tandem, as shown in Fig. 5. The intercity trunk plant arrangement is simplified by providing only one trunk group to the SRT from each distant tandem rather than providing individual trunk groups to the sector tandems.

2.19 In the configuration illustrated in Fig. 6, high-usage trunk groups are established from common control end offices to the SRT when economically justified by the traffic volumes of the selectively routed traffic items. The overflow traffic from these high-usage trunk groups, as well as all SRT traffic from end offices without high-usage trunk groups to the SRT, is routed to the home sector tandem of each end office, and then routed via the ***final*** trunk group provided between the sector tandem and the Selective Routing Tandem.

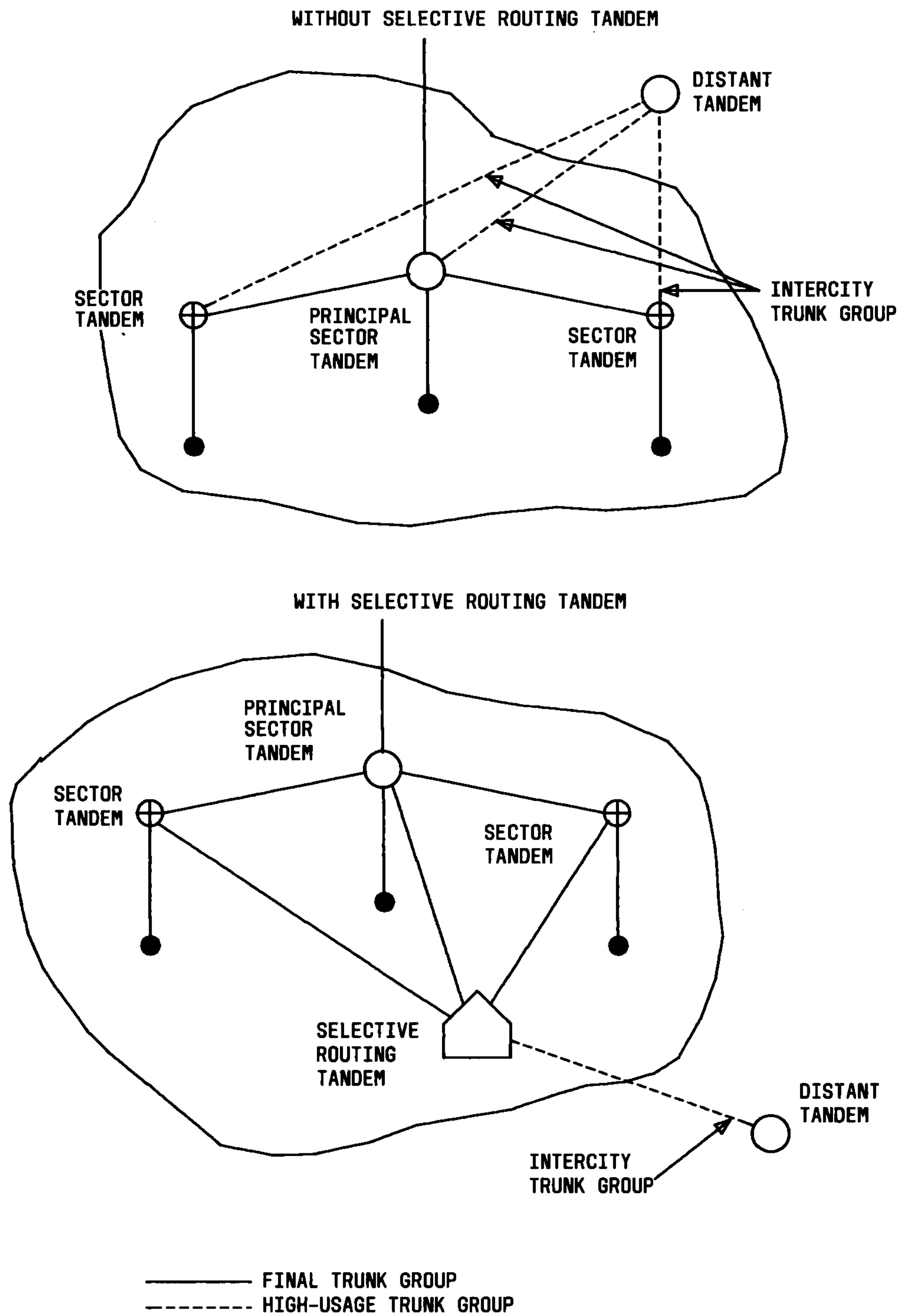


Fig. 5—Intercity Trunking with and without Selective Routing Tandem

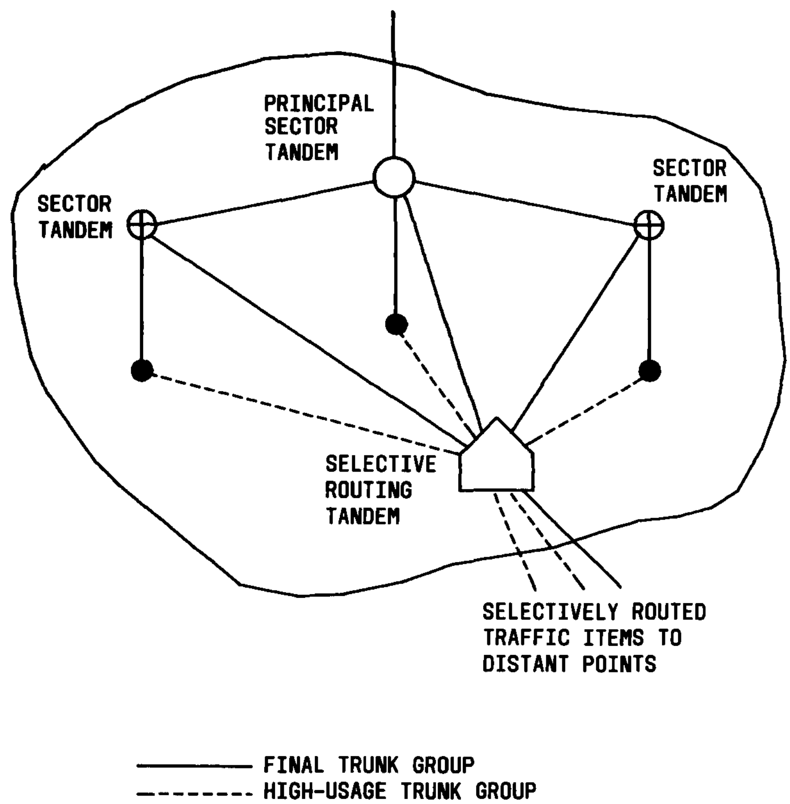


Fig. 6—High Usage Trunking to Selective Routing Tandem from End Offices

2.20 The trunk groups carrying traffic between the Selective Routing Tandem and the distant points may be terminated on any switching system in the distant area. In Fig. 7, the SRT first routes traffic to the distant end office, then to the sector tandem of the distant end office, and finally to the distant Principal Sector Tandem in the distant metropolitan area. Selection of alternate routes is covered in more detail in Sections 780-402-130 through -150. In these examples, trunk groups to distant end offices and sector tandems are engineered on a high-usage basis; the trunk group between the SRT and the Principal Sector Tandem is engineered on a final route basis. If the distant area selected does not have a Principal Sector Tandem, the final route would be established to the Principal NPA tandem serving that area.

2.21 One-way outgoing high-usage trunk groups may be established from sector tandems to handle the SRT items overflowing the end office to SRT high-usage trunk group. These groups may be terminated at distant end offices or distant sector tandems. If 2-way trunk groups were allowed, then incoming traffic would not be directed to the SRT, the concentration effect of the SRT would be negated, and the full reduction in intertoll splintering might not be achieved.

2.22 The reduction in interarea trunk group splintering and double switching is achieved in the SRT configuration at the expense of a more complicated and costly tandem-connecting network. In an SRT network, end office traffic is splintered into two segments—the traffic items routed to the SRT and the remaining traffic items routed via the sector tandem arrangement. This generally results in a less efficient tandem-connecting trunking arrangement. Studies indicate that SRT configurations are most beneficial in metropolitan areas and the more densely populated NPAs.

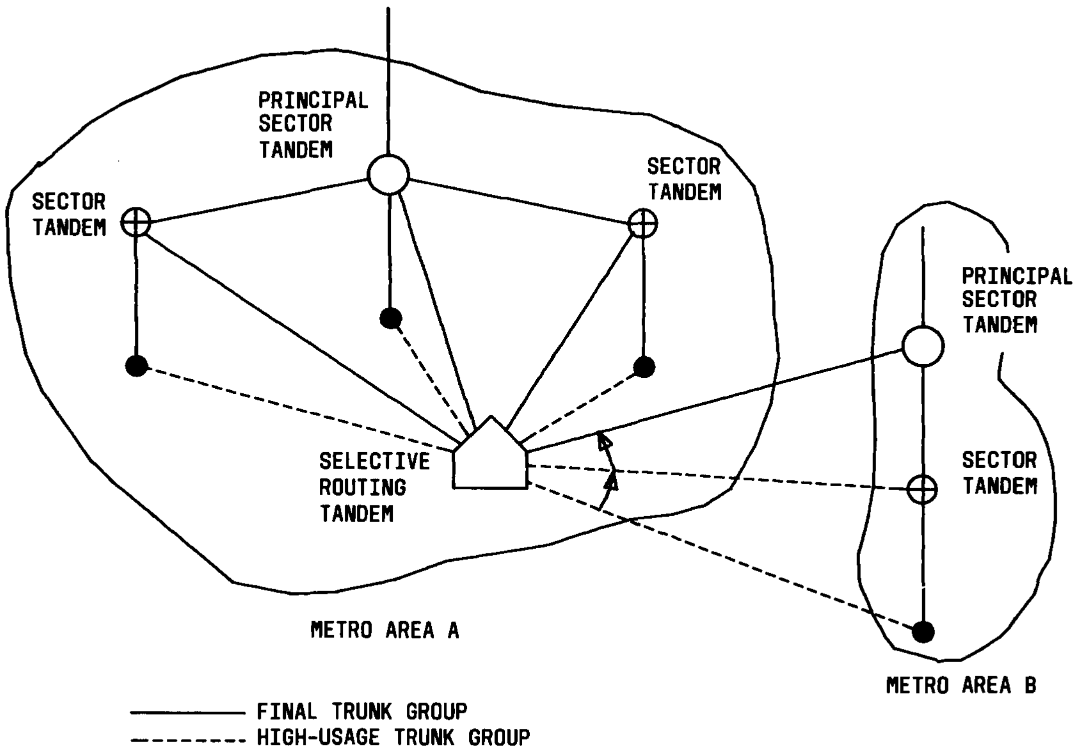


Fig. 7—Trunking Between Selective Routing Tandem and Distant Points

2.23 Based on these studies, guidelines have been formulated and are available in toll planning documents. They aid in determining when an SRT configuration should be considered for a particular area and for determining which traffic items should be handled on the SRT. The economic evaluation of this configuration, in order to assess the trade-offs between reduced interarea trunking costs and increased toll-connecting costs, should be performed with a long-range planning tool such as the Long Range Switching Studies (LRSS).

2.24 In this part, the concept of a Principal Sector Tandem and also of a Selective Routing Tandem have been introduced. In each case, the discussion was limited to a tandem performing either function but not both. Since bypass high-usage trunk groups (intra-routing ladder trunk groups which skip one or more tandems) are an integral part of a sector tandem configuration, for those areas in which the use of a tandem solely as an SRT cannot be justified, a combined Principal Sector Tandem/Selective Routing Tandem (PSRT) may be an economical alternative.

2.25 A PSRT is conceptually a PST with new criteria for the determination of those traffic items to be bypass trunked. In particular, in a PSRT configuration two types of traffic items may be selected for bypass trunking:

(1) Those items which would normally bypass route to a PST (low volume items for which

no high-usage trunks from the sector tandem prove in).

(2) Those items which would normally be selected to route directly to an SRT (items for which the trunking costs per traffic unit are largest).

2.26 The use of a PSRT expands the field of use of the SRT concept to smaller metropolitan areas with fewer tandems. In addition, in those areas in which significant bypass trunking to the PST already exists, the increase in tandem connecting costs associated with the SRT function are decreased. The economic evaluation of this alternative can also be performed with LRSS.

3. METROPOLITAN AND NONMETROPOLITAN NETWORKS

A. General

3.01 As discussed in paragraph 1.03, metropolitan and nonmetropolitan networks often use configurations which differ from the North American Network. This permits, and in some cases results from, less sophistication in the switching systems used for metropolitan traffic.

3.02 Metropolitan and nonmetropolitan networks are generally 1- or 2-level networks and they may, or may not, employ high-usage trunk groups and automatic alternate routing. Trunk groups are frequently 1-way exclusively and tandems may or may not be employed.

3.03 As the message network evolves to an all common-control network with electronic switching, it is expected that metropolitan and nonmetropolitan configurations will also evolve to where 2-way trunk groups will be standard and alternate routing will be employed where a tandem is required. One-way versus 2-way trunking considerations are discussed in Section 780-402-160 and alternate route trunking is discussed in Section 780-402-120.

3.04 The particular configuration used in a metropolitan or nonmetropolitan area is ordinarily a function of the size of the area (number of end offices) and the type of switching systems used. Four types of configurations are in common use today. Two of these, the nonalternate route—nonhierarchical (single level) network, and the nonalternate route—hierarchical network which employs one or more tandems, are used mainly where switching systems are step-by-step or panel. The other two types of configurations, the single tandem network with alternate routing, and the multitandem network with alternate routing, are used with common-control switching systems. These four types are discussed in more detail beginning in paragraph 3.08.

3.05 It should be recognized that two or more types of configurations may be employed in an area. This occurs ordinarily as networks evolve and newer types of switching systems are added for growth, or are installed to replace older equipment.

3.06 Two-level networks are frequently integrated with the North American Network, where switching systems and trunk groups used for one network also function for completing calls to and from the other. Part 4 provides more information on combining 2-level and 5-level networks.

3.07 The number of tandems to be employed in a metropolitan or nonmetropolitan area is determined by study. These studies are ordinarily made using long-range planning tools, such as the Tandem Cross Section Program or similar mechanized study tools. It is the ***number*** of tandems along with the ***type*** of end office switching equipment which determines the type of configuration to be used. Several variations of the multitandem type configuration also are used as discussed beginning in paragraph 3.25.

B. Nonalternate Route Networks— Nonhierarchical

3.08 A nonalternate route nonhierarchical network is an arrangement of end office switching systems, interconnected by only-route trunk groups (Fig. 8). No tandems are employed and there is no alternate routing. All end offices must have trunk groups, which can be either 2-way or pairs of one way, to (and from) all other end offices in the area.

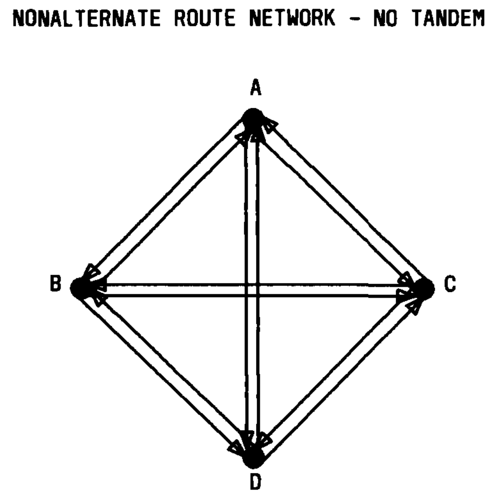


Fig. 8—Nonalternate Route Network—Nonhierarchical

3.09 Areas with a small number of end offices usually use this configuration because the number of trunk groups required to interconnect all end offices is small. As the number of end offices increases, however, the number of trunk groups required increases rapidly. As a result, a network of this type usually evolves to a 2-level hierarchical network of the type described beginning in paragraph 3.12 or 3.17.

3.10 The nonalternate route network may be found with all types of switching systems but is more prevalent in the step-by-step (without common control) environment because of the inability to alternate route. Such step-by-step networks usually evolve to a nonalternate route hierarchical network, as discussed beginning in paragraph 3.12.

3.11 An advantage of the nonalternate route—nonhierarchical configuration is that any network congestion which occurs cannot be spread beyond the originating switching system, and the trunk groups, when engineered to grade-of-service loading criteria, are able to handle momentary overloads without serious service degradation. Offsetting this, the economic advantages of alternate routing are not obtained, and there is no opportunity to take advantage of noncoincident loads to reduce trunk requirements.

C. Nonalternate Route Networks—Hierarchical

3.12 When studies have shown that it is economically feasible to have a tandem arrangement rather than complete interconnection of all end offices with direct trunk groups, a 2-level hierarchical network is established. The 2-level network is made up of end offices and one class of tandem switching system(s). An example is shown in Fig. 9.

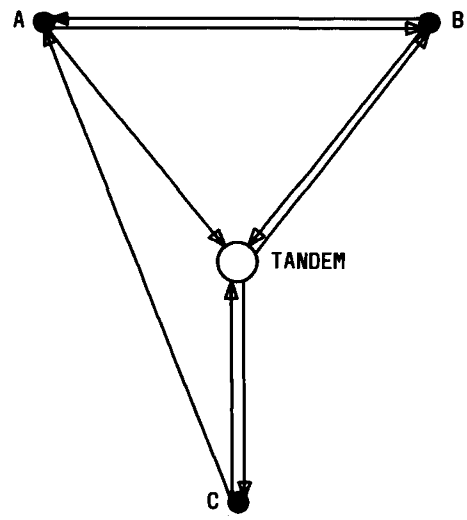


Fig. 9—Nonalternate Route Network—Hierarchical

3.13 The nonalternate route hierarchical configuration is frequently encountered in metropolitan areas with a high percentage of step-by-step switching, where the tandem is used for digit resolving and/or to achieve trunking economies. For example, all traffic for a destination where the "A" digit is "2" might be routed to a switching system serving as a tandem. This tandem would then separate traffic onto routes according to the "B" digit. Usually, but not necessarily, the tandem has trunk groups from a number of end offices offering traffic for the same destination, and the loads can be merged at the tandem to economize on trunks.

3.14 In the example in Fig. 9, end offices A and B are interconnected with only-route trunk groups. C has a trunk group to A, but A to C traffic is routed via the tandem. End offices B and C route all traffic for each other through the tandem. Traffic for C from A and B is combined on a single trunk group from the tandem to C.

Many variations of this configuration result from different quantities and types of end office switching systems in different areas. It will be noted, however, that in all cases, traffic is routed ***either*** on a direct trunk group between the end offices ***or*** it is routed via tandem; there are no high-usage trunk groups. The choice of direct routing versus tandem routing is a function of the economics of load allocation as discussed in Section 780-402-120, or the choice may be dictated by prefix limitations.

3.15 Prefix limitations can exist in step-by-step areas where trunking from existing switch stages already may use all available switch levels. Each new prefix requires a switch level to direct it to the next stage of switching, either in the originating end office, the tandem, or the terminating end office. Where prefix limitations exist, the use of a tandem in a step-by- step network may require more central office equipment.

3.16 In this tandem arrangement, as with the nonhierarchical arrangement discussed above, flexibility is limited since there is only one possible route. Where trunk groups incoming to the tandem(s) are large, as they tend to be where traffic to a large number of terminating points is routed via the tandem, the high occupancy tends to limit congestion to the originating end office under overload conditions. The degree of protection provided the tandem during overloads varies by network, but first route tandems are less susceptible to overloads than are tandems which carry mostly overflow traffic.

D. Single Tandem Network—Hierarchical—With Alternate Routing

3.17 In an environment of end offices which have alternate routing capability, the single tandem network with alternate routing is the logical outgrowth of a nonalternate route—nonhierarchical network. The single tandem network is a 2-level configuration in which overflow from all high-usage trunk groups is routed via the single tandem. First-routed traffic is also routed via the tandem where high-usage or only-route trunk groups between end offices are not justified.

3.18 Figure 10 shows an example of a single tandem configuration. The tandem provides the overflow route for high-usage trunk groups A-B, A-C, C-B, and C-A and the first route for B-A and B-C traffic. In this example, only the trunk group between the tandem and end office C is 2-way, as dictated by economics and equipment types. Section 780-402-160 contains 1-way versus 2-way considerations.

SINGLE TANDEM - WITH ALTERNATE ROUTING

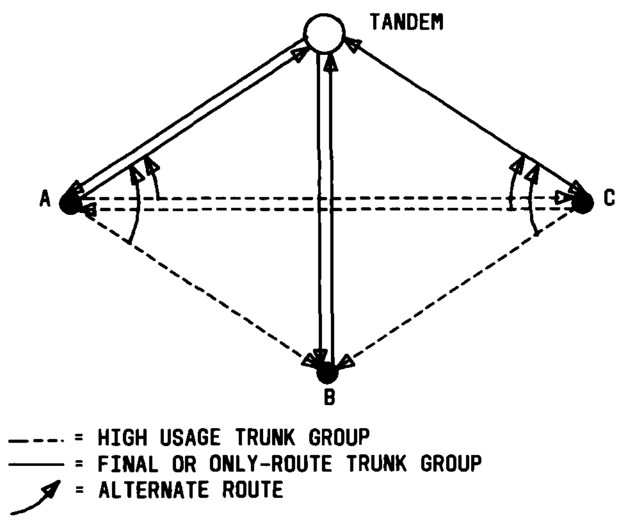


Fig. 10—Single Tandem with Alternate Routing

3.19 It should be noted that only final trunk groups are terminated at the tandem. The high-usage (and only-route) trunk groups connect the end offices. First-routed and overflow traffic are merged on the tandem trunk groups to effect trunking economies.

3.20 Where high-usage trunk groups are established from an end office, Local Automatic Message Accounting (LAMA) features may be required if billing recording is necessary. Common control switching systems, mainly ESS and Crossbar, can provide the capabilities required where economics justify. The capabilities of the various switching systems to record call billing details are summarized in Section 780-402-170. Where an end office does not have the required translation or recording capability, traffic must be routed to a tandem where these features are available.

3.21 The single tandem alternate routing configuration offers the advantage of greater flexibility and lower cost when compared to nonalternate route configurations. Two possible routes are available for any call offered first to a high-usage trunk group, and unanticipated loads between end offices can sometimes take advantage of temporarily idle capacity on the tandem route. Similarly, only-route trunk groups between end offices can sometimes be relieved by permitting them to overflow via the tandem. Such arrangements must be viewed as expedient, however, and normal economic routing restored as soon as possible after capacity becomes available in the preferred route.

3.22 In any network in which the tandem provides the overflow route for traffic first routed on high-usage trunk groups, the tandem is subject to congestion from overload. Small increases in the load offered to high-usage trunk groups can result in large increases in the load overflowed from those trunk groups, and then offered to the tandem. The sensitivity of the tandem to network overloads is a function of the size of the trunk groups incoming to the tandem. Larger trunk groups, due to their higher occupancy, saturate sooner and protect the tandem by blocking calls at the originating switching system. Network controls, usually consisting of alternate route cancellation at subtending offices, may be necessary to assure that the tandem can continue to function effectively during overloads.

3.23 Most single tandem alternate route networks contain some end office pairs which are connected by only-route trunk groups. Thus, two types of network configuration are combined and the end offices involved are part of both configurations.

3.24 Most small-to-medium size metropolitan areas require no more than one tandem for metropolitan traffic, and one may even be adequate where metropolitan and North American traffic are combined. Long range studies using the Tandem Cross Section Program, as discussed in paragraph 3.43, are made to determine the number of tandems required.

E. Multitandem Networks

3.25 When growth causes the tandem requirements in a metropolitan area to exceed the capacity of a single switching system, additional tandems must be added. This is done by sectoring the area, with one tandem serving each sector.

3.26 There are four different trunking and routing configurations for interconnecting the sectors in a multitandem network. These are discussed in the following paragraphs.

3.27 ***Multitandem Network—Originating Sector Configuration***—In this configuration, the tandems carry only traffic ***outbound from*** their sector, ie, traffic ***from*** end offices in their sector ***to*** other sectors. Traffic originating in an end office is first routed to the called end office on a high-usage trunk group, assuming there is sufficient traffic to support such a trunk group. Overflow traffic and first-routed tandem traffic outbound from the sector is routed to the sector tandem. The sector tandem has final trunk groups to all end offices in all other sectors. Figure 11 depicts an originating sector configuration.

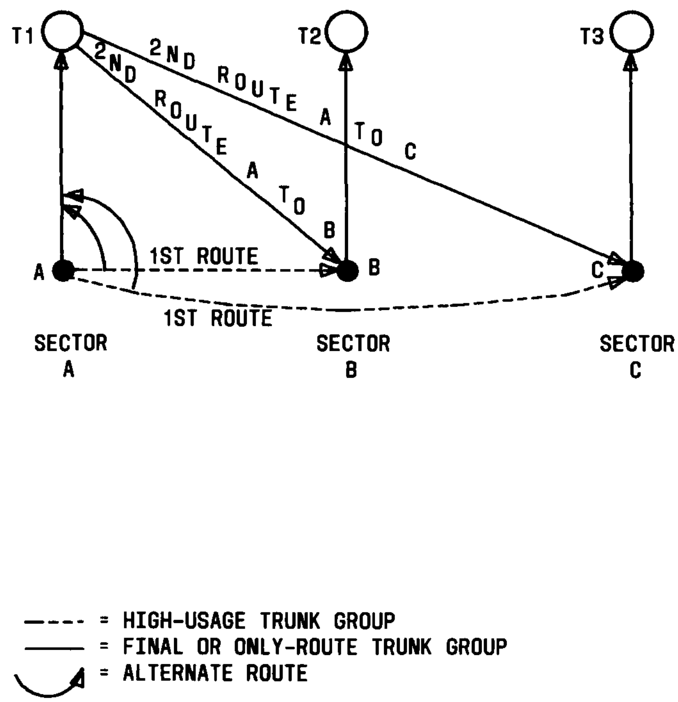


Fig. 11—Originating Sector Configuration—Single Tandem Switch with Single Stage Alternate Routing

3.28 Tandem trunk groups in this configuration are 1-way exclusively. This is necessary in order for the tandem to serve only outbound traffic. Traffic in the opposite direction, ie, B to A and C to A in Fig. 11, is routed through originating sector tandems T2 and T3, respectively. Where this type configuration is employed, all sector tandems in the area are ***originating*** sector tandems for intersector traffic, each serving only the traffic outbound from its sector. Traffic originating within a sector, destined for another end office in the same sector, also may route via the sector tandem. For this traffic, the tandem serves as a single tandem within an originating sector tandem configuration.

3.29 Since the sector tandems have incoming trunk groups only from the end offices in the sector, but have outgoing trunk groups to all other end offices, the larger more efficient incoming trunk groups tend to saturate under overload, offering a degree of protection for the tandem. This protection increases as the number of sectors increases. The relatively few end offices served by a tandem also keep the administration of network controls relatively simple.

3.30 Offsetting the advantages of the originating sector configuration are the facts that (1) there is never more than one alternate route available, (2) there must be a final trunk group from each sector tandem to each end office outside its sector, and (3) idle capacity can exist in one direction, while the tandem route in the opposite direction between the same two end offices is overloaded. The combined sector tandem configuration discussed in paragraph 3.38 overcomes these problems and it is the recommended configuration wherever a sectored arrangement is employed.

3.31 ***Multitandem Network—Terminating Sector Configuration***—In this configuration, the tandems carry only traffic ***inbound to*** the sector, ie, traffic ***to*** the sector end offices ***from*** all other sectors. As with the originating sector configuration, traffic is routed first on a high-usage trunk group between the end offices if one is justified. Overflow from these trunk groups and the first routed tandem traffic is routed to the sector tandem in the ***terminating*** sector. The sector tandem has completing final trunk groups to each end office in its sector. Figure 12 depicts a terminating sector configuration.

3.32 As with the originating sector configuration, tandem trunk groups are 1-way exclusively with the tandem serving only that traffic inbound to the sector end offices. Traffic in the opposite direction, ie, B to A and C to A in Fig. 12, is routed through the terminating sector tandem for A, which is T1. All sector tandems are ***terminating*** sector tandems for intersector traffic, each handling only traffic inbound to its sector end offices. Intrasector traffic can use the sector tandem as a single tandem, as was the case with the originating sector configuration.

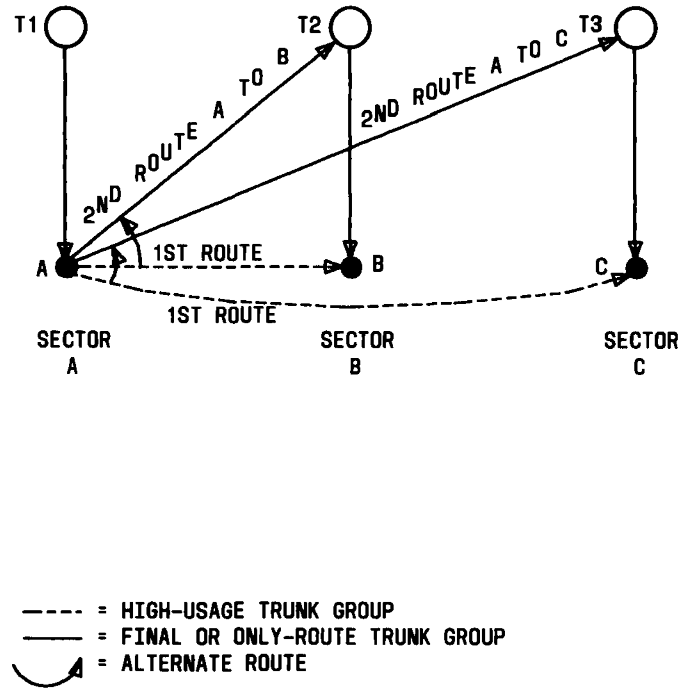


Fig. 12—Terminating Sector Configuration—Single Tandem Switch with Single Stage Alternate Routing

3.33 The tandem protection capability under overload, provided by the originating configuration, is absent with the terminating sector arrangement, because the large trunk groups are on the outgoing side of the tandem rather than the incoming side. The outgoing trunk groups terminate at the end offices in the sector and they are large in comparison to the trunk groups which are incoming from all of the end offices in the other sectors. Under general overload conditions, the outgoing trunks may become saturated while capacity still exists on the incoming trunks. The use of network controls to protect the tandem is more complex than with the originating sector configuration, because the controls must extend to the larger number of end offices which have trunk groups to the tandem.

3.34 The terminating sector configuration lacks the singular advantage of the originating sector plan while having all of its disadvantages. The use of this configuration is not recommended; rather, the combined sector configuration should be used. The terminating sector configuration is included here only to acquaint the reader with its structure and features.

3.35 ***Multitandem Network—Central Tandem Configuration***—The central tandem configuration is a 3-level multialternate routing arrangement, as depicted in Fig. 13. The central tandem appears as a single tandem in that it has final trunk groups to and from all end offices in the metropolitan area. The end offices are in a terminating sector type configuration, except that the trunk groups from the end offices to the terminating sector tandem are high-usage instead of final, and they overflow to the final route via the central tandem. The central tandem also may be a sector tandem.

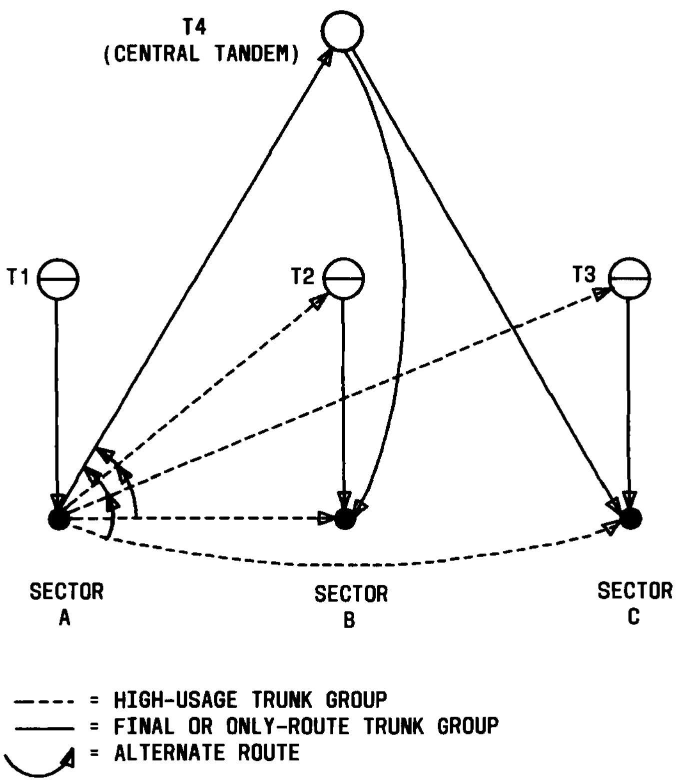


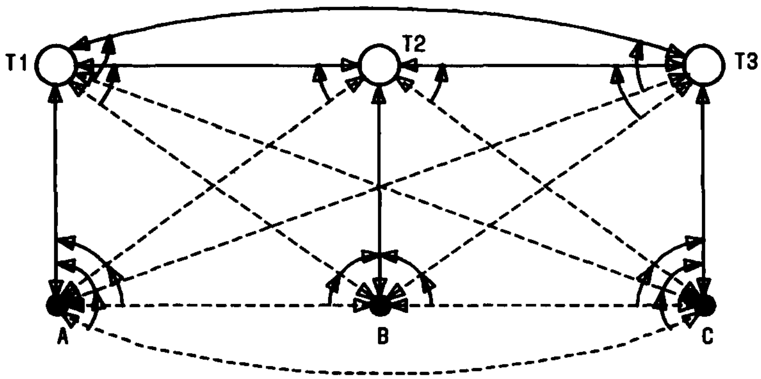
Fig. 13—Central Tandem Configuration—Single Tandem Switch with Multistage Alternate Routing

3.36 No call ever traverses more than two links. Trunk groups between end offices can be 1-way or 2-way, but trunk groups from end offices to the sector tandems must be 1-way to achieve the required overflow pattern via the terminating sector. Trunk groups to and from the central tandem can be either 1-way or 2- way.

3.37 This configuration is no longer recommended because the central tandem is subject to congestion under general overload. This occurs because the excess traffic is, for the most part, route-advanced to the final route where it is concentrated on the central tandem. Network controls can be used to alleviate this condition, but the load controls must be applied at all end offices in the metropolitan area since they all have trunk groups to the central tandem. Since no call traverses more than two links, the trunk groups are normally designed to metropolitan transmission standards. This prevents the use of this configuration where metropolitan and North American traffic are to be combined. (This is true of the originating and terminating configurations as well.) Wherever multiple tandems are necessary, the recommended arrangement is the combined sector tandem configuration.

3.38 ***Multitandem Networks — Combined Sector Tandem Configuration***—The combined sector tandem configuration is a 2-level multialternate route arrangement which provides a maximum of four routes between any two end offices, depending on the number of high-usage trunk groups which are justified.

3.39 Figure 14 depicts a 3-sector arrangement with a full complement of trunk groups. The first-choice route between the A and B end offices is the high-usage trunk group, A-B; the second choice route from A to B is via the "distant" tandem, A-T2-B; the third choice route is via the home sector tandem, A-T1-B; and the last choice route is via the intertandem final trunk group, A-T1-T2-B.



SECTOR A	SECTOR B	SECTOR C
ROUTE	A→B	A→C
FIRST	A-B	A-C
SECOND	A-T2-B	A-T3-C
THIRD	A-T1-B	A-T1-C
FOURTH	A-T1-T2-B	A-T1-T3-C

NOTE: ALL TRUNK GROUPS MAY BE ONE-WAY OR TWO-WAY. IF ONE-WAY TRUNK GROUPS ARE USED, A ONE-WAY TRUNK GROUP MUST BE ADDED IN THE OPPOSITE DIRECTION. TRUNK GROUPS IN THIS ILLUSTRATION ARE SHOWN TWO-WAY FOR SIMPLIFICATION.

---- = HIGH-USAGE TRUNK GROUP
—— = FINAL OR ONLY-ROUTE TRUNK GROUP
↗ = ALTERNATE ROUTE

Fig. 14—Combined Sector Tandem Configuration with Multistage Alternate Routing

3.40 Trunk groups in the combined sector tandem configuration can be either 1- or 2-way; but, in either case, the final route to and from an end office is via its own sector tandem. High-usage trunk groups may be of metropolitan transmission design, but the intertandem trunks must be designed to North American Network Standards, since any call which traverses this link will be a 3-link call instead of two.

3.41 High-usage trunk groups are established in accordance with criteria for load accumulation and trunk group sizing, as discussed in Section 780-402-120 and in Sections 780-402-130 through 780-402-150. The routing pattern discussed above conforms with the routing standards discussed in Sections 780-402-130 through 780-402-150.

3.42 The combined sector tandem configuration, so named because both incoming and outgoing traffic for a sector are combined on the same tandem, is the recommended configuration whenever a sectored arrangement is required. It provides the greatest flexibility because of its extensive alternate-routing capability and its ability to adjust to changing traffic patterns and load conditions.

3.43 A combined sector tandem configuration normally is established when growth causes tandem loads to exceed the capacity of a single tandem. Long-range studies, using mechanized tools like the Tandem Cross Section Program, are ordinarily used to establish the point in time when two or more tandems are required.

F. Other Considerations

3.44 As discussed in paragraph 3.05, various configurations described may be combined in a given metropolitan or nonmetropolitan area. Figure 15 illustrates one such combination. A step-by-step tandem and a number of end offices in a nonalternate route hierarchical configuration are combined with an ESS tandem, with its subtending common control end offices, in a single tandem alternate routing configuration.

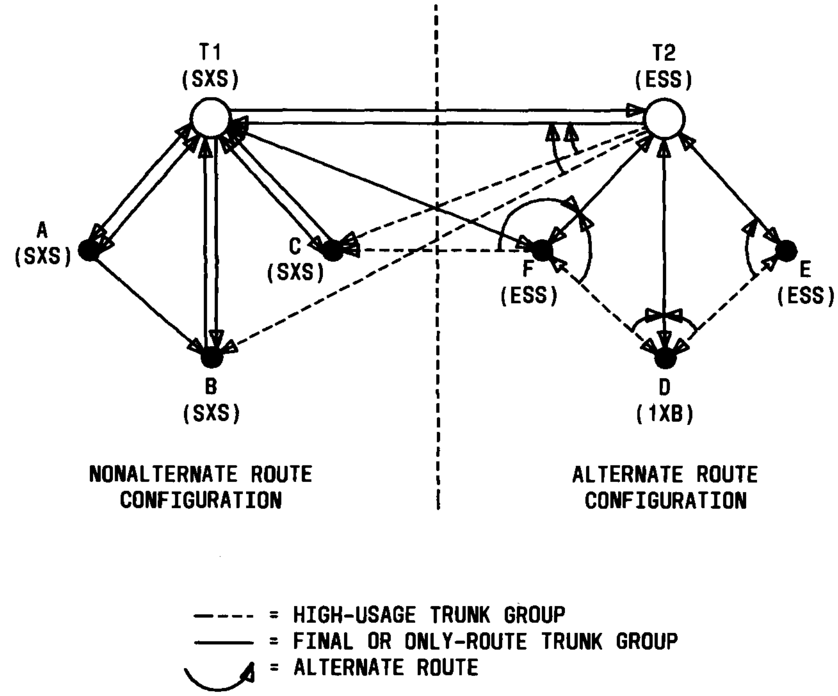


Fig. 15—Two Network Configurations Combined in a Single Area

3.45 The provision of any of the subtending high-usage trunk groups is dependent upon offered loads and design parameters. Consequently, in an actual network, some of the high-usage trunk groups shown might not be economically justified. With ESS, the practicality of establishing 2-way trunk groups enhances the opportunity to prove-in more high-usage trunk groups than would be possible on a 1-way basis.

3.46 Some traffic cannot be routed directly from end office to end office on high-usage or only-route trunk groups, even though there is sufficient load to support such trunk groups. Such traffic is usually routed to the home tandem in the following situations:

- ***Centralized Automatic Message Accounting (CAMA) recording:*** Any traffic requiring detail billing must be routed to a tandem for CAMA recording when there is no recording capability in the end office.
- ***Pulse conversion:*** Some switching systems do not have compatible pulsing and must use a tandem for pulse conversion.
- ***Six-digit translation:*** Some end office switching systems may not have 6-digit capability or capacity. Where 6-digit translation is required, traffic may have to be routed to a tandem where this capability exists.

3.47 Where sectoring is required for both the North American Network and a metropolitan network, there may be engineering and administrative advantages to having the sectors coincide, ie, having the same grouping of end offices in the North American sectors as in the metropolitan sectors. This will not always be possible, however, because of different traffic patterns in the two networks.

3.48 Continued growth of metropolitan network traffic may lead to an excessive number of sectors. The use of selective routing tandems to minimize trunk group splintering and maintain the proper number of sectors should be considered in these cases, as discussed beginning in paragraph 2.16.

3.49 Certain items of metropolitan and North American Network traffic may be combined on common trunk groups to and/or from sector tandems or selective routing tandems. This is discussed further in Part 4.

3.50 There are additional considerations where traffic is handled at an operator location. Some of these are discussed in Part 5.

4. CONSIDERATIONS IN COMBINING METROPOLITAN AND NONMETROPOLITAN NETWORKS WITH THE NORTH AMERICAN NETWORK

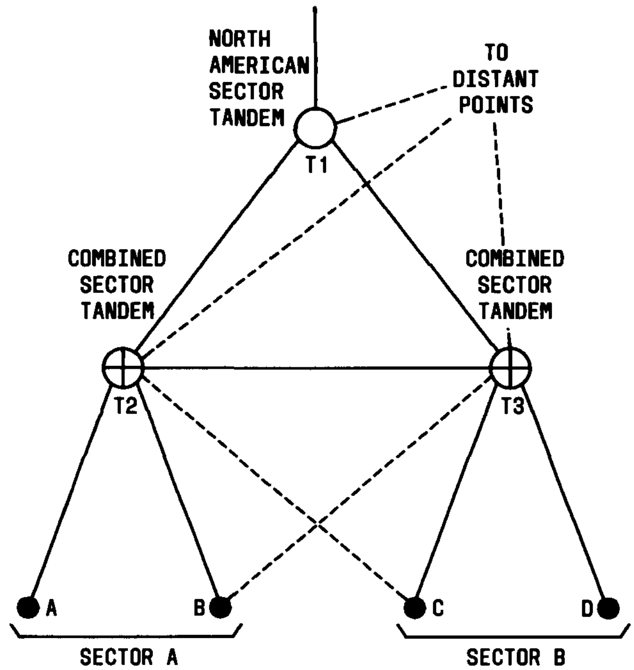
4.01 The sector tandem network configurations used in the 5-level North American Network and in the metropolitan and nonmetropolitan 2-level networks provide opportunities to combine the traffic of both networks onto common tandem connecting trunk groups, and use the same sector tandem switching systems. There may be trunking economies and service advantages to be achieved by combining these two networks, particularly where the respective busy hours and busy seasons are noncoincident.

4.02 There are three basic arrangements or combinations of a 2-level metropolitan, or nonmetropolitan, network and the 5-level North American Network which could be used in any sectored area. These arrangements are:

(a) A totally combined network where all originating and terminating last choice trunk groups between end offices and associated tandem switching systems are used in common for both the 2-level and 5-level networks. (See Fig. 16.)

(b) A total separation between the 2-level network and the 5-level network. (See Fig. 17.)

(c) A mixture of both (a) and (b), where some of the sectors use combined trunk groups and common tandem switching systems and other sectors have separate trunk groups and switching systems. (See Fig. 18.)



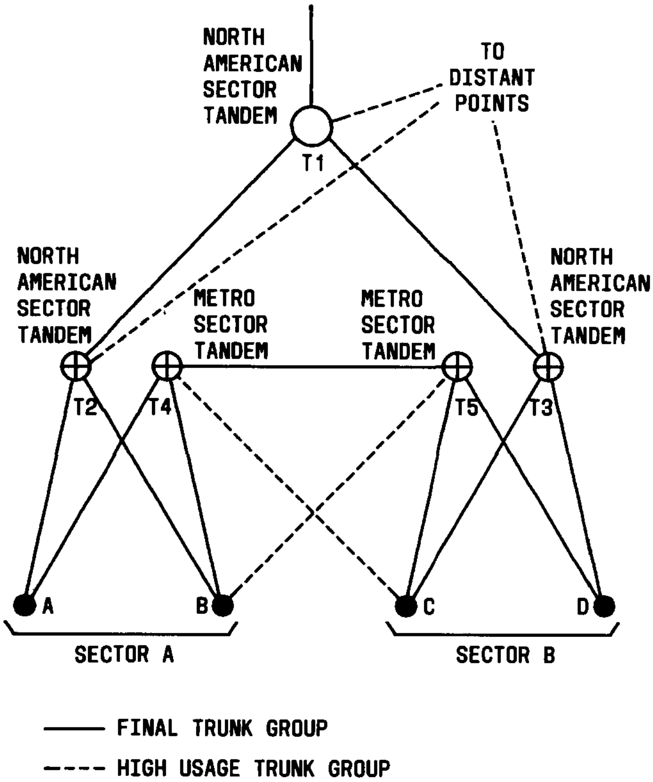
—— FINAL TRUNK GROUP

---- HIGH USAGE TRUNK GROUP

TRUNK GROUP TRAFFIC

2 LEVEL ONLY	– B-T3, C-T2, T2-T3
5 LEVEL ONLY	– T2-T1, T3-T1, T1, T2 & T3 TO WORLD
COMBINED 2 & 5	– A-T2, B-T2, C-T3, D-T3

Fig. 16—Combined 2-Level and 5-Level Networks



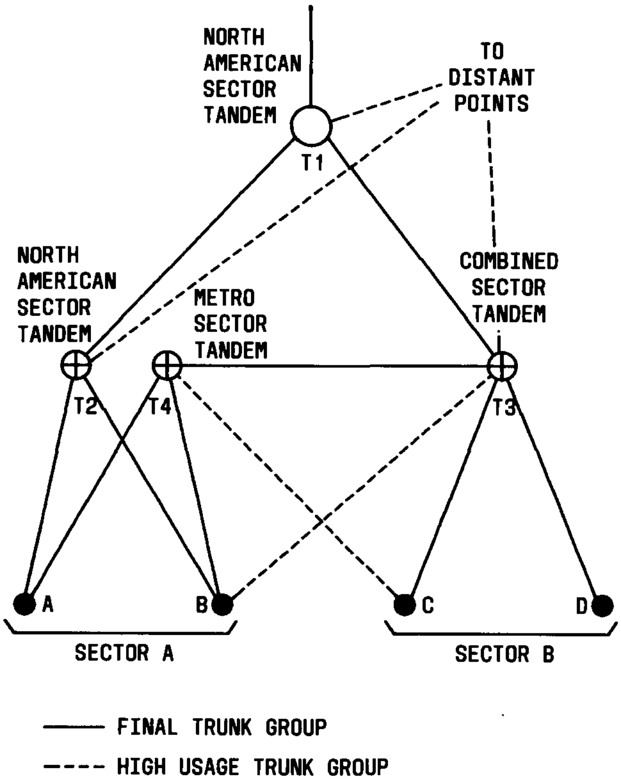
TRUNK GROUP TRAFFIC

2 LEVEL ONLY – A-T4, B-T4, C-T5, D-T5, T4-T5, B-T5, C-T4

5 LEVEL ONLY – A-T2, B-T2, C-T3, D-T3, T2-T1, T3-T1, T1, T2 & T3 TO WORLD

COMBINED 2 & 5 – NONE

Fig. 17—Separate 2-Level and 5-Level Networks



TRUNK GROUP TRAFFIC

2 LEVEL ONLY – A-T4, B-T4, T4-T3, B-T3, C-T4

5 LEVEL ONLY – A-T2, B-T2, T1-T2, T1-T3, T3-T1, T1, T2 & T3 TO WORLD

COMBINED 2 & 5 – C-T3, D-T3

Fig. 18—Partially Combined 2-Level and 5-Level Networks

4.03 The following paragraphs describe various interrelationships to be considered when engineering any area served by both a 2-level network and the 5-level North American Network.

4.04 High-usage trunk groups should be developed to the extent possible. These trunk groups can absorb a portion of the network growth, by bypassing one or more tandem switching systems, reducing the need for additional tandem switching system capacity. This includes trunk groups to tandems both within and beyond the home metropolitan area.

4.05 Selective routing tandems can be used to handle the growth of both the 2-level and

5-level networks, once the desired number of sectors has been developed. This applies to all metropolitian areas whether they use a combined, mixed, or separate 2-level—5-level network. Further discussion on selective routing tandems can be found in paragraphs 2.16 through 2.23.

4.06 The home tandem switching system(s) for each end office should be equipped to handle originating customer-dialed traffic from that end office, its CAMA and Traffic Service Position or Traffic Service Position System (TSPS) traffic, as well as all final-route terminating traffic. Using the same tandem for all these traffic items normally provides the most economic intertandem facility arrangement and the most stable data base (not affected by routing changes) for improved forecasting accuracy. This also eases the job of documenting and providing routing information to others.

4.07 When 2-level and 5-level networks are combined, the service and transmission criteria for the combined networks are those which are most stringent of the two networks. Normally, the 5-level North American Network criteria are the most stringent.

4.08 Trunk groups between end offices and tandem switching systems which have been combined to carry traffic for both the 2-level and the 5-level networks will result in fewer total required trunks. This saving in trunks is derived from the greater efficiency of larger size trunk groups, fewer trunk groups, and the benefits received from noncoincident busy-hour busy-season traffic carried on the two networks.

4.09 When the 2-level and the 5-level networks are combined, additional traffic measurement data may be required to provide the needed information to meet the requirement of traffic separation procedures. Point-to-point traffic data, by type of call and its destination, also may be required to determine what traffic, by volume and type, is routed over combined trunk groups and switching systems. This information is necessary for rerouting and rehoming traffic and developing new high-usage trunk groups.

4.10 Meshing of traffic between the two networks requires that hourly traffic data be available for a sufficient number of hours and days to estimate the busy hour and busy season of each of the two networks and of the combined arrangement.

5. OPERATOR SERVICES INFLUENCE ON NETWORKS

A. Toll and Assistance Services

5.01 Operator Services exert an influence on networks that cannot be ignored. The trunk engineer must take into account the traffic loads generated by Operator Services when designing network configurations, because the peak hours are often different for operator-serviced and handled (0+ and 0-) traffic than for customer-dialed calls. Operator traffic also may route differently than customer-dialed traffic.

5.02 The older type operator systems, referred to as cord-type switchboards (eg, 3C, 3CL) are manually operated switching systems. The operator receives information from a customer or another operator, records any necessary billing information, selects an outgoing trunk, and supervises the call. Billing accuracy, routing, and trunk selection often depend on the ability of the operator to interpret the customer needs and perform the necessary functions without error. Many switchboards today have trunks to tandem switching systems which do the routing and trunk selection for the operator.

5.03 In order to reduce routing and billing errors and speed up call processing, thereby reducing costs and providing better service, mechanization of the switchboard operation was undertaken. The result is a Traffic Service Position System (TSPS) where the customer may dial the destination code, have the operator record other information (eg, credit card, third party charge, collect) and have the calls automatically rated and timed for billing and a route automatically selected by the associated tandem. The result is a shorter average holding time per call (less nonconversation trunk holding time) and less human error.

5.04 When calls are switched manually, there is sometimes a misuse of the trunk groups which can be accessed from the switchboard. Ordinarily, capacity is not provided for this traffic in these trunk groups. Such misrouting is not possible with TSPS and traffic data are more accurate as a result.

5.05 Customer-dialed operator-serviced or operator-handled traffic must be routed over a trunk group from each end office to the tandem switching system, via the TSPS or cord switchboard, without any intermediate switching or concentration because: (1) Transmission impairment results from the addition of another switching system and transmission link. Some calls could be subjected to more than the permissible nine links end-to-end. (2) The end-to-end probability of blocking increases from the addition of another link. It may cost more to obviate this impairment than the potential savings from the proposed concentration. (3) Calling number identification signals are not readily switched intact through an intermediate switching system.

5.06 The trend to larger tandem switching systems and more economic transmission facilities has brought about a trend to close small operator services locations and absorb the load at distant centers. The trunk engineer must be one of the key members of the group planning changes of this nature because of changes in the flow of network traffic.

5.07 Figures 19, 20, and 21 illustrate consolidation of operator and tol! center facilities in a multisector area served by cord switchboards. End offices, as shown in Fig. 19, have access to, and are accessed from, the operator switchboard on dial 0- traffic in both sectors. When operator positions are consolidated, as in Fig. 20, 0- traffic ***from*** the end offices is trunked only to one operator location serving both sectors (in this case located in sector B). Any traffic from the operator ***to*** the end offices in the distant sector (A) is completed via the tandem switching system on which the end office homes. Calls from the operator to end offices in sector B are completed on trunks from the switchboard to the end office (or via the Primary Center tandem—these trunk groups are not shown in the figure).

5.08 When operator positions ***and*** toll center tandem switching systems are consolidated (Fig. 21), trunks ***to and from*** the operator are established to the end offices for 0- calls. In the example in Fig. 21, the Primary Center tandem ***may*** switch traffic ***to*** the end office for the operator if so arranged. In TSPS locations, traffic from the switchboard ***to*** the end office ***must*** be completed by the associated tandem.

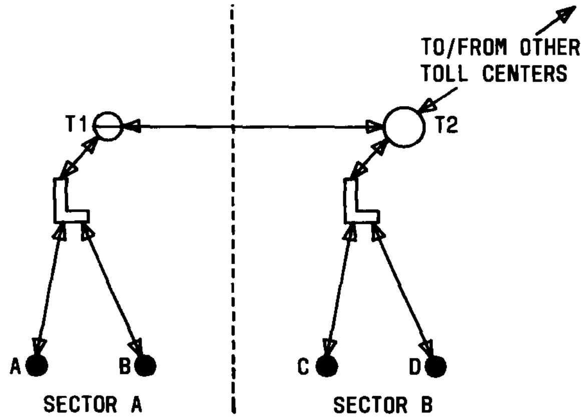


Fig. 19—Toll Center Operation *Before* Consolidation of Operator Facilities

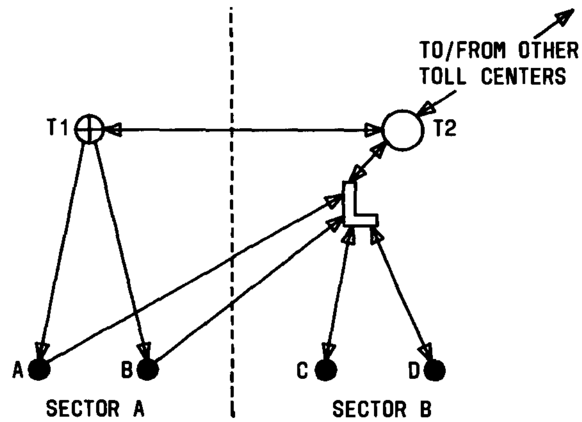


Fig. 20—Toll Center Operation *After* Consolidation of Operator Facilities

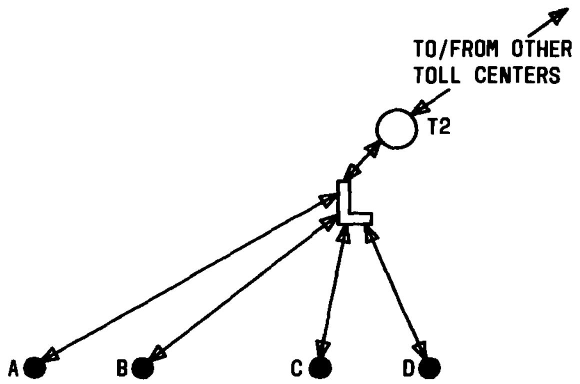


Fig. 21—Toll Center Operation After Consolidation of Operator and Toll Switching Facilities

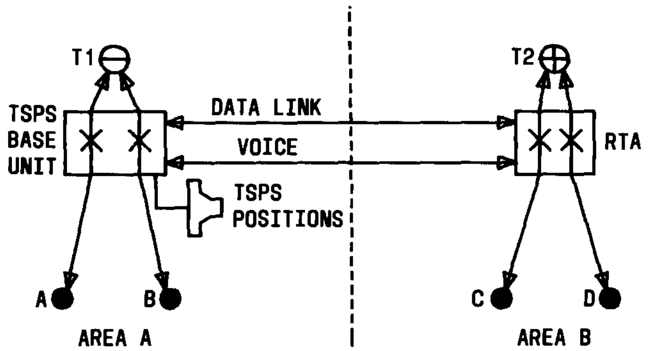


Fig. 22—TSPS with Remote Trunk Arrangement (RTA)

5.09 A TSPS using a Remote Trunk Arrangement (RTA) permits the extension of TSPS services to areas served by small toll centers which cannot, by themselves, support a TSPS. This arrangement allows the operator services and the recording of billing information to be performed from a favorable, centralized location. The RTA (Fig. 22) utilizes common data and voice links between the RTA and the TSPS base unit. After processing at the base unit is completed, calls originating in area B are then switched through the "home" switching system T2.

5.10 This arrangement maintains the balance of traffic, inward and outward, at the "remote" tandem since calls processed at the base unit are actually completed through the remote tandem. Operator and customer-dialed traffic often have dissimilar busy hours. Since all traffic items originating at the end offices served by the "remote" tandem are routed through it, better utilization of the facilities of the remote tandem is possible. When possible, traffic that normally "homes" on a particular switching system should be switched at that location, whether direct-dialed by the customer or processed through an operator.

5.11 Not all operator services are mechanized by TSPS. Certain calls such as mobile, verification, etc, require a certain amount of operator control not available in TSPS. Some of these services are discussed more fully in subsequent paragraphs.

B. Number Services

5.12 Number services operations, basically directory assistance, intercept, and rate and route, have a definite influence on the network and should be taken into account when engineering the network. Automatic Call Distributors (ACDs), used to distribute incoming calls to operators, often process a high volume of short holding time calls. Capacity must be provided for these calls wherever this traffic is routed. Tariff changes may increase or decrease traffic loads significantly or may change peak traffic periods.

5.13 An example of a number services function change influencing network design is a change to charging for Directory Assistance, illustrated in Fig. 23 and 24. It is possible "411" trunks may not be needed at all, especially from non-AMA type switching systems, but the load on "1" level trunks (LAMA, CAMA/ONI, CAMA/ANI) may increase significantly at the cutover. Traffic formerly being trunked on 411 trunks may be routed first to the toll center (1-411 or 411) for recording of billing information, then routed from the Toll Center Switching System to the Directory Assistance Center. (This is required for all non-common control SxS end offices as well as No. 3 ESS, No. 3 XB, No. 5A XB, and panel end offices. Those end offices equipped for LAMA may route 411 traffic to the Directory Assistance Center without the directing code 1. See Section 780-402-170 and the sections applicable to the various switching systems for additional billing recording equipment information. It ***may*** be more economical to combine the 411 calls with LAMA calls to the toll center where the directory assistance traffic is separated and trunked to the DA Center.

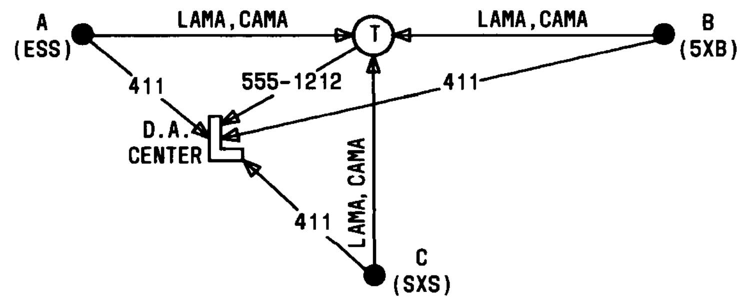


Fig. 23—Trunking to Directory Assistance *Prior* to Charging for Directory Assistance Calls

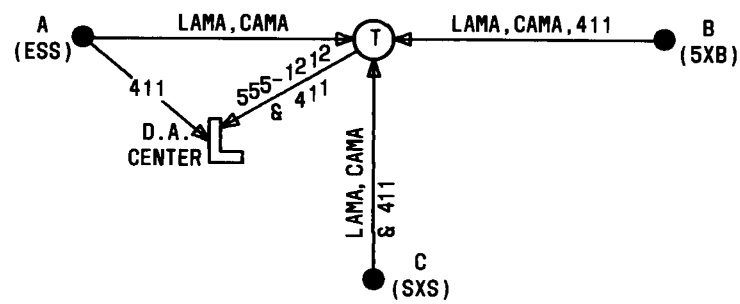


Fig. 24—Trunking to Directory Assistance *After* Conversion to Charging for Directory Assistance Calls

C. Automatic Intercept Service (AIS)

5.14 AIS is a mechanized computer file-storage system, providing the customer with a simulated voice answer regarding the status of a number not in service. The location of the system and transition from an operator-handled system to the AIS affects the trunking network. Shorter holding times change traffic quantity requirements when converting to AIS. There also is a need for trunks to switch those customers not satified with the AIS answer (or those numbers, eg, 4-party, not identifiable by AIS) to an operator for processing. The network configuration may change as a result. Figures 25 and 26 provide examples of manual intercept switchboards and automatic intercept services.

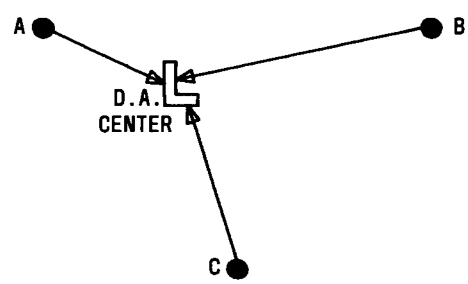


Fig. 25—Trunking for Manual Intercept Service

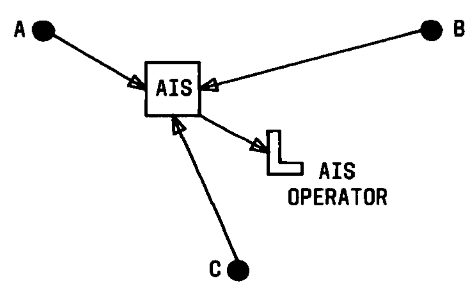


Fig. 26—Trunking for Automatic Intercept Service

D. Miscellaneous Services

5.15 Certain parcels of traffic, though small, must be given consideration when configuring the network. Those items considered here are mobile, ship-to-shore, toll station, overseas, and verification traffic.

5.16 Mobile (land radio) and Marine (ship-to-shore radio) services are not presently designed to be handled by TSPS systems. Many of these systems have been installed to use customer-directed dialing without requiring operator servicing of the calls (except for "0" operator calls). However, those systems requiring an operator to complete the calls will continue to be handled by cord switchboards. Current information should always be consulted regarding availability of special features, such as mobile and marine, on TSPS.

5.17 Toll station calls are those to some customers serviced manually by cord switchboard operators. TSPS presently is not designed to process toll station calls and these calls must be switched to a cord switchboard for completion. Toll station trunk groups usually are engineered individually as a part of the North American Network terminating in a cord switchboard.

5.18 An end office with a separate trunk group to 611 repair service will have a trunking change when 611 trunks are eliminated and a 7-digit repair service number is used in accordance with the System standard. Trunk groups in multiswitching system areas should be monitored closely to assure that peaks in repair calling on a 7-digit basis do not overload the network and block other calls.