TRUNKING CONSIDERATIONS—NETWORK
ENGINEERING LOAD SELECTION CONCEPTS
GENERAL ENGINEERING CONCEPTS
NETWORK OPERATIONS METHODS

CONTENTS PAGE

FIGURES

1. GENERAL

1.01 This practice is concerned with ***concepts*** for the ***selection of loads*** to be used in sizing trunk groups in the message network. While the concepts are applicable to trunk groups in nonalternate route networks, the primary emphasis is on trunk groups in alternate route networks where noncoincidence and interdependence are critical factors.

1.02 Whenever this section is reissued, the reasons for reissue will be covered in this paragraph.

1.03 Concepts discussed in this practice are applicable to both trunk servicing and trunk forecasting. In the case of trunk servicing,

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considerations discussed in the 780-403-2ZZ series must be reviewed prior to connecting or disconnecting trunks, based on the loads for a particular study period. In the case of trunk forecasting, the post selection of busy-season busy-hour loads from a number of study periods involves the problem of ***data equating***. Over a base year, the loads developed for a trunk group or network cluster can be influenced markedly by growth, relief units, route transfers, rehoming of switching systems, conversion of high-usage trunk groups to grade-of-service trunk groups, or vice versa. Recognition of such changes is critical to the busy-season, busy-hour (BSBH) load-selection procedures and is referred to as data equating. Data equating is discussed in detail in Sections 780-402-520, 530, and 540. These sections also address the problem of planned changes in each of the future forecast years as they affect the identification of significant hours and study periods.

1.04 In this section, the load selection process will be viewed as occurring in ***static*** networks. It is assumed that for static networks none of the types of change discussed above occurs during the base year. That is, the network configuration, in terms of both switching and trunking, remains unchanged throughout the base year and traffic patterns recur in the same hour and study period.

1.05 The purpose of discussing load selection concepts in such idealized networks is to develop load selection criteria that will enable a trunk engineer to duplicate the idealized network from a trunking viewpoint. This involves reducing the data universe to only those loads (by hour and study period) required to verify that every trunk group is required and has the correct numbers of trunks. Any load selection criteria that fails to verify the existing idealized trunking requirements is inadequate.

1.06 In addition to assuming static networks, this section also assumes that all required data are available from which to select loads. The determination of data requirements is covered in the 780-401-ZZZ series, but is influenced by the concepts covered in this section, as well as the concepts and procedures covered in Sections 780-402-520 and 530.

1.07 The system recommendations presented in this section are referred to as the ***significant hour*** concept for load selection. This concept of load selection is dependent upon the fact that existing trunk group sizing algorithms employ a single hour of load. In the Traffic Routing and Forecasting System (TRFS) under development, a new sizing algorithm will be introduced. Multihour engineering, which uses more than one hour of load, will be used to determine trunk requirements for high-usage trunk groups. When TRFS is introduced, new load selection concepts will be presented in an updated section.

1.08 If the average time-consistent busy hour for the loads between all points in a network were the same hour, there would be only one significant hour for load selection and sizing purposes. Since such complete coincidence seldom occurs, care must be taken to ensure that any noncoincidence in loads for the various hours and study periods is properly accounted for in the trunk forecasting process.

1.09 A significant hour is, therefore, one for which the loads between the various points in a network must be considered in the load selection and engineering processes, in order to avoid service degradation and to minimize total trunk requirements to the extent possible.

1.10 A complete understanding of the significant hour concept is essential for load selection purposes since proper load selection ultimately determines whether objective grades of service will be attained economically. Further, the determination of the data to be collected to engineer a network properly cannot be made without understanding the concepts covered in this section.

1.11 References in this section to load selection concepts are based on American Telephone and Telegraph Company recommendations. References to other concepts, procedures, data requirements, service levels, and equipment quantities are illustrative only. The appropriate section(s) should be reviewed to determine the current AT&T recommendations where illustrative references have been used in this section.

1.12 For the standard meaning of terms and definitions used in this section, see Section 780-400-305, "Glossary of Trunk Facilities Terms and Definitions." For completeness, several fundamental definitions are included here in this section.

2. FUNDAMENTAL CONSIDERATIONS

2.01 Prior to discussing the significant hour concept for load selection, certain fundamentals should be clearly understood. Since service objectives are related to BSBH results, it follows that load selection is always based on some type of busy hour.

A. Types of Busy Hours

2.02 There are four basic types of busy hours:

(a) ***Group Busy Hour (GBH):*** The time-consistent hour for which maximum load occurs.

(b) ***Network Cluster Busy Hour (NCBH):*** The time-consistent busy hour for a network cluster in which the sum of the carried loads on the high-usage trunk groups and the offered load to the final trunk group is the greatest. (See paragraph 2.18 for the different types of network clusters.)

(c) ***Service Busy Hour (SBH):*** A time-consistent busy hour during which the trunks required in a grade-of-service trunk group exceed the trunks required during the busy hour to which the trunk group would normally be engineered. When the trunks required in an SBH exceed the trunks required in the corresponding GBH or NCBH by more than a predetermined amount (see the 780-400-4ZZ series), a problem busy hour (PBH) exists. Thus, a PBH is a special case of an SBH rather than a basic type of busy hour.

(d) ***Office Busy Hour (OBH):*** The hour in which the maximum load on a switching system, desk, etc, occurs.

2.03 The four types of busy hours discussed provide the basis for load selection. In paragraph 2.02, reference is made to a ***time-consistent busy hour (TCBH)***. A TCBH is the identical hour each day during which, over a number of days, the highest average traffic occurs. In the case of high-usage and final trunk groups, TCBH data are required because of the load interdependence among such groups that must be recognized in trunk forecasting and servicing.

2.04 Reference also has been made in paragraph 2.02 to the busy hour to which a trunk group ***normally*** would be engineered. An only-route trunk group normally is engineered to its GBH-average business day (ABD) load. A final trunk group normally is engineered to its NCBH-ABD load. High-usage trunk groups normally are engineered to the maximum of their NCBH-ABD loads.

2.05 A distinction is made also between ABD busy hour data and weekend busy hour data. Since Saturday and Sunday traffic usually differ from ABD traffic in volume and destination, it is recommended that separate averages be computed for ABD and for Saturday and Sunday data, respectively. If traffic distributions by destination permit, Saturday and Sunday data may be combined.

2.06 In addition to the average busy-hour load, it is necessary to know the peakedness and day-to-day variation of the traffic to select all significant hours. Peakedness is discussed in Section 780-400-340 and day-to-day variation in Section 780-400-335. Given a high peakedness and/or day-to-day variation, a lower average offered load may indicate a higher number of trunks required to meet a service objective than those indicated by the highest average offered load. Frequently, this condition is associated with a skewed within-the-hour distribution of traffic prevalent in reduced rate periods.

B. Types of Loads and Load-Sets

2.07 Loads, as used in trunking, are obtained by averaging a series of hourly loads on a time-consistent basis. The number of hours to be included in the average on an ABD basis (assuming no data loss) ranges from 5 to 20 (one hour from each of 5 to 20 consecutive business days). On a weekend basis, the average load for Sunday or Saturday historically has been based on four consecutive Sundays or Saturdays (non-combined) or eight consecutive Saturdays and Sundays (if combining is permitted based on traffic patterns). Current recommendations as to the number of hours required for developing average loads are covered in Section 780-401-130.

2.08 Insofar as load selection is concerned, the following types of average loads frequently are referred to:

(a) ***Significant load:*** A load for a significant hour that must be considered in the network engineering process. A significant load is expressed in terms of average offered load (and average carried and average overflow load, where required) for a trunk group. It is always an NCBH, SBH, or GBH.

(b) ***Control hour load:*** The highest significant hour load for a trunk group is referred to as its control hour load.

(c) ***Base load:*** The average first-route offered load between two identified points or areas in a network from which future loads are forecast. See Sections 780-402-520 and 530 for more detail regarding trunk-group base loads and traffic-item base loads. A base load is historical in that it is derived from data processed from preceding study periods.

2.09 A ***load-set*** is the matrix of base loads that results from a statement of load for each specified pair of points in a network.

C. Types of Trunk Groups

2.10 The message network is composed of trunk groups that fall into three general categories:

(a) ***Grade-of-service trunk groups:*** Trunk groups engineered to a specific blocking objective (ie, an only-route, special final, or final trunk group).

(b) ***High-usage trunk groups (generic):*** Trunk groups designed to overflow to an alternate route with the amount of overflow (and trunk group size) dictated by overall network economics.

(c) ***High-usage trunk groups (expedient):*** Trunk groups designed to overflow to an alternate route with the amount of overflow (and trunk group size) controlled by considerations other than overall network economics, such as for service protection in the case of parallel protective high-usage groups.

2.11 The types of trunk groups discussed in this section include the following:

- ***Primary high-usage trunk group (PHU)***
- ***Intermediate high-usage trunk group (IHU)***
- ***Switched-overflow high-usage trunk group (SHU)***
- ***Bypass high-usage trunk group (BHU)***
- ***Combined-overflow final trunk group (COF)***
- ***Route-advance final trunk group (RAF)***
- ***Switched-overflow final trunk group (SOF)***
- ***Parallel protective high-usage trunk group (PPHU)***
- ***Divided high-usage trunk group (DHU)***
- ***Restrictive high-usage trunk group (RHU)***
- ***Only-route trunk group (ORG)***

2.12 It is impractical in a concepts section to consider all of the possible trunking arrangements that could exist in the message network. Further, a review of the principles involved in the load selection concepts should enable the trunk engineer to cope with special local arrangements. For example, if an ORG such as an intra end office trunk group in a No. 5 Crossbar switching system has been divided into two parts (a high-usage part route-advancing to a theoretical final part) to overcome full access limitations, the high-usage part does not belong to any network cluster. The 2-part arrangement does not change the ORG into another type of trunk group.

D. Types of Network Configurations

2.13 A network is defined as an arrangement of switching systems interconnected by trunk groups. A network configuration is a particular arrangement for interconnecting switching systems by trunk groups. The various types of network configurations are of interest from a load selection viewpoint, in that, load selection concepts differ in complexity from a nonalternate route network to the 5-level North American Network.

2.14 Section 780-402-110 is devoted to discussing network configurations and diagrams are provided for a variety of configurations that either are recommended, frequently used, currently in use on a limited basis, or may be used in the near future based on present planning concepts.

2.15 For load-selection purposes in a static network, nonalternate route networks (whether nonhierarchical or hierarchical) always are composed of switching systems interconnected by ORGs. Since ORGs are independent, they represent the simplest case insofar as load-selection concepts are concerned.

2.16 Alternate route network configurations, however, introduce numerous complications into load-selection concepts. As discussed and diagrammed in Section 780-402-110, there are three basic categories:

- Single-stage, two-level configurations
- Two and 3-level, ***multistage*** configurations
- The 5-level ***multistage*** North American Network configurations.

E. Types of Network Clusters

2.17 A network cluster is a final trunk group and all high-usage trunk groups that have at least one terminus in common with it and for which the final trunk group is in the last-choice route-chain. The network cluster (and its busy hour data) is the basic unit considered in alternate route network engineering for load selection, and is supplemented by service busy-hour data as required.

2.18 There are three types of network clusters basically identifiable by the type of overflow traffic offered to the final trunk group.

- ***Combined-Overflow Network Cluster (CONC)***
- ***Route-Advanced Network Cluster (RANC)***
- ***Switched-Overflow Network Cluster (SONC)***

2.19 Figure 1 illustrates the three types of network clusters, their respective final trunk groups, and the high-usage trunk groups that belong to each network cluster. Figure 1 is a combined sector tandem network with all one-way trunking. Figure 2 is a 3-level, hierarchical network configuration with one-way trunking for end offices and with 2-way trunking among the tandems. Both figures indicate the criteria that determine whether a high-usage trunk group does or does not belong to a particular network cluster. Failure to meet ***all*** of the criteria excludes a high-usage trunk group from a network cluster.

2.20 The summary on each figure indicates that high-usage trunk groups of the types illustrated always belong to two network clusters, even though the overflow reaching the final trunk group of the network cluster may have passed through a number of alternate routes prior to reaching the final trunk group of the network cluster in question.

> ***Note:*** If a mixture of one-way final trunk groups and 2-way high-usage trunk groups is introduced into an alternate route network configuration, a 2-way high-usage trunk group may belong to three or four ***basic*** network clusters. This is illustrated in paragraph 4.08.

F. Types of Alternate Routes

2.21 An alternate route is the second or subsequent choice path for traffic between two points, usually consisting of two trunk groups in tandem. A high-usage trunk group always has one alternate route and may have two or more depending upon the network configuration. However, as discussed in Part 5, the number of alternate routes for a given high-usage trunk group is irrelevant for load selection purposes after the second alternate route, since the absolute amount of overflow passed to a third, fourth, etc, alternate route has lost any statistical significance even if it could be quantified accurately and would recur in a predictable fashion.

2.22 In multistage networks, the alternate routes for traffic items offered to a trunk group may differ from the trunk group alternate route

(TGAR). This distinction is important in developing the appropriate first-route offered load for trunk groups that receive overflow (refer to Section 780-402-540).

2.23 In Fig. 3, the distinction between TGAR and a traffic item alternate route (TIAR) is illustrated. The TGAR for trunk group 2 is composed of trunk groups 4 and 8. Two traffic items are offered to trunk group 2, A2→Z1 and A2→Z2 traffic. The TIAR, groups 4 and 3, for the overflow item A2→Z1 differs from the TGAR for trunk group 2; while the TIAR for A2→Z2 traffic includes the TGAR for trunk group 2.

2.24 In a hierarchical network, the ***last-choice route*** for the completion of calls between two switching systems always consists of grade-of-service trunk groups and is referred to as the last-choice route-chain. With reference to a high-usage trunk group, the last-choice route-chain starts at the origin and ends at the terminus of the high-usage trunk group. Thus, the last-choice route-chain for trunk group 2 is its TGAR. The last-choice route-chain for a traffic item routing via a high-usage trunk group, with at least one terminal at a tandem, always contains at least ***one more*** grade-of-service trunk group than does the last-choice route-chain of the high-usage trunk group type being discussed. In Fig. 3, the last-choice route-chain for traffic item A2→Z2 is composed of groups 4, 8, and 7. However, the last-choice route-chain for traffic item A2→Z1 is the last-choice route-chain of trunk group 1.

3. OBJECTIVES OF LOAD SELECTION

3.01 The primary objective of load selection for trunk network design purposes is to provide the statement(s) of average offered ***first-route*** load(s) per point-pair in a network. These base loads are the basis for projecting future loads which, in turn, are required to size future trunk groups. A secondary objective is to accomplish this with the ***minimum*** number of average offered first-route load statements per point-pair, giving due recognition to any service or cost risks involved.

A. Technological Constraints That Impact on Load Selection Objectives

3.02 Except in the simple case of an only-route trunk group, there is no direct means of ***simultaneously*** identifying an average offered load as significant and of quantifying the average offered first-route load. For example, while the average first-route load offered to a PHU trunk group can be derived from trunk group measurements for any given hour in any study period, there is no way of knowing which of the loads is significant. Interdependence among the high-usage and final trunk groups in an alternate route network and noncoincidence among the loads offered to these groups preclude identifying significant hours (and associated loads) on an individual trunk group basis.

3.03 Given that the significant hours and study periods have been identified for a network, it is impossible to develop, from individual trunk group measurements, the average offered first-route load for trunk groups having an average offered load consisting of first-route ***and*** overflow traffic items. Either the first-route load must be directly quantified using point-to-point data, or the overflow component must be quantified and subtracted from the averaged-offered load. This can be accomplished utilizing the Network Disassembly Procedures discussed in Section 780-402-540. Where these procedures rely on developing estimates of average overflow loads from trunk group measurements only, or in combination with point-to-point data, even assuming complete and valid data, their accuracy declines with the progression from single-stage alternate route networks to multistage alternate route networks consisting of 2- through 5-level hierarchies.

3.04 The need to estimate such average first route loads in an indirect manner imposes constraints on the secondary objective of load selection that would not exist in an ideal environment (ie, time-consistent load-sets must be retained at least through the network disassembly procedure).

B. Sequential Objectives for Load Selection

3.05 As a result of these technological constraints, the objectives of load selection become sequentially:

(1) Identification of those hours in which loads are significant to the design of a specific network.

(2) Selection of the average offered (and average overflow loads, as required) for all trunk groups in a specific alternate route network for

each of the time-consistent hours identified in (1).

(3) Using the time-consistent loads from (2), conversion is made of the average offered loads for trunk groups receiving overflow to average first-route loads per trunk group, using the Network Disassembly Procedures (Section 780-402-540). In an idealized static network, the primary objective of load selection has now been accomplished, since average first-route loads are available per required point-pair to create the required time-consistent load-sets for a specific network.

(4) To meet the secondary objective (ie, the minimum number of load-sets required), the load-set profiles, by volume and destination, can be compared to ensure that statistically significant differences exist among the load-sets. Any load-set(s) that is statistically equivalent to another load-set may be deleted.

3.06 Until more effective tools are developed for quantifying first-route loads, existing technological constraints must be kept in mind when evaluating alternate load selection strategies. In addition, a strategy that might be attractive in a static network may be unattractive in a dynamic network and vice versa. Sections 780-402-520 and 550 discuss load selection in dynamic networks.

4. LOAD SELECTION PROBLEMS

4.01 In a static network, there are two fundamental problems involved in load selection: (1) the data universe and (2) noncoincidence and interdependence. The latter two problems have been shown together since, if there is no interdependence, noncoincidence is irrelevant. Again, it should be stressed that dynamic networks introduce a variety of other problems that will ***not*** be discussed in this section.

A. The Data Universe

4.02 On an Average Business Day (ABD) basis, the complete data universe for a year consists of 24 hours a day, 5 days a week, and 52 weeks. Using a ***rolling*** 4-week average, there would be 1248 (24×52) time-consistent load-sets for a network. Given a metropolitan network with 30 end offices, there would be 870 (30×29) one-way traffic items between the end offices in a load-set. Multiplying 1248 by 870, the result is 1,085,760 statements of load for a relatively small network. There is no need to extrapolate such figures to the Bell System to realize that some form of data reduction is not only essential, but practical. Weekend data merely magnify the problem.

B. Data Reduction

4.03 There are three phases to data reduction:

(1) Data collection only for selected hours and/or weeks during a 12-month period. This subject is discussed in the 780-401-1ZZ series.

(2) Retention of only the significant hourly data required to properly develop first-route loads using the Network Disassembly Procedures.

(3) Deletion of significant hour first-route loads that are not statistically different, given the accuracy range of short-term samples.

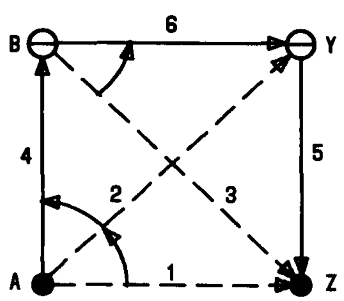
4.04 In evaluating the concepts discussed subsequently, it is important to recognize the available data universe. The smaller the universe, the greater the risk that service may be impaired in a noncollected hour or study period. Therefore, caution is needed in seeking a minimum cost network in a minimum data environment or in a load selection concept that drastically reduces the collected data to data that are ***assumed*** to be significant.

C. Interdependence and Noncoincidence

4.05 Interdependence is not only a consequence of alternate routing, it is a primary objective. The concept of a high-usage trunk group is to delete those trunks that would be marginal (uneconomical) in terms of CCS carried, but that would be required if it were a grade-of-service trunk group. The marginal CCS from a number of high-usage trunk groups could then be aggregated as overflow load and routed via a tandem(s) on a more economical basis. The trunk groups receiving overflow, however, cannot be sized until the amount of overflow to be received is quantified. Thus, trunk groups receiving overflow are dependent upon the trunk groups overflowing to them, although the hours (and associated loads) significant to a trunk group receiving overflow may differ from those of high-usage trunk groups overflowing to them. From a load selection standpoint, a high-usage trunk group is now, at least, partially dependent upon the trunk groups to which it overflows. Thus, there is mutual dependence or interdependence among a high-usage trunk group and the trunk groups in its alternate route(s).

4.06 Because of this interdependence among high-usage groups and groups in their alternate routes, noncoincidence of traffic offered to these groups becomes a critical factor in the selection of loads for engineering alternate route networks. Examples of recurring noncoincidence are the day versus evening busy hours of trunk groups, as well as end offices, and variations in busy seasons, such as winter versus summer loads in resort areas.

4.07 The extent of interdependence (and the importance of noncoincidence) is related to the type of network configuration. To illustrate the interdependence and noncoincidence problems, consider Sketch 1 which depicts a 2-level, multistage sector tandem configuration.



(TYPE TRUNK GROUP NUMBERING)
SKETCH 1

In this sketch, there are three network clusters defined by final trunk groups 4, 5, and 6. Trunk groups 1, 2, and 4 form a RANC; trunk groups 2, 3, and 6 form a CONC; and trunk groups 1, 3, and 5 form a SONC. Thus, the ***basic*** network clusters (defined by final trunk group numbers) are for:

- Trunk Group 1: 4 and 5
- Trunk Group 2: 4 and 6
- Trunk Group 3: 5 and 6

4.08 However, load selection related solely to basic network clusters would not be satisfactory if noncoincidence existed among the three network clusters. The offered load to trunk group 3 is composed, in part, of the overflow from trunk group 2 destined for Z. As a result, it is necessary to quantify the overflow from trunk group 2 in the NCBH of trunk group 5 in order to estimate the first-route load to group 3 in one of its significant hours. Thus,trunk group 5 defines a ***supplementary*** network cluster for trunk group 2. Similarly, the offered load to trunk group 2 is dependent on trunk group 1 and, therefore, trunk group 6 defines a supplementary network cluster for trunk group 1.

4.09 The most extensive interdependence is in the 5-level North American Network, in which a high-usage trunk group may be involved in 2 to 7, or more, network clusters.

5. THE SIGNIFICANT HOUR CONCEPT

A. Introduction

5.01 Regardless of the procedures recommended for sizing a network, a service/cost effective network can be constructed properly only if all the loads that are significant to the forecasting process are available. These loads are required in the disassembly of total offered loads into first-route loads, the sizing of individual trunk groups, and in the assembly of first-route and overflow loads into total offered loads. The control hour load is used for sizing; other significant hours are used in disassembly and assembly procedures. This overview endeavors to identify both the hours that ***theoretically*** should be considered for the various types of trunk groups and networks, and also the key elements that pertain to them.

5.02 The significant hour concept for load selection is applicable to trunk groups in both nonalternate route and alternate route networks. The concept is quite simple for only-route and final trunk groups, but is more complex for high-usage trunk groups even in an idealized, static network with fixed numbers of switching systems, given load-sets that will recur and the optimal number of trunk groups and trunks required per trunk group.

5.03 Two extremes exist in reducing the data for an alternate route network to a single statement of load per point-pair.

(1) Selection of the GBH, busy season load for each point-pair in a network. This would ensure service protection at potentially significant cost penalties.

(2) Selection of the busy season, busy hour during which the maximum load for the ***entire network*** is the highest. This would be a time-consistent load-set that would entail unacceptable service risks if any appreciable degree of noncoincidence existed. The busy season, busy hour for an ***entire network*** is not a criterion of the significant hour concept except indirectly if zero noncoincidence occurred among all of the basic components.

5.04 Somewhere between the two extremes cited, is a load-selection strategy that involves acceptable service/cost risks. The significant-hour concept forms the basis for all approaches to the problem.

B. Nonalternate Route Networks

5.05 The potential significant hours for a static only-route trunk group are:

- ABD-GBH
- SBH (ABD and weekend)

Note: If the only-route trunk group is a candidate for conversion to a high-usage trunk group, all of the factors applicable to high-usage trunk groups must be considered.

5.06 In a static network there is no interdependence among the only-route trunk groups involved. Without interdependence, it is necessary to size each only-route trunk group to its ABD-GBH, busy season or to SBH (if a PBH exists).

5.07 In the case of only-route and final trunk groups, the probability of three or four busy hours, respectively, is remote. If they exist, however, failure to consider them in a load selection process could lead to service degradation.

C. Alternate Route Networks

5.08 In a static network, the significant hours for a high-usage trunk group are dictated by the network configuration. The significant hours in all cases are NCBHs, the SBHs of final trunk groups, or the OBH of a tandem(s). Considerations for identifying the significant hours for a high-usage trunk group are discussed in succeeding paragraphs.

Basic Network Cluster Busy Hours

5.09 Except for parallel protective and divided high-usage trunk groups, high-usage trunk groups usually belong to two (or more) basic network clusters in accordance with the criteria discussed in Part 2. An NCBH is developed by summing the carried loads on all high-usage trunk groups in a network cluster, plus the offered load to the final trunk group of the network cluster. The hour with the highest summarized load is the NCBH; this, in effect, is the GBH of the network cluster. Failure to include this hour in a load selection process is conceptually the same as ignoring the GBH of an only-route trunk group with essentially the same result—service degradation on the final trunk group of the network cluster.

5.10 Since a high-usage trunk group belongs to two or more basic network clusters with potentially different NCBHs, failure to recognize high-usage trunk group loads in each basic NCBH could result in service degradation on some final trunk group(s). Conversely, assuming statistically significant differences among the various NCBH loads for selected high-usage trunk groups, the actual load offered to a final trunk group may be higher in an hour other than the NCBH of the final trunk group (dependent upon the sizing of the subtending high-usage trunk groups). In evaluating results, the latter condition would appear to be an SBH problem for the final trunk group. However, the trunks provided would be adequate if the basic NCBHs and associated load-sets for subtending high-usage trunk groups were recognized in the load selection process. Recognition of basic NCBHs and associated load-sets may eliminate the need for special procedures to treat numerous SBH problems or simply to eliminate many SBH problems.

Supplementary Busy Hours

5.11 In order to develop first-route offered loads from total offered loads for a trunk group, overflow loads from subtending high-usage groups in the control hour of the group under consideration must be quantified. Therefore, the control hour of each trunk group in a high-usage trunk group alternate route(s) becomes significant to the trunk forecasting process. Failure to recognize this noncoincidence among the significant hours of the alternate route legs can lead to overstatement or understatement of average offered loads and average overflow loads with either cost or service penalties involved.

5.12 To guarantee that the data necessary to disassemble the network are available, the selection of significant hours and the determination of the control hour are performed from the highest level of the hierarchy downward.

5.13 The basic NCBH of trunk groups in a third or subsequent alternate route are ***not*** specifically recognized as being significant to a high-usage group because of the lack of statistical significance in the associated volume of load. Even the impact of one high-usage group on its second alternate route is marginal and the actual volume cannot be quantified with a high degree of accuracy. However, the cumulative impact of 10 to 30 high-usage groups overflowing to the same group can be important in the determination of first-route loads and in the proper distribution of loads throughout the network.

Service Busy Hours

5.14 Each network cluster has a final trunk group with potential SBHs. Such hours, if they exist, are significant to high-usage groups associated with the final trunk group and associated network cluster.

5.15 Of course, NCBHs are more critical to load selection than SBHs. A load selection process utilizing the ABD-GBHs of final trunk groups as the criterion for selecting loads for all subtending high-usage trunk groups would produce a less optimal network than one geared to NCBHs. This stems from the fact that, on an ABD basis, the GBH of a final trunk group does not necessarily coincide with its NCBH (ie, a SBH exists). Failure to include the NCBH and associated point-pair loads almost guarantees SBH problems even though inclusion does not preclude SBHs.

5.16 There is reason to believe that SBH busy-season problems on final trunk groups have been overstated due to lack of appreciation of the variability of short-term samples, whether based on 20- or 5-day averages. The accuracy ranges of short-term samples are discussed in Sections 780-401-ZZZ, 780-402-ZZZ, and 780-403-ZZZ. Given an only-route trunk group of 50 trunks with traffic characteristics (call rate, holding time, day-to-day variation and peakedness) completely identified for a long-term process, as well as a perfectly measured and stable environment, average offered loads based on 20-day samples could indicate a trunk requirement falling from 47 to 53 trunks 95-percent of the time, and blocking ranging from 0.3 to 1.9 percent, even though the ***long-term values*** of 50 trunks required and one-percent average blocking would be attained. Average offered loads based on 5-day samples normally indicate a broader trunk requirement range (95-percent of the time) of 45 to 55 trunks and a blocking range of 0.0 to 2.9-percent. From a statistical standpoint, results falling in the ranges cited for the two different sample sizes would be equivalent to a long-term 50-trunk requirement and one-percent average blocking. The ranges cited are sensitive to offered load size, level of day-to-day variation, and peakedness (ie, relatively broader ranges for small loads, higher levels of day-to-day variation and peakedness). See Section 780-402-510 for more detail.

5.17 Since operation does not take place in a perfectly measured stable environment, nor can the true long-term characteristics of traffic flow be determined, it is more than likely that the ranges indicated represent a lower boundary. Thus, in many instances, SBHs are considered PBHs when, in fact, no problem exists except on reports. The preceding discussion is not meant to imply that no PBHs exist on an ABD Saturday or Sunday basis. There is ample evidence, particularly in the 5-Level North American Network, that Sunday PBHs exist since there are nine percent no circuits (NCs) well outside the reasonable accuracy ranges for short term samples. There is also reason to believe that PHBs may exist on ABD calendar days (eg, Mondays or Thursdays in college towns).

5.18 PBHs on final trunk groups should be recognized in the load selection process to avoid service degradation on final trunk groups. Section 780-402-450 discusses the procedures for identifying PBHs, the apparent cause of the problem, and alternate procedures for correcting the problem, depending upon the cause; (1) a substantial increase in the first-route load offered to the final versus substantial increases in overflow from selected high-usage trunk groups, or (2) skewed within-the-hour traffic distributions.

Tandem Office Busy Hours

5.19 The OBH of the tandem(s) in a network is significant in that the volume of CCS to be switched at a tandem can be controlled by the sizing of selected high-usage trunk groups. Long-haul high-usage trunk groups involving an end office, at least at one end, can be justified only if tandem relief in the OBH is provided.

5.20 To verify the idealized, static network in relation to tandem switched CCS (or other OBH indicator), the OBH of each tandem would be identified. It is improbable that such an OBH would not coincide with one of the basic and supplementary NCBHs ***or*** one of the basic and supplementary SBHs already being considered. If it were a unique hour, the high-usage and final trunk groups would be generally sized to higher loads than those measured in the OBH. An OBH load-set could be created with the same constraints used for basic and supplementary NCBHs in 3- to 5-level multistage networks. The point-pair loads over-contributing to the OBH could then be identified by examining one hour on one day if high-day engineering was the criterion, or by examining one hour for 10 specific days and computing average loads for this hour for all trunk groups for which the OBH was considered significant. While this is conceptually possible if required, the usefulness or practicality of this approach in a dynamic network is limited. Studies would be required to demonstrate any year-to-year correlation in the high day(s) and the over-contributing trunk groups. Lack of general correlation would destroy the usefulness of the data.

Significant Hours for Final Trunk Groups

5.21 For a final trunk group in a static network, the significant hours are:

- ABD-NCBH
- SBH (ABD or weekend).

Final groups normally are sized to their ABD-NCBH because of the interdependence of the final and its subtending high-usage groups. It should be noted that a final group GBH is ***not*** necessarily significant to its sizing.

D. Summary

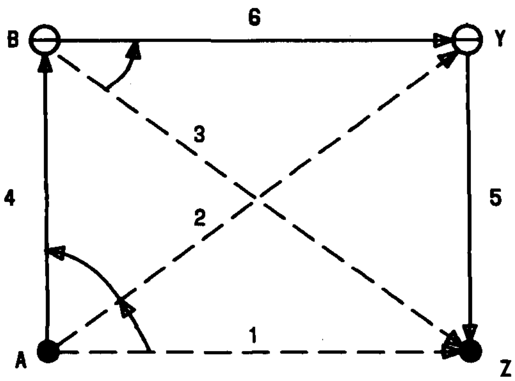
5.22 To summarize, the significant hours to be selected for a high-usage group are:

- NCBH at each end of the group
- Control hour of each high-usage group in associated first and second alternate routes
- NCBH and SBH, if one exists, of each final trunk group in the first alternate route
- SBH of each home final group.

The GBH of the high-usage group should be considered if conversion to a grade-of-service trunk is planned.

5.23 Detailed procedures with illustrative examples are presented in Section 780-402-530. As discussed earlier, the concepts presented in this section are related to single-hour trunk engineering concepts. At an appropriate time, before the release of TRFS, the load selection concepts associated with multihour trunk engineering will be presented.

PROBLEM: IDENTIFY THE NETWORK CLUSTERS AND ASSOCIATED FINAL AND HIGH-USAGE TRUNK GROUPS FOR THE 2-LEVEL NETWORK SHOWN BELOW:



CRITERIA FOR A HIGH-USAGE TRUNK GROUP TO BE INCLUDED IN A NETWORK CLUSTER:

A - THE HIGH-USAGE TRUNK GROUP MUST HAVE AT LEAST ONE TERMINUS IN COMMON WITH THE FINAL TRUNK GROUP.

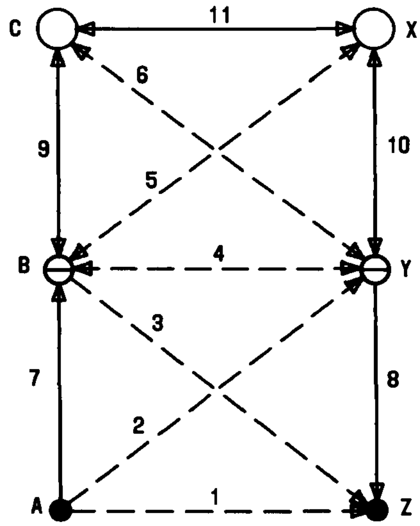
B - THE FINAL TRUNK GROUP MUST BE IN THE LAST-CHOICE ROUTE-CHAIN OF THE HIGH-USAGE TRUNK GROUP.

SOLUTION: EACH HIGH-USAGE TRUNK GROUP MUST BE TESTED WITH EACH FINAL TRUNK GROUP FOR EACH OF THE CRITERION. THE FOLLOWING MATRIX SUMMARIZES THESE TESTS. IN THE TWO CRITERION COLUMNS, A √ MEANS THE HIGH-USAGE TRUNK GROUP PASSED THE TEST AND AN F MEANS IT FAILED.

FINAL TRUNK GROUP		TYPE NETWORK CLUSTER	TESTING OF HIGH-USAGE GROUPS						GROUPS BELONGING TO CLUSTER
			CRITERION A			CRITERION B			
			TRUNK GROUP			TRUNK GROUP			
NO.	TYPE		1	2	3	1	2	3	
4	RAF	RANC	✓	✓	✓	✓	✓	F	1,2
5	SOF	SONC	✓	✓	✓	✓	F	✓	1,3
6	COF	CONC	F	✓	✓	✓	✓	✓	2,3

Fig. 1—Network Clusters and Associated Final and High-Usage Trunk Groups for a 2-Level Network

PROBLEM: IDENTIFY THE NETWORK CLUSTERS AND ASSOCIATED FINAL AND HIGH-USAGE TRUNK GROUPS FOR THE 3-LEVEL NETWORK SHOWN BELOW:



CRITERIA FOR A HIGH-USAGE TRUNK GROUP TO BE INCLUDED IN A NETWORK CLUSTER:

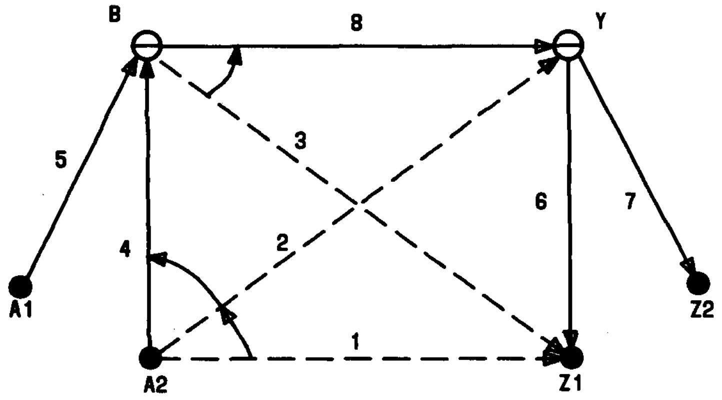
A - THE HIGH-USAGE TRUNK GROUP MUST HAVE AT LEAST ONE TERMINUS IN COMMON WITH THE FINAL TRUNK GROUP.

B - THE FINAL TRUNK GROUP MUST BE IN THE LAST-CHOICE ROUTE-CHAIN OF THE HIGH-USAGE TRUNK GROUP.

SOLUTION: EACH HIGH-USAGE TRUNK GROUP MUST BE TESTED WITH EACH FINAL TRUNK GROUP FOR EACH OF THE CRITERION. THE FOLLOWING MATRIX SUMMARIZES THESE TESTS. IN THE TWO CRITERION COLUMNS, A ✓ MEANS THE HIGH-USAGE TRUNK GROUP PASSED THE TEST AND AN F MEANS IT FAILED.

FINAL TRUNK GROUP		TYPE NETWORK CLUSTER	TESTING OF HIGH-USAGE GROUPS												GROUPS BELONGING TO CLUSTER
			CRITERION A						CRITERION B						
			TRUNK GROUP						TRUNK GROUP						
NO.	TYPE		1	2	3	4	5	6	1	2	3	4	5	6	
7	RAF	RANC	✓	✓	✓	✓	✓	F	✓	✓	F	F	F	F	1,2
8	SOF	SONC	✓	✓	✓	✓	F	✓	✓	F	✓	F	F	F	2,3
9	COF	CONC	F	F	✓	✓	✓	✓	✓	✓	✓	✓	✓	F	3,4 & 5
10	COF	CONC	F	✓	F	✓	✓	✓	✓	✓	✓	✓	F	✓	2,4 & 6
11	COF	CONC	F	F	F	F	✓	✓	✓	✓	✓	✓	✓	✓	5,6

Fig. 2—Network Clusters and Associated Final and High-Usage Trunk Groups for a 3-Level Network



TRUNK GROUP 2 (IHU) TGAR-GROUPS 4 & 8

TRAFFIC ITEMS OFFERED TO GROUP 2		ROUTES			LAST-CHOICE ROUTE-CHAIN
TYPE ITEM		FIRST ROUTE	ALTERNATE ROUTE		
FIRST ROUTE	OVERFLOW		FIRST	SECOND	
A2 → Z2	-	2 & 7	4,8, & 7	NONE	4,8, & 7
-	A2 → Z1	1	2 & 6	4 & 3	4,8, & 6

TRUNK GROUP 3 (SHU) TGAR-GROUPS 8 & 6

TRAFFIC ITEMS OFFERED TO GROUP 3		ROUTES			LAST-CHOICE ROUTE-CHAIN
TYPE ITEM		FIRST ROUTE	ALTERNATE ROUTE		
FIRST ROUTE	OVERFLOW		FIRST	SECOND	
A1 → Z1	-	5 & 3	5,8, & 6	NONE	5,8, & 6
-	A2 → Z1	1	2 & 6	4 & 3	4,8, & 6

Fig. 3—Traffic Items Routing via IHU or SHU Trunk Groups