IMPROVED TRAFFIC NETWORK ADMINISTRATION PROCESS UTILIZING END-TO-END SERVICE CONSIDERATIONS

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ABSTRACT

The advent of stored-program-controlled (SPC) switching has permitted low-cost acquisition of data identifying the disposition of each call reaching a network switch in a corporate network. The data contains sufficient call detail to permit accurate estimation of end-to-end (E-E) loads and service (blocking and delay). The SPC load and service characterization has been utilized by a new system of computer programs to administer (reconfigure) a switched network to satisfy the E-E service objectives at a near-minimum cost. This paper describes the new traffic administration process and its initial application to several U.S. corporate networks, resulting in both cost reductions of 5 to 10 percent over the network designs achieved by traditional administration methods, and more uniform grade of service distributions.

1. INTRODUCTION

The SPC switching capability available for modern corporate networks offers many features aimed at improving traffic efficiency. Among these are: the ability to vary network routing as a function of time of day to obtain savings afforded by noncoincidence of busy-hour traffic; and the capability of queuing on trunks, access lines, and off-net facilities to trade off delay in call setup for blocking. However, the most important traffic efficiency feature may be the low-cost acquisition of data identifying the disposition of each call reaching a network switch. The data contains sufficient call detail to permit accurate estimation of E-E loads and service (blocking and delay).

In support of two new SPC switched network offerings to U.S. corporate customers, a new traffic administration process has been formulated to take advantage of the extensive data available for these networks. A set of computer programs, known collectively as the Enhanced Network Administration System (ENADS), has been developed to implement this process, utilizing E-E loads estimated from the call detail data to reconfigure a switched network to satisfy the E-E service objectives at a near-minimum cost. This paper presents an overview of the new administration process and its application to several U.S. corporate networks. However, the applicability of this process extends beyond private networks to the administration of moderately sized public networks that may experience extensive shifts or growth in traffic demands and sufficient technological modernization to permit low-cost acquisition of call detail data, in addition to the traditional traffic measurements.

Following a brief discussion of the relevant traffic features of SPC networks available for corporate customers (Section 2) and a description of the network data utilized for administration (Section 3), the new administration process, consisting of three sequential stages, is described in Section 4. The final section contains representative results obtained from initial applications of this work. The emphasis of the paper is in characterizing the functions performed by the new administration process; details of the computer algorithms have been omitted.

2. RELEVANT TRAFFIC FEATURES OF PRIVATE NETWORKS

The administration process described in this paper was established particularly for networks dedicated to multilocation corporate customers, as illustrated in Figure 1. For a typical customer, the network interconnects 50 to 200 locations (such as research and development laboratories, manufacturing facilities, sales offices, etc.), each served by a Private Branch Exchange (PBX) or Centrex system. The network switches (typically three to ten per network) may be located at telephone company central offices, offering a shared switching capability for several customers. Each customer pays only for the switching capability utilized for his network, based upon his circuit terminations at the switch. Alternatively, network tandem switching dedicated to each customer may be provided by stored-program-controlled PBXs located on the customer premises. Private line circuits, leased by the customer from the telephone company or other common carrier for the customer's sole use, serve to connect the cus-
customer locations (referred to as on-net service points) to the network switches and the switches to each other. These circuits are referred to as network access lines and trunks, respectively.

By dialing a suitable network access code, subscribers at a customer location can reach all of the on-net service points via a uniform numbering plan, typically requiring seven digits. Upon entering the network at a switch, calls route progressively from one switch to the next (under stored program control) toward the destination, without assurance of subsequent completion at the next switch.

ENADS addresses itself to networks employing two-level hierarchical interswitch routing. A six-switch network is illustrated in Figure 2, with the St. Louis and Detroit switches homing on Chicago, while the Boston and Atlanta switches home on New York. Calls routed from Detroit to Boston which encounter all circuits busy on a direct group, may overflow first to the trunk group to New York and then on a final trunk group to New York. Once reaching Chicago, the calls try the direct group to Boston and, failing that, try the alternate route on a final trunk group to New York.

![Figure 2 - Two-Level Hierarchical Interswitch Routing](image)

Also illustrated in Figure 2 is the use of one-way bypass access lines from a network switch (New York) to a distant PBX (homed on the Boston switch) which does not home on that switch. The objective of this feature is to reduce circuit termination charges at the network switches and the line-haul cost of private network circuits whenever there is sufficient traffic to the large PBXs to warrant bypass circuits. In Figure 2, calls reaching the New York switch attempt to complete to the destination via the bypass access line group and alternate route, if necessary, to the final trunk group connecting the New York and Boston switches.

Typically, approximately half the network traffic is destined for locations that are not on-net service points. In such cases, calls are said to "hop-off" the network at a switch and enter the public telephone network at a designated central office. The circuits that connect the private network to the public network are referred to as off-net circuits and are of three principal types:

(a) Foreign Exchange (FX) circuits: These are private lines leased to the customer who connect a switch in his network to any one of approximately 10,000 central offices serving the U.S. public telephone network. The charges for these circuits depend on circuit length and are identical to those for network trunks and access lines. There are additional (usually minimal) charges for completing calls within the public telephone network.

(b) Wide Area Telephone Service (WATS): This service provides the customer with circuits connecting a given switch on his network typically to a nearby toll office (class 4 or higher) and may provide flat-rate calling within certain limits to any stations on the public telephone network within a specified area around the entering toll office. Monthly charges for WATS circuits vary according to the geographic calling radius (WATS band).

(c) Local circuits to the public telephone network: These circuits connect the given customer's switch to the nearest local (class 5) central office. This permits off-net calls to access the public telephone network as if it were a station originating at the local office. Local or toll charges will be incurred for each off-net call accessing these circuits, depending upon the call destination.

The preceding discussion indicates that a wide range of on- and off-net circuits is available to complete calls destined for off-net locations. The flexibility this range offers is illustrated in Figure 3. In this example, a call originating at an on-net service point at Dallas, Texas is destined for an off-net station in Boston, Massachusetts. The principal alternatives illustrated in this example are to: (1) hop-off the network at the originating switch (referred to as "head-end hop-off"); or (2) utilize the network trunks to route the call as close to the destination as possible and then hop-off the network at the terminating switch (referred to as "tail-end hop-off"). In this case, the preferred route is tail-end hop-off.

![Figure 3 - Example of Off-Net Routing Alternatives](image)

Under SPC switching, network routing can be further complicated by establishing multiple routing patterns that vary according to time of day to take advantage of noncoincidence busy-hour traffic caused by the geographic time zone differences throughout the U.S.

Another traffic efficiency feature is call queuing for network circuits. Off-hook queuing enables the calling party who encounters all-circuits-busy on all available routes to wait in queue, off-hook, until a circuit becomes available. By introducing this queuing facility in the call setup process, circuit efficiency may be improved by allowing call attempts to "camp-on" busy circuits until they become idle or if the waiting call is camped-out of the system. Still greater circuit efficiency can be achieved via ringback queuing which permits the calling party to be rung back by the network switch, after delays of to several minutes, when a circuit becomes idle.
3. NETWORK DATA REQUIREMENTS

Perhaps the most important traffic efficiency feature afforded by the new SPC switched network is the low-cost availability of extensive network data that can profitably be utilized for traffic administration. In particular, two types of network data are essential for the administrative process described in this paper: call detail data and traffic measurements on circuits and queues.

For each call attempt reaching a network switch, the desired call detail record should contain the following information:

(a) Identity of the calling and called locations, the network access privileges of the calling party, and the time the call was placed.

(b) Disposition of the call (e.g., whether the call completed to the destination; whether it queued at the recorded switch; identity of the incoming and outgoing circuits seized).

(c) The call setup and holding times.

The call detail data are utilized to estimate the E-E offered loads, E-E blocking, and delays for calls queued in the network.

Necessary supplements to the call detail data are the traditional traffic measurements on all circuit groups terminating at the network switches and queuing arrangements established for each group. In particular, peg count, overflow, total usage, and maintenance usage are required hourly. Additionally, because the circuit group sizes might change during the day, a measurement of the number of circuits in the group is also desired on an hourly basis.

The queue-related statistics include peg counts, queue overflows (calls finding all queue slots busy), queue usage, and number of calls experiencing a waiting time greater than 7 seconds, for each queue facility on an hourly basis. The number of queue slots is also required for each facility.

In conjunction with the call detail data, the traffic measurements provide the following capabilities:

(a) Cross-checks with call detail data to ensure adequate data validity.

(b) A low-cost means of monitoring network performance and making individual adjustments to circuit group and queue sizes, without requiring the full E-E administration process.

4. NETWORK ADMINISTRATION PROCESS

The following discussion assumes that a data acquisition system is available to centrally collect the call detail records and traffic measurements (for up to 24 hours) from each switch, on a daily basis, for as many consecutive business days (20 to 60) as necessary to obtain a representative traffic profile of the network loads and service. The network administration process, depicted in Figure 4, consists of the following three consecutive stages:

(a) Stage 1: Data Validation and Initial Administration. This process is performed for the first several weeks and utilizes the traffic and call detail data to examine the validity of the traffic register assignments and the network routing pattern translations which control call processing. In addition, outlier circuit groups are identified which exhibit abnormally high or low blocking during the first few weeks and suitable initial adjustments to group size are made.

(b) Stage 2: Network Service Appraisal and Redesign. This process is aimed at determining the least-cost network configuration (in terms of switch locations, call routing, and sizing of circuit groups and queues) that satisfies certain customer-specified E-E blocking and delay objectives. The validity of this network optimization process depends upon the accuracy of the network offered loads; 4 to 6 months are generally required to ensure adequate data collection and subsequent analysis.

(c) Stage 3: Ongoing Administration. After an "optimal" configuration has been implemented, this final stage of the administration process provides an efficient, low-cost means of monitoring traffic performance without relying on the voluminous call detail data required in Stage 2. Circuit group blocking and delays are periodically estimated from traffic measurements and compared with link objectives establish in the previous stage. Modifications are made on a group-by-group basis unless the new changes are deemed excessive and a new E-E (Stage 2) analysis is repeated.

Figure 4 - Enhanced Network Administration Process

4.1 ENADS Stage 1 - Data Validation and Initial Administration

The most important activity associated with network administration immediately following a network cutover or major augmentation is the data analysis required to assure the validity of call processing, network routing, and traffic register assignments. Five types of data validity checks are employed:

(a) Identification of missing data.

(b) Traffic measurement self-consistency checks.

(c) Call detail self-consistency checks.
(d) Comparison of call detail data with network routing guide.

(e) Cross-checks of traffic measurements with call detail data.

The first two categories of checks are consistent with those used in traditional administration processes which rely on circuit group peg counts and usage. Call detail data additionally affords an excellent opportunity to validate the accuracy of the network routing translations that control call processing at each switch. For example, a call that is shown to seize an outgoing trunk at switch A should require a record of that call at switch B with the corresponding incoming circuit. In addition, the time at which the incoming circuit was seized at B should correspond to the time of outgoing trunk seizure at A. Such a comparison may demonstrate that clock times recorded at the network switches are in proper synchronization. By comparing call detail data to the network routing guide, it may be found that, because of switch translation errors, calls to certain destinations are not accessing the appropriate trunk groups, resulting in high blocking.

In general, it has been found that the call detail data used for network administration is highly accurate (i.e., one percent or less erroneous). This is because this data is used primarily for corporate billing rather than for administration, which mandates high reliability and strict accuracy.

Typically, when a new communications network is installed or a major modification is implemented, the offered load estimates used to design the network are only approximate. Recognizing that a careful traffic administration analysis requires lengthy data collection (e.g., 6 to 12 weeks), it is necessary to respond quickly to conditions of significant overprovisioning and underprovisioning immediately following cutover or major augmentation of the network. In practical consideration necessitates the early use of traffic measurements on circuit groups and queues, once validated by the process just described, over the first week or two of network service.

If during the group busy hours, consistently low occupancy is experienced on certain groups, cautionous adjustments should be made in reducing the size of these groups, in successive stages. It should be noted that the introduction of a new service may cause increased traffic demand; consequently, prudent adjustments are recommended. Similarly, certain circuit groups may experience excessive blocking for the first week or two following network cutover or augmentation. In such cases, it is appropriate to adjust the size of these groups in order to reduce blocking and thereby provide reasonable customer service.

In all of these outlier adjustments, no attempt is made to optimize the network configuration. Rather, the principal objective is to make modest changes to the size of outlier groups when conditions are severe enough to warrant such change, in advance of the network reconfiguration process. As a result, precise traffic engineering methods are not needed to initiate these adjustments. Furthermore, for groups that vary only modestly from design objectives, no changes are recommended.

**4.2 ENADS Stage 2 - Network Service Appraisal and Redesign**

Once the data has been validated and initial adjustments made to outlier circuit groups, the essential tasks of the network administration process are to: (1) accurately characterize network offered loads and existing network service; and (2) determine the least-cost network design to meet these objectives (after confering with the customer to select the representative offered loads and desired service objectives). These are the principal objectives of Stage 2 of the ENADS process, which consists of the five functional steps depicted in Figure 5.

![Figure 5 - ENADS Stage 2: Network Service Appraisal and Redesign](image)

**4.2.1 Step 1 - Offered Load Characterization**

An important prerequisite of network load estimation is the selection of a stable traffic period with a sufficient number of representative business days during the busy season to accurately estimate E-E loads. In addition, outlier days caused by exogenous events that inhibit or stimulate normal traffic patterns should be excluded from load estimation. Tracking network loads for stability and identifying outlier days is principally accomplished by graphically displaying the total daily volume of call detail data (measured in byte counts of storage), as illustrated in Figure 6.

![Figure 6 - Tracking of Daily Call Volume Following Network Cutover](image)

In the illustrated example, call rates experienced during the first few days following cutover were substantially greater than those of the weeks that followed. This may be caused by experimental use of the new service by company employees. If several outlier days during
which call volumes were inhibited by weather conditions or holidays are removed from consideration, the traffic volumes experienced late in February and throughout March would be approximately 15 percent greater than the traffic volumes recorded during the first month of service. Following this period, subsequent growth of traffic slowed to around 1 or 2 percent per month. It is essential, therefore, that a sufficient period of time be used to track network loads for stability before efforts are made to provide detailed load estimation from the data.

A second important load characterization is illustrated in Figure 7. In this case the total day traffic is displayed over a stable 4-week period (based on the results illustrated in Figure 6) which normalizes the daily loads by the average business day traffic experienced over the entire month. It is evident in this example that Friday traffic is substantially (5 or more percent) below the daily average whereas Monday and Tuesday are somewhat higher. On the basis of this analysis, it was decided to exclude Fridays from consideration in estimating network traffic. The exclusion of Friday traffic and the additional days caused by weather or holiday conditions resulted in an increase in busy-hour traffic in excess of 5 percent over estimates that included all data.

The third important characteristic of network load is the distribution of the hourly loads throughout the day. The number of significant hours depends upon customer calling characteristics and the geographic dispersion of customer locations over time zones. Figure 8 depicts a representative distribution of total network load over a 24-hour period for a corporate network with locations throughout the U.S. and Canada. Although the total network load peaks at 1 to 2 p.m. Central Standard Time, as many as 6 or more significant hours are needed for load/service estimation to adequately reflect both morning busy periods on the East Coast and afternoon busy periods on the West Coast. Furthermore, tariffs providing private network access to the U.S. public network via WATS depend upon total usage per month, requiring load estimates for all hours in which there is consequential load.

4.2.2 Step 2 - End-to-End Service Characterization
Perhaps the most important concept employed by ENADS is its use of E-E blocking and delay objectives in determining the optimal network configuration. The availability of call detail data for calls which fail to complete in the network permits the calculation of E-E blocking between all pairs of service points and for each "significant" hour of interest.
queued. Furthermore, calls progress through existing commercial networks, even those operating under SWC, on a progressive (switch-by-switch) basis. This means that a call entering the network at switch A and encountering a delay in waiting for a free circuit to switch B may, after seizing a circuit to switch B, eventually be blocked at the subsequent switch in its attempt to complete to the destination. In this way, a customer can encounter a blocking condition after a substantial wait in queuing elsewhere in the network. Thus, service objectives for networks with queues must include an upper bound on the probability of being blocked after waiting some specified period of time.

In summary, three types of service objectives apply to networks that utilize call queuing: E-E blocking probability; mean delay to completion; and probability of blocking following a specified delay in call setup.

4.2.3 Step 3 - End-to-End Load Estimation

After selecting the representative traffic periods and characterizing the existing service, the next step in the administration process is to estimate the first-offered P-P loads for each hour of interest over the business day, averaged over a representative period of 10 to 20 days.

Recognizing that private networks are commonly engineered for high E-E blocking objectives (typically ranging from 0.05 to 0.25), the offered loads computed for the subsequent synthesis process must be first-offered, loads exclusive of retrials of calls encountering network congestion. The method used in ENADS to estimate the first-offered load $a(i,j)$, from service point i to service point j, in hour h is given by:

$$a(i,j) = \frac{1}{1 - R(h)} \left[ \frac{1}{1 - B(h)} \right]$$

where:

$f(h)_{(i,j)} =$ The carried load, estimated directly from call detail data. This is simply the sum of the call duration for all calls in hour h that successfully complete from i to j in hour h.

$B(h)_{(i,j)} =$ The P-P blocking probability computed from call detail data in Step 2.

$h_{(i,j)} =$ The total offered load (including retrials) estimated for i to j in hour h.

1 - $B(h)_{(i,j)} =$ The total offered load (including retrials) estimated for i to j in hour h.

To reduce the total offered load by the portion that encounters network congestion and returns as retrials, a retrial propensity factor, $R(h)$, is computed from call detail data as follows:

$$R(h) = \frac{\text{Number of blocked calls originating at service point i to the same service point j in hour h.}}{\text{Number of ineffective attempts from service point i in hour h.}}$$

During the subsequent synthesis process the first-offered loads must be inflated by retrials resulting from new blocking objectives.

4.2.4 Step 4 - Network Synthesis

The principal objective of the administration process is to determine the least-cost network configuration that satisfies the desired E-E service constraints. Network synthesis is achieved by breaking the problem into six sequential design stages, as depicted in Figure 10.

![Figure 10 - Network Synthesis Process](image)

**Given**

1. Location of on-net and principal off-net service points that originate or terminate network traffic.
2. Multitour P-P offered loads (determined in Step 3).
3. Network tariffs (i.e., circuit prices) associated with tandem switching, call queuing, private line circuits, and off-net toll charges.
4. Desired objectives for E-E blocking and delays (determined from Step 2).
5. Existing network configuration.

**Design Stages**

1. Switch Selection and PBX Homing

The mechanized algorithm relies on the designer specifying a list of candidate locations, any required switches (tandems), and the minimum or maximum number of switches. Certain of the locations may be specified as required for the solution. The algorithm begins by selecting all the candidate switches and homing the on-net service points to the closest switch, unless homing "overrides" are specified by the designer. After estimating network cost for the initial solution, the algorithm evaluates the cost resulting from the removal of each switch, in turn, and selects for removal the switch which results in the greatest cost saving. This step is repeated until the desired
The network designer specifies objective average E-E blocking probabilities for on- and off-net traffic. The computer algorithm allocates between E-E objectives among the three network components: access line (switch access), trunk (interswitch), and off-net facility blocking. For each value of interswitch blocking, the average blocking for access line and trunk groups can be computed from the E-E objectives, and the corresponding network cost can be approximated. To permit these computations, an assumption is made about the proportion of traffic completed via interswitch routing. This assumption is subsequently verified following Step 4.

The algorithm initially computes network cost associated with two values of interswitch blocking, which provides upper and lower bounds on the desired value. Utilizing a systematic search technique, the algorithm selects the interswitch blocking objective that minimizes network cost. It has been found that low-cost networks can be achieved for a range of blocking levels allowed. The algorithm also determines the maximum blocking for access line groups, which satisfies upper bounds on E-E blocking specified by the designer.

The algorithm utilizes a variation of the traditional "ECCS" method (Reference 1) to compare the cost of going via a direct group from a distant switch to the PBX destination versus an alternate route to the destination home switch. The algorithm considers multihour loads and the possibility of full grouping all traffic on the bypass access line group if the traffic is sufficient to warrant this.

5. Off-Net Routing and Facility Engineering

The computer algorithm systematically evaluates the trunk and switching costs resulting from different combinations of switches selected as upper level in the hierarchy, and the lowest cost configuration is selected. The method for sizing high-usage and final groups, given multiple sets of switch-to-switch loads that reflect noncoincident busy-hours resulting from time zone differences, is similar to the technique developed by Eisenberg described in Reference 2. The new method, developed by R. N. Rao (Reference 3) extends Eisenberg's original work to higher blocking objectives (such as 5 to 10 percent on finals) which are typical of corporate networks. The Rao algorithm partitions the network into appropriate segments and iterates through the process, each time updating the marginal capacity estimated on alternate routes. To satisfy the switch-to-switch blocking objectives at a minimum cost, some or all of the alternate routes in the hierarchical pattern may be skipped and certain of the high-usage groups sized as full groups (i.e., no alternate routing permitted).

The complexity of time-varying on-net routing and trunk queuing currently requires the network designer to rely on the service evaluation process (see Step 5) and manual design decisions to identify the groups most appropriate for trunk queuing and groups which have sufficient spare capacity during certain hours to be candidates for time-varying routing.

6. Sizing of Access Line Groups and Queues

Initially, each access line group is sized so as to satisfy the maximum blocking objective. For each group, the ratio of the incremented carried load per additional circuit to the cost per circuit is computed and the groups are ordered according to this ratio. The group with the greatest incremental load per dollar per circuit is chosen to be increased in size by one circuit and a new load/cost ratio is computed. In this manner, the access line groups are systematically increased in size, one circuit in the network at a time, to satisfy the average blocking objective for access line groups (in the same manner for final group). At a minimum cost, access line queuing at the network switches is included in the analysis.
Step 5 - Network Service Evaluation

The final step of the network service appraisal and redesign process, by an iterative approximation, is the determination of link blocking, delays, and redesign objectives. As described in Step 4, this service evaluation capability is utilized to determine the service implications of any customer-specified design changes.

After an agreement has been reached on the network design, the service evaluation procedure is used to compute the expected blocking probability and delay parameters for each network circuit group and queue. These parameters are used in the ongoing traffic engineering of the network based on circuit group traffic measurements rather than more complex P-P analysis.

A computer algorithm described in an earlier ITC paper (Reference 4) has been successfully utilized to obtain steady-state blocking performance for an alternate routing network without queues. The algorithm utilizes a two-parameter traffic model to relate the mean and variance of the P-P offered load to the mean and variance of the total traffic offered to each circuit group, by apportioning the loads to the links encountered along each network route. From the link offered loads, link blocking probabilities are computed and suitably combined to obtain P-P blocking probabilities. The computation procedure is an iterative one, in which improved results obtained in each iteration are utilized in the subsequent one until conditions for iteration terminations are satisfied.

This work has recently been extended by A. J. M. Kester to address alternate networks with queues. An interrupted Poisson process (Reference 9) is used to model link offered load, and a three-state model of trunk group behavior that distinguishes between: one or more trunks available (state 1); all trunks busy, queue empty (state 2); and all trunks busy, one or more calls in queue (state 3); are combined to compute link blocking and mean delays on each circuit group with queues. Initial link blocking and delays are assumed and used to distribute each P-P offered load to the various links and queues accessible to the traffic, as in the Katz algorithm. The important extension is that link delays encountered along the network routes are used to inflate the holding time and, consequently, the effective offered loads on prior circuit groups and queues. The accumulated effective link and queue offered loads determine the next (improved) estimates of link blocking and delays.

Enact Stage 3: Ongoing Administration

Once the optimal network design has been determined in Stage 2 and suitable link objectives for blocking and delay have been established, the ongoing administration process consists of the following principal components:

(a) Traffic measurements (TM) recorded on all circuit groups and queues during the significant hours identified in Stage 2 are collected for 10 to 20 consecutive business days during the study period. The data is validated utilizing consistency tests identified in Stage 1 for TM data only. Validated hourly data are then averaged over the days comprising the study period.

(b) Adjustments to the size of existing circuit groups or queues are recommended whenever sufficient disparity exists between the link blocking or delay objectives and the link traffic performance as estimated from measurements. Note that for interswitch trunks and off-net facilities, the key indicators of whether adjustments are required are the traffic readings in the optimal redesign determined in Step 4. This service evaluation capability is utilized to determine the service implications of any customer-specified design changes.

An assessment is made of whether the number of network changes resulting from individual link analyses exceeds a given proportion of total network circuits. If so, then a decision to undertake a major network reconfiguration (Stage 2) based on P-P offered loads, may be appropriate.

The frequency with which the ongoing administration process is repeated will vary according to the needs of the corporate customer. It is anticipated that three to six repetitions per year of Stage 3 of the administration process will be most common; this is in sharp contrast to the frequency of the optimal redesign process which will typically be warranted only once every year or two. The computational cost of the ongoing administration process has been found to be only 5 to 10 percent of the cost of a network redesign (Stage 2) that utilizes the more voluminous call detail data.

5. Application of New Administration Methods to Corporate Networks

The administration process outlined in this paper has been applied to several U.S. corporate networks during the past 2 years. In certain cases, the results obtained by the new administration process were compared to the design achieved by traditional administration methods, which rely on traffic measurements on the circuit group. For a network incurring monthly charges of approximately $1 million, savings in the range of 5 to 10 percent were common. In addition, improved E-E service was achieved.

For a representative network configured by classical administration methods, significant service improvement was achieved without additional cost by redistributing the blocking, as illustrated in Figure 11 (compare with Figure 9) so that traffic parcels receiving high blocking obtained substantially improved service at the expense of parcels that had been receiving virtually no blocking.

Figure 12 summarizes ten principal network design considerations. In each case, savings were obtained by the enhanced administration.
process over the results obtained using the more traditional administration methods. Note that the principal contributors to the 7 percent savings are:

(a) Allocation of E-E blocking between trunks/access lines/off-net facilities.
(b) Improved off-net routing and engineering of off-net facilities.
(c) Economic allocation of blocking objectives among access line groups.
(d) Improved multihour trunk engineering methods.

Note that the complex features such as time-varying routing and call queuing contributed little to the overall savings. Thus, based on experiences illustrated in Figure 12, it is felt that a properly designed network, utilizing accurate call detail data, provides sufficient network efficiencies so that many of the network feature enhancements such as call queuing produced very modest savings.

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7. REFERENCES