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Stored Program Controlled Network:

Routing of Direct-Signaling Messages in the CCIS Network

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This paper compares and contrasts the two methods currently used to route messages through the common-channel interoffice signaling (CCIS) network. Since its introduction in 1976, the CCIS network has been providing routing of telephone signaling messages between switching offices using permanent virtual circuits. In 1980, a new datagram routing capability, called direct signaling, has been added that significantly enhances the network's ability to interconnect Stored Program Control (SPC) systems. Stored program control systems interconnected by the signaling network can now communicate in support of improved SPC network services in addition to CCIS trunk-related call-control signaling. This paper briefly reviews banded telephone routing and then describes and compares direct signaling routing. The new flow control procedures required to implement direct signaling are discussed and two examples of applications using direct signaling are presented.

I. INTRODUCTION

This paper describes the basic components and message routing in the common-channel interoffice signaling (CCIS) network. Examples are used to show how direct signaling supports services which may be provided by offices connected to the new CCIS network. Basic knowledge of the existing CCIS network is assumed, but background information may be obtained from Ref. 1.

Since its introduction in 1976, the CCIS network has been providing addressing and routing of trunk-related telephone signaling messages for interconnection of switching offices. In 1980, a new capability, direct signaling, was added which significantly augments the network's capability to interconnect Stored Program Control (SPC) systems. The evolving network is called the SPC network, reflecting that offices interconnected by the signaling network have new stored program capabilities and are no longer connected only for trunk-related CCIS signaling.

Whereas telephone messages routed by band are confined to a preassigned end-to-end signaling path, direct-signaling messages are not banded but contain a full destination address. Direct-signaling messages are addressed by offices to gain access to a network feature. The signal transfer points (STPs) route direct-signaling messages to their destination address, regardless of where in the network the message originates, independent of any assigned signal paths. The typical direct-signaling relationship is not between two switching offices but is between an action point (ACP) and a dialed-number translation data base, called a network control point (NCP). An ACP is an office with the direct-signaling capability that provides access to NCP features. Many of the CCIS switching offices already connected to the network are ACPs. The direct-signaling capability was essential to provide network-wide access to NCP features.

II. BASIC CCIS

The CCIS network is a packet-switched network handling telephone-signaling messages defined within the CCIS protocol. The CCIS network is a quasi-associated system, achieving the economies of signaling traffic concentration through STPs, since few trunk groups are large enough to justify direct associated links. The network is redundant to provide the high reliability required for telephony. The signaling links initially operated at 2400 b/s, but 4800-b/s links are now being installed.

The end-to-end band assignments through the network are used for trunk-related signaling between two switching offices. Trunks are grouped into bands of 16 trunks. Within a band, each trunk is identified using a 4-bit trunk number. Each band is identified by a 9-bit band number. Thus, each trunk is assigned a 13-bit identifier called a label. The basic unit of routing in the network is the band. The STPs only look at the band and not at the trunk number in the label.

Most of the message format codes are reserved for banded messages to make the trunk-related signaling most efficient. When a message heading code indicates that an incoming message is banded, the STP uses the incoming signaling link number and band as the input to a translator which outputs the outgoing link and band. The new band is substituted for the old band, and the message is transmitted on the outgoing link. In this manner, each module of 16 trunks has a unique signaling path through the network consisting of the band and link between each signaling point (switching office or STP) along the way.

In a sense, an end-to-end permanent virtual circuit is established for every band. The large community of interest between switching offices (because of the trunks between them) and the high efficiency of CCIS justifies the administrative expense of assigning dedicated signaling paths.

The network redundancy is provided as follows, with reference to Fig. 1. Two STPs, called mate STPs, are provided in each region. Access links (A-links) from a switching office to an STP are provided in pairs, called mate links, with one link to each STP. Bridge links (B-links) from each STP to mate STPs in another region are also provided in mate pairs. The quad of four links between regions fully interconnects mate STPs in different regions. Mate links operate in a load-sharing mode, with adaptive procedures directing all the traffic from a failed link to its mate in case of link failure. Mate STPs are interconnected by cross links (C-links) which have no band assignments, but are used to complete a signal path via the mate STP when the direct A- or B-links have failed.

Additional links may be provided in layers (each pair of A-links or quad of B-links is a layer) to increase the signaling capacity for CCIS trunk growth. The band assignments on each layer of links are independent of all other layers.

III. DIRECT SIGNALING

Direct signaling is a datagram type of service, with network routing capability based entirely on a destination address in the message independent of the origination point. Direct signaling is a new address-

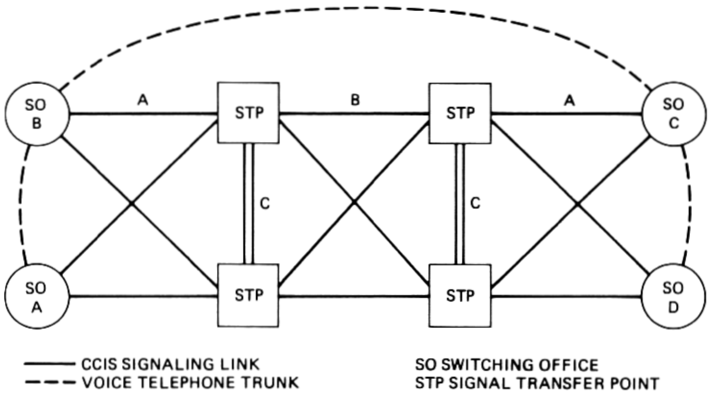


Fig. 1—Common-channel interoffice signaling network.

ing capability which does not require a fixed end-to-end relationship between signaling nodes like trunks between switching offices. Direct-signaling messages are not associated with any particular link or administratively assigned path through the network. The new signaling capability accommodates the addition of NCPs which contain features in the form of dialed-number translation data bases. Addresses in direct-signaling messages may be customer-dialed digits, thus, providing a customer feature through an ACP. With the features available in the network, it is economically attractive for ACPs to gain access to the network for non-trunk-related signaling. A network with ACPs and an NCP is shown in Fig. 2.

To provide the direct-signaling capability, each signaling node identifies its pools of signaling links, defined as all the links which terminate on a common far-end signaling node. Since mate STPs are load sharing, the two pools of links to mate STPs together form a combined pool. Thus, more than one layer of links between signaling points, which were previously independent, are now coupled (in a pool) for direct-signaling purposes.

Because of network growth, there usually is more than one link in a pool. A load-balancing algorithm distributes the direct-signaling traffic over all the links in a pool. A traffic measurement (which is updated every minute) is used to determine the desirable load distribution. If one link in a pool is carrying less banded traffic because of an imbalance in assignments, that link will carry more direct-signaling traffic. This results in more efficient overall use of the links.

Routes, identified at STPs, are used to relate a message destination address to the pool of links associated with that address. If the

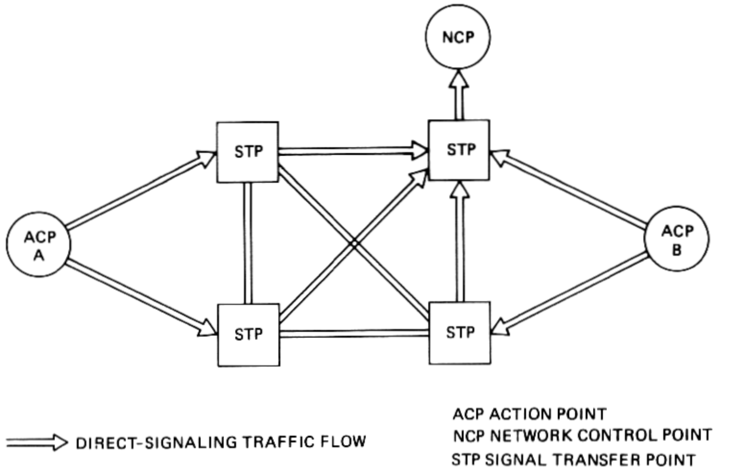


Fig. 2—Common-channel interoffice signaling direct-signaling routing.

destination is in another signaling region, the route points to the combined pool of links to the mate STPs in that region.

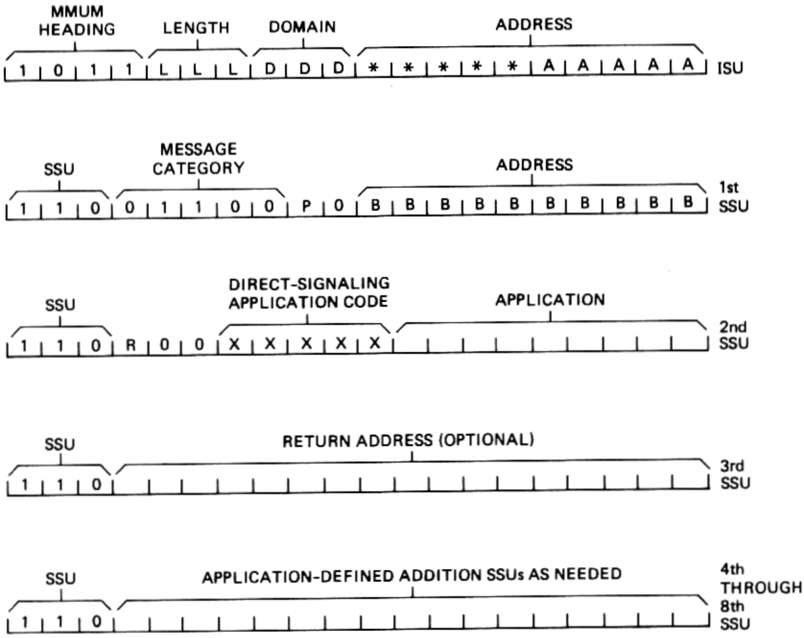
With direct signaling, the concept is introduced that a node in the network may perform more than one function and that each of those functions needs to be uniquely identified in the network. The first application of this concept is in the NCP, which itself has a unique identity and which may host more than one application, each with its own identity. The NCPs are installed in pairs, collocated with mate STPs. The network identifies each of the functions separately so that it can control routing to those functions separately.

Direct-signaling addresses are modified by the domain field contained in each message. There are two basic capabilities, distinguished by domain equal to zero and domain greater than zero. Domain zero is for addressing by function number. Each separately identifiable function is assigned its own function number at each location in the network. A function number, presently 14 bits, may be used as the destination address of that function at each network location. When the domain is greater than zero, the address consists of two three-digit numbers each coded as a 10-bit binary number. Domains greater than zero are distinctive for two reasons. First, the pair of three-digit numbers may be customer-dialed digits to give the customer access to a feature identified by the domain- and dialed-digit combination. Second, with multiple domains greater than zero, the address space is expanded so that the same six-digit address can be routed to different destinations in the network by combining that six-digit number with different domains. Presently, domains one and two are used, and existing format capacity will allow expansion to domain number seven.

A function at an NCP must be accessed by many addresses, such as the set of 800 numbers processed at a particular NCP. Direct signaling achieves a mapping of multiple addresses to a single destination. Thus, a set of common customer-dialed numbers, which could have been dialed from anywhere in the network, may be routed to the same NCP containing the translation data base for those numbers. Other sets of numbers for the same feature may be routed to different NCPs that are provided for growth.

Figure 3 shows a typical direct-signaling message with a return address. The message heading code in the initial signal unit (ISU) is used for all miscellaneous multiunit messages (MMUMs). A special message category code in the first subsequent signal unit (SSU) is reserved for direct-signaling messages. Each direct-signaling application is assigned a unique direct-signaling application code.

When an STP receives a direct-signaling message, it looks at the address fields and determines the outgoing route. The STP has routing tables providing for all valid network addresses. If there are no routing



* SPARE BIT POSITION WHEN ROUTING BY FUNCTION NUMBER (DOMAIN = 000)

Fig. 3—General direct-signaling message.

restrictions, the STP selects a link from the pool of links to that destination.

Since the direct-signaling message is not associated with a particular signaling path, the destination address does not identify the originator. Messages which need to identify the originator have format space allocated for the return address, which is always the originating function number. As an example, a direct-signaling application may consist of an inquiry-reply operation at an ACP. The direct-signaling inquiry message is addressed to an NCP application using a domain greater than zero. The inquiry contains the originating ACP's function number, which is used by the NCP with domain zero to address the reply.

An administrative advantage of direct signaling is that only the network needs the routing data to access any destination, especially feature destinations at NCPs. The ACPs do not know, nor do they need to know, the location of the NCP which is the destination of their direct-signaling inquiry. Such an inquiry may be sent on any A-link (which by definition terminates on the home STPs), and all the routing is handled by the network. Because of this approach, network administrators have the flexibility of moving feature destinations around in the network to accommodate growth without the ACP awareness that any changes are made.

Traffic destined to an NCP which originates in the same region will routinely produce C-link traffic if it is sent to the wrong STP. In terms of system resources, this C-link traffic is the only penalty which results from putting direct-signaling routing data only in the STPs. However, much of the traffic is destined for different NCP regions, to which all STPs have direct pools of links. STPs route this traffic directly to the correct STP, so C-link traffic is avoided. The originating office is merely accessing a feature, and it is not concerned about where the physical destination turns out to be in the network.

Because direct-signaling routing is via the most direct path, a signaling link failure causes the direct-signaling traffic to be carried by the remaining links in the same pool. The STPs themselves are backed up by the signaling paths through the mate STP. If all the links in a pool fail, there is still an alternate path via the mate STP. In addition, some feature functions, such as 800 Service, are backed up at the NCP equipped at the mate STP. The NCP functions with backups are called duplex functions; one NCP is called the primary destination, while the mate is called the secondary destination.

The STPs are notified of a duplex function failure through the function out-of-service procedure. A direct-signaling function status message is sent to each adjacent STP. When a duplex NCP function is out of service, the network performs secondary routing to the mate secondary function. If an NCP fails, all the functions at that node fail; however, the secondary routing to the mate NCP is automatically performed for those duplex functions by the adjacent STPs. When a previously failed function is returned to service, function in-service messages are sent to restore normal routing.

The ACPs will not be aware of a function failure at one of the duplex NCP functions, for the network is solely responsible for the secondary routing. When one of the duplex functions fails, there is additional C-link traffic because of messages originating in the NCP region but arriving at the out-of-service function's NCP. The C-links are engineered to carry this expected level of traffic.

The ACPs become aware of failures or overloads in the network by a response method; every blocked message requesting a reply is modified and returned to the originator with the appropriate failure indication. The originator receiving a network failure message is required to cut back traffic to limit the amount of ineffective attempt traffic in the network.

If a duplex function fails during a failure of its mate, the adjacent STPs recognize the complete function failure when they receive the function out-of-service messages. In this case, all of the direct-signaling inquiries addressed to the failed function will be returned to the originating ACP. Originating nodes maintain a list of all inaccessible addresses and limit the number of inquiries to those addresses to one message every 10 or more seconds until either NCP of the pair is restored to service.

If an NCP is not directly accessible from an adjacent STP in another signaling region because of link failures, its primary traffic could be alternate routed to the mate STP and from there transmitted directly to the primary NCP. If all direct links to the primary NCP location are failed from another signaling region, the traffic may be directed to the secondary NCP, where it would be forwarded to the primary destination via the C-links.

The direct-signaling reply message transmitted by the NCP is addressed to the origination of the inquiry message. The reply message also can be alternate routed through a mate STP to bypass link failures.

IV. COMPARISON OF BANDED AND DIRECT SIGNALING

To meet signaling delay requirements, all trunk-related signaling utilizes the band as a concise identification of both the originating and terminating points of the message. Since call setup messages are short, most of them only one signal unit, their network transit time is faster (because of shortest possible queueing delay and emission time) and more efficient use is made of the signaling links. Since trunk-related signaling is an unmistakable indication of a large community of interest between offices, the efficient assigned signaling path is a reasonable means for the network to provide for this interest.

Direct-signaling messages are longer because of their less efficient message codes, their longer addresses, and their originating addresses. Since direct-signaling traffic is balanced over a pool of links, it can make more efficient use of the links and compensate for the coding inefficiency. Direct signaling does not replace banded signaling but is ideal where signaling needs are significantly different from trunk-related signaling:

(*i*) When signaling delay is not as critical.

(*ii*) When the community of interest is between an ACP and an NCP, whose physical destination may be anywhere in the network and is unknown to the ACPS.

(*iii*) Where the feature is implemented at several physical network locations, all operating simultaneously to share the total feature traffic load.

(*iv*) Where the mapping of multiple customer-dialed addresses to a single destination or feature is desired.

(*v*) Where flexibility is needed to move a destination between NCPS without ACP knowledge or intervention.

(*vi*) When the communication is point to point, but there are no trunks that require band assignments.

In many cases, the above signaling needs could have been accommodated by the assignment of pseudo-bands (not related to trunks) between every ACP and NCP. But that would have required a prohibitive volume of data for ACPs to know which NCP should be addressed by each inquiry. Also, the network administrative burden, which is confined to the STPs for direct signaling, would have been extended to the ACPs at considerable expense.

Both banded- and direct-signaling routing techniques are necessary and compatible in the CCIS network. The ACPs can be connected to one network and take advantage of both CCIS per-trunk signaling and the new services provided through direct signaling.

V. AN EXPANDED 800 SERVICE EXAMPLE

An example of how direct signaling can provide for new SPC network features is Expanded 800 Service. A complete description of the Expanded 800 Service capability is contained elsewhere in this issue. In this example, Expanded 800 Service is provided for a reservation service. The feature will allow parties in all sections of the country to dial the same Expanded 800 Service number and each call will be routed to the nearest reservation center that is open at the time the call is made. Each call is advanced to a CCIS office, the ACP for this service, which transmits a direct-signaling inquiry message to an NCP collocated with one of the STPs. The inquiry message contains the dialed 800 number, the NCP of the calling party, and the function number of the originating CCIS office. The Expanded 800 Service application at the NCP performs a validity check on the inquiry and transmits a direct-signaling reply message back to the originating CCIS office. The reply message contains the direct distance dialing (DDD) number of the appropriate reservation center to which the call is then completed as if it had been dialed directly by the calling party, except that the reservation center pays for the call.

If the central office local to the reservation center has CCIS capabilities, the busy or idle status of the called lines can be transmitted to the NCP using direct-signaling status messages. When all the called lines are busy, the call can be directed to another reservation center or a busy reply message can be returned to the CCIS office originating the inquiry causing generation of a busy tone for the calling party. Thus, Expanded 800 Service provides improved operation of the switched network and also new service capabilities.

VI. EXPANDED 800 SERVICE IMPLEMENTATION

Expanded 800 Service is implemented as follows: Each of the three-digit codes a customer dials immediately after dialing 800 is assigned to a pair of NCPs. A single pair of NCPs will provide service for many three-digit codes. Each NCP of a pair is designated to be the primary destination for approximately one-half of the three-digit codes served by the pair as determined by traffic considerations. That same NCP is also designated to be the secondary destination for the remaining three-digit codes assigned to the pair of NCPs. Under normal conditions, all of the direct-signaling inquiries addressed to a given three-digit code are routed to the primary NCP, as shown in Fig. 2. When either of the NCPs fails, its primary traffic will be routed to the mate NCP, the secondary destination for each of those three-digit codes. The procedures used to perform this secondary routing were described earlier.

VII. AN AUTOMATED CALLING CARD SERVICE EXAMPLE

The Expanded 800 Service example is but one of the services and features made possible by the direct-signaling capability. Another planned service is Automated Calling Card Service, which automates credit card, collect, and third-number-billed calls. Automated Calling Card Service reduces requirements for operators and provides improved fraud protection. Additionally, Automated Calling Card Service provides new service possibilities such as preauthorized collect and improved third-number billing capabilities. A complete description of the direct dial credit card capability is contained in this issue of *The Bell System Technical Journal.*

VIII. AUTOMATED CALLING CARD SERVICE IMPLEMENTATION

The data bases accessed for Automated Calling Card Service are not duplicated at mate STPs in contrast to the backup strategy used for Expanded 800 Service. Since the customer has dialed the called number with automated operator services, the customer's call can be completed even when a reply is not returned for the data base inquiry. This results only in a temporary decrease in automated fraud protection. However, with Expanded 800 Service the customer's call cannot be completed if no reply is received for the data base inquiry. Customer service objectives necessitated the implementation of a backup data base strategy for Expanded 800 Service. The requirement that accurate called lines busy status be contained in the NCPs at all times necessitated implementation of the primary/secondary backup strategy previously described for Expanded 800 Service.

Alternate routing to an Automated Calling Card Service data base in case of link failures is identical to the alternate routing used to access a primary Expanded 800 Service NCP in case of link failures. If an Automated Calling Card Service data base itself should fail, all its inquiries are returned by the STP collocated with the failed NCP. If the collocated STP should fail, this failure is recognized by all adjacent STPs which then return the blocked inquiries to their origination nodes. As with Expanded 800 Service, originating nodes maintain a list of all inaccessible or overloaded addresses and limit the number of inquiries to one message every ten or more seconds until the data base is restored to service.

IX. CONCLUSION

The concept of direct-signaling routing has been described and compared with call setup routing by bands. Routing by bands is very efficient for the trunk-related signaling traffic necessary for call setup. Direct-signaling routing provides the addressing and administrative flexibility necessary for implementation of SPC network services and features. The brief descriptions of Expanded 800 Service and Automated Calling Card Service provided examples of the SPC network features made possible by implementation of the direct-signaling capability. The generalization of such SPC network service capabilities revolutionizes the types and number of potential services made available to telephone customers.

REFERENCES

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