

# COMMON CHANNEL SIGNALING NETWORK EVOLUTION

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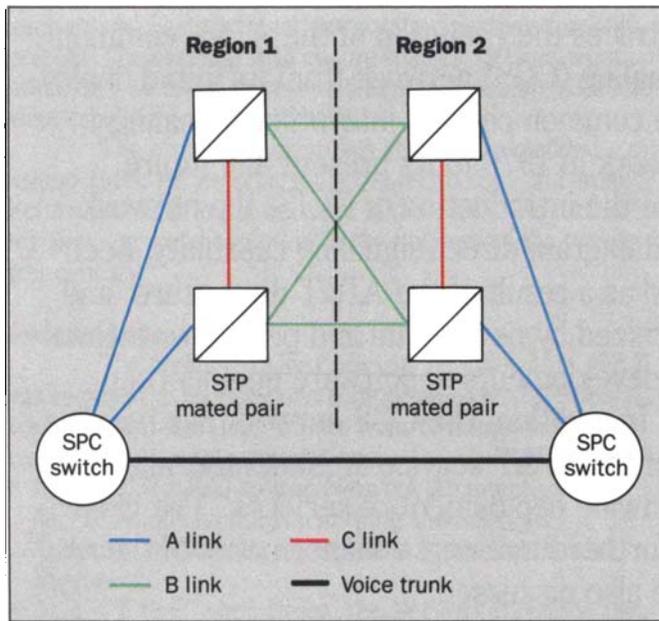
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This paper traces the evolution of the AT&T common channel signaling (CCS) network from its initial deployment as the common channel interoffice signaling (CCIS) network in 1976 to its present and future forms. Since the introduction of CCIS, the network has: added datagram direct-signaling capability, been reconfigured as a result of the AT&T divestiture, and been modernized by new digital and processor technology and by developments in software engineering techniques. In addition, the CCS network has become a key part of the AT&T service architecture, allowing faster nationwide deployment of services. The globalization and further functional enhancements of the network are also discussed.

## Introduction

The AT&T *common channel signaling* (CCS) network was first introduced in 1976. Known originally as the common channel interoffice signaling (CCIS) network, this network first improved the traditional trunk signaling between *stored program control* (SPC) toll switches. This initial capability improved the speed and cost associated with call setup and disconnect on the nationwide intertoll transmission network. The CCIS network provided the means of communicating short messages among the SPC switches efficiently and quickly. The CCIS network was composed of mated *signal transfer points* (STPs) interconnected by 2.4 kilobit-per-second (kb/s) analog data links. In 1979, 1AESS™ switches were added.

During 1980, the CCIS network was further enhanced by the introduction of a datagram capability called direct signaling, and the modification of the signaling links to operate at 4.8 kb/s to handle the increased load. Datagram capability allowed the SPC machines to launch queries and obtain responses via the CCIS network. It also provided the concentration of a portion of the call control intelligence into databases called *network control points* (NCPs) that connected directly to the CCIS network at certain STPs. The SPC machines connected to the CCIS



**Figure 1. The common channel interoffice signaling network.**  
**SPC = stored program control; STP = signal transfer point.**

network queried the NCPs and received instructions for action in response. Thus, they became known as *action points* (ACPs). This architecture allowed the faster nationwide deployment of new service features, and the introduction of some services that could be provided more efficiently with centralized intelligence, rather than having the intelligence resident in each ACP. Examples include 800 service and calling card service, both of which include interactive customer modifications of call setup, or progress instructions on a real-time basis.<sup>1</sup>

In 1985, the signaling network was further enhanced by the incorporation of the 2STP and 56-kb/s digital links. This new network was named the common channel signaling 7 (CCS7) network. This new network uses the American National Standards Institute (ANSI) North American version of the International Telegraph and

Telephone Consultative Committee (CCITT) Signaling System 7 protocol.

The system will continue to change as new protocols are adopted (e.g., global use of CCITT No. 7), new hardware and architectures are deployed, and new capabilities are introduced.

#### **The Original CCIS Network (1976)**

Before the introduction of CCIS signaling in 1976, most signaling between switching systems within the AT&T network was performed by the single frequency (SF) / multi-frequency (MF) method.<sup>2</sup> The SF units determined the busy/idle state of each trunk by placing a single-frequency tone (typically 2600 Hz) on each trunk in the idle state. Thus, when a switching system placed a call on a trunk, it first removed the SF tone from that trunk indicating to the far end that a call was to be placed on the trunk. Once the initial indication of call placement was verified, the originating switch used MF signaling to transmit the routing information to the distant end. When the called party answered, the distant end removed the SF tone from the return direction, indicating answer to the originating end, thus initiating the billing for the call.

In tandem switching, each switch in turn repeated this process until the called party was reached. This method was both expensive, because of its individual trunk supervisory costs, and slow, because of the transmission of routing digits through successive tandem connections. It was not unusual for the call setup under this arrangement to be in the range of 10 to 20 seconds, which was both annoying to the calling party and wasteful of network resources.

As the switching technology evolved to a stored program control environment, in which the common control equipment was based on electronic processors, the overhead associated with call setup became a more dominant factor. However, because the initial ESS™ switching systems were deployed as local switches, the SF/MF signaling method remained the dominant intertoll scheme until 1976 when the 4ESS toll switch was first introduced

in the network.

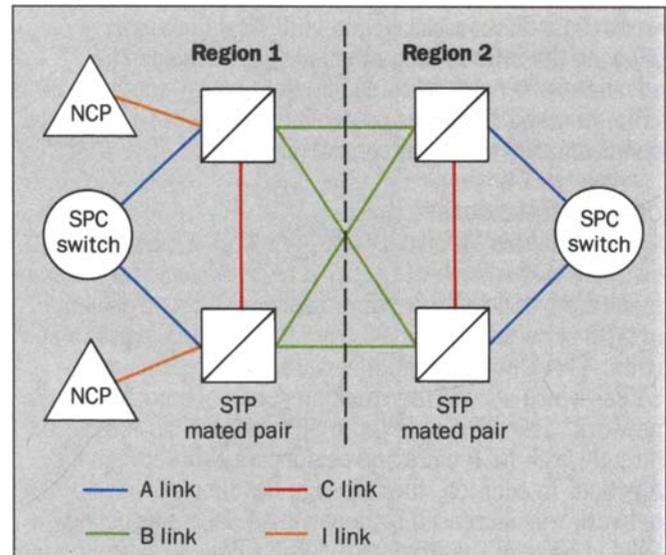
AT&T introduced the common channel interoffice signaling (CCIS) network<sup>3</sup> concurrently with the 4ESS toll switch. This network, shown in Figure 1, used 2.4-kb/s signaling links to transmit the signaling and network control information between the toll switches. These signaling links followed a different path than the trunks used to carry conversations between the parties. However, because one 2.4-kb/s link could provide the signaling and control for more than 2000 trunks, in excess of the total voice trunks between two switches, the signaling network was made up of regional signal transfer points (STPs), which are packet data switches that provide concentration of traffic and direct the messages to the appropriate toll switch.

The network was divided into 10 signaling regions with a pair of STPs per region. Each of the regional STPs was connected to each of the served toll switches via diverse, redundant A links to improve the reliability of the network. The regional STPs were fully connected to each of the distant region STPs via diverse B links, to insure interregional continuity. Each of the regional STPs was connected to its mate via C links, which provided a path for connections between switches if there was a failure of the redundant A or B links or distant STPs.

The STPs in the network were provided by a portion of the processor associated with the 4A-electronic translator system (ETS). Message routing within the STP was performed by a band and label scheme that defined a virtual signaling circuit where 512 bands of 16 trunks could be accommodated.<sup>4</sup> This allows 8192 voice trunks to be uniquely identified on a specific signaling link.

#### **Datagram Direct Signaling (1980)**

In 1980, a direct-signaling capability (datagram) was added to the CCIS network. This capability allowed messages to be sent from a signaling point to any other signaling point in the network and supported a new network architecture in which a portion of the switched network routing instructions could be placed in a database



**Figure 2. The common channel interoffice signaling network with datagram direct-signaling capability added. SPC = stored program control; STP = signal transfer point; NCP = network control point.**

shared by multiple SPC switches. This architecture is shown in Figure 2. These common databases became known as network control points (NCPs). The SPC switches became known as action points (ACPs) because they performed actions based on instructions from the NCPs. This required an inquiry-response capability in the CCIS network.

The communications between the ACPs and NCPs was performed by a new feature of the CCIS network called *direct signaling*.<sup>5</sup> Unlike banded (trunk) signaling, direct signaling required the ability to direct messages on a destination-routing basis through all STPs. Thus, the direct-signaling messages included a unique destination address that was used by the STPs to route the message based on a table that associated destination addresses with physical points in the network. With this, the CCIS net-

work could direct messages to individual functions, allowing the introduction of unique services such as advanced 800, with features like time-of-day routing, call prompter, and customer-controlled routing of traffic based on information stored at central databases.<sup>6</sup>

#### **CCIS Network Growth**

As the AT&T network grew both in terms of SPC switches and volume of traffic, it became necessary to augment the initial CCIS network capacity. First, the number of STP pairs was increased from the initial 10 pairs to 16 pairs. Three of the additional pairs were used as area STPs, which served the trunking needs of a portion of the network. The remaining three STP pairs were associated directly with NCP pairs and performed a direct-signaling function. In addition, the message handling capacity of the network was increased by deploying 4.8-kb/s signaling links in place of the original 2.4-kb/s links. STP processing capacity was also increased as the original shared use of the ETS processor was removed when the switch function at each STP location was transferred to new 4ESS machines.

#### **The Impact of AT&T Divestiture on the CCIS Network**

On January 1, 1984 the court-ordered AT&T divestiture became effective. Divestiture established *local access and transport areas* (LATAs), which defined local market areas. AT&T became an inter-LATA carrier providing communications services between these LATAs. Under the divestiture agreements, the STPs, NCPs, and inter-connecting data links were assigned to AT&T.<sup>7</sup> The minor use of these facilities by the divested Bell Operating Companies (BOCs) was provided under contract.

Equal access to the inter-LATA carriers under divestiture was provided mostly by MF/SF signaling. However, a new multi-stage MF outpulsing arrangement was added to forward the originating number to the inter-LATA carrier for billing and other purposes.

#### **CCS7 Network (1985)**

During 1985, the STP capability was enhanced by

the introduction of the 2STP, based on the AT&T 3B20 duplex (3B20D) processor and an associated processor interconnect capability (PIC). In addition, 56-kb/s digital facilities were provided between the STPs. The 2STP uses the CCITT Signaling System 7 protocol and provides the message transfer part (MTP) function.<sup>8</sup> The MTP can route a message reliably and quickly from one point in the signaling network to any other point. The resulting network has been named the common channel signaling 7 (CCS7) network. The relationship between the CCIS and CCS7 networks is shown in Figure 3. Initially, the CCS7 network was used to augment the trunk signaling capabilities of the 1STP network using the embedded CCIS6 (ECIS6) protocol. ECIS6 interacts with CCS7 and allows switching systems connected to the 1STP network to communicate with other switches connected to the 2STP network. However, during this transitional period, all switching systems are connected to either the 1STP or 2STP locations via 2.4- or 4.8-kb/s signaling links.

#### **CCS7 Destination CCIS (1986)**

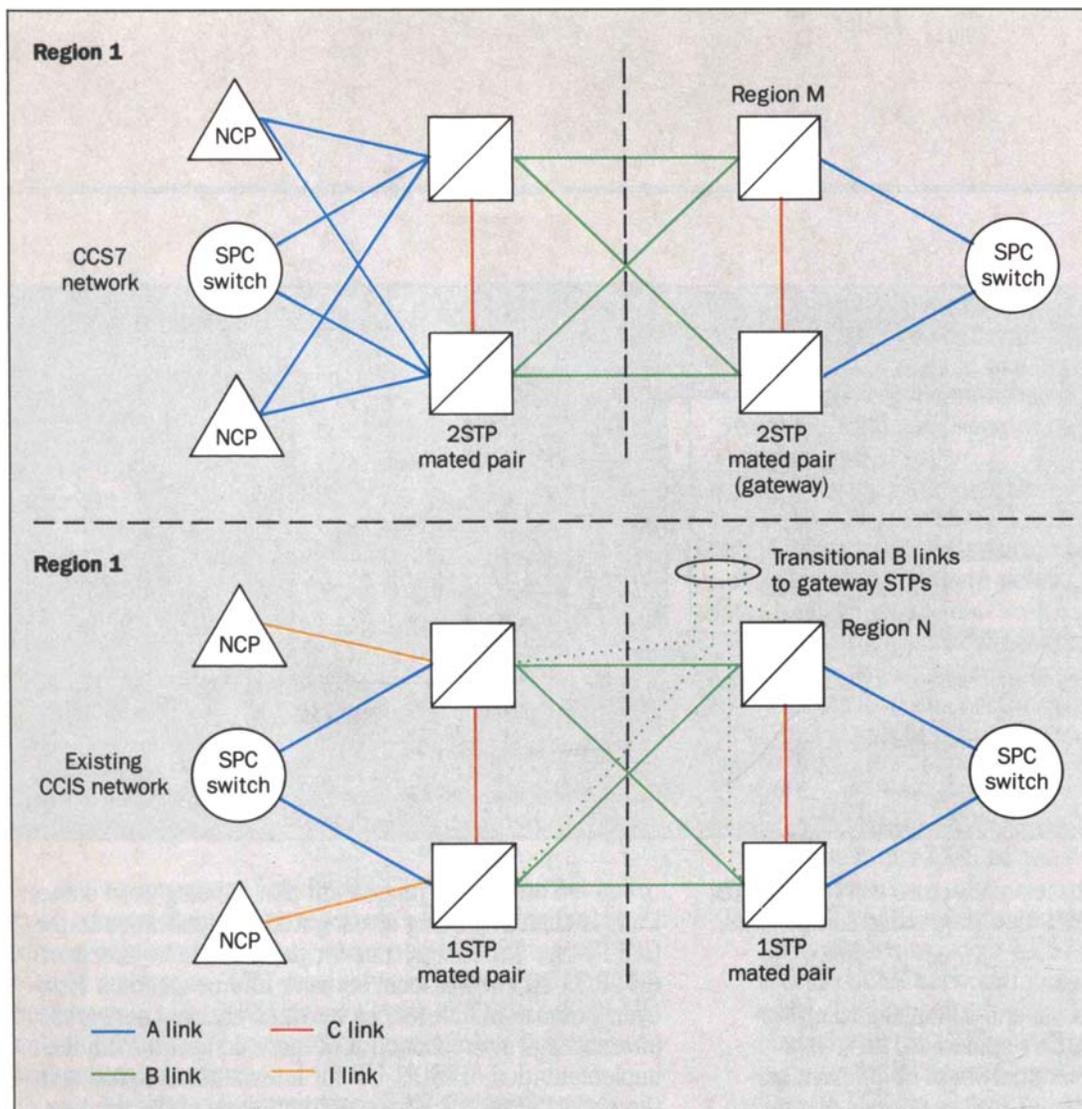
In 1986, the CCS7 network was expanded to include direct signaling. This was done by adding new capabilities in the NCPs to allow 56-kb/s connecting links, and the ability to route direct-signaling messages within the 2STPs. For transitional compatibility, a new destination CCIS6 (DCIS6) interworking protocol was deployed.

The 4ESS and 5ESS™ switches in the network will use the Integrated Services Digital Network User Part (ISDN-UP) to control call setup and will have the capability to support ISDN services. The ISDN-UP will use the services of the already deployed MTP and provide a broad set of switched digital services.

In 1987, the CCS7 network evolution will include the migration of most of the NCPs to the new network, and the digital connection of 4ESS switching systems via 56-kb/s links.

#### **Evolution of NCP Services to a Distributed Architecture**

The increasingly demanding requirements of call-processing services such as the AT&T card service,



**Figure 3. The relationship between common channel interoffice signaling and common channel signaling 7 networks. With the 2STP, messages can be routed reliably and quickly from one point in the signaling network to any other point.**

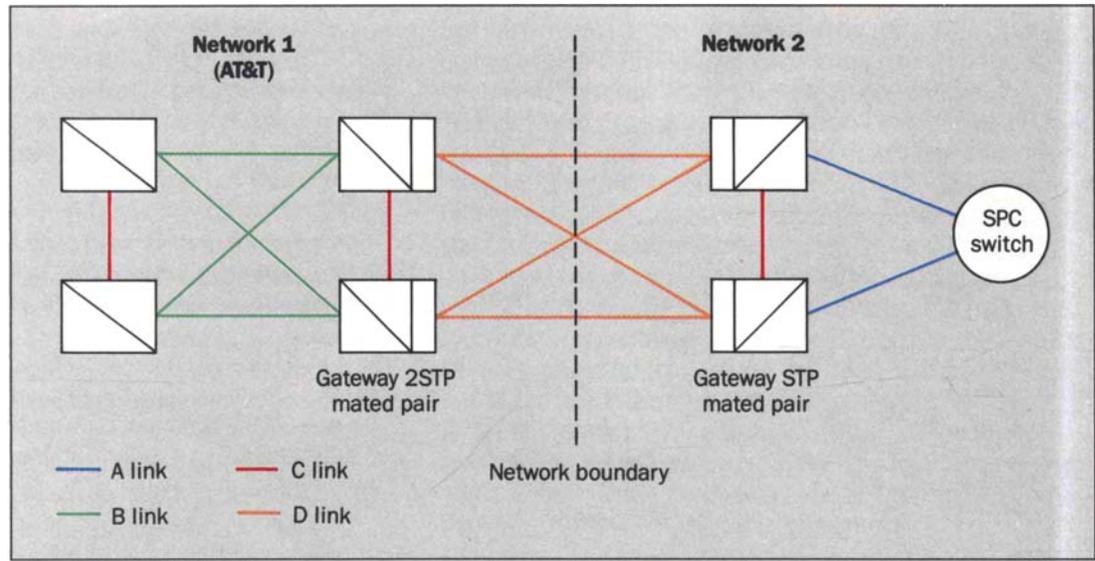
advanced 800, and software defined network (SDN), have led to a steady evolution of the NCP architecture toward more distribution. This is to increase versatility of usage, flexibility of growth, and performance. At the same time, we will be able to introduce more new services.

The original NCPs introduced in 1980 consisted of AT&T 3B20 duplex processors and multiple disk drives. The 3B20D handled all the functions, including query processing, database administration and updates, and signaling. The first step towards a distributed NCP architecture was in the signaling architecture. In 1985, the NCP incorporated a highly reliable processor interconnect capability (PIC) with the same technology used in the

2STPs. It provides communication between the CCS network and the NCP application databases in a 3B20D host. Signaling links from the STPs to an NCP terminate through link nodes (LNs) on the PIC. The CCS query messages could access an NCP through the LNs and travel to the appropriate database application in the 3B20D. Similarly, query responses destined to the CCS network could exit from the NCP through the PIC and the LNs.

The future NCP architecture will also have more distribution. Initially, the 3B20D computer will continue to serve as host to the NCP distributed environment and the PIC will remain the vehicle for interprocess communication and signaling-link termination. To attain distributed query

**Figure 4. Inter-connecting networks using designated STPs as gateways. The gateway STPs screen all incoming messages to prevent unauthorized use of network resources.**



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processing, the NCP database architecture will feature the integration of multiple transaction-processing components.

#### **CCS7 Network Interconnection**

With the potential for end-to-end signaling services and the adoption of CCS7 standards, there is a growing effort to interconnect networks of different carriers and different countries, as well as various privately owned networks. It is expected that in the future all North American networks will have CCS7. Therefore, AT&T is currently involved in defining a standard CCS7 interface for use between networks. Initially, this new interface will consist of 2STPs deployed in pairs as illustrated in Figure 4. Links interconnecting gateway STPs are D links.

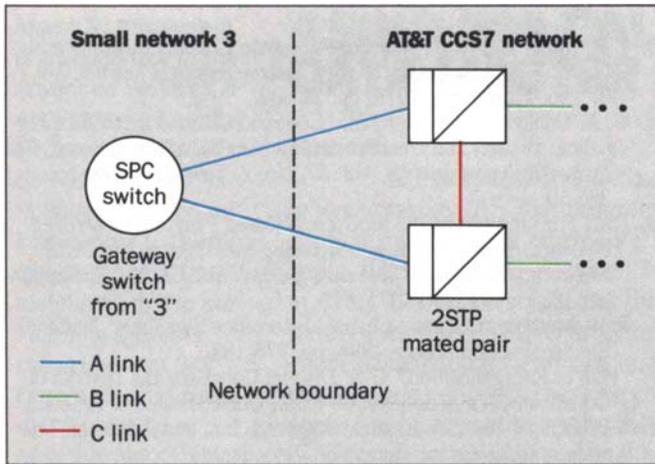
This network configuration assumes that interconnecting networks will use designated STPs as gateways. The gateway STPs will be required to screen all incoming messages to prevent unauthorized use of network resources and services.

Figure 5 shows interconnection of a small network that does *not* have STP gateways.

The same arrangement that is being used domestically is currently being investigated for application to the CCITT No. 7 message transfer part/telephone user part (MTP/TUP) international network interconnection. However, because of differences between national networks, international interconnection is more complex. With the implementation of ISDN-UP for international signaling in the early 1990s, it is expected that many of the existing domestic services will be extended to embrace the international networks as well.

#### **CCS7 Support for ISDN Services**

Common channel signaling was designed for signaling between network entities. Integrated Services Digital Network (ISDN) protocols are designed for out-of-band signaling all the way to the end user. Much of the current effort in ISDN is in defining protocols and architectures for providing the out-of-band signaling from the end-user premises to the network. However, to provide end-to-end service, the network has to transport the end user's out-of-band signaling, using CCS or other means.



**Figure 5. Interconnection of a small network that does not have STP gateways.**

An important benefit of CCS7 is its inherent ability to support feature transparency, i.e., allowing for the passing of information that can only be interpreted and used by end-users. This capability can be attained by interworking the ISDN Q.931 protocol with the CCS7 ISDN-UP, and extending ISDN to switched-access users through network interconnection.

Methods for supporting CCS7 feature transparency include: (a) message-associated user-to-user information and (b) temporary and permanent signaling connections. Message-associated user-to-user information could be passed along with regular CCS7 call control messages, as opposed to using signaling connections specifically established for that purpose. The transfer of transparent information would generally be done after the signaling connection (temporary or permanent) is established. However, message-associated transparent information could be transferred during the establishment and/or termination phases of the signaling connection.

Both AT&T and the regional BOCs are deploying ISDN signaling in their networks. Once in place, ISDN

offers capabilities such as

- Per-call selection of service and bandwidth
- Combined voice, data, and even video on a single call
- Calling-number identification at the terminating end (for example, a digital display of the calling number during ringing) and
- Sophisticated multimedia teleconferencing capabilities.

Furthermore, ISDN will make it possible to add new features and improve the implementation of existing services such as software-defined networks and advanced 800.

There is a considerable ongoing effort in national and international standards organizations to address protocol issues such as support for packet transmission and separation of call control from user (bearer) control information in ISDN.

#### **Potential CCS Network Enhancements**

The future CCS network will probably be configured as follows:

1. The ISDN-UP will be used throughout North America. As local carriers adopt CCS7 ISDN-UP and equal access, CCS7 network interconnect will provide for end-to-end digital services. The signaling connection control part (SCCP) will be used to provide data capability for ISDN user-to-user information.
2. The CCITT No. 7 protocol will be used internationally. First, the telephone user part (TUP) will provide basic call setup to countries that chose to use this protocol initially. However, because of its increased flexibility and support for digital services, the ISDN-UP will be used to extend domestic ISDN services worldwide.
3. The interconnection with local exchange carriers as they expand their own CCS systems will enhance LATA access service and allow new inter-LATA services.
4. AT&T services will evolve as the flexibility and capacity of the CCS7 protocol is utilized. The transaction capability application part (TCAP) will provide an effi-

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cient protocol for direct-signaling query and response, to support new database and switch-based services. The interworking of CCS7 with the Q.931 ISDN access protocol will allow end-to-end services that are not possible with in-band signaling and will provide more efficient and innovative use of the network.

### Conclusion

The evolution of the AT&T common channel signaling system has been shown to be a critical part of the AT&T network and services. It has provided a cost-effective means of providing flexibility in the marketplace. The system is expected to evolve as new capabilities and needs are identified.

### Acknowledgment

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