AT&T COMMUNICATIONS ISDN ARCHITECTURE

Marda L. Higdon, Judith T. Page, and Peter H. Stuntebeck

***Marda L. Higdon** is head of the Network Interface Planning Department and **Judith T. Page** is head of the Advanced Services and Architecture Planning Department, both at AT&T Bell Laboratories in Holmdel, New Jersey. **Peter H. Stuntebeck** is division manager of the Service Concepts Division at AT&T Communications in Basking Ridge, New Jersey. Ms. Higdon joined AT&T in 1972. She holds a B.A in mathematics and computer science from the University of Iowa, and an M.S. in computer science from Northwestern University. Ms. Page joined AT&T in 1977. She holds a B.A. in mathematics from Marywood College and a Ph.D. in statistics from the University of Pennsylvania. Mr. Stuntebeck joined AT&T in 1973. He holds a B.A. in physics from Thomas More College and a Ph.D. in physics from the University of Notre Dame.*

As announced in June 1985, AT&T Communications will introduce its initial Integrated Services Digital Network (ISDN) in 1987. AT&T Communications ISDN will expand the level of interaction between AT&T's intelligent, digital network and customer premises equipment and, thus, provide major new capabilities for meeting customers' telecommunications needs. This article discusses the building blocks that underlie AT&T Communications ISDN and the customer needs that these capabilities address.

AT&T Communications is planning its Integrated Services Digital Network (ISDN) to solve specific customer problems, increase customer productivity, and allow customers to manage costs and changes more efficiently.

Initially, our ISDN planning has focused on business customers. Primary market research has indicated that these customers need to access and interact with all forms of information, including voice, data, text, graphics, and image.

Specifically, customers tell us that they want continued access to a rich menu of services. They want the ability to customize their services for specific applications and implement changes in their services more quickly and easily. They want flexibility—and control over that flexibility—to reduce access costs, adjust service capacity, and monitor how the services perform. They want digital services at a wide range of transmission rates.

Customers also want easy integration of new service features and capabilities, and service-independent access. They want stable, open interfaces that permit graceful, independent evolution of customer-premises equipment and network services. Finally, they want easy and cost-effective communications that span the globe.

But, each customer has its own set of specific needs and priorities. Therefore, AT&T Communications strategy is to place into its network the basic ISDN building blocks that allow customers to customize their own best solution.

AT&T Communications ISDN Architecture

In Roca's article (page 5), Figure 8c presents an overview of the AT&T Communications ISDN architecture. It shows how the ISDN building blocks fit together as an integrated network.

The building blocks that AT&T Communications will implement include:

- AT&T Communications *Service Node* (see panel on page 29). The Service Node is the customer's gateway to the AT&T Communications family of nodal services, including MEGACOM℠ and MEGACOM 800 services, the Accunet® family of services, Software-Defined Network (SDN) service, and voice-grade private lines.
- *Integrated access.* Integrated access allows customers to integrate switched and private-line services over a single DS-1 link to the AT&T Communications Service Node.
- ISDN *primary-rate interface.* This interface has a 23B + D channel structure, and is available on an integrated access DS-1 link to the AT&T Communications Service Node.
- *Out-of-band signaling.* This signaling scheme uses the International Telegraph and Telephone Consultative Committee's (CCITT) standard, layer 3 (Q.931) protocol on the D channel. Thus, it establishes a stable, open interface that carriers and equipment vendors worldwide have adopted. (See Aldermeshian's article, "ISDN Standards Evolution," page 19.)
- *CCS7 common channel signaling network.* Soon, this signaling network will replace CCIS (common channel interoffice signaling) as an out-of-band system of signaling between AT&T Communications network elements. Because of its longer message format and layered structure, the CCS7 network will open the way for new custom-calling features.
- Increasingly *digital, backbone network.* This nationwide AT&T Communications network includes extensive lightwave and digital radio routes. By the end of 1988, these digital lightwave links will extend to Europe with the TAT-8 lightwave system, and across the Pacific with HAW-4/TPC-3.
- *64-kb/s clear-channel capability.* This capability enhances the AT&T Communications transmission network to give customers unrestricted use of the ISDN channel structure's 64-kb/s bandwidth.
- *Intelligent, software-controlled AT&T Communications network.* AT&T Communications gives customers more direct control, using existing and new network management and control services—such as Advanced 800 service, SDN service, Accunet T1.5 customer-controlled reconfiguration, and Dataphone® digital service's secondary-channel service.

With integrated access to the Service Node, customers can combine individual DS-0 access circuits onto a dedicated DS-1 access channel. The DS-0 access circuits may carry switched services, private-line services or, usually, a combination of both. This cost-effective, integrated interface for voice and data lays the foundation for AT&T Communications primary-rate interface.

Integrated access consists of three major functional elements:

- *Access integration.* Customer equipment at the customer's location merges individual DS-0 access circuits onto a DS-1 integrated-access channel.
- *Access transport.* The DS-1 signal is transported from a customer's location to an AT&T Communications Service Node. The customer may obtain this function under tariff from the local exchange carrier, AT&T, or other service provider, or may provide the function directly.
- *Integrated-access distribution.* At the AT&T Communications Service Node, the DS-1 integrated-access channel is separated into individual DS-0 circuits that are routed to the appropriate Service Node equipment. Typically, AT&T's Digital Access and Cross-Connect System (DACS) is used as the integrated-access distributor.

Integrated access is available to AT&T Communications customers via Accunet T1.5 service for access and the M24 service function that fans out DS-1 access chan-

AT&T Communications Service Node Architecture

As a result of divestiture and competitive forces in the telecommunications industry, the AT&T Communications network is undergoing major changes. A key element in the evolving digital network architecture is the Service Node—a serving office that acts as a customer gateway to AT&T Communications new nodal services. Its key technologies include the 4ESS™ switching system, the common-network-interface (CNI) ring, and the Digital Access and Cross-Connect System (DACS).

With the approval of tariffs that unbundle access, AT&T Communications now offers high-capacity access via Accunet® T1.5 lines between the customer's location and the Service Node. It also offers a wide range of nodal services that begin at the local Service Node and terminate either at a distant Service Node or customer location.

To enhance network efficiency and provide additional customer functions, the AT&T Communications Service Node also emphasizes technological and operational integration.

The first AT&T Communications Service Node went into service in 1985 in Philadelphia, Pennsylvania.

nels to 24 individual DS-0 channels. These channels then interconnect to a wide range of AT&T Communications nodal services.

The ISDN primary-rate interface[1] is a logical extension of DS-1 integrated access. The CCITT-standard ISDN definition assigns each of the 24 time slots in the integrated-access facility to a particular channel category. A time slot is either a 64-kb/s bearer channel, called a B channel, or a 64-kb/s data channel, called a D channel. (A 384-kb/s H0 channel has six time slots, while a 1536-kb/s H11 channel contains all 24 time slots.)

B channels are the paths that carry voice or data communications to or from the network. The D channel—the new entrant in the ISDN customer-to-network interface—carries signaling information about transactions or calls on the B channels that it supports. It also may carry customer data packets. (See Roca's article, "ISDN Architecture," page 5.)

The new signaling channel carries a message-oriented signaling protocol that is defined in CCITT standards. It is the first out-of-band, standard protocol for a customer-to-network interface that incorporates circuit-switched connections.

Traditionally, signaling information is carried "in-band"—in the same channel as the voice or data communications it controls. This in-band signaling method uses up to 8 kb/s of the 64-kb/s channel, which limits the customer to an effective bandwidth of 56 kb/s. Also, in-band signaling is status-oriented (on-hook/off-hook) or pulse- or tone-oriented (dial pulses or Touch-Tone digits). A message-oriented technique offers much more flexibility and power.

The CCITT standard for the message-oriented, out-of-band signaling protocol is a layered definition. It is consistent with the first three layers of the well-known open systems interconnection (OSI) reference model. (Also see "ISDN Standards Evolution," page 19.)

Layer 1, which is defined in CCITT recommendation I.431, specifies the electrical and physical characteristics of the entire integrated-access facility. It uses a standard DS-1 signal, preferably with the extended superframe format, although D4 framing is also permitted.

Layer 2 defines the basic interface interactions for transmitting frames of information over a channel. On the D channel, LAPD (Link Access Protocol D) is used as specified in CCITT recommendation Q.921.

The ISDN functionality is primarily found at layer 3. The CCITT Q.931 protocol is used over the D channel for call or transaction control. Across the network, the ISDN user part of CCS7 complements the Q.931 access protocol for setting up circuit-switched connections.

Q.931 messages have specific, well-defined functions. For example, the messages required to establish a typical voice call include Setup, Alert, Connect, Disconnect and Release (see Figure 1). Each message contains several information fields, some mandatory and some optional. The encoding of the required data and the message formats themselves are all part of the ISDN standard.

As Figure 2 shows, the 23B + D facility from the customer location will terminate either on an AT&T Communications DACS or 4ESS™ switch. The D channel is routed to the common-network interface ring (CNI), which interprets the message and takes appropriate action.

If communication is needed within the AT&T Communications network to serve the customer's request, the CCS7 network signaling is used between 4ESS switches, signal transfer points, and network control points. Q.931 messages are used between the customer and the AT&T Communications Service Node to which the customer is directly connected. Within the public-switched network, signaling other than Q.931 preserves the network's efficiency and integrity.

Since 1976 when common channel signaling was first introduced, AT&T has used out-of-band signaling extensively in its network. Thus, providing out-of-band signaling to the customer is simply an evolutionary step.

To permit two customers to communicate even though only one of them may have ISDN capability, full interworking is provided in the network. That is, a customer may use the ISDN protocol to start a call, but the network may use in-band signaling (or some other type) to complete the call if the terminating customer does not have ISDN-capable equipment. The result is a fully functional ISDN interface to the network. (However, the functionality of the terminating customer's non-ISDN equipment would limit the end-to-end ISDN capabilities.)

All AT&T Communications services—whether circuit-, packet-, or channel-switched—ride on the internodal facility network that connects AT&T Communications Service Nodes. The internodal network is rapidly converting to a digital network, as a result of new and cost-effective lightwave and radio technologies.

The AT&T Communications network is being planned to support 64-kb/s clear-channel capability that gives the customer unrestricted use of the 64-kb/s bandwidth. To support this capability, AT&T Communications will use bipolar eight-zero substitution, or B8ZS, a proposed standard for ensuring an adequate density of "ones" on the facility.

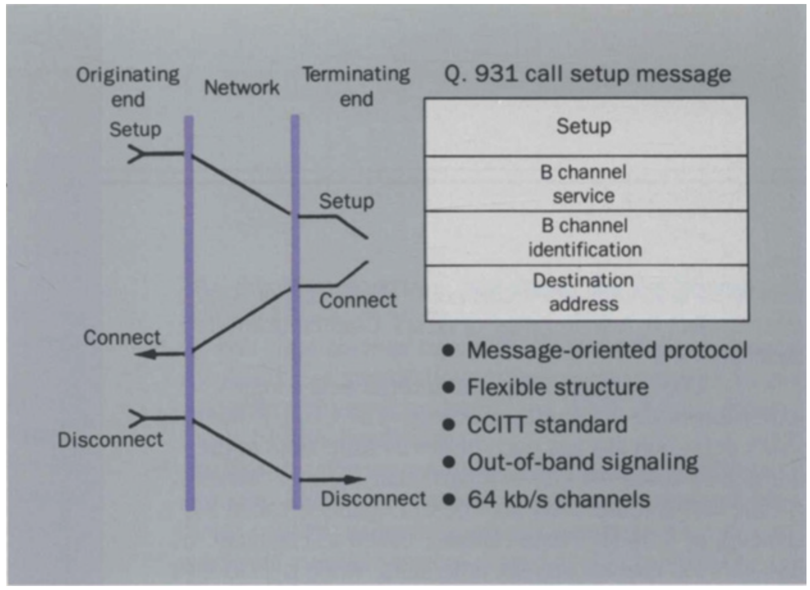

Figure 1. Establishing a voice call typically requires end-to-end exchange of Q.931 messages, each containing several information fields. Required data items include the type of message (e.g., Setup or Connect) and the identification of the B channel to which the message pertains. Individual messages may have additional requirements, such as the called number that is required in the Setup message for a switched call. As an option, the calling number or other user-generated information can be included in several messages.

Finally, direct customer control and network management capabilities are an important aspect of existing AT&T Communications services and can be enhanced by ISDN. In the network, software-controlled technologies, service-management software systems, and network-applications processors support customer-control capabilities. With ISDN, the D channel could carry control information between the customer and the network and between equipment at two of the customer's locations.

Technology's Role

Integrated digital technology in the AT&T Communications network plays an important role in the evolution to AT&T Communications ISDN. This technology includes digital switches, cross-connect systems, and interoffice facilities; thus, it provides end-to-end digital connectivity.

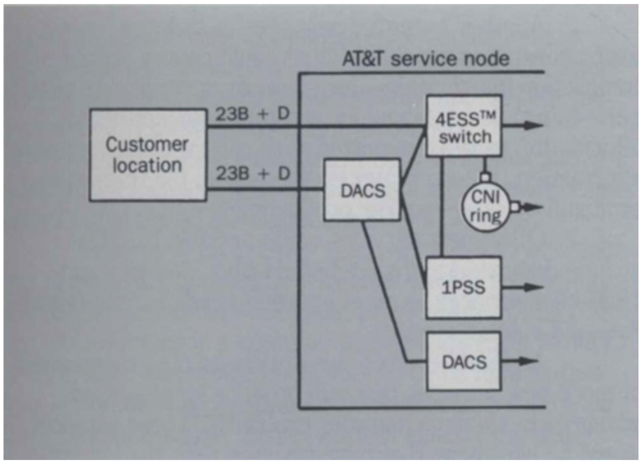

Figure 2. In the AT&T Communications ISDN network, digital signals from the customer's location terminate on a DACS or a 4ESS switch. When the DACS serves as an integrated access distributor, it sends individual DS-0 channels to the respective service-providing equipment—other DACSs for private-line services, the 1PSS packet switch for Accunet packet service, or the 4ESS switch for public-switched services. The D channel terminates on the CNI ring that acts as a signaling and packet distributor.

The 4ESS switch was the first AT&T switch to feature time-division digital switching. It was also the first toll switch to be designed with stored-program control from the outset.

This switch is already rich in the features AT&T Communications requires for switched-network services between local access transport areas (LATAs). With each generic program, the 4ESS switch's existing capabilities are being overlaid with new ones. Recent generic programs, for example, allow AT&T Communications to offer new switched nodal services, such as MEGACOM, MEGACOM 800, Accunet switched 56, and SDN services.

To support ISDN, AT&T added significant developments to the 4ESS switch and the CNI ring, a token-passing ring technology.

The CNI ring is used with the No. 2 signal transfer point as part of the common channel signaling network. It has evolved to a common technology that will also be used with the 4ESS switch, network control points, the 5ESS™ switch, and the No. 1 packet switching system (1PSS).

Developed by AT&T in 1981, DACS is a digital system that electronically cross-connects 64-kb/s channels within a DS-1 signal and provides DS-1 test access. It provides a spectrum of features to keep abreast of changing customer needs.

The DACS will continue to be used both as an integrated-access distributor and a service provider for many AT&T Communications digital services, including Accunet T1.5 customer-controlled reconfiguration services. In addition, DACS is expected to support new ISDN capabilities.

In the internodal facility network, AT&T is deploying single-mode terrestrial lightwave systems—such as FT3C and FTX180—on low-growth routes and in places that need systems immediately.

On high-growth routes, AT&T will install FT Series G electronics that use only single-mode fiber pairs at line rates of 1.7 Gb/s with 20-mile repeater spacings.

Service on the TAT-8 and HAW-4/TPC-3 intercontinental undersea cables will be available in 1988. Both systems use single-mode fiber to provide transmission in the 295 Mb/s range.

In the digital-radio area, 4-GHz systems—such as the TD-90 and the TD-180—provide a vehicle for rapid expansion of digital connectivity. They will re-use much of the radio equipment already in the ubiquitous, TD analog radio networks, while expanding the circuit capacity.

ISDN Services and Applications

ISDN basic capabilities can be used to define specific new AT&T Communications services and features. For example, "call-by-call service selection" will enable the customer to specify, dynamically, the B channel to be used on each call, independent of the switched service requested. This feature reduces access costs and eliminates provisioning intervals, enabling customers to be more flexible and productive.

CCITT ISDN signaling protocols will be used for customer-to-network and customer-to-customer exchange of control and signaling information. These protocols provide the opportunity for new services and features, such as selective-call handling, call screening, and station-message detail recording.

For example, the ISDN signaling channel can deliver the originating station identification to the called party. As the call is completed (and before the called attendant is alerted to the incoming telephone call), the called customer's database computer system can use the station identification to retrieve the calling customer's record. When the called attendant answers the ringing telephone, the caller's record will be on the attendant's screen.

This capability not only enables called customers to personalize the service that they offer to their callers, but also increases worker productivity by reducing the attendant's time on each transaction.

Knowing who is calling or which station is being used for calls helps customers decide how to treat the incoming call. For example, they can choose to forward it or take messages, or use the displayed information as an initial security screen.

In addition, the network can use the signaling channel to provide information to the customer, such as network performance, traffic usage, and other status-monitoring data. This information, when coupled with customer-equipment controllers, can provide powerful, new network-management capabilities for end-to-end customer networks.

Another potential new service includes "user-to-user information capability" that could convey certain transaction information—for example, a credit-card number—to a called database or computer system. If the information were transmitted with call-associated signaling information, the customer could shorten the transaction time and increase worker productivity.

Other new services made possible by ISDN include dedicated and switched 64-kb/s, 384-kb/s and 1536-kb/s services to meet growing needs for end-to-end data and video transport.

As ISDN evolves, we anticipate creative invention of more new services that will produce revolutionary advances in solving customer problems. These advances would be like those that have resulted over the last ten years from stored-program-control networks, CCIS, and microprocessor-based transmission terminals. At the time, few foresaw the rich array of services that are now available in the AT&T Communications network based on those capabilities.

This is the true realization of ISDN—the expansion of the intelligent, digital AT&T Communications network for new levels of customer interaction.

ISDN Technology and Service Trends

By early 1987, AT&T will have introduced ISDN capabilities into the network, supported by the 4ESS switch—with the CNI ring—and DACS.

After 1987, AT&T will enhance and expand these technologies and introduce other new technologies into the network. More powerful microcomputers and dedicated, hard-disk storage devices will expand ring technology to provide additional storage, processing, and control of the call-processing flow. These elements—when connected to rings in the network—will provide more intelligence and storage capabilities throughout the network, thus distributing functionality and processing.

New ISDN features and capabilities will be available, supported by transmission systems. For example, channel banks and various multiplexers—in addition to DACS—may be enhanced to provide standard ISDN interfaces. They would be able to understand and process the powerful ISDN message-oriented protocols.

Having such capabilities in both switching and transmission technologies will lead to flexible control capabilities within the AT&T Communications network.

A key new technology that we expect to be important to the AT&T network is wideband-packet technology. A wideband-packet network could provide integrated transport and switching in a common packet form for a variety of voice, data, and image applications. Once information from any of these applications is converted to packets, all these packets traverse the network in exactly the same fashion.

From a services perspective, AT&T Communications ISDN will evolve toward more integration, increased network functionality, additional service applications, improved network management and control functions, and higher bandwidth services. These and other exciting service opportunities will continue to unfold as AT&T Communications ISDN evolves through the late 1980s.

Reference

1. AT&T Communications, *Integrated Services Digital Network (ISDN)—Primary Rate Interface*, Technical Reference, Pub. 41459, June 1985.

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