CORPORATE NETWORKING: EVOLUTION AND ARCHITECTURE

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Corporate networks are growing in popularity and providing more benefits to their users. These networks are based on leading edge, digital communications technology and provide a smooth migration to the Integrated Services Digital Network (ISDN)—the intelligent, corporate network of the 1990s. As the papers in this issue on intelligent networking will show, AT&T has been and continues to be at the forefront of intelligent, corporate networking with business-communications solutions that provide a rich set of capabilities and an excellent application platform to meet customer needs in the future. To set the framework for the issue, we describe the history of corporate networking and the 1990s' corporate-network architecture. We also discuss the role of AT&T's Definity® communications system in modern, corporate-network applications.

Background

Over the last twenty years, corporate switched networks have evolved from simple, private-line, analog voice networks into intelligent, digital voice, data, and video networks that support many user applications. This evolution was possible because the local exchange carriers, the interexchange networks, and customer-premises equipment (CPE) had rapidly adopted digital technology and distributed intelligence.

In the last five years, customers have created custom, private, voice and data networks by using the AT&T long-distance network—or *virtual private networks*. The fast growth of virtual private networks has brought the benefits of corporate networking to an expanded number of customers and has firmly established the hybrid network (i.e., private and virtual private) as the preferred architecture in the United States. This architecture, which is based on digital connectivity and distributed processing in the network and on the customer's premises, is

Panel 1. Abbreviations, Acronyms, and Terms

adjunct — intelligent peripheral for a private branch exchange

ANI — automatic number identification

ASAI — adjunct-switch application interface

AUDIX — audio information exchange

B channel — 64-kb/s bearer channel

BOS — bit-oriented signaling

BRI — ISDN basic-rate interface

CCITT — International Telegraph and Telephone Consultative Committee

CCS7 — common-channel signaling system 7; interoffice signaling that follows CCITT standards

centrex — central exchange; a service that provides direct inward and outward dialing for extensions on a switch in a local operating company's central office

CPE — customer premises equipment

D channel — 64-kb/s, out-of-band signaling channel

DCP — digital communications protocol

DCS — Distributed Communications System

DMI — digital multiplexed interface

DMI-BOS — digital multiplexed interface with bit-oriented signaling

DS-1 — a 1.544-Mb/s digital signal that provides 24 channels

ETN — electronic tandem network

I/O — input or output

ISDN — Integrated Services Digital Network

ISO — International Organization for Standardization

LAN — local-area network

LATA — local-access transport area

layer 2 protocol — Q.921; CCITT recommendation for the ISDN link-layer protocol

layer 3 protocol — Q.931; CCITT recommendation for the ISDN network-layer protocol

NCOSS — network control operations support system

NCP — network-control point

OSI — Open Systems Interconnection; a set of standards jointly recommended by the ISO and CCITT

PRI — ISDN primary-rate interface

PBX — private branch exchange

SDDN — Software Defined Data Network

SDN — Software Defined Network

SID — station identification

tandem — a switching system or PBX that carries voice or data traffic that originates and terminates at other locations

TDM — time-division multiplexed

tip and ring — standard, analog, telephone-network loop interface

TTTN — tandem tie-trunk network

voice-band data — data converted into the 3-kHz (kilohertz) bandwidth by using modems (i.e., modulators/demodulators) at the end points

WATS — wide-area telecommunications service

X.25 — CCITT recommendation for a packet-switching protocol at the link and packet layers

permitting today's smooth migration to ISDN—the basis for the corporate networks of the 1990s. By using standard ISDN communications interfaces, enhanced out-of-band signaling, and increased processor and switch interactions, the corporate networks are able to support an increasing variety of value-added applications. (Panel 1 defines acronyms and terms used in this paper.)

This paper lays the groundwork for this issue by describing:

- The evolution of corporate networking from private-line networks to virtual private networks
- Today's ISDN-based corporate-network architecture and its key features
- AT&T's Definity communications system that provides the customer-premises portion of the corporate network and enables modern, corporate-network applications.

The rest of this issue addresses in more detail new capabilities in the intelligent, corporate network—such as automatic call distributors, switch-to-computer networking, voice-storage processing, and voice and data applications—as well as the synchronization and transmission performance of these new networks.

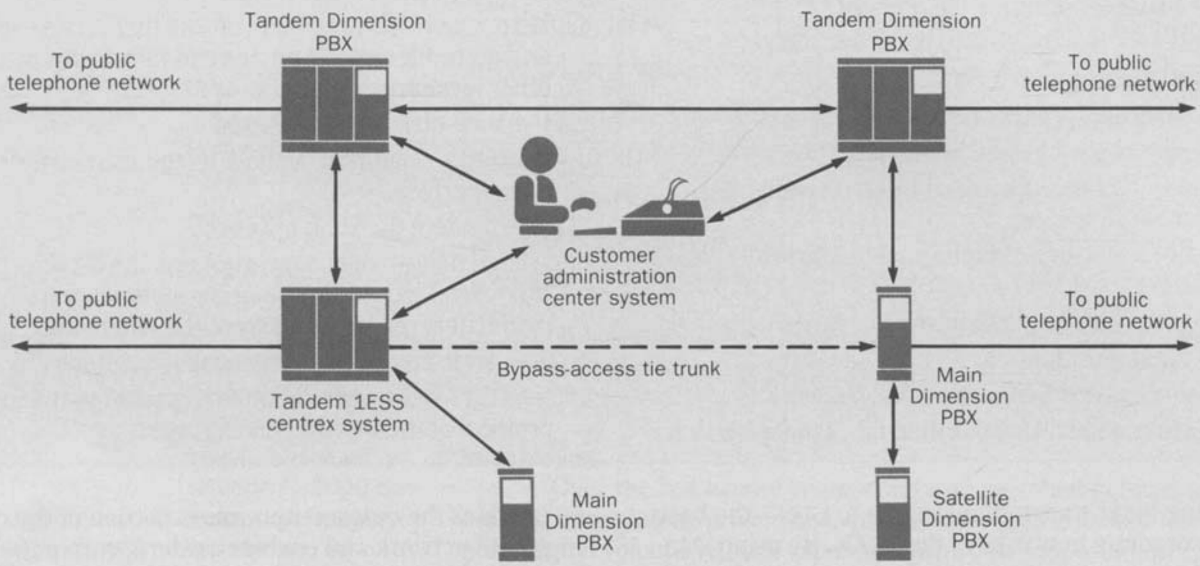
The Electronic Tandem Network

Modern, CPE-based corporate networks had their beginning in 1978 when AT&T introduced electronic tandem networks (ETNs).[1]

Panel 2. Elements of an Electronic Tandem Network

The flexibility of electronic tandem switching allows tandems to be configured in an almost unlimited variety of ways to form an electronic tandem network.

In the ETN (which AT&T introduced in 1978), two Dimension PBXs and a 1ESS centrex system serve as tandems that are linked by tie trunks. Main and satellite PBXs at other company locations "home" on the tandems, but don't have the same capabilities. Tandems and main PBXs can provide access to the public telephone network, and bypass-access tie trunks carry significant one-way traffic between locations. The customer administration center system—with dial-up connections to each tandem—monitors network activity, collects data, and allows customers to control the features of the tandems.



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Before ETNs became available, the private, CPE-based networks were tandem tie-trunk networks (TTTNs) that used electromechanical switches and user dialing for routing calls. The use of TTTNs grew in the 1950s, because the application of tandem switches and private-line facilities proved more attractive economically than the use of the public switched network.

But in TTTNs, the originator of the call had to select the route of each call. He or she dialed, in succession, the trunk-access code of each switch in the path followed by the destination's station number.[1]

In 1978, AT&T introduced the ETN with Feature Package 8 for the Dimension® PBX and tandem switching on the 1ESS™ centrex system. These tandem switches were intelligent in the sense that they could receive calls on an incoming trunk, interpret the dialed digits, and route the call on an appropriate outgoing trunk. In 1978, the trunks were analog and ETNs were designed to carry voice and low-speed, voice-band data. The ETN automatic, tandem switching was based on the switching concepts and hierarchical routing used in the public network. As a result, corporate networks now could use *uniform dialing*—i.e., the use of a single, seven-digit number to call a given location, regardless of the source of the call in the private network. Uniform dialing was accomplished through the *automatic alternate routing* feature of the PBX or centrex system that provided routing based on the three-digit location code of the private-network dialing plan.[2]

In addition, the ETN introduced several cost-containment features. Customers could control the calling privileges of each station and each user on the ETN. For example, the telecommunications manager could control which facilities and destinations each station could access, and individuals could be given authorization codes to override station restrictions.

ETNs also introduced *automatic route selection*, where the tandem switches automatically choose the most economical path for off-network calls by using routing patterns that are based on the time of day. To this day, these capabilities remain the foundation of switched corporate networks.

To support the ETNs, AT&T developed not only the Feature Package 8 software for the Dimension PBX, but also the rules and tools for the design of these networks and for the management of ETNs. AT&T supported the installation of complex ETNs and Bell Laboratories designed precutover test plans. A customer administration center system was also introduced in 1978 to manage these networks. And in 1979, an operations-support system—the network control operations support system (NCOSS)—was introduced that used call-detail records to monitor ETN operations and support AT&T maintenance.[3] Today, an upgraded NCOSS is still in operation, supporting AT&T's corporate networking customers as part of AT&T's QualNet℠ enhanced support program.

Panel 2 presents a diagram that appeared in a 1979 *Bell Laboratories Record* article.[3] It provides a good summary of ETNs as they were introduced in 1978.

Corporate Network Evolution

Several evolutionary steps have converted analog ETNs into today's intelligent, corporate networks:

- The migration from analog switches and transmission to digital switches and digital transmission
- The introduction of intelligent, out-of-band signaling between PBXs
- The introduction of virtual private networks.

The Move to Digital. The first step was the migration of the ETN's analog switches and analog transmission to digital switches and digital transmission. This migration continued through most of the 1980s, and most of the analog PBXs deployed in the early growth years of ETNs have been replaced in large, corporate networks.

Modern, digital PBXs now dominate corporate networks. One example is AT&T's Definity communications system[4] with its high-function digital station equipment, digital switching of both voice and data, and such optional capabilities as automatic call distribution and voice processing. These systems are fully compatible with the old ETN tandem switches, provide efficient DS1 interfaces and, in addition, can be upgraded easily to ISDN nodes. [DS1 is a 1.544-Mb/s (megabits per second) digital signal that provides 24 channels.]

The evolution to digital facilities started in the early 1980s with the availability of leased, 1.544-Mb/s (T1), private-line digital facilities. These facilities quickly became the backbone of the network that joins the ETN tandem switches and replaced analog, voice-grade circuits. In addition, sections of the private-line, voice-grade data networks were converted to digital facilities using T1 multiplexers.[5] The integration of voice and data at the facility level on T1 links provided important economic benefits and helped the growth of ETNs.

Today, the availability and pricing of fractional T1 service—and, specifically, AT&T's Accunet®

spectrum of digital services—provide strong economic incentives to eliminate voice-grade private lines altogether. [*Fractional T1* service allows customers to lease a fraction of the twenty-four 64-kb/s (kilobits per second) channels of a T1 line (i.e., 1, 2, 4, 6, 8, or 12 channels) at lower prices than the equivalent number of voice-grade private lines.]

Out-of-Band Signaling for PBXs. Another evolutionary step to today's intelligent, corporate networks was the introduction of intelligent, out-of-band signaling between PBXs for advanced features.

AT&T's Distributed Communications System (DCS) is a pre-ISDN private-network offering. First introduced in 1982, DCS now provides the transparent operation of 22 features across a private-line PBX network.[2] Today, such features as calling-name display, distinctive alerting, priority calling, leave-word calling, automatic call back, and call waiting are available between stations connected to different switches. In addition to these station features, DCS offers attendant features and supports centralized AUDIX voice mail. (AUDIX stands for *audio information exchange*.) An overlay packet network provides the out-of-band signaling for this enhanced functionality.

DCS is a highly successful, private network offering with a growing customer base. The wide acceptance of DCS bodes well for customer acceptance of value-added, ISDN corporate networking.

Virtual Private Networks. In 1985, while the cost of T1 private lines was dropping and T1 backbone networks and ETNs were dominant, another major trend emerged. Virtual private networks, which are based on the intelligence in the interexchange carrier's network, were introduced. Initially, this intelligence had provided the translation of dialed 800 numbers to the internal AT&T-network numbering plan in centralized databases. It now was applied to providing a private-network dialing plan and screening on the public networks.[6]

In late 1985, AT&T's first Software Defined Networks (SDNs) became operational and started a major trend that has changed the nature of corporate networking. SDN was initially targeted at very large corporate customers. However, the attractiveness of the service, together with reduced prices, made private networking practical for smaller corporations.

Virtual networks offer several advantages:[6]

- First, of course, are the economic advantages, such as lower per-call cost and usage-sensitive pricing.
- SDN also eliminates the need for the customer to implement and manage a complex private network. This minimizes the technical and financial risk associated with selecting and buying or leasing the equipment and facilities needed to implement the network.
- With switched access through the local operating companies, it is possible to bring many more small, customer locations onto the virtual network than would be economical in a private-line ETN.
- In addition, today's virtual networks—such as AT&T's SDN—offer a wide range of service and management options that allow a high degree of customization.

Today, these advantages make virtual networks the architecture of choice for most inter-LATA voice networks. (LATA stands for *local-access transport area*.)

In the United States, virtual private networks currently are not widely available from the local operating companies, so there is no practical alternative to intra-LATA ETNs. Thus, the typical intra-LATA portion of a corporate network carries both ETN-switched voice and private-line data traffic that is multiplexed onto shared digital facilities. In contrast, inter-LATA voice and switched, digital data traffic is most often carried over a virtual private network, while the inter-LATA non-switched, data traffic is likely to use dedicated T1 or fractional T1 facilities.[7] As a result, today's corporate networks tend to be a complex, hybrid mix of virtual and private-line components.

The common denominator in this complex, hybrid, networking environment is the use of digital switching and digital facilities. (Two papers in this issue discuss the transmission performance and synchroniza-

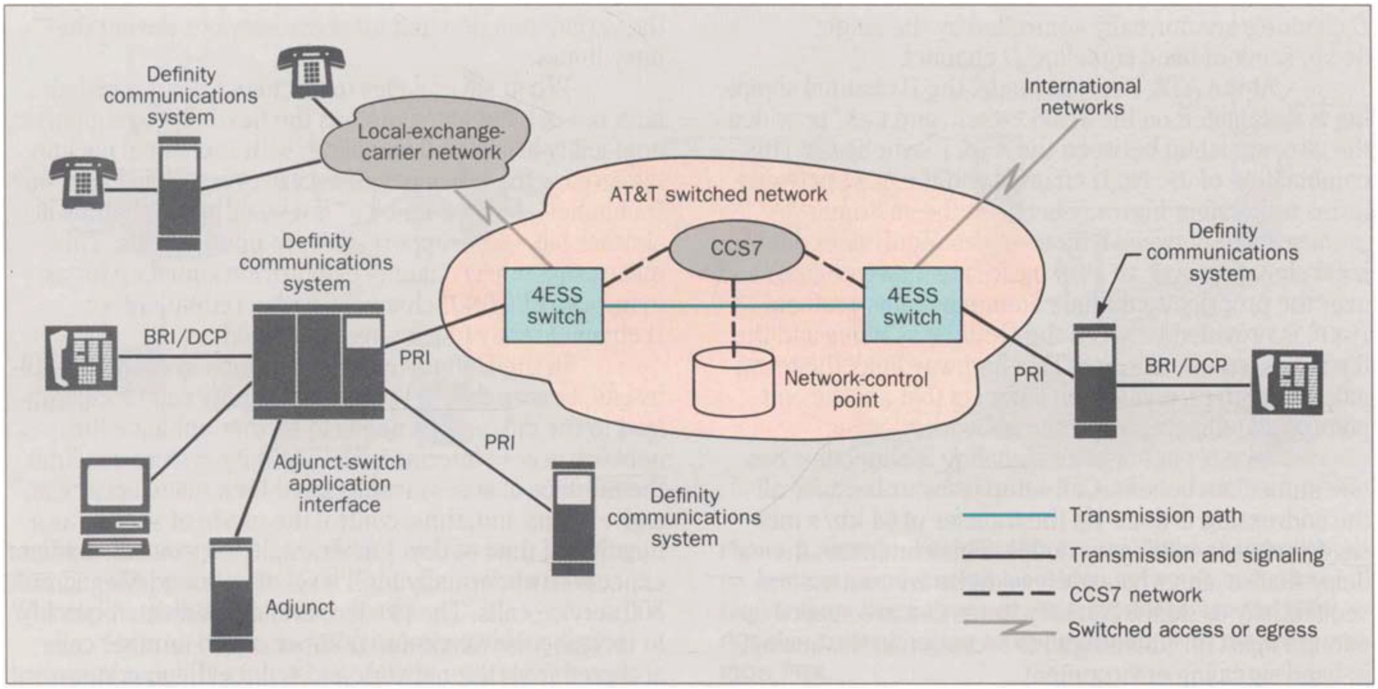


Figure 1. Hybrid, corporate Integrated Services Digital Network (ISDN). The corporate network's core is the AT&T switched network. Connected to this core are ISDN switching systems, such as the Definity communications systems, on the customers' premises. The ISDN primary-rate interface (PRI) provides the interface between these PBXs and the AT&T network.

tion of such complex, digital switched networks.[8,9]) Regardless of the specific mix of private and virtual private networking, the hybrid, digital network infrastructure forms the base for the intelligent ISDNs that are now emerging.

Corporate ISDN Architecture

The intelligence for the modern, corporate network is based on ISDN digital transport and out-of-band signaling that link sophisticated digital switching systems and intelligent terminals, adjuncts, and host computers.

End-to-End ISDN Connectivity. Figure 1 illustrates the ISDN connectivity in a hybrid corporate network. The core of this network is the AT&T switched network, which consists of:

- 4ESS™ ISDN switching systems.
- The CCS7 common-channel signaling network. (CCS7 stands for *common-channel signaling system 7.*)
- The databases of the network-control points (NCP).

Connected to this core are ISDN switching systems, such as the Definity communications systems, that are located on customers' premises. The interface between the Definity systems and the AT&T network is the ISDN primary-rate interface (PRI), which has the 23B+D channel structure. That is, its twenty-three 64-kb/s bearer or

B channels are normally controlled by the single 64-kb/s, out-of-band signaling *D* channel.

At the AT&T service node, the D channel signaling is terminated on the 4ESS switch, and CCS7 provides the ISDN signaling between the AT&T switches.[10] This combination of the PRI D channel and the CCS7 network forms a signaling highway between the customer-premises and network ISDN switches. Equivalent out-of-band signaling over an ISDN basic-rate interface (BRI) and over the proprietary digital communications protocol (DCP) is provided between the Definity systems and the terminals, computers, etc. This highway links the terminals, computers, and switch adjuncts that are the end points in intelligent, corporate networks.

An ISDN out-of-band signaling architecture has one immediate benefit. Call setup is faster because all the addressing is done via the transfer of 64-kb/s messages between intelligent nodes. This eliminates the delay that results when address digits are transmitted sequentially as dual-frequency tones that are spaced far enough apart for unambiguous reception in the analog, in-band signaling environment.

Efficient Network Access. ISDN out-of-band signaling provides *call-by-call selection*, which allows the Definity switching systems to select an AT&T network service for each of the bearer channels on a call-by-call basis. For example, the Definity communications system can make an SDN call, followed by an Accunet switched-digital-service call on the same B channel.

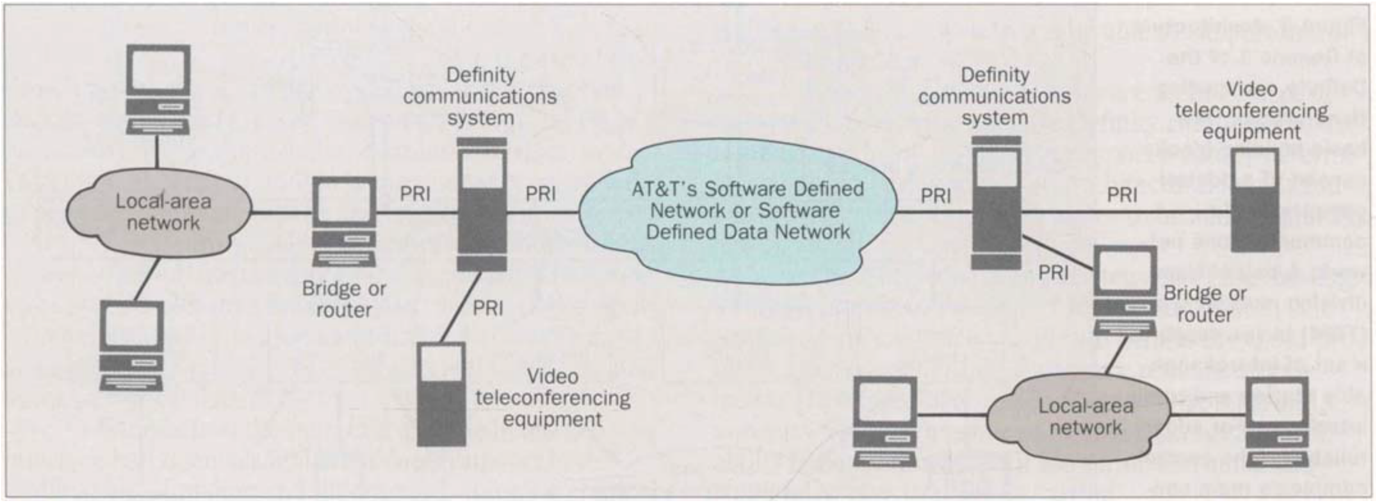
This real-time channel-selection capability increases the call-carrying efficiency of the PRI access. It also permits the access to be customized to fit a customer's changing needs.[11] If several different transport options and services are provided in the same call-by-call access group, significant efficiencies can be realized compared to individual trunk groups dedicated to each service. For example, corporate customers have experienced a 5- to 50-percent reduction in the number of access B channels required. This reduction depended on the total level of traffic, number of service types, and the variation in demand for these services during the busy hours.

When several PRIs to the network are needed, ISDN out-of-band signaling has the flexibility to support nonfacility-associated signaling, with D channel backup to increase the efficiency of access even more. Here, one D channel—backed up by a "hot standby" D channel in another PRI—can support traffic in up to 20 PRIs. This means that one D channel can provide signaling for as many as 478 ISDN B channels, with a redundant D channel ready to take over if needed.

In the Definity communications system, the call-by-call, bearer-channel control capability can be customized to the customer's needs to further enhance the network-access interface. The Definity system can limit the number of access trunks used for a given service at a given time and, thus, control the grade of service as a function of time of day. For example, suppose a customer expects an abnormally high level of in-bound Megacom® 800 service calls. The PRI access can be adjusted quickly to increase the maximum number of 800-number calls accepted from the network and reduce the maximum number of other calls on the PRI so the 800-number calls will not be blocked.

Transport for End-to-End Services. ISDN out-of-band signaling has another function beyond the efficient control of bearer channels. It carries additional information associated with the calls on the bearer channels, information that will be used to implement supplementary services. For example, one simple, but important, piece of information carried across the D channel and the CCS7 network is the calling-party identity or billing number. This number can be displayed at the receiving end or used for screening calls.

ISDN also provides for signaling between end systems that is passed transparently across the AT&T network. These signals serve as a signaling transport that the CPE can use for innovative, and possibly proprietary, services. The ISDN user-to-user signaling information and the facility message are two examples of ISDN signaling



facilities that are used as building blocks for a growing number of applications. (See Rubinstein, Ryva, and Warwick in this issue for details.[12])

Hybrid, corporate ISDNs also provide a digital transport capability for users of the corporate network. The fundamental building block of this transport is the 64-kb/s B channel on the PRI and on trunks in the carrier networks. At different times, the same B channel may carry voice, voice-band data, rate-adapted asynchronous digital data, and 56-kb/s and 64-kb/s digital data—all controlled via the D channel. The D channel uses a specific information element, called the *bearer capability*, to identify the type of information being carried in a call. The information element is passed through the network between the ISDN nodes to route the call on the appropriate network facilities without the need for separate dialing plans for voice and digital-data calls. This ability to identify the call type becomes especially important when calls are routed off the corporate network to the public, interexchange-, or foreign-carrier networks.

The ISDN BRI also provides the transport for the switch-to-computer applications that Foard, Spindel, and Verma describe[13] in this issue.

Figure 2. In this corporate ISDN of the future, bandwidth on demand interconnects local-area networks and video teleconferencing equipment. These devices use the ISDN PRI over building wiring to communicate with the corporate ISDN PBX.

Bandwidth on Demand. ISDN signaling will support *bandwidth on demand*, which allows users or applications to select the digital bandwidth needed for each call on the corporate network. As the first stages of bandwidth on demand, the AT&T network is offering 384 kb/s today, and we expect 1.536 Mb/s to be available before the end of 1991. These capabilities are important steps to achieving full bandwidth on demand and the associated efficiency and flexibility that will become available to corporate ISDNs in the 1990s. Figure 2 illustrates a future, corporate ISDN configuration that provides bandwidth on demand for interconnecting local-area networks (LANs) and video teleconferencing equipment. (See Rubinstein, Ryva, and Warwick in this issue for more detail on these applications.[12])

We expect that PRI will be extended to the end points on the corporate network. That would allow such

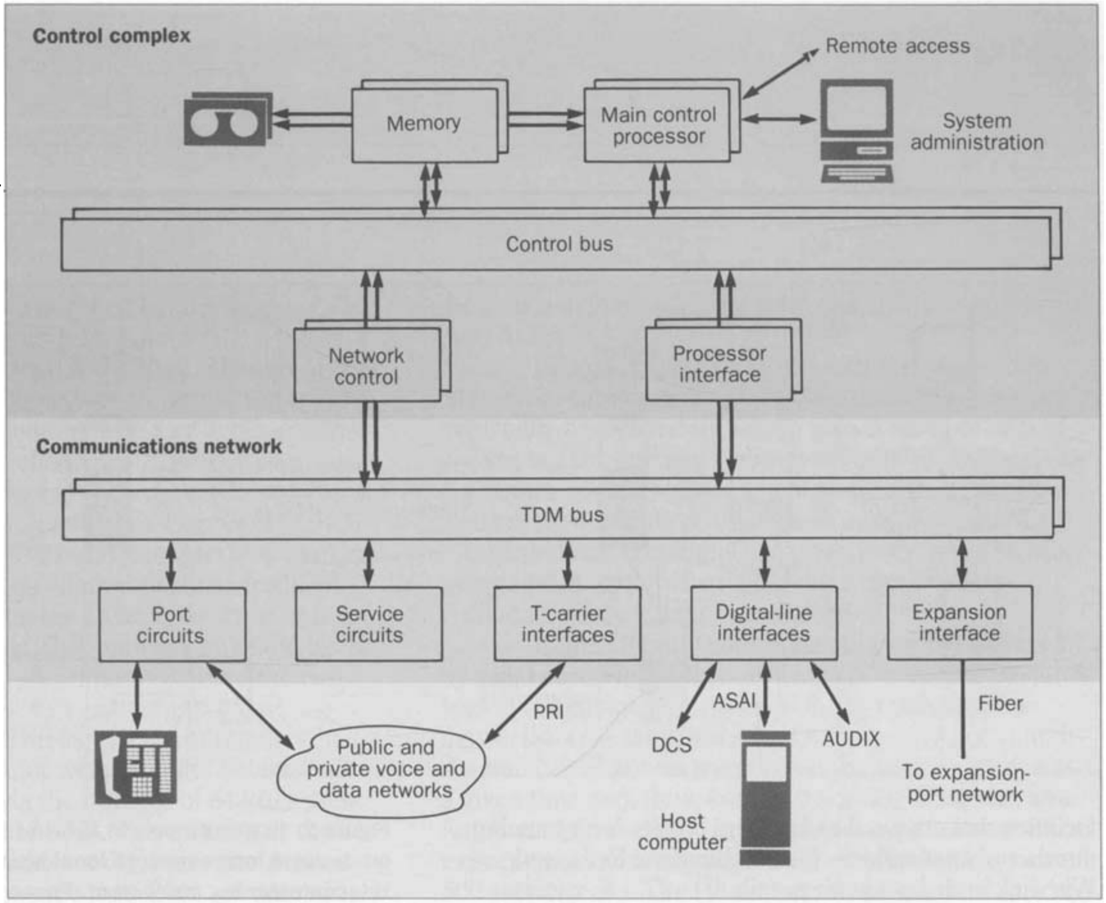


Figure 3. Architecture of Generic 1 of the Definity communications system. The basic building blocks consist of a control complex and a communications network. A pair of time-division multiplexed (TDM) buses supports a set of interchangeable station and trunk interfaces. For added reliability, the control complex's main control processor, memory, and control bus can be duplicated.

devices as LAN bridges or routers and video teleconferencing systems to be connected over building wiring and use ISDN PRI to communicate with the corporate ISDN PBX. Thus, at the start of each call, the LAN router or video teleconferencing system will not only send an address to the Definity communications system, but will also request a specific bandwidth for the call. In turn, the Definity system will seize the necessary bandwidth on the PRI access to the network and place the call over AT&T's Software Defined Data Network (SDDN) or Accunet switched digital service.

Bandwidth on demand is a logical extension from the usage-sensitive nature of today's virtual network to ISDN and will maximize the efficiency of corporate ISDNs.

Definity Communications System ISDN Architecture

The architecture of the Definity communications system provides a smooth migration to ISDN and intelligent networking.

The basic building blocks of the Definity communications system's hardware architecture (Figure 3) consist of a control complex and a communications network that are connected by a pair of time-division multiplexed (TDM) buses. Part of the bandwidth of the TDM buses is used as a control channel between the control complex and the intelligent, port circuits in the communications network.

The *control complex* consists of the processor, memory boards, mass-storage unit, and interface boards that allow either direct I/O access or switched access through the communications network. The main control processor, memory, and control bus can be duplicated for additional reliability.

The key elements of the *communications network* are the two parallel TDM buses—a set of printed wires that traverse the backplanes of all the carriers. For reliability, the dual-bus structure permits continued operation at reduced capacity if one bus fails.

All port boards, as well as the interface boards in the control complex, have direct access to the TDM bus. Switching functions are performed using the TDM bus and the distributed time-slot-interchange logic on each port board. While the TDM bus is limited to 64-kb/s switching, only minor additional functionality is needed to provide wideband switching (e.g., 384 kb/s).

The Definity system's hardware architecture has always featured universal, port-slot hardware. Therefore, any port circuit from a family of port circuits that support a range of standard station and trunk interfaces [e.g., analog tip and ring, DCP, ISDN BRI and PRI] can be located in the universal slots.[14]

Even before the ISDN era, a single-board DS1 interface had been available that could support both "robbed-bit" signaling and bit-oriented, common channel signaling (i.e., DMI-BOS). The ISDN architecture builds on and continues this strength.

To support ISDN PRI, the challenge is to handle the layer 2 (Q.921) and layer 3 (Q.931) protocols that are carried on the signaling channel of an ISDN PRI. To accomplish this in the Definity communications system, the signaling channel (or D channel) is routed through the TDM bus and terminated at a port on the processor-interface board that communicates directly with the call processor. The layer 2 protocol is terminated on the processor-interface board, and the layer 3 protocol is routed to the processor software for further processing. As a result, the same DS1 board hardware can be used to support robbed-bit signaling; bit-oriented, common channel signaling (i.e., DMI-BOS); or message-oriented, ISDN-PRI signaling.

As ISDN becomes fully deployed, a more efficient way to handle the ISDN-PRI protocol is to route the signaling packets on the 24th channel of the DS1 interface through a packet bus to a packet-handler board. To accommodate such an evolution, a packet bus had been included in all previous releases of System 75 and in Generic 1 of the Definity communications system. One advantage of using the packet-bus signaling architecture is that the Definity system will be able to support more ISDN PRIs and BRIs.

From the outset, the software architectures of System 75, System 85, and the Definity communications system have been designed to support a variety of terminals and trunk interfaces. This architectural foundation allows new protocols and interfaces to be added naturally and cleanly.

The ISDN PRI is only an extension of the existing T1-trunk interface. To support PRI, we added new, self-contained logic at the low layers to handle the Q.931 protocol. The remainder of the software remains largely intact. Therefore, interworking between ISDN-PRI and non-ISDN facilities becomes a simple task, because the ability to communicate with the various terminal and trunk interfaces has always existed.

An ISDN Application Platform

The Definity communications system is an excellent platform for value-added, corporate networking applications. These applications improve networking efficiency and network management, enhance resource sharing, and provide new services for the users of corporate networks.[15] ISDN networking, together with the Definity system's call processing, provides the basis for all these applications.

The natural integration of ISDN PRI into the software allowed the Definity system's developers to concentrate on features and applications that provide synergy with the AT&T public network and value-added applications. System 75 and System 85, the predecessors to the Definity communications system, already supported a large set of ISDN-like features, so the migration to ISDN was relatively easy.

For example, an X.25, out-of-band signaling channel has been used to implement the Distributed Communications System's feature transparency between systems, as well as a "smart" interface to AT&T's AUDIX voice mail system. This out-of-band signaling stream uses the same protocol interface board as the PRI D channel to link the TDM bus to the control complex. The X.25 signaling capability provides a base for migrating the Definity communications system to ISDN PRI and the adjunct-switch application interface (ASAI).[13]

As an illustration of the Definity system's versatile architecture, it was possible to increase the efficiency of PRI access quickly by introducing nonfacility-associated signaling and D channel backup to allow one D channel to signal reliably for as many as 20 PRIs.

Today, the Definity system's call-processing software provides several useful ISDN capabilities that improve network management and efficiency. The call-by-call service selection feature allows a customer to integrate into a single trunk group those facilities that had been dedicated to a specific service (e.g., WATS, Megacom or Megacom 800 service, or SDN). Sophisticated, routing software uses call-by-call service selection to choose the optimal network service or private-line PRI trunk for each call whether it is voice, voice-band data, or digital data. Integrated, bandwidth-management services are provided that allow a customer to control, measure, and adjust—in real time—how the various services use the call-by-call trunk groups, without requiring network intervention.

To improve their telemarketing centers' operation, many customers have used the calling-party number information (i.e., SID/ANI) that AT&T's Megacom 800 service provides over the ISDN-PRI network egress. (SID is the *station identification*, and ANI is the *automatic number identification.*) SID/ANI applications have produced major productivity gains, reduced recurring costs, and speeded up customer service. (See Harvey, Hogan, and Payseur in this issue for details.[16]) In addition, PRI networking between two Definity-system call centers can be used to provide intelligent sharing of the traffic load (termed *look-ahead interflow*) to increase their efficiency.

To facilitate data connectivity, the Definity communications system supports the established Accunet switched digital and switched digital international services, as well as the new SDDN capability recently made available to users of the AT&T network. SDDN and a PRI network interface give the Definity communications system an *autorestoration* capability; i.e., it can automatically restore any disruption in connectivity within a rigorously defined time period.

Other applications for the use of the rich ISDN signaling are emerging. For example, user-to-user information now may be sent between Definity communications systems as part of call setup and call tear-down messages. Today, the Definity system sends the calling- and called-party name information in the user-to-user information element of the call setup messages. Other applications will emerge. An effort to define standards is proceeding that will make possible the transfer of user-to-user information at any time during a call. When such signaling becomes available over the public switched ISDN, the feature transparency now available with DCS out-of-band signaling over private lines could be migrated to the public network. As a result, customers will be able to build virtual, value-added networks that eliminate the need for dedicated, private-line facilities.

In the future, the most important feature of a networking application platform based on the Definity communications system may be the adjunct-switch application interface. ASAI—an open, ISDN and OSI-based interface that is available to the industry—provides a two-way dialog between the Definity communications system's call-processing software and a computer's application software. In addition, ASAI defines a set of building blocks that can be used to provide functional integration of telephony and data services for applications. The first wave of ASAI applications will focus on telemarketing, in-bound and out-bound call management, and security. But in the future, ASAI will be the enabler of an increasing number of other value-added networking applications in Definity-system corporate networks. In this issue, the paper by Foard, Spindel, and Verma describes[13] this interface and its applications.

Conclusions

Corporate networking has come a long way since the first Dimension PBX, stored-program, ETN switches were deployed 12 years ago. The digital technology for both switching and transmission has provided a solid basis for today's intelligent networks. AT&T continues to be in the forefront of intelligent, corporate networking, with virtual private networks, the Distributed Communications System, and ISDN. Today, the AT&T solution to intelligent, corporate networking provides a rich set of capabilities and an excellent application platform to meet customer needs in the future. Bandwidth on demand and networked, ASAI-like functionality will be the keys to the evolution of value-added application networks.

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