INTELLIGENT NETWORK DIRECTIONS

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The main emphasis of the global products issue of the *AT&T Technical Journal* on intelligent networking is on the directions, platforms, and technologies needed to support the graceful introduction of intelligent networks (INs) by public switched telephone network (PSTN) providers. This paper introduces the objectives, principles, and attributes of IN, and offers a "roadmap" to AT&T's future IN architecture planning. The key attributes of IN architecture are service-independence, compatibility and synergy with existing networks, flexibility, and distributed intelligence. These qualities make it ideal for future network needs. We describe a scenario for an intelligent network built on standards, customer needs, and our experience with earlier versions of IN.

Introduction

The development of stored program control (SPC) switches in the 1960s made it possible to introduce many new and sophisticated telecommunications services that have benefited both users and public switched telecommunications network (PSTN) providers. The introduction of out-of-band signaling techniques, now embodied in the Signaling System No. 7 (SS7) and the Integrated Services Digital Network (ISDN), expanded the geographical coverage of these services from switch-based to regional, and eventually worldwide. At the same time, continued evolution in the services and management areas led to more sophisticated services for the user. Combining these major advances in telecommunications has spawned a new type of service-providing network, known as the intelligent network (IN).

The IN separates the functions necessary for call switching from those needed for applications and services. This separation has allowed platform capabilities to be introduced that permit the PSTN provider to build new services. Figure 1 illustrates such a platform, composed of three layers. The bottom layer represents the access signaling the network element uses to communicate with other network elements. The middle layer represents the core functions provided by the network element. The top layer represents the service independent building blocks. A service can be made up of a unique combination of such building blocks, and communicates with the network element through application signaling. This architectural innovation is converting today's monolithic network architecture into a service-independent, capabilities-based platform.

AT&T has built and offered IN products and services since 1967. The digitization of the AT&T network and the introduction of common-channel signaling via the 4ESS™ switch in 1970s paved the way for IN networking. The introduction of the DSDC (direct service dialing capability) in the early 1980s allowed AT&T's Network Services Division (NSD) to offer new services. The direct service dialing capability also led to many network products, including databases such as the network control point (NCP), intelligent peripherals (IP) such as the network services complex (NSCX), and services management systems (SMS) to introduce and manage many IN-based services.

The PSTN providers [e.g., local exchange carriers: LECs in the U. S., British Telecom in the U. K., SIP (Società Italiana per l'Esercizio delle Telecomunicazione, P.A.) in Italy, Telefónica in Spain] are deploying or planning their own IN-based services. Dialed number services (e.g., 800 or Freephone service) are characterized by their ubiquitous access and use of a dialed number to signify a special service. Virtual business group services [for example, private virtual network (PVN) and multi-location business group (MBG) services] are based on establishing a virtual business group within the PSTN. They aim to offer business customers feature-transparent operation for their private network features. Billing and account services (e.g., alternate billing services based on line information database (LIDB) applications and calling card services) establish alternate billing for calls. Personal mobility services (e.g., Personal Number Service or Follow Me service) enable a caller to reach service subscribers even if they are traveling. Televoting services use IN to count the calls made to a specific number. Terminating services [e.g., local area signaling services (LASS)] are based on incoming call information, and are designed to provide call-related information, improved screening, and call routing to the users. Origination-based services (e.g., area wide calling service) use the calling party's number to decide the routing of the call.

Panel 1. Terms and Acronyms in This Paper

AIN	advanced intelligent network
AOL	application oriented language
ASP	advanced services platform
BRI	basic rate interface
CCITT	International Telegraph and Telephone Consultative Committee
CPE	customer premises equipment
CS1	Capability Set 1
DDSN	digital derived services network
DSDC	direct service dialing capability
ETSI	European Telecommunications Standards Institute
IN	intelligent network
IP	intelligent peripherals
ISDN	Integrated Services Digital Network
LASS	local area signaling services
LEC	local exchange carrier
LIDB	line information data base
MBG	multi-location business group
NAP	network access point
NCP	network control point
NSCX	network services complex
NSD	Network Services Division (AT&T)
OAM&P	Operations, Administration, Maintenance, and Provisioning
OS	operations system
PBX	private branch exchange
POTS	plain old telephone service
PRI	primary-rate interface
PSTN	public switched telephone network
PVN	private virtual network
SCE	service creation environment
SCN	service circuit node
SCP	service control point
SIP	Società Italiana per l'Esercizio delle Telecomunicazione, P.A.
SMS	services management systems
SPC	stored program control
SSP	service switching point

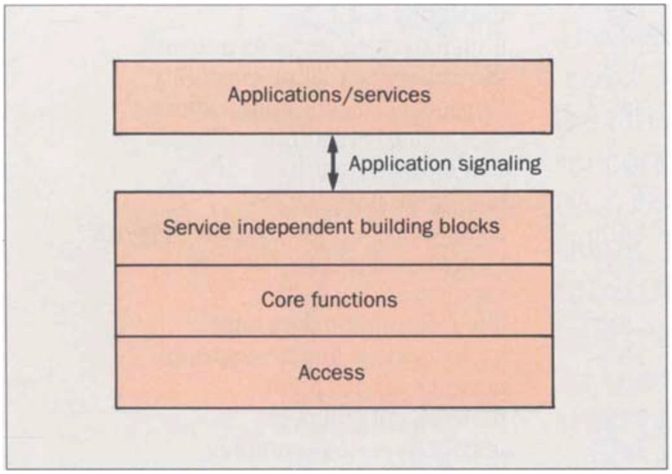

Figure 1. A model of an intelligent network platform, showing layers of access signaling, network element core functions, and service independent building blocks. Applications and services, represented by the top box, communicate with the network elements via application signaling.

The LECs have deployed 800, line information database, and LASS services. They are starting to deploy their second generation of IN, known as Advanced intelligent network (AIN) Release 0. Ameritech[1] and Bell South[2] have announced plans to deploy their AIN Release 0 using the AT&T's A-I-Net Advanced Services Platform (ASP)[3] that provides dialed number, origination-based, private virtual network, Follow Me, and many other services. In the U.S., AT&T has been the first to offer products to introduce IN gracefully in the LEC networks. Bell Communications Research (Bellcore) is currently working with the LECs and telecommunications vendors, including AT&T, to develop the next generation IN for the U. S., known as AIN Release 1.[4]

British Telecom has implemented the digital derived services network (DDSN) using the AT&T international intelligent network.[5] Here too, AT&T has been the first to offer IN products to a PSTN provider outside the U. S. The DDSN went into operation in 1986 with a switch-based basic Freephone service. Its capabilities were enhanced in 1989 with the introduction of advanced Freephone service. In Spain, Telefónica will be introducing an intelligent network in late 1991.[6] Again, this network is implemented on the AT&T international IN, providing advanced Freephone service, calling card service, personal number service, and televoting service. SIP will introduce an IN in its Italian network in 1992.[7,8] This IN is also implemented on the AT&T International IN, offering advanced Freephone service, premium charge service, televoting service, virtual private network (similar to the private virtual network in the U.S.) service, and single destination routing service.

This issue of the *AT&T Technical Journal* is timely because the global interest in IN is growing rapidly. Its emphasis is on directions, platforms, and the underlying technologies needed to support the introduction of IN by PSTN providers. It will cover global IN architecture directions, experiences, and implementations around the world; service logic creation technologies for rapid service creation and deployment; opportunities for new network elements in the IN; strategies for IN operations, administration, maintenance, and provisioning (OAM&P); and the IN direction for evolving toward a service-ready infrastructure for the 1990s and beyond.

Driving Forces for IN

Telecommunications users of the 1990s are becoming more sophisticated in their needs. Today's residential customers are eager to use the network's intelligence for their benefit. For example, they would like to use the network to screen calls, restrict their children's use of the phone for "adult" or party line services, and even store messages. The rapid advances in personal computers, customer premises equipment (CPE), and private branch exchange (PBX) equipment have led to user expectations that the PSTN also should evolve at the same swift pace and rapidly introduce many new customized services.

Today's businesses see the PSTN as a competitive marketing tool. Users would like to increase their business efficiency by using the power of information movement and management the PSTN offers. In today's world, many businesses may not have face-to-face contact with their customers. Therefore, they would like to present a good image to those customers over the networks. They may also want to provide a personal service to their clients: e.g., having customers' accounts ready on the agent screen even before the agent answers the customer's call. Therefore, these businesses want many new services—or customized existing services—to meet their special needs.

At the same time, business users would also like to control their costs by taking advantage of the efficiency provided by the network. Many customers are demanding private virtual networking capabilities that allow them to use the PSTN and reap the benefits of a private network without having to maintain it.

From the perspective of the PSTN provider, the motivation for IN is user satisfaction. This will allow PSTN providers to eventually achieve their primary goal: increased revenue generation from their networks. The PSTN providers would like to introduce services rapidly to meet customer needs. The stored program control switches— such as the 1ESS™ and 1A ESS™ switches introduced in the 1960s, the 4ESS™ switch introduced in the 1970s, and the 5ESS® switch introduced in the 1980s—allowed the PSTN providers to introduce many new services. With the addition of service-independent capabilities in these switches, and with the service creation capabilities of new products, the PSTN providers will continue to offer many new services more rapidly.

As users demand customized services, the PSTN provider wants to be able to provide them by manipulating customer-specific data in the network. This manipulation capability allow the PSTN provider to tailor services on the basis of customer needs.

IN Objectives and Attributes

Although the concept of IN is not new, the definition of what constitutes one is still evolving. The industry is driving toward the following objectives in defining IN:

- The PSTN provider wants capabilities that enable rapid service introduction, service creation, and service customization.
- The PSTN provider wants to use products from multiple vendors to build its networks.
- The PSTN provider has a substantial investment in the network to provide a rich set of telecommunications features and services. It is a good strategy to evolve existing network technologies. Thus, the IN architecture should be compatible with the existing network architecture.
- Future networks will be introduced in a series of progressive network changes, leading to a target architecture. IN architecture should be a part of these progressive steps. The capabilities of IN must be enhanced as new technologies emerge.

These objectives, together with the driving forces for IN, lead us to formulate a set of attributes of IN to define a robust, evolvable IN architecture:

- A *service-independent, capabilities-based architecture* is needed so the PSTN provider can add new services quickly and easily. This architecture uses service-independent building blocks that can be sequenced flexibly to create new or customized services.
- The *flexible distribution of service logic and service-supporting functions* to various network elements allows the PSTN provider to choose an IN architecture that matches its network topology. Thus, the individual network elements can be upgraded easily without disrupting other services.
- *User-friendly, flexible service creation functions* give the PSTN provider the tools to create new services or customize existing services based on user requirements.
- An *open architecture* with a set of *standard interfaces* promotes a multi-vendor environment.
- New IN-based services must coexist with existing switch features. The potential interworking between switch-based and IN-based services will lead to a rich set of enhanced capabilities that will be competitive with the capabilities provided in PBXs and customer premises equipment.

AT&T's IN Direction

There are many driving forces for IN introduction. Nevertheless, starting with a full set of IN capabilities supporting all the attributes mentioned above may not be practical or cost-effective. The capabilities a PSTN provider must implement should be those its customers have requested. For example, U. S. LECs are currently implementing their second generation intelligent network, AIN Release 0. They are also working with Bellcore to define the technical capabilities necessary for the next phases (Release 0.1 and Release 1) of AIN architectures. This phased approach permits the graceful introduction of key IN technologies and allows the PSTN provider to reap its immediate benefits. It also paves the way for future introduction of innovative IN technologies. To define a standard set of capabilities for IN, PSTN providers and telecommunication vendors are working actively in the standards bodies such as the International Telegraph and Telephone Consultative Committee (CCITT) and the European Telecommunications Standards Institute (ETSI) to define a first set of standard IN capabilities known as Capability Set 1 (CS1). Having a standard CS1 for IN will pave way for a worldwide deployment of IN.

AT&T's Current IN Implementation. The diversity of customers' service requirements dictates the need for different IN implementations. To a large extent, AT&T's IN architecture supports different market needs using the same set of IN capabilities. As IN-based services have evolved, the architecture has correspondingly evolved.

The first network-wide intelligent service supported in the network was 800 or Freephone service. At first, it was provided in the toll exchanges; intelligence resided in the switching software. As the need increased for more intelligence in the network, maintaining a distributed architecture and supporting many of these capabilities became increasingly difficult. In 1982, the architecture evolved to position a centralized network control point to provide centralized access to customer data.[9,10] In 1984, as part of the direct service dialing capability architecture, a second type of network control point was deployed to move towards service-independent logic and flexible service-independent capabilities at the network control point.

Introducing service-independent capabilities caused the architecture to assume a more centralized function. It also allowed a greater level of service programming power. The direct service dialing capability was the first application using the IN concepts, and can truly be considered the forerunner of today's IN. It was the first example of service-independent capabilities that could be reused across multiple services (e.g., 800 and private virtual network), and provide some level of customer programming capability.

In 1986, industry users focused on another IN architecture geared to support 800 and private virtual network services similar to AT&T's 1982 architecture but at a local end office level. In 1987, AT&T's IN architecture expanded to support international applications. A key requirement for international IN deployment was that it be introduced into the network without any major disruption to existing network elements. An overlay architecture is ideally suited to this application because it can be introduced with minimal effect on the existing network.

Figure 2 illustrates AT&T's IN architecture. Based on the specific customer needs, the PSTN provider may choose to deploy a subset of this architecture. The architecture is the foundation for the future growth of IN. Switching functions are separate from the service-supporting and service logic functions, i.e., digit collection and announcements, and how service should work. These separate functions can then be distributed to many physical network elements. Future architectural developments will allow greater flexibility in distributing these functions.

The current IN architecture has the following elements:

- *Service switching point (SSP).* The major function of the SSP is to detect events—called *triggers*—that indicated an IN call. After this triggering, the service switching point suspends call processing and starts a

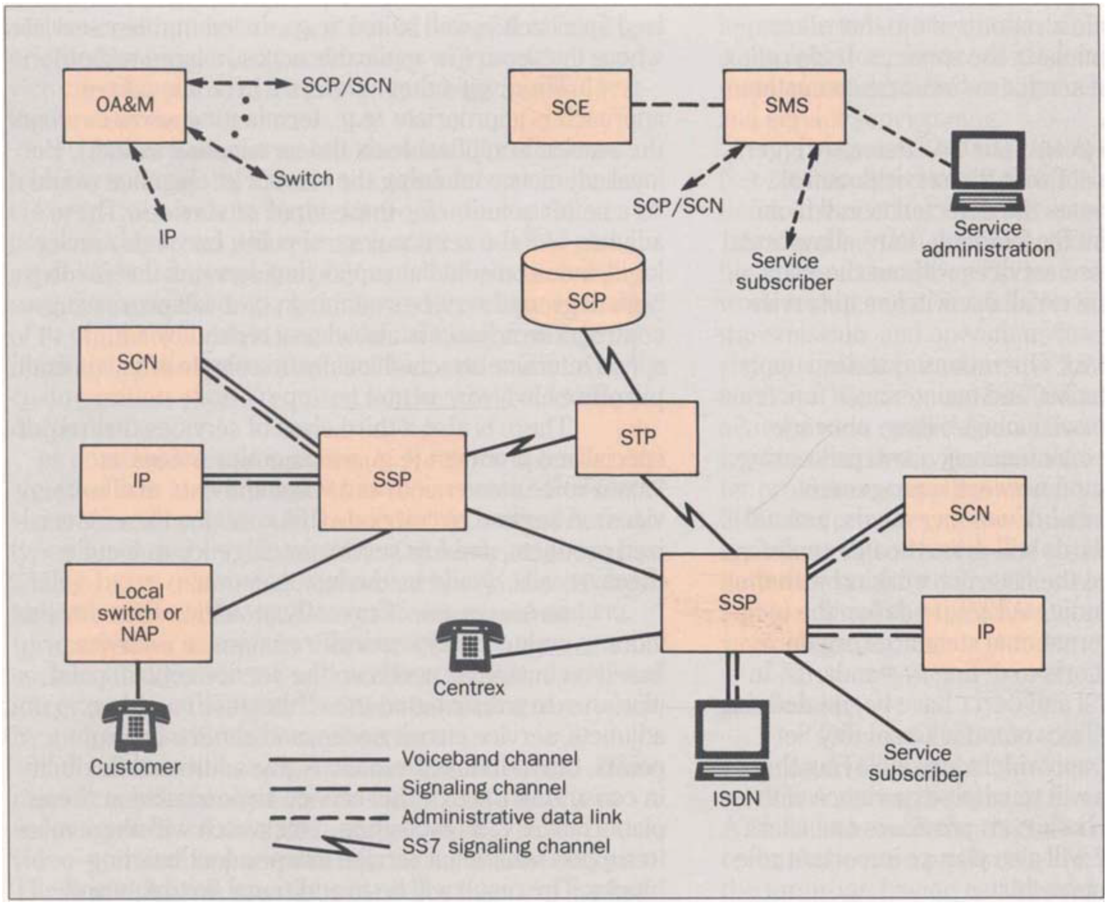

Figure 2. The architecture of the intelligent network as currently applied in AT&T.

series of transactions with the *service control point* to determine the final handling of the call.

- *Service control point (SCP)*: The service control point is a real-time database system that, based on a query from the service switching point, performs subscriber- or application-specific service logic, and then sends back instructions to the service switching point on how to continue call processing.
- *Intelligent peripheral (IP)*: IPs provide service assistance functions such as announcements, post-dialing digit collection, and speech recognition.
- *Service circuit node (SCN)*: The service circuit node is a programmable network node that allows the PSTN provider to create new circuits-related services involving voiceband information synthesis, interpretation, repetition, or translation.
- *Service creation environment (SCE)*: The SCE is a service creation system that allows the PSTN provider to create new services or customize existing services.
- *Service management system (SMS)*: The SMS is a

provisioning and administration system that allows PSTN providers to administer the services. It also allow the PSTN provider and service subscribers to customize IN-based services.

- *Network Access Point (NAP)*: The NAP detects triggers but cannot communicate with the service control point. Therefore, it routes the detected IN call to an service switching point for handling. NAPs allow broad access to many IN-based services without the PSTN provider having to convert all its switches to service switching points.
- *Operations systems (OSs)*: Operations systems supply operations, administration, and maintenance functions that include service provisioning, billing, network maintenance, service maintenance, alarm processing, traffic measurement, and network management.

IN Evolution Direction. Customer needs, technology advances, and standards will drive the IN's evolution. In the U. S., Bellcore and the LECs are working with the vendor community, including AT&T, to define the technical evolution of IN. International standards organizations have also begun efforts to define IN standards. In Europe, for example, ETSI and CCITT have begun defining the functions and capabilities of IN for Capability Set 1. And as noted, many PSTN providers are deploying the initial IN architecture. This will transmit experience with the IN-based services to both PSTN providers and users. This early IN experience will also play an important role in the evolution direction for IN.

AT&T's Evolution Direction. AT&T views the evolution of IN according to seven main themes:

Distributed IN architecture. The service logic, for maximum flexibility in rapid service introduction, will be distributed to more network elements. For performance reasons, the switch-based services will continue to play an important role. The present IN architecture advocates a central database architecture using the service control point containing the service logic. Future intelligence distribution in the network will depend on both network and service topology. There are services for which a centralized approach is well suited (e.g., dialed-number services where the service is applicable across a large region).

There are other services where a localized approach is appropriate (e.g., terminating services where the service is applicable on the terminating switch). But local adjuncts containing the service intelligence would be a better solution for these types of services. The adjunct, like the service control point, executes service logic, but is targeted at supporting services that involve a high degree of service switching point call processing control. The adjunct is also characterized by a high-speed interface attached locally to a single office or multiple offices in a wire center.

There is also a third class of services that require specialized products (e.g., messaging services such as FAX-to-voice conversion, and voice and data mailbox services). A service circuit node that contains these specialized products, and has service intelligence to handle these IN calls, would be the best solution.

Service creation. Currently, IN allows the PSTN provider to create a new service or customize a service based on customer needs on the service control point platform. In a distributed IN architecture involving adjuncts, service circuit nodes, and service control points, the switch will evolve to give additional flexibility in consulting the external service logic located at these platforms for call disposition. The switch will also evolve to support additional service-independent building blocks. The result will be in additional flexibility and capabilities for service creation. The services residing in the adjuncts, service circuit nodes, and service control points can be created either by vendors, service providers, or enhanced service providers. Thus, the trend in telecommunication networks is towards converting the network from its independent monolithic stored program control switches to a platform. As a result, there will be many opportunities to create new and innovative services. The service programmers who create these new services can write new services without knowing the underlying implementation-specific details. A separate service creation environment based on application-oriented language (AOL) technology will provide a service creation platform for creating, debugging, and testing new services.

Global intelligent network platforms. The current trend is to design IN to meet the needs of specific markets or PSTN providers. In the future, as the capabilities of IN grow, this trend will reverse toward providing global capabilities using a global platform. Globalization will save future marketing, planning, and development costs of IN products and services by broadening coverage, maximizing the reuse of applications, and minimizing the customization efforts required for the worldwide introduction of IN.

Network access architecture. Network access signifies how a user connects to the network. The services offered by IN should be accessible from all access types supported by the network. Currently, IN supports analog [POTS (plain old telephone service)] access and, to some extent, ISDN BRI (basic rate interface) and PRI (primary-rate) access. As other access arrangements such as broadband ISDN and wireless are introduced and integrated into the PSTN, these access arrangements will be integrated with the IN architecture.

Information movement and management support. While most IN applications discussed today relate mostly to voice services, other traffic—e.g., data, image, and video—present opportunities for new IN-based services. These information management and movement applications differ from voice applications in their call processing requirements. However, the fundamental IN concepts of separating application and service functions from the switching functions are still relevant.

Operations. A service-independent IN architecture will require changes and enhancements to established ways of performing the OAM&P functions in the network. A truly service-independent network will also require service independence for its OAM&P functions; otherwise, the service introduction and provisioning bottleneck may easily shift from the PSTN to the OAM&P network. IN will impact the OAM&P in the areas of network security, data administration, service testing and verification, measurement, network traffic management, service maintenance, and service provisioning.

Progress toward long-term IN architecture. The Service Net-2000 architecture is AT&T Network Systems' solution to the need for a service-based infrastructure for the 1990s and beyond. Its product architecture allows flexible deployment options to be built on the present network architecture. Service Net-2000 integrates switching, transmission, and operations functionalities for a consistent, unified infrastructure for rapidly introducing new services. The Service Net-2000 architectural platform allows a wide range of services and applications including broadband services and information services, and faster provisioning and restoration services. Service Net-2000 also provides a powerful and customizable network environment so PSTN providers and their customers can define and rapidly deliver new services and applications, and to control and use OAM&P resources within the network elements.

Conclusion

This introduction to the *AT&T Technical Journal* issue on AT&T's global products for the intelligent network has shown the driving forces and attributes of IN. AT&T has been in the forefront of offering innovative IN technologies and products. AT&T will continue to be in the forefront, having established an architecture based on Service Net-2000 to allow a service-based infrastructure for the 1990s and beyond.

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References

1. Ameritech, "Ameritech Intelligent Network Release 0 Architecture Overview," *AM SR-OAT-000019*, Issue 1, Arlington Heights,

Illinois, July 1989.
2. "AT&T Unveils AIN Line," *Telephony*, Vol. 220, No. 11, March 18, 1991, p. 9.
3. M. Efros, D. Frech, K. Krusinski, and E. G. Sable "Switching and Network Capabilities to Support 1991 Intelligent Networks," *Proceedings of 1989 National Communications Forum*, National Communications Forum, Chicago, Illinois, October 1989, pp. 291-298.
4. Bell Communications Research, "Advanced Intelligent Network Release 1 Network and Operations Plan," *Special Report SR-NPL-001623*, Issue 1, Morristown, New Jersey, June 1990.
5. G. J. Roberts, "The Digital Derived Services Network," *British Telecommunications Engineering*, Vol. 6, July 1987, pp. 105-119.
6. Rafael de Sadaba, "Redes Inteligentes: Un Concepto de Red Avanzado para el Desarrollo y Provision de Servicios de Telecomunicacion," TELECO '91, Jornadas Tecnicas, Libro de Resumenes, Mayo 1991.
7. J. Williamson, "Europe Moves on Intelligent Nets," *Telephony*, Vol. 219, No. 12, September 10, 1990, pp. 20-22.
8. P. Bagnoli, E. Cancer, and E. Guarene, "The Introduction of The Intelligent Network In Italy—A Strategic Objective and Challenge for the 90's," *Proceedings of the 13th International Switching Symposium*, Stockholm, Sweden, May 27-June 1, 1990, Conference Proceeding Vol. IV, pp. 155-160.
9. S. Horing, J. Z. Menard, R. E. Stachler, and B. J. Yokelson, "Stored Program Controlled Network: Overview," *Bell System Technical Journal*, Vol. 61, No. 7, Part 3, September 1982, pp. 1579-1588.
10. J. J. Lawser, R. E. LeCronier, and R. L. Simms, "Stored Program Controlled Network: Generic Network Plan," *Bell System Technical Journal*, Vol. 61, No. 7, Part 3, September 1982, pp. 1589-1598.

Biographies (continued)

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