THE EVOLUTION OF GLOBAL INTELLIGENT NETWORK ARCHITECTURE

George Y. Wyatt, Alvin Barshefsky, Robert V. Epley, Marc P. Kaplan, and Krish P. Krishnan

Alvin Barshefsky, Robert V. Epley, Marc P. Kaplan, Krish P. Krishnan, *and* ***George Y. Wyatt*** *are with AT&T Bell Laboratories. Mr. Barshefsky is a supervisor in the International Systems Development Department. For the past four years, he has been responsible for developing and testing features in support of intelligent networks in the United Kingdom and in Spain. He joined AT&T in 1970, after receiving a B.S. in engineering physics from the University of Illinois at Urbana. In 1974, he received an M.S.I.E. in operations research from Lehigh University, Bethlehem, Pennsylvania. Mr. Epley is a member of technical staff in the Core Evolution Platform Management Department at AT&T Bell Laboratories in Naperville, Illinois. He helps evolve the software architecture of the 5ESS® switch and has worked extensively on* (continued on page 25)

AT&T's global intelligent network architecture (GINA) describes the process that will set the direction to support basic features and architectures for a global intelligent network (IN) in AT&T Network Systems. An IN contains network elements that enable service logic, data, and service resources to be distributed in the network. GINA bridges the gap between today's network offerings and future platform IN offerings for AT&T Network Systems products worldwide. This paper describes the IN architecture we are striving to achieve and the underlying technology needed to realize it on a global scale.

Introduction

The goal of AT&T's global intelligent network architecture (GINA) is to support AT&T's global market needs for intelligent network (IN)-based solutions using a core set of capabilities and a common architectural platform. (See Panel 1 for definitions of abbreviations, acronyms, and terms.) To save future marketing, planning, and development costs incurred during globalization, AT&T Network Systems is broadening requirements, reusing software, and minimizing customization of AT&T's IN products that are available for worldwide sales. As a secondary goal, AT&T and customers can use the IN platform to introduce new services rapidly to different market segments.

Current INs allow human/machine interactions to add value to the processing and completion of a telephone call. We can tailor this programmed intelligence to satisfy subscribers' needs as they occur. Potentially, the network's added intelligence can generate substantial revenues for the telecommunications administration [international telecommunications network providers (PTTs) and domestic local exchange carriers (LECs)] if callers and subscribers to the services perceive that the network adds value to the call. We can broaden the definition of an IN to encompass not just voice, but other types of public and private networks and information, to add network-wide intelligence to the completion of information transfers. Because an IN reuses network capabilities in a service-independent way, new network services can be introduced rapidly.

In this paper, we describe emerging IN concepts and the evolution of IN architecture from its inception to its role today. We describe the infrastructure required to support these emerging concepts and address how they are being realized in AT&T's global IN platform. There is no question, however, that we must temper any evolution toward a global architecture with timely, cost-effective recognition of the changing needs of the marketplace.

Panel 1. Abbreviations, Acronyms, and Terms

ANSI/T1S1	American National Standards Institute/Telecommunications and Signaling Technical Committee
CCITT	International Telegraph and Telephone Consultative Committee
CM	call model
ECSA	Exchange Carrier Standards Association
EIA	Electronic Industries Association
ETSI	European Telecommunications Standards Institute
FE	functional entity
GINA	global intelligent network architecture
GSM	Groupe Special Mobile
INCM	intelligent network conceptual model
ISDN	Integrated Services Digital Network
LEC	local exchange carrier
LTA	long-term architecture
NMS	network management system
OA&M	operations, administration, and maintenance
PCS	personal communications services
PE	physical entity
PIC	point in call
PSTN	public switched-telephone network
PTT	Posts, Telecommunications et Telediffusion (France); international telecommunications network providers.
RBOC	regional Bell operating company
SIB	service-independent building block
SPC	stored program control
SS7	Signaling System 7; a signaling protocol used by Bellcore and the LECs that follows Bellcore technical requirements and ANSI standards
TIA/IS-41	Telecommunications Industry Association/Interim Standards-41
UIS	Universal Information Services

Emerging IN Concepts

The IN concept is well suited to support the emerging telecommunications trends toward a wide range of new services. Although they differ in appearance to service subscribers (who subscribe to an IN service) and end users (typically, a caller to a service subscriber), these new services share a common set of functions, i.e., the architectural concept of the IN meets the needs of these service trends.

The IN concept is an extension of, rather than a replacement for, traditional service control. Since an IN primarily affects only the internal service processing of switching systems, it should have little influence on the signaling procedures of a traditional network. Therefore, we can place intelligent nodes in existing networks without affecting traditional network operations or capabilities.

IN-based services often need the capabilities of more than one network. Most often, these networks are characterized by a distributed architecture (where network functions are distributed in the network rather than being centralized at a single node) that contains functional entities (FEs), each of which is a collection of distinct actions. Functional entities (see Appendix A) can span many types of conceptual telecommunications networks (see Figure 1):

- *Basic telecommunications network.* Commonly known as the public switched-telephone network (PSTN), this network controls basic telecommunications services (for example, local and transit/toll switching, voice and data calls) offered to a user. It detects whether control of a call should be transferred to the IN.
- *Intelligent network.* This network manages intelligent telecommunications services offered to a user. It includes specialized telecommunications functions, such as customized announcements, voice recognition, encryption, and network resource assignments.

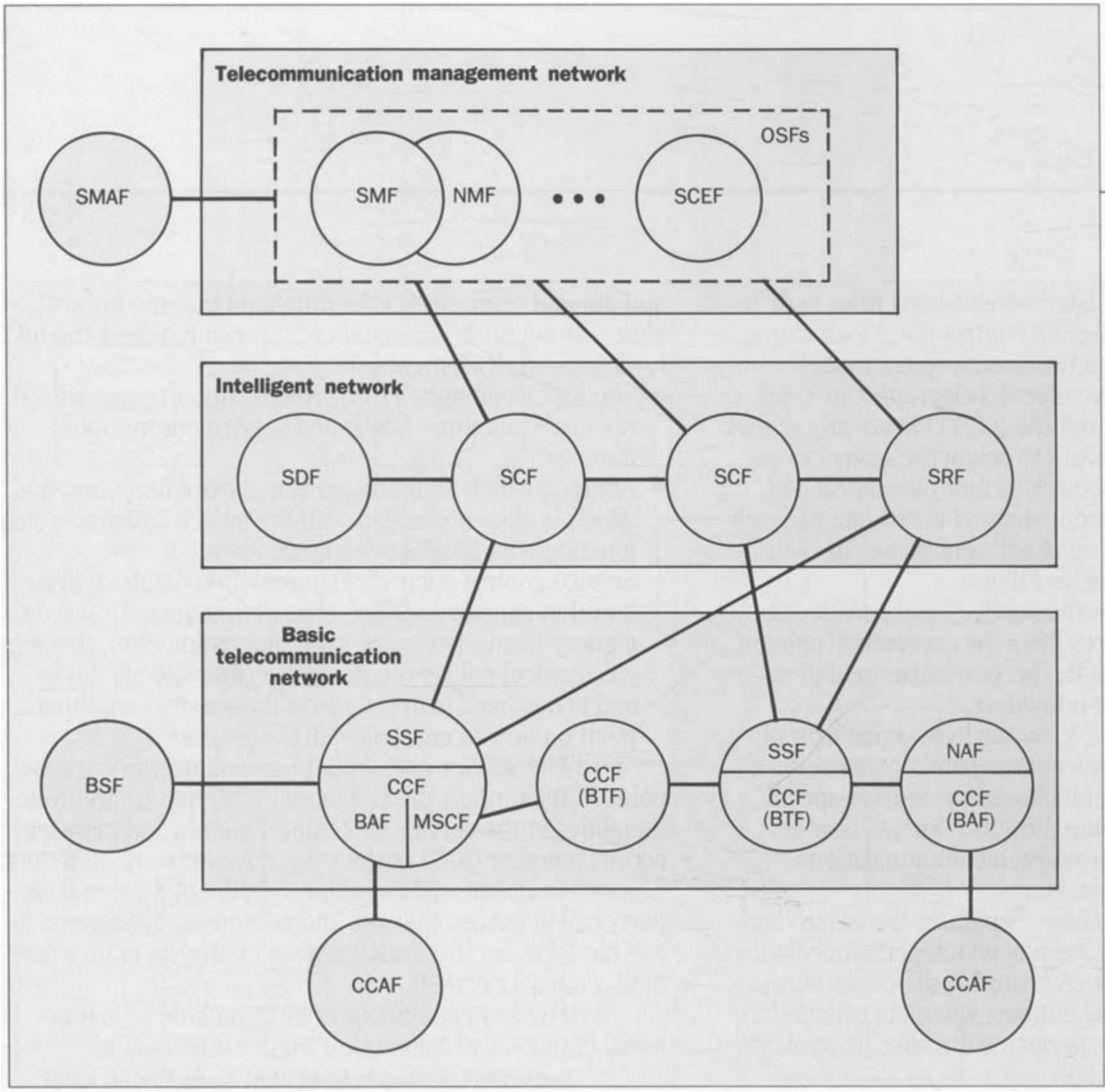

Figure 1. This example shows network-related functions required for IN architecture. The basic telecommunications network detects if control of a call should be transferred to the IN, which provides specialized telecommunications functions. The telecommunications management network controls support for basic telecommunications network and IN functions.

- *Telecommunications management network.* At present, this network controls telecommunications support for basic telecommunications network and IN functions. In the future, this will include functions such as service creation, service provisioning, service deployment, and service management.

To a large extent, the interdependence of network parts is primarily a function of the services provided. Services can be centralized or distributed. However, the degree to which intelligence can be distributed in the network depends on the existing capabilities of the elements in the PSTN.

The reasons for centralizing the elements are:

- To deploy new service logic flexibly without requiring software updates in all switching systems
- To store and manage customer-dependent data in one area, which precludes the need to distribute and to store it at each exchange.

The degree of centralization may vary, depending on service characteristics and the type of network. For example, service logic may be centralized at the local, regional, or national level. Depending on the network architecture, the service logic may be distributed, while the customer data may remain centralized; or, the customer data and its related service logic may be distributed to local stored program control (SPC) exchanges.

The intelligent network conceptual model (INCM) used by the International Telegraph and Telephone Consultative Committee (CCITT) is not an architecture, but rather a framework to relate the many IN concepts to each other. It comprises four planes, each of which represents a different abstract view of an IN. Each plane, and the relationship of adjacent planes to each other, is briefly described as follows:

- *Service Plane.* Defines the services and service features provided by the IN from the customers' point of view. This plane hides the service implementation, i.e., how the service is put into effect.
- *Global Function Plane.* Views an IN as a platform of service-independent network capabilities, or service-independent building blocks (SIBs). Service-specific logic is used to combine the SIBs to create new services unique to a particular telecommunications administration or customer.
- *Distributed Function Plane.* Separates the IN into logical functional entities, each of which performs distinct actions in the network. A grouping of actions across one or more functional entities, when coordinated by communication flows, performs the specific network capabilities of a given SIB.
- *Physical Plane.* Comprises the physical entities (PEs), i.e., the physical hardware to support the functions (for example, service control point, service circuit node) of an IN and the protocol required for communication among them. Each physical entity consists of one or more functional entities.

Reference 1 describes the CCITT conceptual model in detail. As we will show, AT&T's vision of the intelligent network conceptual model corresponds closely to the CCITT model.

Core Global Platform Capabilities. A global IN architecture requires key fundamental capabilities, as identified in the intelligent network conceptual model. These key capabilities can reside in different network elements and depend primarily on the functions that the network elements support. For instance, SIBs can reside at the following network elements:

- Service circuit node (SCN), which supports specialized resource functions (SRFs) and service control functions (SCFs).
- Adjunct, which supports service control functions, and which is closely coupled with the switch call-processing functions over high-speed links.
- Service control point (SCP), a real-time database system that supports service control functions. Based on a query from the service switching point (SSP), the service control point executes subscriber-specific logic and sends back instructions to the service switching point on how to continue call processing.

The service switching point and network access point (NAP) support the call model (CM) and trigger functionalities in the service switching function and network access function (NAF) of the respective network elements. The *call model* describes call processing of a general two-party call in terms of events and responses. A *trigger* is a call model event that satisfies a set of criteria (e.g., a particular number dialed).

The key capabilities of an IN include SIBs, functional entities, and call model/trigger functionalities.

Service-independent building blocks. A SIB can exist independently, or it can coexist with other SIBs in the same network element. IN-based services can be distinguished from one another by the sequence of SIB functions and by the specific parameters within each SIB.

For the global platform, a complete set of SIBs must be defined to support current, and possibly future, IN services. This activity has already begun at AT&T. We may need additional SIBs to support personal communications services (PCS), as well as other emerging services of interest to all service providers. Standards bodies (i.e., CCITT, ETSI, and ANSI/T1S1) are currently in the process of defining SIBs.

Functional entities. The conceptual architecture provides sufficient detail to define the scope of the IN-

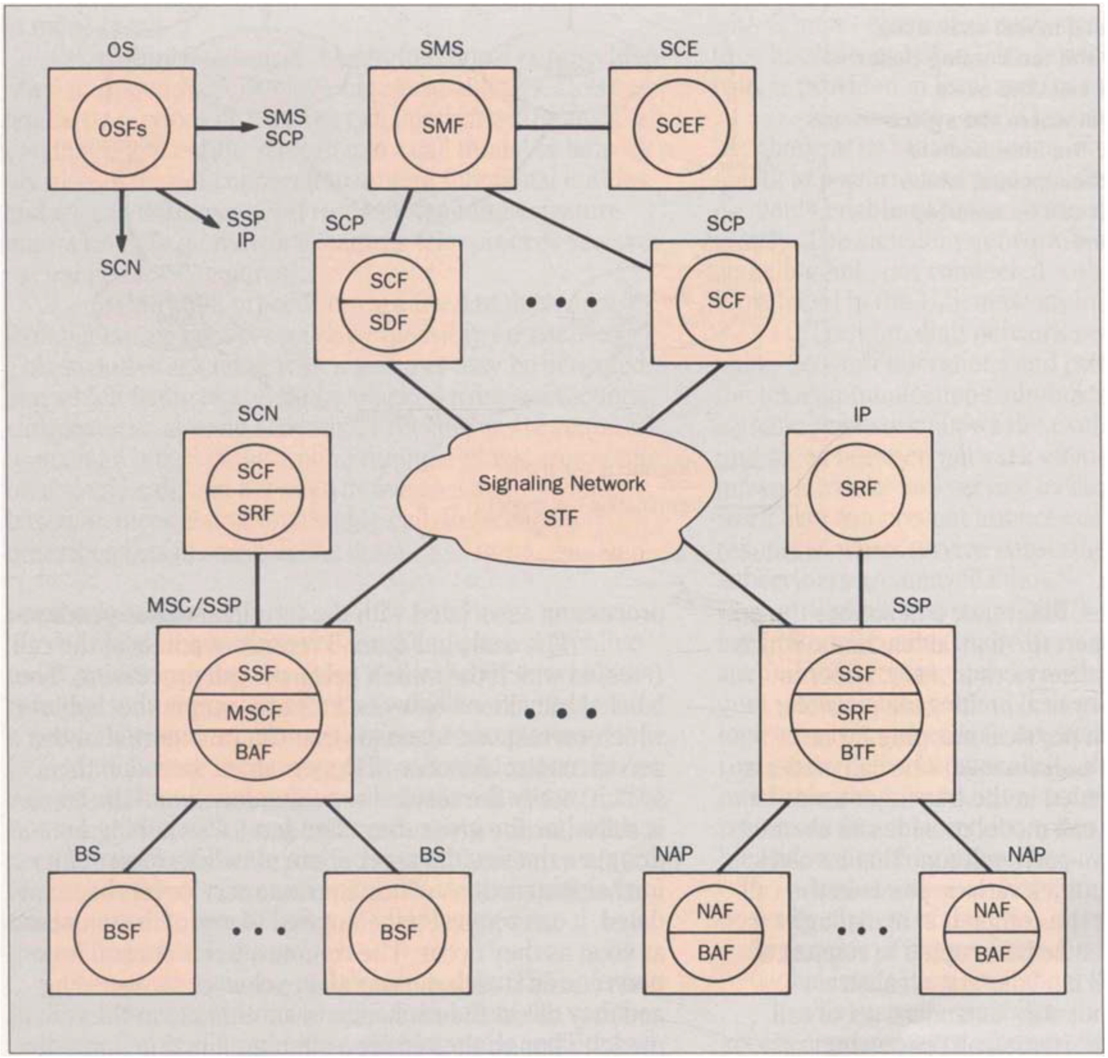

Figure 2. Physical mapping of the functions for an IN. This figure shows how network functions can be grouped in a physical entity. For example, we can package the service resource function in a service switching point, service circuit node, or intelligent peripheral, based on network traffic or customer demands. Similarly, the service control function can reside in the service control point, service circuit node, or the service switching point. Since each function is unique, it can be grouped with other functions to satisfy the telecommunications administration, service provider, and/or subscriber needs. The signaling network performs the signaling transfer function.

based service functions. The logical architecture shown in Figure 1 is an abstract representation of the functions that will contain IN capabilities.

Messages exchanged between different functional entities direct SIBs in the service logic programs to process IN-based service. Service logic programs are IN-based services tailored to the needs of a service subscriber or the telecommunications administration.

The physical architecture defines the physical entities in the network and the external interfaces required

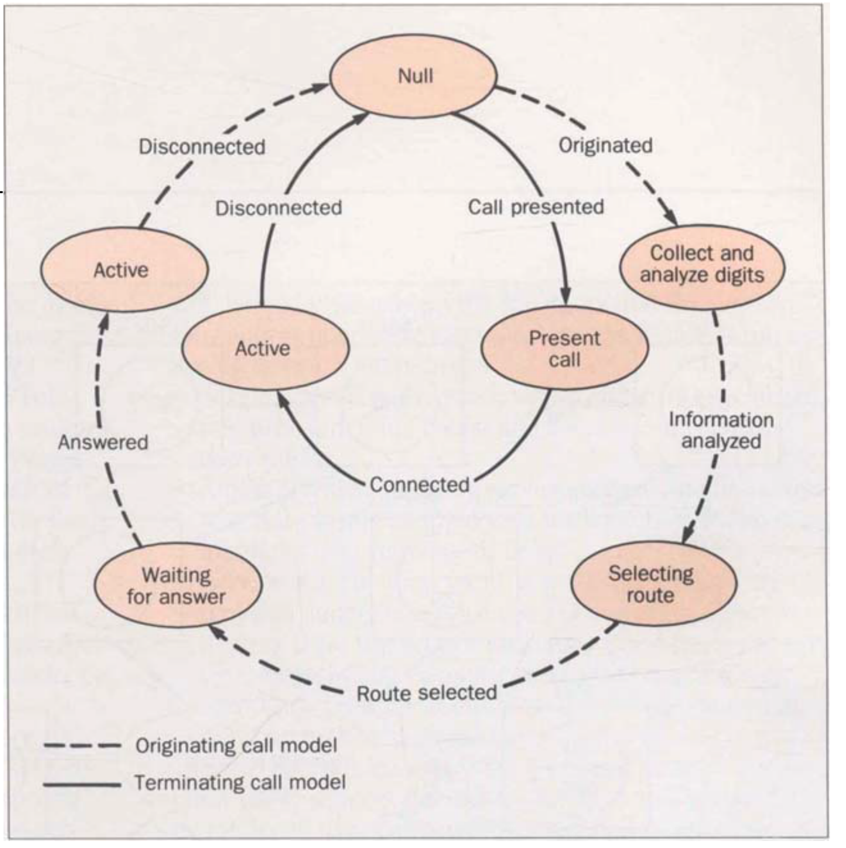

Figure 3. This typical IN call model shows the originating (outer circle) and terminating (inner circle) halves of a typical call. The ovals represent points in the call where the switch performs call processing. The intermediate labels represent trigger checkpoints, which correspond to events that can be reported to the service control function.

to support the IN services. Reference 2 describes the network elements that support the logical functions, which in turn provide intelligent services in an IN. Different mappings of logical to physical entities are possible; Figure 2 shows one such physical mapping for an IN.

Call model/trigger functionalities. The call model is another key element needed in the transition toward a global platform. A basic call model provides an abstract switch view of a basic two-party call (one that involves no IN processing). It identifies various points in the call (e.g., at origination or at the completion of dialing) where call processing can be interrupted to request IN processing. Because call models vary, an abstract representation helps to identify a standard set of call model trigger checkpoints for IN call processing.

Figure 3 shows the originating and terminating halves of a call in a typical call model. We can add or delete points in the call model to enhance its basic capability. The originating half of the call model reflects the switch processing associated with the originating party's view of a basic call, and the terminating half reflects the processing associated with the terminating party's view.

The ovals in Figure 3 represent points in the call (PICs) at which the switch performs call processing. The labeled transitions between PICs are trigger checkpoints, which correspond to events that can be reported to the service control function. Trigger tables, stored in the switch, notify the service switching function if the trigger is active for the given user. The service switching function then queries the appropriate network element for further instructions. Once a remote service has been initiated, it can request to be notified of any of these events as soon as they occur. The remote service control function returns SIBs that direct the exchange's processing and may direct the exchange to another PIC in the call model. Though the service switching function normally stimulates the service control function, the service control function can itself initiate a service, such as a wake-up service.

The service switching point must support the call model and trigger functionality to give users access to IN-based services. Reference 3 describes call models in more detail.

Feature Interaction. The IN functional entities identified in Appendix A display unique capabilities. However, typical IN services or features can interact with more than one functional entity. We can use a call model to help identify likely areas of cooperation among functional entities, and we can define general rules that minimize feature interactions (e.g., network features take precedence over exchange-based features).

Arbitration procedures are used to determine which features take precedence (possibly for each user). This includes selecting which features may be activated and which features should be blocked from interactions with features already activated. Procedures are required to manage interactions among multiple IN features acting on a single call, and between IN features and exchange-based features acting on a single call. Reference 3 describes this in some detail.

IN Infrastructure

As we have observed, exchange-based architectures are converging toward a "centralized" IN architecture that contains more efficient, effective controls over a network's services. The centralized IN architecture is being influenced, in turn, by new concepts and attributes emerging from various standards bodies (i.e., CCITT, ETSI, ECSA, and ANSI/T1S1) and other industry forums. In this section, we describe the underlying technologies required to support the conceptual model. These technologies are fundamental to provisioning and deploying next-generation, IN-based services.

Service Switching Point Functionality. The software in switches separates basic call control from the service control of an IN. The service switching point requires a call model and trigger tables. In addition, we will need new platform capabilities to communicate with external entities (e.g., service logic in service control point, service circuit node, or adjunct) or internal entities (service logic that resides within the service switching point). The service switching points must also communicate with other IN elements, using standard IN protocols, as they become available. The service switching point typically is provided in local and/or transit exchanges.

Signaling Network. The signaling network is the backbone of IN-based services. The signaling network's ability to perform message switching between network elements enables it to use network resources more efficiently. The signaling network, which uses a separate signaling link, not connected with voice traffic, was first introduced in the U.S. network in 1976.

The signaling network performs functions essential to network operations and provides many benefits for the telecommunications administration. For example, the signaling network allows the exchange of information messages between network elements without tying up network trunks and service facilities. A signaling network also can prevent unnecessary tie-ups of network resources when service subscribers are busy or paths to subscribers are unavailable.

Signaling system 7 (SS7), a specific type of signaling protocol, carries many types of information elements, such as calling-party number, which are useful for intelligent service management. For example, if the service logic receives the caller's origination information, it can route automotive repair calls to the nearest auto mechanic shop. In addition, access to some network resources (such as service control points) is only possible with a signaling network.

Network Access. Network access serves two purposes in support of the IN:
- Separation of access from service
- Global interaction among networks.

To make IN capabilities available to all types of access arrangements, we must develop service management independently of the access arrangements. This separation of service management from network access would allow the same network-wide, IN capabilities to serve a variety of access arrangements, from analog lines to wireless, and, in the future, to broadband and other high-speed optical links.

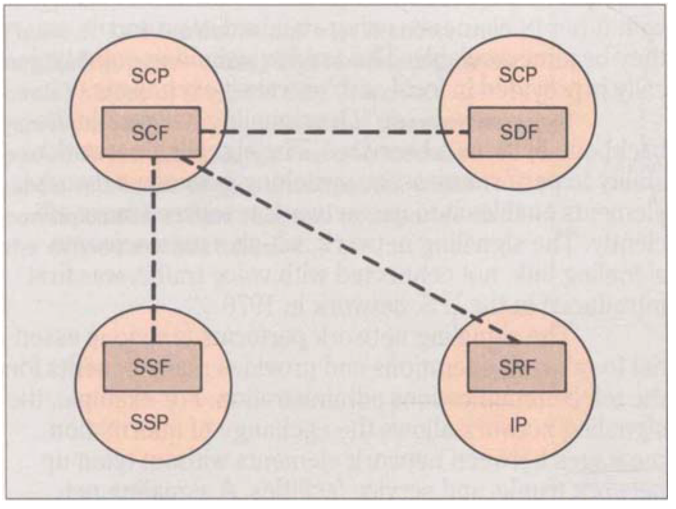

Figure 4. The functional IN interfaces demonstrate key relationships between IN functions. For example, the service control function logically accesses the service data function to obtain customer information. The customer's service data function can reside either in the same service control point or in a different service control point.

As IN-based services proliferate, connectivity to multiple networks can become a significant bottleneck. Different networks will have to work together to support IN-based services. For example, a global IN platform would need to work with both domestic and international versions of the Integrated Services Digital Network (ISDN), as well as with wire-line and wireless networks.

Functional Interfaces. To support the emerging IN concepts, we also need to support standard interfaces in a multivendor environment, which are already present in many networks. Existing exchanges must be able to access all IN capabilities in their network. Although no standards currently exist for an IN, they eventually must support the following functional interfaces (refer to Figure 4):

- *SCF to SSF.* To execute service logic containing SIBs that have been created by telecommunications administrations and service subscribers. AT&T has taken the lead in defining SIBs for its current and planned service offerings and is currently offering these SIBs to LEC and international customers. These SIBs embody the capabilities currently under consideration by the standards bodies.
- *SCF to SRF.* To provide specialized resource functions, as dictated by the logic in the service control function.
- *SCF to service data function (SDF).* To access customer data while the service logic is executing within the service control function.

Standards bodies are currently addressing other interfaces not shown in Figure 4, such as those between the service control function and service management function (SMF), or service creation environment function (SCEF) and service management function.

From Concepts to Reality

AT&T's IN implementation[3-5] uses network elements currently being defined by standards bodies, including the service switching point, service control point, signal transfer point (STP), and service management system (SMS). Some of these network elements can share a common platform for IN-based services. Intelligent peripherals (IPs) and network access points (NAPs) will be required to support future service capabilities for all markets. Although it performs the same functions, the operations support system (OSS) uses different network elements in the domestic and international markets.

Figure 5 shows how the global IN may look in the future. Many of the conceptual capabilities described in Appendix A readily fit into the global IN architecture. AT&T's IN architecture contains several new network elements, including the service circuit node, adjunct, and service creation environment. A service circuit node, which combines the functionality of an intelligent peripheral and a service control point, provides several benefits to the telecommunications administration: support of local network and exchange needs, trial of new services, and reduced deployment cost. The target architecture will continue to evolve to meet AT&T's strategic objectives and, as standards and customers' needs dictate, to

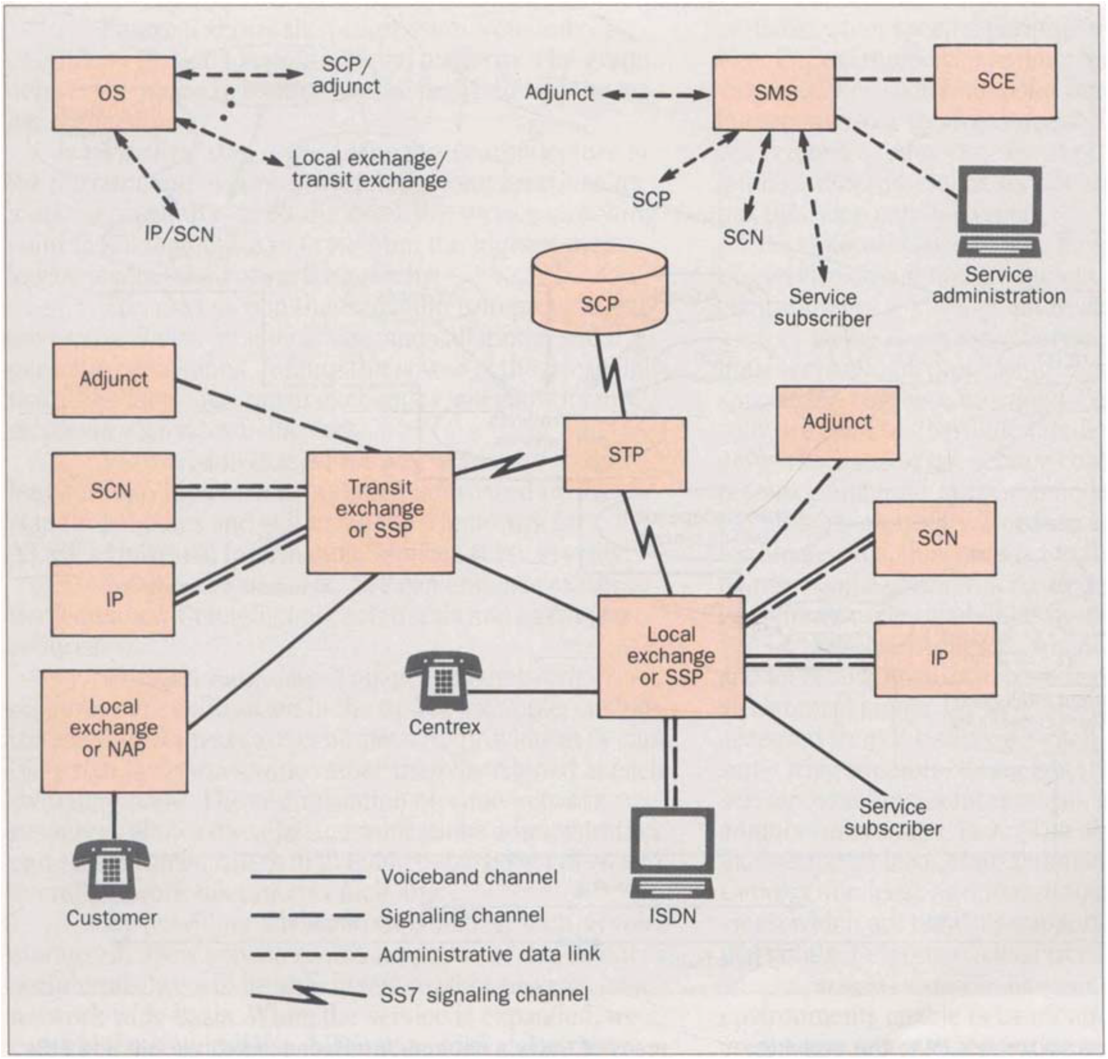

Figure 5. A projection of how the global intelligent network architecture may look in the future. Based on the needs of the telecommunications administration, service providers, and subscribers, service circuit nodes and adjuncts are added to support the global intelligent network architecture. The service circuit node integrates the functions of the service control point and the intelligent peripheral, whereas an adjunct provides local service control point functions. These new network elements will support local customer service needs.

add new capabilities.

Customers' needs are shaping the evolution of IN architecture. As always, the primary objective of the network provider is to minimize obsolescence of existing network resources, while maximizing revenue potential. We can achieve this goal by adding new services, increasing architectural flexibility, and addressing customers' needs by:

- Maintaining existing IN products and capabilities
- Introducing new capabilities without making existing products obsolete
- Introducing new products to generate new revenue.

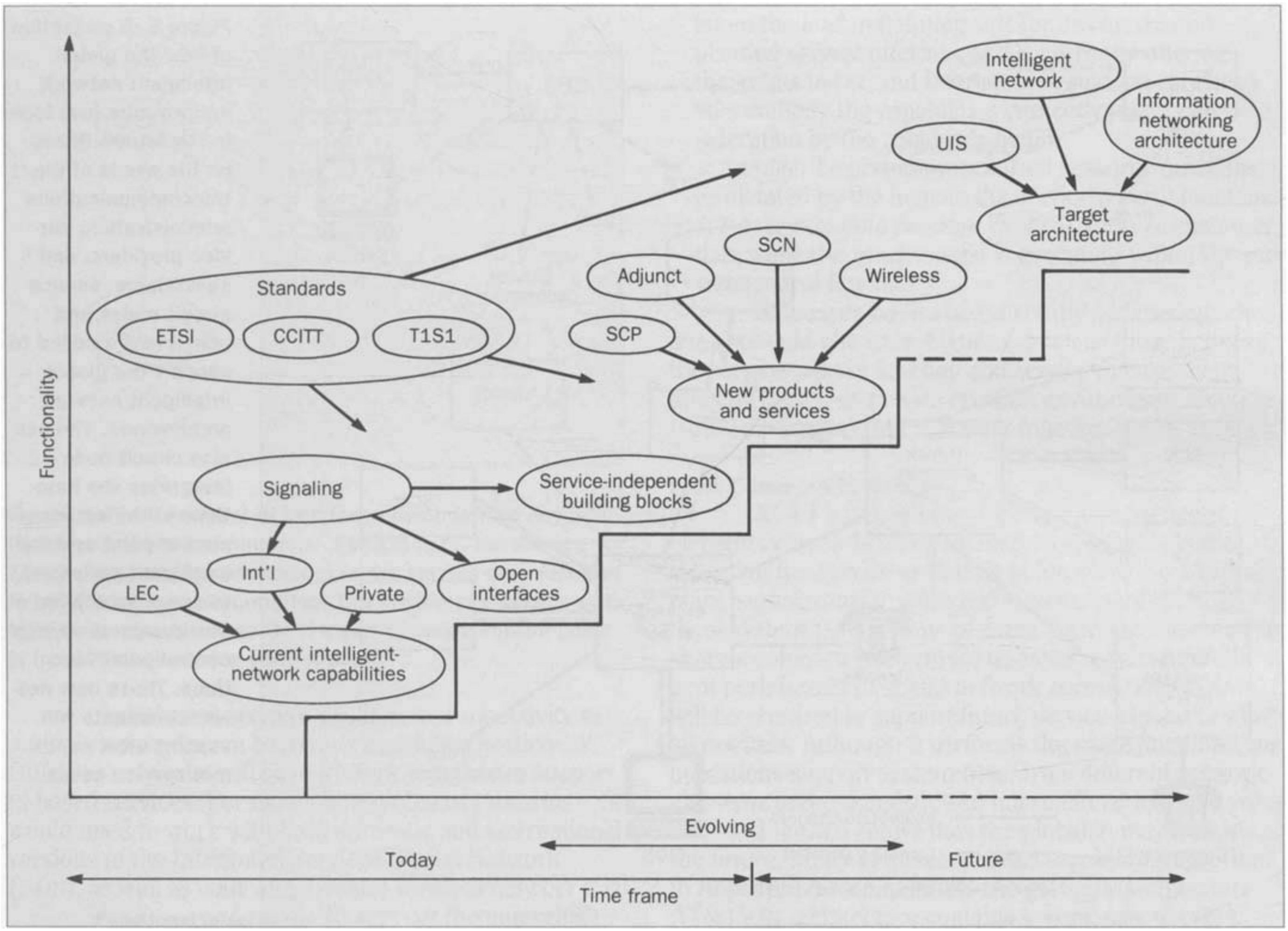

Figure 6. The progression from today's IN to the evolving global platform. Major milestones define the path to the target architecture. This progression begins with the current IN capabilities of the Regional Bell Operating Companies (RBOCs) and some of the PTT networks. We will standardize many of today's network interfaces. Next, we will add SIBs, and call model and trigger table capabilities. We envision that AT&T's IN will evolve to the long-term architecture being created in the standards bodies, and will make AT&T's UIS architecture a reality.

Figure 6 shows the progression from today's IN implementation towards a global platform. The graph depicts the major milestones in the realization of the target architecture.

The first step towards the target architecture is the introduction of service switching point functionality in the network. Based on the PSTN, the service switching point functionality can migrate from the highest to the lowest level of the network hierarchy.

The next step in the transition is to provide platform capabilities, including SIBs, and call model and trigger table capabilities. Adding the power of these capabilities at the local and transit exchanges will allow us to create new services using SIBs.

We envision that AT&T's IN will evolve to the long-term architecture (LTA) being addressed by the standards bodies and will make the framework for AT&T's Universal Information Services (UIS) a reality.

Enhanced IN Elements. We can enhance existing IN elements with intelligent peripherals and assist procedures.

Intelligent peripherals. Today, some network resources are centralized in the IN. For example, customized announcements are centralized to provide an IN capability that is network-wide rather than distributed at each switching node. The centralization of some network resources allows the telecommunications administration and service subscribers to manage IN-based services and overall network operations efficiently.

By providing advanced capabilities, such as voice storage, in a few service switching points or intelligent peripherals, we will be able to test market services on a network-wide basis. When the service is expanded, we can add the required capabilities to additional nodes.

Assist procedures. An assist procedure enables the service logic to access resources residing in other nodes of the network. If a node requires a specific service capability, assist procedures can locate and use the capability at another network node.

The assist procedure also makes service available when specific peripherals are busy or out of service. For example, if an announcement unit is out of service, a service switching point may return an error code in response to a service request. The service logic then can request a temporary assist procedure from another intelligent peripheral or service switching point that also has the same announcement.

New IN Elements. The new IN elements include the service circuit node, adjuncts, and service creation environments.

Service circuit node. Service circuit nodes provide both service logic processing and call terminations for specialized resource functions. Service circuit nodes typically are used to distribute intelligence throughout the network. Some of the service control and specialized resource functions are combined to provide the service circuit node capability. Because service circuit nodes can terminate calls, they connect to the service switching points using ISDN interfaces. Reference 6 describes service circuit node capabilities more fully.

Adjuncts. Adjuncts, which contain service logic and local customer data, have capabilities similar to service control points, but at a local level. Adjuncts are accessed from the service switching points through the same trigger points. Using a high-speed data link, the service switching point requests instructions from the adjuncts in message form. The adjuncts would most likely support local, transaction-intensive services (e.g., Centrex services) as opposed to network-routing services, which are typically supported by the service control points. Reference 3 describes the adjuncts.

Service creation environment. Service creation environments enable network and service providers to create new revenue-generating services that are independent of equipment vendors' deployment schedules. Many administrations are asking vendors of IN equipment to provide them with service creation environment capabilities. This is also true of large service subscribers, who prefer to control the operation of their IN-based services.

In the current service creation environment,

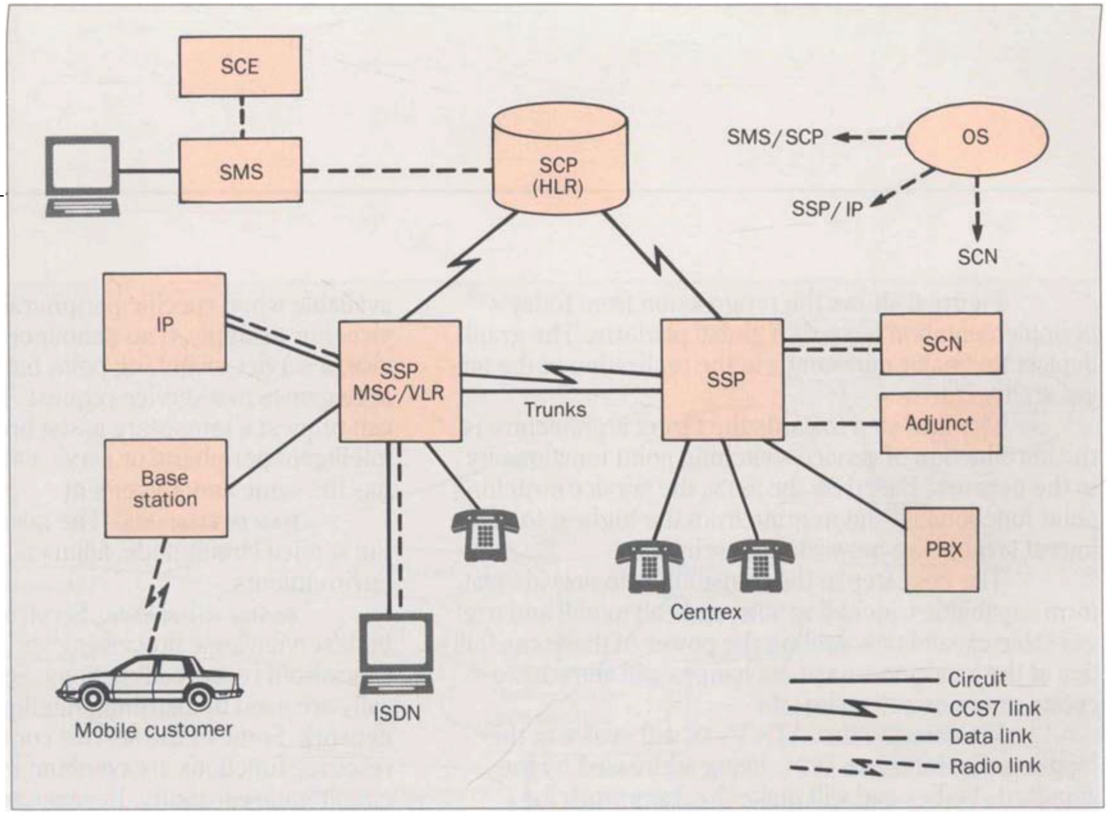

Figure 7. PCS application supported by an IN. The service control point maintains the home location register, while the local exchange, serving as a service switching point, maintains the mobile switching center and visitor location register. Using wireless or wire-line terminals, subscribers have access to the IN and personal communications services.

service subscribers can control services using existing capabilities or modifying parameters within these capabilities. Current service creation environments are user friendly and support updates of service control points and service circuit nodes. The next generation of service creation environment also will support updates of intelligent peripherals and adjuncts. Because SIBs are being defined for the IN, it is now possible to develop a service creation environment platform to support new services and direct them to appropriate physical entities.

Any new service creation environment capability must be user friendly. In addition, it must provide extensive validations for new IN-based services so they do not have an adverse effect on the overall operation of the network or the subscribers' services. Further, service creation environments must be able to address operations, administration, and maintenance (OA&M) and provisioning needs for each new service. Application-oriented languages (decision graphs, finite-state-machine programming models) are currently being investigated to address the complex task of designing a robust service creation environment that is easy to learn and use to create new services. Reference 7 describes additional details of the service creation environment capabilities.

Extending the Platform. The Personal Communications Network, which provides users with wireless access, has been defined by Groupe Special Mobile (GSM) in ETSI and by TIA/IS-41 in EIA/TIA in the United States. Trials of this network are being conducted throughout Europe and the United States.

The GSM architecture consists of a home location register (HLR), the equipment identification register (EIR), and the authentication center (AUC), all of which can be maintained at a central node in the network. The central node's master file contains the wireless customers' records. Local records for wireless customers are maintained at the visitor location register (VLR). The VLR information can be located in the mobile switching center (MSC), or in the adjunct.

As Figure 7 shows, mobility services, also called personal communications services, have strong synergies with the evolving IN architecture. An IN control structure offers a robust platform to support PCS applications.[8] Many of the conceptual model requirements for the IN apply to PCS. Integrating PCS services on an IN platform potentially reduces an administration's operations, maintenance, and training costs. In addition, we can provide many new revenue services for PCS using IN service features.

From an architectural perspective, we can view wireless access as a technology (such as ISDN or broadband ISDN) that service subscribers can use to access the network. This network can be fully integrated with local exchanges or provided as an overlay architecture.

The IN can flexibly separate call and connection control from the underlying access infrastructure. As such, an IN platform also can support PCS applications. From a network entity viewpoint, the network access function is conceptually similar to a base station system in the mobile communications world. The service switching functionality could be implemented in a mobile switching center, allowing that center to interact with service control residing in other network elements (e.g., the home location register that resides in the service control point and the visitor location register that resides in adjuncts).

Future Directions

The term "intelligent network" was coined less than four years ago. By using service-independent platform capabilities, we are making tremendous strides toward bringing that concept to reality. Even activities in international standards bodies (i.e., CCITT, ETSI) are accelerating the formalization of IN recommendations. CCITT is also beginning to address the integration of the IN-based applications to support ISDN, wireless, PCS, and universal personal telecommunications. We also expect the IN to play a major role in broadband ISDN applications.

Future directions include a distributed architecture using the service-independent platform capabilities of the IN. This platform should allow us to introduce emerging technologies and applications transparently into the network. Beyond that, network providers, service providers, and service subscribers want these products to produce as much revenue as possible. To this end, the objective of all IN vendors is to provide a flexible, low-priced, evolvable set of network elements using standard or open interfaces that can satisfy service providers' and subscribers' needs.

Acknowledgment

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Appendix A. Global Functional Entities

- *Call control function (CCF).* The CCFs described in the CCITT model perform the following functions:
  - *Basic access functions (BAFs).* These are the local exchange capabilities. The local exchange primarily supports user network signaling and can access basic telecommunications services using the basic transit functions.
  - *Basic transit functions (BTFs).* The primary function of the transit exchange, which contains BTFs, is to support basic telecommunications services requested by a basic access function.
  - *Mobile switching center function (MSCF).* The MSCF efficiently controls and manages the base station for mobile applications. It communicates with basic access functions and/or basic transit functions to perform switching-related functions. It will communicate with the service switching function for service control functions.
- *Call control agent function (CCAF).* The CCAF allows users to access the local exchange and controls a call while it is being established, connected, and cleared (e.g., regular telephones, ISDN terminals).
- *Network access function (NAF).* The NAF detects the need for service control function involvement and forwards the call to an entity with service switching function to gain access to service control function. This functionality can be added to basic access functions without service switching function capability. The NAF detects most kinds of triggers, informs the service switching function of the existence of these triggers, and forwards call control to the service switching function. NAFs give widespread access to IN-based services, although they perform fewer functions than the service switching function.
- *Service switching function (SSF).* The SSF can detect the need for service control function involvement (triggering) and respond to call-processing requests by the service control function. These capabilities can be used by basic freephone, advanced freephone, calling card, personal number, and televoting services, to name a few. The SSF is an addition to the basic access function and basic transit function to provide for IN operation.
- *Specialized resource function (SRF).* The SRF provides specialized telecommunications capabilities, such as DTMF digit collection, specialized announcements, and voice recognition.
- *Service control function (SCF).* The SCF can take over call control temporarily from the service switching function and can control elementary telecommunications functions in the basic access function, basic transit function, and specialized resource function from a remote location.
- *Service data function (SDF).* SDF handles access to both service-related and network data and checks data consistency.
- *Signaling transfer function (STF).* STF routes signaling messages to appropriate network elements based on global title translation (GTT) capabilities and subsystem numbers (SSNs) associated with the messages.
- *Base station function (BSF).* Base stations play a passive role from a call control viewpoint. They perform the tasks associated with establishing and managing the connection between the mobile station and the "wired" path to the service switching point.
- *Home location register (HLR).* The HLR, which is accessed by the mobile switching center to verify subscriber features, contains customer record information for all wireless subscribers.
- *Equipment identification register (EIR).* The EIR contains customer terminal identification records for all wireless subscribers. It is accessed by the mobile switching center to verify terminal authorization for subscribers.
- *Authentication center (AUC).* The AUC contains customer authorization codes for all wireless subscribers. It is accessed by the mobile switching center to verify a subscriber's security access.
- *Visitor location register (VLR).* The VLR contains

customer record information for the most recent and active wireless subscribers. It contains a copy of subscribers' home location register data and is accessed by the mobile switching center to verify subscriber features.

- *Operations support systems function (OSF)*. The OSFs are general telecommunications network management functions, in accordance with the telecommunications management network (TMN) concept of CCITT. The management of IN services belongs to the category of telecommunications network management functions. Figure 1 shows only those OSFs related to IN service management. The OSFs (service management function, service creation environment function, etc.) provide the means for service provisioning, service maintenance, service management billing, service administration, and service performance measurements. Some OSFs are:
  — *Service management access function (SMAF)*. The SMAF provides for the human-machine communications interface to the operations systems function(s).
  — *Service management function (SMF)*. The SMF is an operations support systems function that supports customer control, provisioning, testing, deployment, and management for IN-based services.
  — *Service creation environment function (SCEF)*. The SCEF enables the network operator and/or the service subscriber to create and develop new IN services.
  — *Network management function (NMF)*. NMF manages the network.

Biographies (continued)

intelligent networking, most recently concentrating on feature interactions and the switch adjunct interface. At the University of Wisconsin, in Madison, he received a B.A. in chemistry; at Indiana University, at Bloomington, he received an M.A.T. in chemistry and an M.S. in computer science. Mr. Epley joined AT&T in 1976. Mr. Kaplan is a supervisor in the Next-Generation Architecture Department at AT&T Bell Laboratories in Holmdel, New Jersey. He is responsible for developing an AT&T Intelligent Network (IN) architecture that encompasses advanced service control of premises, local exchange, interexchange, and international networking. He is an active participant in CCITT IN standardization activities. In 1971, he received a B.S. in systems engineering from the University of Illinois, Chicago, and in 1976, an M.S. in civil engineering of urban systems from Northwestern University, Chicago, Illinois. Mr. Kaplan joined AT&T in 1982. Mr. Krishnan is a supervisor in the International Intelligent Network and Personal Communications Network Department in the International Switching customer business unit. Currently, he is market manager for the United Kingdom. His previous responsibilities included managing groups that dealt with competitive analysis of switching products and billing planning for IN services. In 1969, he received a B.E. in electronics and telecommunications from Madras University, India, and in 1981, an M.S. in computer sciences from University of Pittsburgh, Pittsburgh, Pennsylvania. Mr. Krishnan joined AT&T in 1983. Mr. Wyatt is a supervisor in the Intelligent Network and Signaling Services Management Department at AT&T Bell Laboratories in Holmdel, New Jersey. He is responsible for network architecture planning for the domestic market, as well as the global platform architecture to support AT&T's IN products worldwide. He is an active participant in IN standardization activities. In 1979, he received a B.S. in computer science from Monmouth College, New Jersey, and in 1981, an M.S. in computer science from Stevens Institute of Technology, Hoboken, New Jersey. Mr. Wyatt joined AT&T in 1968.

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