INTELLIGENT NETWORK PLATFORMS IN THE U.S.

Ernest G. Russo, M. Tawfik Abdel-Moneim, Linda L. Sand, Laura J. Shaw, Patricia D. Taska, and Ronald J. Wojcik

M. Tawfik Abdel-Moneim *and* ***Patricia D. Taska*** *are supervisors in the 5ESS® Switch Software Applications Department at AT&T Bell Laboratories (Indian Hill Park) in Naperville, Illinois.* ***Laura J. Shaw*** *is a supervisor in the Intelligent Network and Signaling Services Management Department at AT&T Bell Laboratories in Holmdel, New Jersey;* ***Ernest G. Russo*** *is a member of technical staff in that department; and* ***Ronald J. Wojcik*** *was a supervisor in that department.* ***Linda L. Sand*** *supervises the Denver Field Office for AT&T Bell Laboratories in Colorado. Mr. Abdel-Moneim, supervisor of the Call Processing Applications Group, is the project manager responsible for development of 5ESS switch call processing for the field trial of U S West's Rapid Service Delivery Project/adjunct software architecture. He*
(continued on page 43)

To the local-exchange carriers (LECs), the intelligent-network concept is a strategic goal for building new services and becoming more responsive to their customers. To meet the LECs' objectives, AT&T has introduced its A-I-Net™ advanced-services-platform (ASP) products. AT&T's offering for the ASP supports the intelligent-network concept while still interworking with existing switch-based features. Thus, the LECs can maximize use of their previous investment in network-switching hardware and software while still offering new services through the ASP's distributed network intelligence. AT&T has also been working with the Regional Holding Companies and Bellcore to plan their Advanced Intelligent Network Release 1 architecture, which has been proposed as the next-generation, intelligent-network platform. Advanced Intelligent Network Release 1 makes possible an even wider variety of services than the ASP by defining a more flexible switch interface with a corresponding expansion of the communications interface between the switches and external-service-logic nodes. This paper describes the architecture, features, and services provided by AT&T's ASP as well as the new capabilities planned with Advanced Intelligent Network Release 1. We focus primarily on AT&T's 5ESS® switch features.

Introduction

The LECs see intelligent-networking products as a strategic need for building new services and becoming more responsive to their subscribers. Such products support a distributed-processing environment, which gives the LECs more flexibility in providing services. (An

Panel 1. Abbreviations, Acronyms, and Terms

adjunct — a remote processor that supports Bellcore's Advanced Intelligent Network Release 1 capability
AIN — Bellcore's or a local telecommunications company's advanced intelligent network
AMA — automatic message accounting
ANSI — American National Standards Institute
ARS — automatic route selection
ASP — A-I-Net advanced services platform
Bellcore — Bell Communications Research
BRCS — Business and Residence Custom Services
BRI — ISDN basic-rate interface
DSU — digital-services unit
feature interaction — the action of the ASP with one or more other features
intelligent network — a telecommunications-network architecture that permits distribution of service logic, data, and service-assistance functions in the network
ISDN — Integrated Services Digital Network
LASS — local-area signaling services
LEC — local-exchange carrier; a Bell operating company or independent telecommunications company that provides local service
MF — multifrequency
NAP — network-access point
OAM&P — operations, administration, maintenance, and provisioning
PBX — private-branch exchange
POTS — plain old telephone service; a call between two users that does not require features
PRI — ISDN primary-rate interface
RAF — recorded-announcement frame
Regional Holding Company — any of the seven holding companies formed as a result of the 1984 Modified Final Judgement
SCE — A-I-Net service-creation environment
SCN — A-I-Net service-circuit node
SCP — service-control point
SLEE — service-logic execution environment
SMS — A-I-Net service-management system
SQL — ANSI structured-query language, a standard database-access language
SS7 — Signaling System 7; a signaling protocol used by Bellcore and the LECs that follows Bellcore technical requirements and ANSI standards
SSP — service-switching point
STP — signal-transfer point
TCAP — transaction-capabilities application part

intelligent network's architecture enables the LEC to distribute service logic, data, and service-assistance functions throughout its telecommunications network.) At the same time, these products provide open interfaces between network elements, which supports the LECs' objective for a multivendor environment. (Panel 1 defines acronyms and terms.)

To respond to these needs, AT&T has introduced its A-I-Net advanced-services-platform products as Release 0 of Bellcore's Advanced Intelligent Network (AIN) concept. AT&T is also working with the Regional Holding Companies and Bellcore on proposals for supporting the architecture for Release 1 of Bellcore's AIN concept. AT&T's A-I-Net advanced services platform and AIN Release 1 platform are key parts of an evolving set of products that will enable the LECs to achieve their intelligent-network objectives.

AT&T's initial offering for the A-I-Net advanced services platform consists of the service-switching-point (SSP) and network-access-point (NAP) feature packages for the 5ESS switch and the NAP feature package for the 1A ESS™ switch. The advanced services platform supports the intelligent-network concept and has been integrated into the existing infrastructure of switch-based features and switch-based operations, administration, maintenance, and provisioning (OAM&P) functions. (*Provisioning* is the setup process for a switch in which parameters are initialized to operate the switch and its features.) Because of this interworking, the LECs can maximize the use of their previous investment in network-switching hardware and software, while offering new services through the centralized database interface. The advanced services platform can evolve to include more capabilities—such as service-circuit nodes (SCNs),[1] intelligent peripherals, and new switch-based features—that expand the service opportunities. (An *intelligent peripheral* provides such service-assistance functions as announcements and digit collection.)

The AIN Release 1 concept is the next-generation, intelligent-network architecture proposed by the Regional Holding Companies and Bellcore. Because AIN Release 1 expands the interface between switch call processing and an adjunct processor, it will provide opportunities for an even wider variety of services. The expanded interface permits this remote processor to control call processing at many more points in the call than allowed with the ASP feature; thus, customer-specific, line-based features are feasible. Like AT&T's ASP, the AIN Release 1 platform can interface with service-control points (SCPs) and SCNs, but it can also interface to an adjunct—an additional remote processor that supports the AIN Release 1 capability.

This paper describes the products AT&T has introduced to meet the needs of the LECs for intelligent networking—in particular, software releases for the 5ESS switch to meet Bellcore's AIN Release 0, and the work under way to evaluate products for Bellcore's AIN Release 1. We discuss the customer needs that stimulated the development of intelligent-network services. In addition, we describe AT&T's A-I-Net advanced-services-platform products and the architecture and capabilities of the switch product required for AIN Release 1.

Market Environment

What factors are motivating the LECs in their drive toward an intelligent network? As Sable and Kettler state[2] in this issue's introductory paper, these factors are:

- More control of network functionality.
- Faster feature introduction.
- The flexibility to choose which features are developed.
- An environment that supports competitive solutions from multiple vendors.

What is AT&T doing to meet the challenges of its customer needs? AT&T has introduced the A-I-Net products to support AIN Release 0 in the near term and, for the future, is working closely with the LECs and Bellcore to define their AIN Release 1 requirements.

As introductory intelligent-network products, AT&T's A-I-Net advanced-services-platform offerings on the 5ESS and 1A ESS switches are flexible platforms that permit the LECs to begin planning and deploying intelligent-network services. These products support open, standard interfaces—such as Signaling System 7 (SS7)—that other vendors can interface to competitive database products. The A-I-Net advanced-services-platform products are also backwards compatible with existing features and operations interfaces. In addition, AT&T is working closely with its customers to define enhancements that may be needed.

Bellcore's AIN Release 1 concept is viewed as the intelligent-network architecture for the future. It will give remote processors much greater control of switch call processing and, thus, is a broader platform for feature development. However, this flexibility comes with several technical and market challenges (e.g., performance, feature interaction, service opportunities). To address these challenges, AT&T is working to define field and market trials for its A-I-Net products. By carefully monitoring these trials and focusing its resources, AT&T can offer products that meet the LECs' needs.

In the sections that follow, we give an overview of AT&T's A-I-Net advanced services platform, describe the current ASP-product's capabilities on the 5ESS switch,[3] and discuss some of the design considerations in developing its features. Where appropriate, we identify the differences in the 5ESS switch's SSP with the NAP feature. We don't describe the 1A ESS switch's NAP capability here because it is the same as the 5ESS switch's NAP. For details about the other intelligent-network elements, see the paper by Wyatt et al. in this issue.[4]

AT&T's Advanced Services Platform

On the 5ESS switch, the A-I-Net advanced services platform is an enhanced set of capabilities that can provide either service-switching-point or network-access-point functionality. These capabilities, which are based on customer needs (e.g., Ameritech's requirements[5] and Bellcore's TR 402[6]), are generic, service-independent building blocks. Thus, they permit the LECs to provide a wide variety of new services by allowing the switch to interact with a centralized SCP.

Network Architecture, Release 0. The intelligent-network architecture for AIN Release 0 (Figure 1) consists of:

- The service-switching-point (i.e., SSP) feature package for the 5ESS switch (i.e., AT&T's A-I-Net advanced services platform, or ASP).
- A centralized database called a *service-control point* (i.e., the SCP).
- A signaling interface between the ASP and the SCP. This interface uses the transaction-capabilities application part (TCAP) of SS7 messages.
- The A-I-Net service-management system (i.e., the SMS) that, along with the A-I-Net service-creation environment (i.e., the SCE) described by Morgan et al.,[7] provides a user interface for the ASP SCP.

Services can be built from ASP components, SCP command scripts, and existing 5ESS switch-based features. Subscribers can be located on either an SSP or a NAP.

In a typical call scenario through the ASP architecture, a subscriber initiates a call to the network and, thus, activates the ASP feature. When the SSP detects the line or trunk seizure (depending on the type of access arrangement), it suspends call processing and launches a query through the SS7 network to the SCP. The network's signal-transfer points (STPs) will route the query to the proper SCP, according to the service to be provided. For example, the SCPs that control routing for 800-number calls provide different functionality than the ASP does.

At the SCP, the service application will locate the proper service logic and determine proper call handling. The SCP will then formulate a reply to the SSP, sending it commands to route or terminate the call, ask for additional information, play an announcement to the caller, etc. The SCP will also send billing information to the SSP.

We will describe other options for call handling later, when we present service examples.

The NAP feature package, which can be on either a 5ESS or 1A ESS switch, provides access to ASP features in switches that may not support an SS7 interface to the SCP. Thus, the NAP feature package allows greater geographic coverage without the need for direct SS7 connections to an SCP.

When the NAP detects a call that requires ASP services, it forwards the call to the SSP, which can interface with the SCP for further call handling. The SCP's typical responses are similar to those for calls that originate on the SSP. That is, it can play an announcement, collect more caller input, route the call, block the call, etc.

ASP Architecture Goals. The hierarchical, distributed-call-processing architecture of the ASP complements the overall, distributed software and hardware architecture of the 5ESS switch. The A-I-Net advanced services platform was first made available in Release 5E6 of the 5ESS switch software. Its architecture is highly integrated within the general, 5ESS switch architecture to maximize hardware and software reuse and enable useful interactions between a customer's ASP-based services and the existing feature set. This was, and still is, a

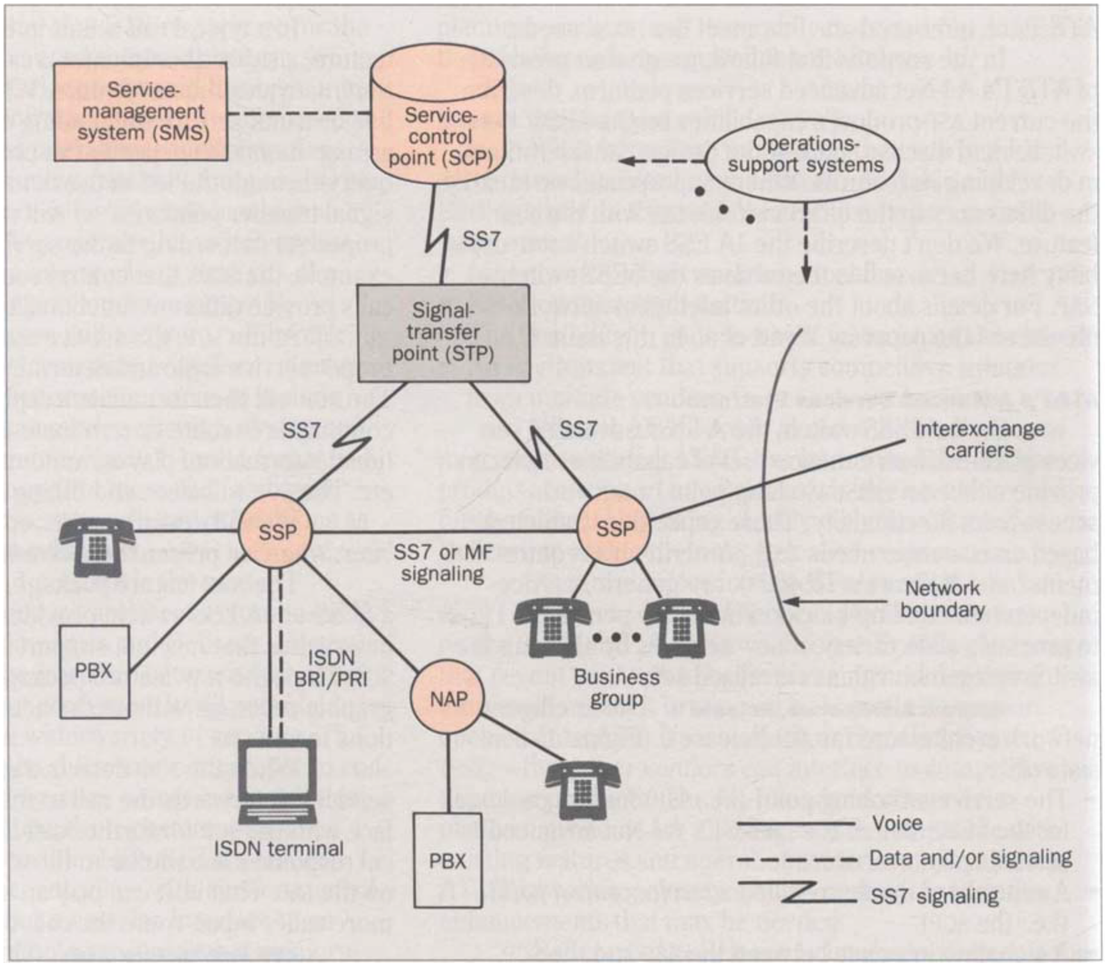


Figure 1. Architecture of AT&T's A-I-Net advanced services platform (ASP). The ASP, an enhanced set of capabilities, provides either service-switching-point (SSP) or network-access-point (NAP) functionality on the 5ESS switch. These capabilities are generic, service-independent building blocks that allow the switch to respond to commands sent from the SCP, enabling the LECs to provide a wide variety of new services.

high-priority goal for all ASP enhancements in current and future releases.

Where possible, the SSP and NAP functionality are integrated within the architecture of the 5ESS switch ASP to standardize the customer interface to different office configurations.

ASP Features. The A-I-Net advanced-services-platform features were developed as a completely integrated feature set embedded in the existing call processing of the 5ESS switch. The ASP supports most of the existing line and trunk types of the 5ESS switch, including access to ISDN basic-rate interface (BRI) trunks, SS7-interswitch trunks, and equal-access trunks. [Exceptions are coin phones; ISDN attendant trunks; and centralized, automatic-message-accounting trunks, which are used in local switching offices that don't do automatic-message-accounting (AMA) recording.]

The ASP also allows the remote SCP to interwork with most of the existing switch-based features [e.g., custom-calling services, local-area-signaling services (LASS), automatic-route selection]. For example, a customer who currently subscribes to the automatic-route-selection (ARS) feature can include routing information sent from the SCP as part of the alternate-route selections. To do this, an option in the ARS list (called an ARS trigger) allows the SSP to query the SCP and return a set of alternate routes from which the 5ESS switch can select.

Briefly, the ASP components are:

- *Triggering on an ASP call.* This refers to the ability to set conditions in switch call processing that, when satisfied, result in an SCP query. Trigger conditions may be based on the call type, dialed code, etc. (We explain triggering in more detail in the next section.)
- *SS7/TCAP signaling.* The ASP supports an SS7 interface to transmit and receive TCAP messages to an SCP. SS7 provides the backbone signaling network for intelligent networking.
- *Digit collection.* In response to commands from the SCP, the 5ESS switch can collect additional digits that a caller inputs. This is useful for services that require additional information from the caller, such as an authorization code or account code, to determine call handling.
- *Announcements.* Based on commands from the SCP, the ASP feature can provide announcements to a caller, using stored messages from the recorded-announcement frame (RAF) of the digital-services unit, model 2 (DSU-2). These can be terminating-type announcements, or part of an interactive session that uses the digit-collection capability.
- *Routing.* The ASP can receive routing information from the SCP. The routes can refer to POTS (plain old telephone service) trunks, private lines, equal-access trunks, or terminating lines.
- *Network-traffic management.* For the ASP, new network-traffic-management controls have been implemented as both manual and automatic controls (e.g., automatic call gap). These controls can be used to manage SCP and signaling overloads.
- *Termination notification.* On request from the SCP, the SSP can inform the SCP about the termination of a call (e.g., busy, answered).
- *Test queries.* This capability is provided for maintenance personnel to simplify provisioning and test network signaling. The craftsperson can initiate a test query to the SCP and set a limited number of the TCAP parameters; the SCP will send a response that can be viewed and validated.
- *OAM&P support.* The ASP feature set has been integrated into the existing OAM&P support structure of the 5ESS switch. Thus, operations-support systems that support other 5ESS switch services can also be used for ASP OAM&P.[8]
- *Billing.* For billing, the ASP supports Bellcore's enhanced AMA format at the SSP. This allows the 5ESS switch to build billing records, using information sent by the SCP. Additional billing modules can be appended to the base billing records, subject to SCP commands, thus providing the capability to construct new types of billing records without additional development. The NAP feature builds AMA records based on existing AMA formats.

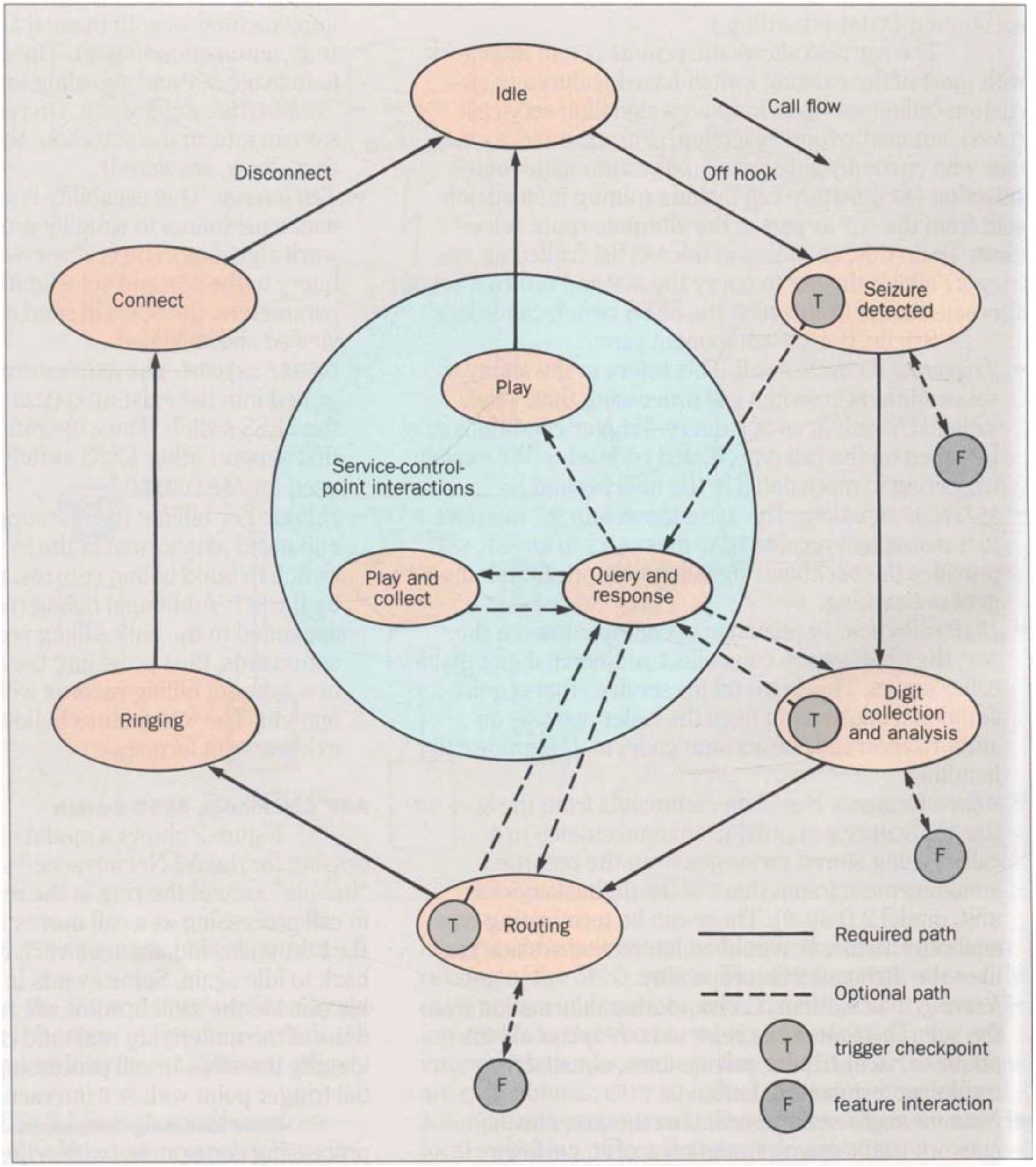
ASP Call Model, 5ESS Switch

Figure 2 shows a model of 5ESS switch call processing for the A-I-Net advanced services platform. Each "bubble" around the ring in the model represents a step in call processing as a call moves from *idle* to *off-hook* (i.e., the caller lifts the receiver), through *disconnect*, and back to idle again. Some events in the bubbles are invisible outside the switch; some are functional representations of the underlying real-time call processing. We also identify the steps in call processing that include a potential trigger point with SCP interactions.

Call-Processing Components. Several major call-processing components within the architecture for the

32

Figure 2. Call-processing states of AT&T's advanced services platform. In this model, each bubble around the outer "ring" represents a step in call processing (starting at *idle* and moving clockwise). Some of these events are invisible outside the switch; others represent the underlying real-time call processing. Some steps include a potential trigger checkpoint with SCP interactions.



5ESS switch ASP map to the call states identified in Figure 2. (By *map*, we mean the component can be represented by a call state shown in the call model.)

The originating-terminal process coordinates most of the steps through the call states, as described here. In a later section, we will describe the call-processing architecture along with the various processes in the 5ESS switch. Figure 3 illustrates the mapping to these call-model states:

- *Seizure detected*, and the associated trigger checkpoint. (The next section discusses triggers.)
- *Digit collection and analysis*, and the associated trigger checkpoint.
- *Query and response* with the SCP, which can occur multiple times.
- *Play and collect*—as commanded by the SCP—which also can occur several times in the state machine.
- *Routing*, and the associated trigger checkpoint.
- *Connect*.

In Figure 2, the feature-interaction points—which can occur multiple times—are also shown where they occur in a call. (*Feature interactions* occur because of the action of the ASP with one or more other features, and are discussed later.)

The 5ESS switch's service logic executes these states in sequence and can iterate on subsets of the states based on commands from the SCP to create services. (We will describe this shortly.)

Triggering on a Call. One of the most powerful capabilities of the advanced services platform is its support for trigger conditions in 5ESS switch call processing. Triggering occurs in both the NAP and SSP, and is the process through which the switch determines that a query must be made to the SCP.

Trigger checkpoints can be set on those call states where call processing may be interrupted and a query formed and launched to the SCP.[3] For the ASP, there are three trigger checkpoints (Figure 2): seizure detected, digit collected and analyzed, and routing. In general, triggers may be set on a per-line, per-group, or per-office basis; and, for particular trigger checkpoints, several types of triggers may be set.

Trigger types. Here, we highlight some of the triggers available with the advanced services platform:

- *Off-hook trigger*. This trigger is detected when a caller goes off-hook and can be set as either *immediate* or *delay*. Immediate-type triggers launch a query to the SCP as soon as the line seizure is detected at the switch. The delay-type trigger is also detected during line seizure, but the query to the SCP is delayed until digits are collected from the caller.
- *Dialing-plan triggers*. These triggers can be set based on the office-dialing plan; individualized-dialing plan; a dialed, feature code; etc. They offer great flexibility for customizing interaction of the 5ESS switch and SCP, depending on the service concept.
- *Automatic-route-selection trigger*. This trigger may be set as part of an ARS list. It allows the integration of SCP-determined routes with an existing set of LEC-offered network features.

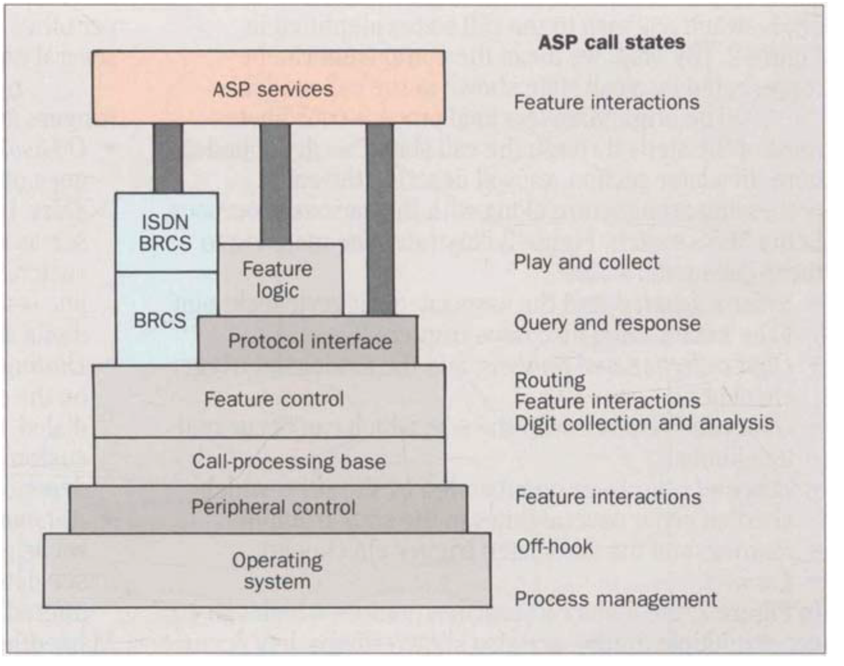
Many other types of triggers are available, such as those based on test-query calls, trunk facilities, or the feature buttons on ISDN-telephone sets.

Service Examples. How can the ASP be used to provide services? As examples, we use predominant services such as 976 screening; warm line; and multilocation, business-group extension dialing.

A typical example of the power and flexibility of ASP to provide new services is its potential use for *screening 976 calls*. Some states require optional blocking of 976-dialed numbers; the ASP can readily provide this through its office-dialing-plan trigger capability. The 976-exchange code can be set as a trigger that, when dialed, will result in an SCP query. Then, the database can determine if the call should be routed, or should be blocked with reorder or, optionally, with an announcement that the dialed number cannot be used from that location.

Another ASP service example is *warm line*, a service that provides default routing for a caller based on the subscriber's preset instructions (e.g., if dialed

Figure 3. Call-processing architecture. The call-processing base handles fundamental call activities, and recognizes ASP-subscribed triggers. It sends requests through feature control to the next level, the protocol interface, to the SCP and handles responses from the SCP via the protocol interface. Feature control administers feature execution within the 5ESS switch and manages logical feature interactions within a single call. Additional feature interactions may be managed at the feature-logic level.



incorrectly, route the call to an emergency number). When the caller goes off-hook, an off-hook-immediate trigger queries the SCP for handling. The SCP then asks the SSP to collect digits from the caller. If the caller enters an incorrect number, the SCP can determine the proper routing.

Multilocation, business-group extension dialing uses ASP capabilities, combined with a business customer's individualized-dialing-plan feature. Calls that originate from a customer location and are dialed as an extension for a remote location are detected in the individualized-dialing plan and sent to the SCP for handling. The SCP will translate the extension dialed into a POTS number and return routing instructions to the SSP. Thus, callers perceive they are part of a much larger business group. This enhances the service for a customer by tying together multiple locations as though they were one large location. The SCP centralizes administration of the numbering and other operational aspects of the service.

The ASP also provides the ability to request an authorization code or personal identification number, an option that can be combined with the services mentioned above. The collected digits can be sent back to the SCP, which validates them and determines subsequent handling (i.e., terminate or route the call).

All the features we've described can be provided to business or residential customers and can be combined with switch-based features (such as call forwarding) to build additional capabilities (such as *conditional* and *unconditional* call forwarding). For business customers, these ASP features can also be combined with Centrex service.

ASP Effect on Call Processing. The ASP call-processing components, which include both the SSP and NAP, can also be mapped into the overall call-processing architecture of the 5ESS switch. However, the NAP functionality is more limited in that—when a trigger is encountered—the call is routed to an SSP, which provides the remaining functionality. Here, we identify how the ASP interacts with and affects the switch's call-processing architecture (Figure 3).

Operating system. The operating system sits at the bottom of the architecture (Figure 3) and provides the backbone for all switch software. Each processor in the 5ESS switch has its own operating system that manages such functions as timing, interrupt servicing, and scheduling of processes within the processor. At this level, such processes as recent change, fault recovery, and overload control are served.

For call processing, the operating system manages application processes, such as the originating or terminating process, that are created for each active call in the switch.

Peripheral control. The next level in the architecture is peripheral control, which recognizes any changes in state on lines, trunks, or peripheral equipment and converts the external signal into an internal, logical event. For example, this level handles:

- On-hooks and off-hooks on lines and trunks
- Conversion of pulses and tones to digits
- Orders to the DSU–2 RAF to play announcements or collect additional digits.

At this level, the ASP has an interface to the DSU–2 RAF to provide functionality for interactive announcements and collecting additional digits, when instructed by the SCP's service logic.

Call-processing base, feature control. This level of the architecture consists of two elements:

- *Call-processing base*, which processes a basic call (or POTS); i.e., a call between two users that does not require features.
- *Feature control*, which becomes involved in call processing when the call requires features. This finite-state machine creates internal call models for each feature that is active on a call.

The *call-processing base* handles all fundamental call activities, such as digit collection and analysis, routing, interfaces to billing and measurements, and playing terminating announcements.

This level recognizes ASP-subscribed triggers. It also sends requests through feature control to the next level, the protocol interface, to launch a query to the SCP. The call-processing base also handles responses from the SCP via the protocol interface.

Customers may use the ASP on POTS lines and trunks. When a customer on a POTS line uses the ASP, processing of the call is handled directly at this level in the architecture.

Feature control administers feature execution within the 5ESS switch. Customers may use the ASP on lines and trunks that are equipped with BRCS (Business and Residence Custom Services), which is controlled at this level in the architecture.

Feature control is a mini-operating system, of sorts, that manages logical feature interactions within a single call. It manages interactions between ASP and switch-based features at three key points in call processing: after seizure detected (off-hook), after digit collection and analysis, and after routing.

Additional feature interactions that occur higher in the architecture may be managed at the feature-logic level, which we will discuss shortly.

Protocol interface. The ASP services are supported over analog lines, ISDN BRI facilities, ISDN primary-rate-interface (PRI) trunks, and both multifrequency (MF) and SS7 trunks. The protocol interface handles all:

- Trunk signaling between private-branch exchanges (PBXs), access tandems, SSPs, and NAPs for any of those facilities that use the equal-access multifrequency protocol or the SS7/ISDN user part protocol.
- Direct signaling between the SSP and the SCP. This signaling uses the SS7/TCAP protocol.

Feature logic, BRCS, ISDN BRCS. In the 5ESS switch's call-processing architecture, specific feature-package software sits above the feature-control level. Figure 3 has two examples of large feature packages that execute at this level: BRCS and ISDN BRCS. Other examples are LASS, emergency 911, and interswitch voice messaging.

At this level, features—such as call forwarding, shared directory number, and multiway calling—interact with the ASP in a predefined state machine. However, if a customer's actions are to be compatible with both the ASP service and the switch-based feature, the switch must always recognize an ASP-service call.

By design, ASP services are constructed and managed by the SCP, not the switch. Thus, the ASP's service logic always has priority over switch-based logic, and the ASP application sits at the top of this architecture to ensure highest priority. This is a fundamental assumption in all ASP interactions with existing switch-based features.

Planning for the Intelligent Network of the Future

As we have described, the ASP provides a flexible platform that can be expanded with new capabilities that can be included as the intelligent-network architecture continues to evolve. Each step in this evolution will expand the platform's capabilities while moving toward the target architecture, the Advanced Intelligent Network Release 1, which is described in more detail in the next section.

In the near term, new capabilities are planned for the A-I-Net advanced services platform. Within the next years, a new set of capabilities—called *Advanced Intelligent Network Release 0.1*—has been proposed by the LECs.[9] For the future, Advanced Intelligent Network Release 1 is viewed as the next major step in the intelligent-network architecture evolution.

ASP Enhancements. The full capabilities of the A-I-Net advanced service platform still have to be explored. As subscribers' needs evolve and new service opportunities present themselves, we can add more capabilities to the switch and support additional network elements in the architecture as they become available. Other feasible, new ASP services or capability enhancements are the addition of distinctive ringing, default routing, TCAP enhancements, increased announcement capability, etc. They allow us to continue to build on the initial ASP offering and add services as the market opportunity is presented.

An example of a new network element is AT&T's A-I-Net service-circuit node[1] and its associated A-I-Net service-creation environment.[8] The SCN is independent of the switch release and, thus, can be included with the ASP, as well as AIN Release 1. It could perform similar functions in an ASP-network environment. The service-creation environment could be used to build services on the SCP, as well as the SCN, effectively isolating the LEC from the specific SCP implementation, whether it be the A-I-Net advanced services platform or the next A-I-Net product. Thus, migration and evolution from each intelligent-network platform would be much smoother.

AIN Release 0.1. Advanced Intelligent Network Release 0.1 has been proposed as a further enhancement to Release 0 and a first application of Release 1. It would include such capabilities as:

- A new TCAP protocol consistent with Release 1
- A terminating-trigger feature
- Display control by the SCP
- A monitor-resource feature.

These capabilities and the others that are proposed would significantly advance Release 0 and smooth the future evolution to Release 1, while still providing full backwards compatibility with Release 0.

Although the implementation details are still being discussed, these features show the evolutionary path that Release 0 is likely to take before Release 1 becomes available. They also show that the future architecture is not a static, planning target but will likely continue to evolve as new service opportunities are identified.

Next Generation—AT&T's Release 1 Switch Plans

This section describes the current view of the next generation of intelligent-network products. It is based on Bellcore's AIN architecture proposals and

U S West's adjunct-call-processing architecture.[10] Here, we describe the architecture planned for AIN Release 1, its significant features, and some of the implementation challenges.

Architecture. Figure 4 shows the architecture of the Release 1 network, which extends the intelligent-network architecture discussed previously (Figure 1).

The term *AIN-switch capabilities* replaces the term SSP used in the A-I-Net advanced services platform, reflecting the additional capabilities and functions that the Release 1 switch provides. These include a more extensive call model, additional triggers and subsequent events, resource-status checking, and switch-data management. As in the ASP, the NAP continues to detect certain triggers and can route the call to the AIN switch for further intelligent-network call processing.

Three network elements that can influence call processing at the AIN switch complement the ASP SCP:

- *Adjunct.* The adjunct's function is similar to the SCP's. Both contain the same functional entity, the service-logic execution environment (SLEE); and both use the same application-level messages to communicate with the AIN switch. However, the adjunct is connected directly to the AIN switch, while the SCP connects via a signal-transfer point. Thus, the adjunct is better suited to services that require an extensive exchange of messages with the AIN switch, and it better addresses services that are geographically localized, e.g., line-based features. The SCP is better suited for services that require centralized data.
- *A-I-Net service-circuit node.* The SCN contains a switch fabric that allows for the termination of bearer channels and direct support of service circuits. (*Switch fabric* refers to the hardware and circuits that allow voice calls to be connected to the SCN. It provides a "talking" path for the caller to receive announcements from the SCN.) As described by Hall et al.,[1] the A-I-Net service-circuit node can support such specialized resources as announcements, voice recognition, voice synthesis, and store and forward for facsimile transmissions. In addition, it supports a service-node execution environment that manages and controls its resources.
- *Intelligent peripheral.* The intelligent peripheral provides additional resources that can be used by the SCP or the adjunct. The intelligent peripheral's resource-control execution environment controls and manages its resources. Like the SCN, the intelligent peripheral is connected to the AIN switch via ISDN. But unlike the SCN, the intelligent peripheral doesn't support service-creation capabilities.

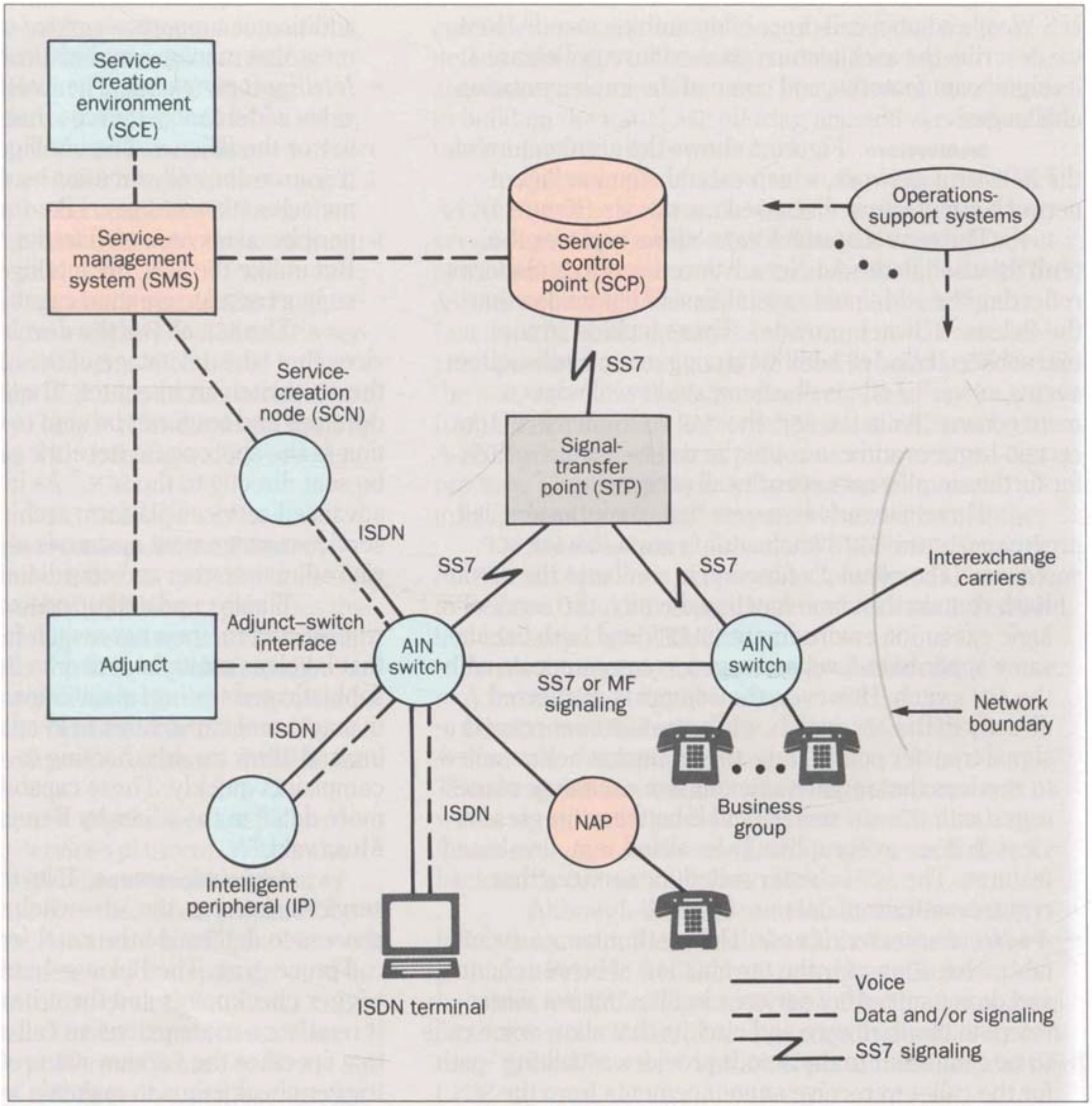
The SCE allows the development of new services that take advantage of the capabilities offered by the AIN-switch architecture. The programs that the SCE develops and tests can be sent to the SMS for distribution to the appropriate network elements, or they can be sent directly to the SCN.[7] As in the A-I-Net advanced-services-platform architecture, the A-I-Net service-management system is also responsible for service administration and coordination.

Finally, updated operations-support systems will support the new AIN-switch functionality. A service that involves multiple network elements requires sophisticated testing, maintenance, and network-management capabilities to keep the network functioning and allow troubleshooting to address customer complaints quickly. These capabilities are described in more detail in the paper by Bennett, Chen, and Morawski.[8]

Switch Capabilities. Like the A-I-Net advanced services platform, the AIN switch will use a triggering process to determine the need for intelligent-network call processing. The Release 1 switch extends the ASP trigger checkpoints and the criteria for those triggers. It requires a more extensive call model (than the ASP) that specifies the various states of the call and the trigger checkpoints to maintain a common view of the call (termed a *connection view*) among the elements involved (e.g., the SCP, adjunct, and SCN).

After the AIN switch detects a trigger and has satisfied the trigger criteria, it:

Figure 4. AT&T's Release 1 network. Here, the intelligent-network architecture presented in Figure 1 is extended by new switch capabilities (which replace the SSP) and the inclusion of an adjunct, the A-I-Net service-circuit node (SCN), and intelligent-peripheral elements. As it does in the ASP, the NAP detects certain triggers and routes the call to the AIN-switch capabilities for further processing.



- Formulates and sends a message to the appropriate network element and execution environment.
- Suspends call processing while awaiting a response.

The service-logic program, through the SLEE, can then ask the AIN switch to perform certain operations, and report the occurrence of desired events. (The SLEE supports the service-logic program by providing a communications environment between the adjunct and the AIN switch, and determines what request to send. In the AIN Release 1 architecture, communications between the SLEE and the AIN switch potentially last for the duration of the call. Multiple messages go back and forth starting with call setup, through the active stage, to disconnect.

Connection view and call model. In the AIN Release 1 architecture, the switch and the other network elements will participate in processing a call. They will use a call-connection view to maintain knowledge of all entities associated with the call. In addition, a call model will be maintained within the switch and the SLEE for the duration of the call.

The connection view divides a basic call connection into three segments: one for the originating side, one for the terminating side, and a segment that joins both sides. The SLEE is only concerned with the call's originating or terminating connection segment that triggered its involvement. A SLEE's control of each segment of a call is independent of its, or a different SLEE's, control of other segments of the call. *Intraoffice* calls have only one originating and one terminating connection segment. For *interoffice* calls, two or more originating and terminating segments may exist—one pair for each AIN switch.

The call model used in the AIN switch specifies the various states of the call's segments and the points where AIN call processing may be required. For the Release 1 switch, the call model is an expanded version of the ASP call model. This call model represents the status of switch call processing and defines the points where call processing can be interrupted or resumed. The call model's states represent abstract points in the call. Each state permits a set of specific AIN-defined events, responses, and actions. As with the connection segments, there is an originating and a terminating call-state model for the originating and terminating segments of the call.

Triggers and requested events. Two types of events at the AIN switch—triggers and requested events—are of interest to the SLEE and may interrupt normal call processing.

As in the A-I-Net advanced services platform, a *trigger* is the occurrence of an event and the satisfaction of conditions set for a particular trigger checkpoint that results in a message to the SLEE. Associated with each state are trigger checkpoints that may require the involvement of a SLEE in the processing of a call. (In the Release 1 switch, the trigger checkpoints are an expanded version of the ASP triggers.) These checkpoints are placed after a switch operation, subscriber action, network event, or failure occurrence.

A *requested event* is an event that is specified by a SLEE or is provisioned and influences the call. A requested event is only active when specified by a SLEE. The SLEE asks the AIN switch to report unconditionally to it when requested events occur. The ability to report the occurrence of requested events is significantly expanded here compared to the A-I-Net advanced services platform, where the SCP could only ask to be notified that the call ended (i.e., termination notification).

As is true for triggers, each event has an indicator that identifies it as a report-only or response-required event and is set either via provisioning procedures or by the SLEE. For *report-only events*, the switch informs the SLEE about the event occurrence and continues normal call processing. For *response-required events*, the switch reports the event occurrence and suspends call processing, while awaiting further instructions from the SLEE on how to proceed. New functionality introduced with the Release 1 switch is the ability to report events without suspending call processing and to administer events through the SLEE.

Connection segment, call-model control. After the AIN switch detects a trigger and has satisfied the trigger criteria, it will create a connection view of the active connection segment and send a message to the SLEE to request its involvement in call processing. Among other information, the requesting message contains the state at which the trigger was detected.

Through various messages, the SLEE can ask the AIN switch to perform certain actions and report the occurrence of desired requested events. The actions requested may alter the connection segment, but most actions involve the transition of the call segment to another state. This transition may require the AIN switch to perform such call-processing operations as collecting information, analyzing information, selecting a route, hunting a facility, or disconnecting the call.

Some actions the SLEE requests involve manipulating the segments in a multipoint call—such as splitting, joining, or moving a leg from the call. Other actions include forwarding the call to another number and merging two connection segments. The ability to perform leg-manipulation and explicitly transit the states is introduced with the Release 1 switch.

For certain participant interactions, the SLEE can direct the AIN switch to provide tones and announcements and collect digits. The resources for these interactions may be located at the AIN switch, the SCN, or the intelligent peripheral. The caller-interaction capability in the Release 1 switch extends the same capability in the A-I-Net advanced services platform.

Finally, a SLEE message that is not related to an existing connection segment may request the creation of a new call. The ability to create a new call as a result of the SLEE request is new in the Release 1 switch.

Resource-status checking. Also new in the Release 1 switch is the ability of the SLEE to query the AIN switch about the status of a resource. The request does not cause call processing to be suspended at the switch.

Resource-status checking allows the SLEE to:
- Maintain the correct status of the available resources.
- Determine if a line or trunk is busy or idle.
- Be informed whenever the status changes.

With this information, the SLEE can:
- Route calls to idle resources.
- Put calls in a queue until the resource becomes idle.
- Keep statistics on the duration of calls.
- Equalize use of the same type of resources.

Data management. The ASP permits triggers to be activated and deactivated through provisioning procedures. In the Release 1 switch, the SLEE can also activate or deactivate triggers and request a trigger's status. The SLEE may also change or retrieve data located at the switch, including call-gap data and such subscriber data as stutter-dial tone, call-screening and speed-calling lists, and call-forwarding numbers.

Billing capabilities. The AIN-switch capabilities can receive instructions from the SLEE that influence the billing of a call. The billing instructions may be included in messages that ask the AIN switch to perform other actions, or they may be carried in independent billing messages. The SLEE can ask the AIN switch to create AMA records, append data or modules to those records, or inhibit those records. In addition, the SLEE can ask the AIN switch to make AMA measurements and send back the data.

Service-Logic Execution Environment. The SLEE is a functional entity that can reside in an SCP or an adjunct. The SLEE provides a service-independent platform where service-logic programs can be invoked. Service-independent capabilities, standard well-defined interfaces, and a standard base language have the potential to permit execution of the same service-logic program in SCPs and adjuncts from different vendors.

Although the implementation of the SLEE is vendor dependent, the SLEE's basic characteristics include:
- A standard base language (C or C++) for developing and porting service-logic programs.
- A standard interface between the SLEE and service-logic programs that allows these programs to access SLEE-supported capabilities.

- A well-defined set of SLEE capabilities that are common across vendors.
- A standard database-access language; i.e., ANSI structured-query language or SQL. (ANSI is the American National Standards Institute. SQL is pronounced *sequel.*)
- Standard interfaces to the network (i.e., to the AIN-switch capabilities) and to the operations-support systems, including the SMS and the SCE.

This level of standardization is a new goal that is being approached with the Release 1 switch.

The functions in the SLEE include:

- Management of internal and external communications
- Management of service-logic-program processing
- A library of service-independent functional capabilities that the service-logic programs can access
- Management of internal data
- Management of internal and external resources
- Network management
- Collection of usage and performance data
- Billing
- Error handling.

Potential Services. The Release 1 switch provides a platform that supports the creation of a wide variety of services that can be customized to satisfy the diverse needs of LEC customers. It can support services that require extensive involvement of the SLEE in call processing, in addition to services supported by the ASP.

For example, *network automatic-call distribution* could be offered through several new and expanded features of the Release 1 switch. Among the features available are: call distribution by geographic area or entered digits; busy or overflow distribution; queuing; call back on busy; expected-time-in-queue information; and queue placeholder.

CLASS® enhancements are another group of services for which the Release 1 switch could support more features. (CLASS is a registered trademark of Bell Communications Research.) For example, the switch's functionality could be used to provide call forwarding on busy or don't answer, customized call waiting, customized audio support, and instant feature activation.

Implementation Challenges. The AIN-switch implementation of Release 1 will offer some important challenges that the industry must address as the effort proceeds. Here, we highlight several areas where attention and effort are being focused: feature interactions, performance and reliability, and OAM&P.

Feature interactions. In general, feature interactions result when the functionalities of the invoked feature overlap those of features already in use, activated, or provisioned. In AIN Release 1, the feature-interaction issue is further complicated because the scope of feature control extends beyond the Release 1 switch to a remote entity, such as the adjunct or the SCP. Now, three feature-interaction categories must be managed:

- Interactions of a switch or locally based feature with other locally based features
- Interactions of a switch-based feature with remotely based features (i.e., adjunct-based or SCP-based features)
- Interactions of a remotely based feature with other remotely based features.

Extensive service analyses still need to be done, and various implementation strategies must be evaluated to simplify interaction management.

Performance and reliability. Stringent performance, availability, and reliability standards must be met if AIN Release 1 networks are to maintain customer expectations of the telephone network.

When a remote entity controls switch call processing, communication delays could be introduced and could result in user-perceived performance degradation. We must conduct performance-simulation analyses for implementations of the Release 1 switch and must take measures to ensure that user-perceived delays are well within the generic requirements for a local switching system. The software architecture must be flexible enough to allow selective migration of remotely controlled feature logic between entities as a way to address issues of the advanced-intelligent network's performance.

In terms of reliability, the industry standard of 2 hours of outage in 40 years places high demands specifically on the switching entity and generally on network management of AIN Release 1. Close coordination of the OAM&P of all intelligent-network nodes is required to meet these requirements. Traffic measurements and maintenance counts need to be collected and reported, so that network-traffic management can respond dynamically to changes in traffic demands and outages of network entities.

OAM&P. Operations, administration, maintenance, and provisioning in the distributed-control environment of the Release 1 switch present some issues in terms of replicated data and synchronized activities of different entities. In addition, we must be able to initiate, validate, and administer the trigger tables. The paper by Bennett, Chen, and Morawski discusses[8] these issues.

Summary

This paper has described AT&T's A-I-Net advanced-services-platform offerings and the initial evaluation under way for AT&T's Release 1 switch offerings, which are targeted for the intelligent-network market. These products respond to the expressed needs of the Regional Holding Companies.

The ASP is an expansion of the existing switch functionality and architecture with an added interface to a remote database. It offers the ability to support many types of services envisioned by the LECs, while still interworking with the existing switch-based operations and feature infrastructure.

Bellcore's AIN Release 1 is seen as the intelligent-network architecture for the future. AT&T's Release 1 switch is being planned as integral to this network architecture. This switch will provide many more capabilities than the A-I-Net advanced services platform by offering a much more flexible interface. However, this close coupling of switch and remote-processing entities presents many technical and market challenges that customers and vendors must address before the full promise of advanced-intelligent networking can become a reality.

AT&T's ASP and the other A-I-Net offerings are positioned to address the strategic need of the LECs to implement intelligent networking. They allow the LECs to begin by deploying AT&T's A-I-Net advanced-services-platform offering for the 5ESS switch now. The ASP can yield valuable insights about providing AIN Release 1 services in the future because its distributed-processing environment, OAM&P, and transition planning are similar to all intelligent-network architectures. Then, when AIN products are introduced, the local networks will be well positioned to begin deploying those services as they become available.

References

1. H. M. Hall, C. D. Carson, E. H. West, and L D. Whitehead, "The AT&T Service Circuit Node: A New Element for Providing Intelligent Network Services," *AT&T Technical Journal*, Vol. 70, No. 3–4, Summer 1991, pp. 72–84.
2. E. G. Sable and H. W. Kettler, "Intelligent Network Directions," *AT&T Technical Journal*, Vol. 70, No. 3–4, Summer 1991, pp. 2–10.
3. "5ESS® Switch Advanced Services Platform Feature Document: 5E6 Software Release," Code 235-190-125, Issue 1, AT&T Customer Information Center, Indianapolis, Indiana, October 1990.
4. G. Y. Wyatt, A. Barshefsky, R. V. Epley, M. P. Kaplan, and K. P. Krishnan, "The Evolution of Global Intelligent Network Architecture," *AT&T Technical Journal*, Vol. 70, No. 3–4, Summer 1991, pp. 11–25.
5. "Ameritech Intelligent Network Release 0 Architecture Overview," AM SR-OAT-000019, Issue 1, American Technical Services, Inc., Arlington Heights, Illinois, July 1989.
6. "Additional Service Switching Point Capabilities (Including Private Virtual Network Services)," TR-TSY-000402, Issue 1, Bell Communications Research, Morristown, New Jersey, November 1987.
7. M. J. Morgan, M. J. Cosky, T. M. Gruenenfelder, T. C. Holmes, Jr., and G. A. Raack, "Service Creation Technologies for the Intelligent Network," *AT&T Technical Journal*, Vol. 70, No. 3–4, Summer 1991, pp. 58–71.
8. R. L. Bennett, J. C. Chen, and T. B. Morawski, "Intelligent Network OAM&P Capabilities and Evolutions for Network Elements,"

AT&T Technical Journal, Vol. 70, No. 3–4, Summer 1991, pp. 85–98.
9. "Service Switching Point Functional Specification (IN Release 0.1)," American Technical Services, Inc., Arlington Heights, Illinois, July 1991.
10. "Advanced Intelligent Network (AIN) Release 1 Switching System Generic Requirements," TA-NWT-001123, Issue 1, Bell Communications Research, Livingston, New Jersey, May 1991.

Biographies (continued)

joined the company in 1980 and has a B.S. in mechanical engineering from Cairo University (Egypt), an M.S. in mechanical engineering from Assiut University (Egypt), and both an M.S and Ph.D. in applied mechanics from Kansas State University (Manhattan). Mr. Russo does systems engineering for AT&T's advanced-intelligent-network product offerings and the evolution of AT&T's A-I-Net™ advanced services platform to Advanced Intelligent Network Release 1. He joined the company in 1977 and has both a B.S. in mathematics and an M.E.E. from Stevens Institute of Technology (Hoboken, New Jersey). Ms. Sand is currently responsible for the customer interface including planning, systems engineering, and evaluation for U S West's Rapid Service Delivery Project. She joined the company in 1979 and has a B.A. in art history from the State University of New York at Binghamton and an M.S. in computer science from Southern Illinois University (Carbondale). Ms. Shaw is a systems engineering supervisor responsible for AT&T's intelligent-network switch products. She joined the company in 1981 and has a B.S. in mathematical science and computer science from Rice University (Houston, Texas) and an M.S. in computer science from Purdue University (West Lafayette, Indiana). Ms. Taska is responsible for planning and development of A-I-Net platforms and features. She joined AT&T in 1977 and has both a B.S. in mathematics and an M.S. in computer science from the Illinois Institute of Technology (Chicago). While at AT&T, Mr. Wojcik was a systems engineering supervisor for the U S West trial requirements, CLASS® requirements, and product applications that employ external-service-logic capabilities. He is now research manager for BellSouth Services in Atlanta, Georgia. Mr. Wojcik has a B.S. in mathematics from Illinois Institute of Technology (Chicago), an M.B.A. from the University of Chicago (Illinois), and a Ph.D. in applied mathematics from Brown University (Providence, Rhode Island).

(Manuscript received February 5, 1991)