INTELLIGENT NETWORKS

Telecommunications systems around the world are facing dramatic changes. Customers are clamoring for new services, and technology is progressing at a disconcertingly fast pace. Concurrently, telecommunications service providers face many mandates from regulatory agencies such as maintenance of low-cost universal service. The only constant for both telecommunications providers and subscribers is rapid change.

At the heart of these rapid changes is the evolution of a concept called the *intelligent network* (IN). The intelligent network has evolved as a way to speed up the development and introduction of telecommunications services and to provide those services in an efficient and cost-effective manner.

The intelligent network is a concept designed to extend the capabilities of telecommunications systems. Our current telecommunications system includes both wireline and wireless networks, and both are heavily dependent on the IN.

The IN was designed to provide telecommunications services independent of call connection services, i.e., switching processes. Additionally, the IN was designed to be independent of hardware, service providers, and network protocols and to be an overarching construct spanning all service providers.

For example, prior to the deployment of the IN, 800 services required *every* switch to have the capability to translate the 800 number to the actual called number and to bill correctly. Additionally, every switch must have the correct number translation table correctly connect the call. When new 800 numbers were added, the translation tables must be updated in *all* switches.

The IN moved the 800 service from the call connection system to the call services systems; thus new numbers are added to the IN 800 database which can be accessed by many switches. The IN separates call connection from service provision.

IN TELECOMMUNICATIONS STANDARDS BODIES

The *International Telecommunication Union* is the international body developing IN standards. The ITU is an agency of the United Nations. The *European Telecommunications Standardization Institute* (ETSI) recommends standards for Europe and *Bellcore* develops North American IN standards.

International Telecommunication Union (ITU)

The ITU was reorganized in 1993 into three sections:

- *Radio Communications (ITU-R).* This section was formed by combining the International Radio Consultative Committee (CCIR) and the International Frequency Board (IFRB). The ITU-R is concerned with the allocation of the RF spectrum, and its regulations are distributed through the Radio Regulations Board.
- *Telecommunications Standards (ITU-T).* This was formed from the International Consultative Committee on Telegraphy and Telephony (CCITT). ITU-T recommendations work to standardize global telecommunications and are usually distributed through conferences and workshops.
- *Telecommunications Developmment (ITU-D).* This was formed from the Bureau of Telecommunications Development (BTD) and develops technical specifications for international public telephone networks.

ITU standards for IN are divided into *capability sets,* e.g., CS-0, CS-1, CS-2, and are the standard for Europe and Asia. The ITU documents are generally referred to as the “Q.12xy” series where the “x” digit identifies the capability set. “Recommendation Q.1200” is the general CS-0 IN structure document (1). The “Q.1201” series includes recommendations for IN architecture principles (2), IN service plane architecture (3), global functional plane architecture (4), distributed functional plane architecture (5), physical plane architecture (6), and other key CS-1 interface components (7–12). Recommendations for IN CS-2 may be found in the “Q.122y” series which includes an introduction to IN CS-2 (13), service plane for IN CS-2 (14), and other CS-2 recommended standards (14–17). See the ITU World Wide Web site at http://www.itu.ch/ for more information.

European Telecommunications Standardization Institute (ETSI)

The ETSI defines technical standards that are generally consistent with ITU recommendations but do not fully adopt the ITU recommendation structure. Some ETSI standards documents are the IN user’s guide for CS-1 (18), IN ETSI:61010 (19), IN distributed functional plane (20), and others (21,22). See the ETSI World Wide Web site at http://www.etsi.org/sitemap/ for more information.

Bell Communications Research (Bellcore)

Standards for the IN in North America are called *Advanced Intelligent Network* (AIN) releases and are produced by Bellcore, e.g., AIN 0, 0.1, 0.2. See the Bellcore World Wide Web site at http://www.bellcore.com/ for more information.

The evolution of IN standards from both Bellcore and the ITU continues. Telecommunications Information Networking Architecture (TINA) and Information Networking Architecture (INA), which are evolutionary offshoots, are discussed separately later.

The two IN standards from the ITU and Bellcore, never very far apart, are getting closer to one another, and it is widely believed that the ITU standards eventually will prevail because of the necessity of producing global telecommunications standards that ease world-wide integration and interoperability. For more detail about telecommunications standards, see Refs. 23 or 24.

TRANSACTION-BASED CALL PROCESSING

New telecommunications services have one thing in common: They require extensive software and hardware support from the underlying telecommunications network. To better understand the current status of telecommunications, we need to go backwards in time. IN as an architecture is a natural evolution of the basic telecommunication network.

J. Webster (ed.), *Wiley Encyclopedia of Electrical and Electronics Engineering*.

The *public switched telephone network* (PSTN) in North America, prior to the breakup of AT&T, was served by a hierarchy of switches with five levels. Class 5 switches or *end-offices* terminated the subscriber local loop. Calls were routed from end-office to end-office over interoffice trunks or they were directed to class 4 or higher switches for further routing depending on the called party and traffic congestion. The class 4 switch was called a toll center. There were three classes of toll center: class 3, class 2, and class 1.

Call routing was a function of the called party location and the traffic volume. Obviously, the shortest route was always the best but it was not always available, and thus the call was occasionally directed to higher level switches for routing.

With the breakup of AT&T and the subsequent separation of local and long-distance service, the upper layers of the switch hierarchy were abandoned for a fully interconnected network of digital switches. The end-office still terminates the subscriber loop but has become much more than a termination center.

The end-office terminates traditional analog voice circuits, but it also has a connection to the MTSOs serving the wireless carriers for the area. The end-office also terminates T1 and higher-speed lines that bypass the switch and are connected to a local connection matrix as well as connected to the LEC's access tandem for inter-LATA and intra-LATA calls.

Until *direct distance dialing* (DDD) was deployed in the early 1950s, all information needed to create connections was stored on individual telephone switches. Stored program control (SPC), which made telephone switches specialized computers, was implemented in network switches such as AT&T's No. 1 ESS which was deployed in 1965 (25). No. 1 ESS provided residential services such as "call waiting" through software resident in the switch. As SPC logic became more complex, it took longer to develop and test new services, and thus it became increasingly expensive and time-consuming to deploy each new innovation as *each* of the 15,000+ switches in the country had to be loaded with the new software. It took 3 to 4 years from conception to delivery for a new service. It was not uncommon to see switch logic exceed a million lines of program code. Many existing switches had to be extended by adjunct processors—special-purpose computers—to correctly interpret numbers that were dialed and execute their associated services. It became increasingly evident that call connection and call service activities had to be separated.

AT&T first accomplished this when they introduced centralized databases to support "Calling Card" and "800 Service." These facilities were implemented at a *network control point* (NCP) and were accessed by a specialized signaling network called the *common channel interoffice signaling network* (CCIS). In the 1980s the ITU defined the common channel signaling system no. 7 (CCS7), which became the intelligent network interconnection mechanism. CCS7 is a packet network that is used for call setup (i.e., *out-of-band* signaling) and is separate from the resources used to connect the call.

After the forced divestiture of the Bell System in the United States, the RBOCs also deployed centralized databases to support 800 service and alternate billing services. The switches, databases, and operations systems that formed these services were collectively referred to as Intelligent Network 1 (IN/1) (26,27). Bellcore recognized that the separation of interconnection and service provision facilities offered huge potential for service development and began development of an expanded IN architecture called IN/2.

RBOCs realized that IN/2 could not be implemented in a timely manner and focused on a subset of IN/2 functionality which could be deployed in stages over several years. At about the same time, switch vendors did not believe that they could deliver sufficient performance to support all of the specified services. Bellcore called a multivendor forum to resolve the concerns of all parties and the results of this forum were published in March 1990 (28). The next stage IN development was called *Advanced Intelligent Network* (AIN) and was defined by a series of numbered releases starting with release 0. AIN 0.1 has been deployed and AIN 0.2 enhancements are currently are being deployed.

In the section entitled "Intelligent Network Conceptual Model," we describe the IN conceptual model. In the section entitled "IN Services," we discuss the IN service structure. In the section entitled "New Telecommunications Services and the IN," we discuss some new telecommunications services and their dependence on the IN. In the section entitled "IN Evolution," we describe the evolution of IN and we conclude the chapter in the section entitled "Conclusion."

INTELLIGENT NETWORK CONCEPTUAL MODEL

Organization and Interface. The overarching purpose of the IN is to provide a framework to deploy advanced telecommunications services to subscribers. We describe IN components and their general function within the framework of providing these subscriber services.

Although implementations are slightly different from vendor to vendor and from service provider to service provider, intelligent network services are delivered by well-defined interactions between switching systems and intelligent network service logic. A key justification for the deployment of the intelligent network is to provide a telecommunications infrastructure that would facilitate the implementation of sophisticated subscriber services.

The best way to view the IN is as a reference model called the *intelligent network conceptual model* (INCM). The INCM is the basis for development of ITU IN standards (29).

The INCM is a four-layer model which, from the bottom up, consists of the physical plane, the distributed function plane, the global function plane, and the service plane. The INCM is shown in Fig. 1. INCM layer descriptions follow.

IN Physical Plane. IN physical component descriptions follow. Entities in the physical plane perform the "real" functions that implement the IN—for example, access and maintain support databases, route control packets, or make call-setup decisions. For more detail see Refs. 15,30,31,24, and 32. The architecture of the physical plane is shown in Fig. 2.

- *Service Switching Point (SSP).* The SSP provides the access point to intelligent network services for the subscriber and executes the *call model* that describes actions to be taken by the IN service layer. The SSP detects IN service requests and formats requests for call implementation instructions from the AIN service logic. The SSP is a logical entity that coexists with the switch; that is, the SSP function has been embedded into switching points and is the access point into the IN.

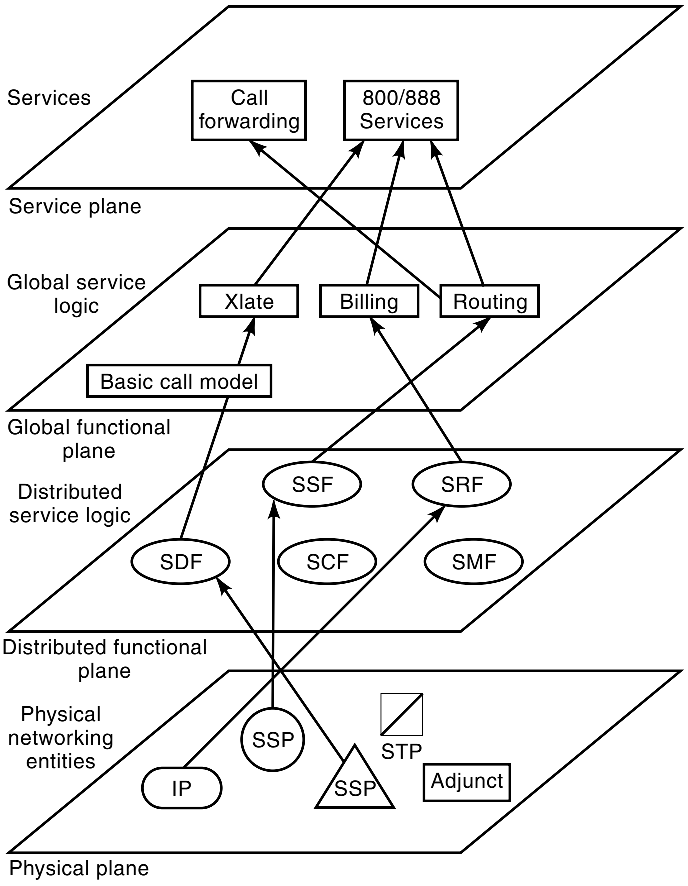


Figure 1. IN conceptual model.

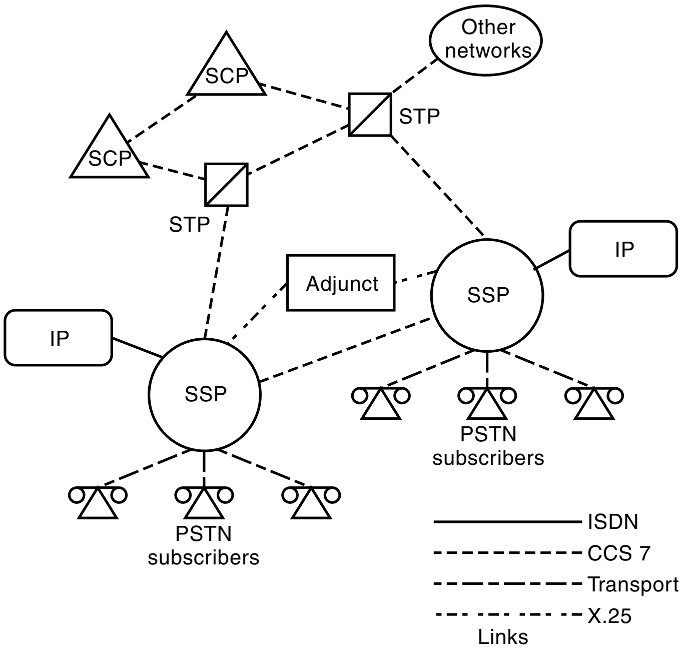


Figure 2. IN Physical plane architecture.

- *Service Control Point (SCP).* The SCP provides the service control function (SCF) and the service data function (SDF). The SCP is responsible for responding to SSP queries resulting from interaction with the call model. The software modules that provide IN services are implemented in the SCP. The SCP provides instructions to the SSP on how to continue with call setup. The SCPs are duplicated—mated—for redundancy and to ensure proper response to service requests. The SCP is both a database and a processing environment. The processing environment contains *service logic programs* (SLPs) that provide specific services to requesting SSPs. The database portion provides information that is processed by the SLPs. For example, an SCP is responsible for number translation in an 800/888 service. The specific 800 SLP uses the dialed 800 number as a lookup argument to query its database for the real number of the called party. The SLP may also use time of day and caller location as additional criteria in selecting the phone number of the called party, e.g., dialing a regional number for a pizza delivery service could trigger an SCP query which would route the call to the location closest to the caller for faster delivery service. Modern SCPs are designed to handle thousands of transactions a second.

  As IN services expand, SCPs will become more narrowly specialized because it would be impossible for them to handle the volume of transactions that will be generated otherwise. Many researchers believe that almost all calls eventually will require an SCP transaction and many calls will generate several. With mandated *local number portability* service (LNP), sometimes referred to as the subscriber's *universal personal number* (UPN), every call may require an SCP database lookup to find the real phone number to be used to route the call in the same way that 800/888 numbers require an SCP translation.
- *Service Data Point (SDP).* The SDP is the platform for the standalone service data function (SDF). The SDP contains both customer and network data that is accessed as part of the execution of an IN service.
- *Intelligent Peripheral (IP).* The IP is the platform that supports the specialized resource function (SRF). The IP responds to directives issued by the SCP or SSP and is used to play out announcements, synthesize speech, provide voice messaging, and speech recognition.

  The IP is accessed through an *integrated speech and digital network* (ISDN) link for better performance, or it may be connected to an SCP through the signaling subnetwork. Since the IP may be responsible for time-sensitive actions such as playing out announcements to the calling or called party, e.g., "Please enter your PIN now," a time-sensitive link is essential.
- *Adjunct (ADJ).* The ADJ provides the same service functions as the SCP and is considered functionally equivalent. The ADJ differs from the SCP only in the interface. The ADJ is connected to SSPs by high-speed links rather than the CCS7 network. Thus, the adjunct may be more suitable to support services that require very fast response. The adjunct usually provides specialized services and may be directly programmable by the service subscriber.

- *Service Node (SN).* The SN provides the CCF/SSF of the SSP, the SDF, and SCF of an SCP, and the SRF of an IP in one physical entity. The SN allows highly specialized functions to be implemented in one physical device, thus reducing the CCS7 network latency and other interdevice communications overhead.
- *Service Management Point (SMP).* The SMP provides the service management function for all physical entities in the IN. The SMP allows maintenance and testing, and provides the interface between IN entities.

IN Distributed Service Plane. Objects in the *distributed service plane* (DSP) are called functional elements and are the service logic functions (software) associated with the hardware elements in the physical plane. Some of the functional elements at the DSP and their associated physical processors follow.

- SSF: Service switching function which is associated with the SSP.
- SCF: Service control function which is associated with the SCP.
- SDF: Service data function which is associated with the SCP. In some implementations, the SDF can co-reside with the SCF in the SCP.
- SRF: Specialized resource function which is associated with the IP.
- SMF: System management function which supports service creation, deployment and maintenance, and is associated with the SMP.
- SCEF: Service creation environment function allows the specification and testing of IN services.

The DFP allows a software function to be viewed independently of the IN physical architecture. Obviously, the software function must at some time be physically implemented on a specific hardware platform once the function has been well-defined; however, this physical association becomes an engineering task.

IN Global Functional Plane. The components of the *global functional plane* (GFP) are called *service-independent building block* (SIBs). Subscriber services are defined and deployed by combining SIBs. SIBs are standardized architecture-independent functions that expect certain standard input arguments such as caller number and calling number and produce certain standard output arguments such as called party number. SIBs perform basic network functions such as collecting digits, verifying an ID number, or translating inputs. The abstractions of the GFP allow a service function definition that is independent of hardware. Thus IN engineers have some flexibility during function implementation.

In Fig. 1, several SIBs (Xlate, Billing, Routing) are shown in the functional plane. These SIBs are used as building blocks to create features (800/888 service, call forwarding) in the service plane. A single SIB may be used to create several service features. For example the three SIBs Xlate, Billing, and Routing are used to make up the 800/888 service feature. The Xlate SIB translates the 800/888 number into actual called party; the Billing SIB determines who should pay for call charges and the Routing SIB uses time of day to determine the actual called party number. The same Routing SIB is used in the implementation of the call forwarding service feature.

IN Service Plane. Subscriber services are called *features.* Magedanz and Popescu-Zeletin (24) further divide features into “call-related” and “management-service-related” features. Call-related features include call waiting, speed dialing, and call forwarding, while management-related features deal with billing, network management, and service deployment.

IN SERVICES

The concept of IN service must be viewed from two perspectives. The first perspective is the definition of service as the addition of functionality for subscribers. Magedanz and Popescu-Zeletin (24) call functionality “value added” services. The second perspective involves video, voice and signaling services and is called “bearer services.”

The IN service concept does not include specific subscriber services, rather the IN is a platform for service development independent of a specific service definition. Included in each new IN version is an expanded set of components that are used to define and deploy specific subscriber services.

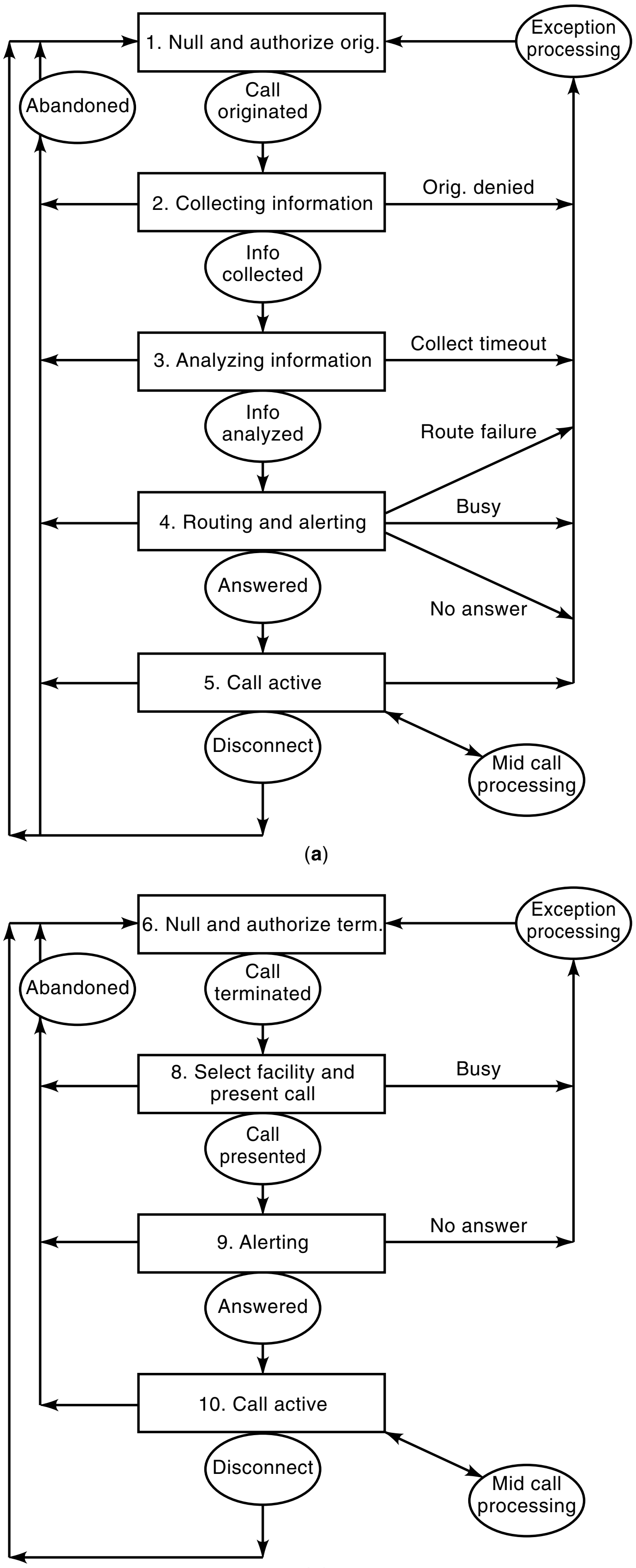
Basic Call Model

A special SIB called the *basic call model* (BCM) (24) coordinates the telephony and call processing portions of a call. The call model consists of a series of common subscriber actions as “off-hook” and “digits dialed.” A BCM is shown in Fig. 3. Figure 3 shows the call origination and termination BCM. *Point in calls* (PICs) are checkpoints in call processing used by the SSP to determine if outside services are required (i.e., SCF services). The *trigger control points* TCPs in the trigger table indicate the specific *service logic processes* (SLPs) to diagnose and provide the requested service. SLPs make up the service control function and reside in the SCP. These SLPs are called to provide the service and guide the SSP in further processing the call.

At each PIC, a decision is made in the switch about the need for AIN services. Figure 4 shows the relationship among CCF, SSF, and SCF logic. If services are required, call processing is suspended at the associated TCP. The trigger table indicates the service logic in the SCP required to progress the call, and the SCF resumes call progressing the CCF logic after providing the requested service. At each PIC in the originating and terminating call model, the switch makes decisions about processing the call on a step-by-step basis.

Actions taken by the calling or called party are noted by the SSP; that is “off hook” (the phone is lifted out of its cradle or “digits dialed”) the called party number has been dialed. The SSP determines at each PIC if additional outside services are necessary to complete the call. The specific action taken by the SSP depends on its SLP and by the specific PIC where the event took place.

The critical point is that although the SSP still must recognize events at PICs such as a subscriber dialing an 800/888 number, the SSP does not have to take action itself to provide the requested service; rather, the SSP off-loads the service request to another AIN component—an SCP or adjunct. The



(a)

(b)

Figure 3. Basic call model. (a) Originating call model. (b) Terminating call model.

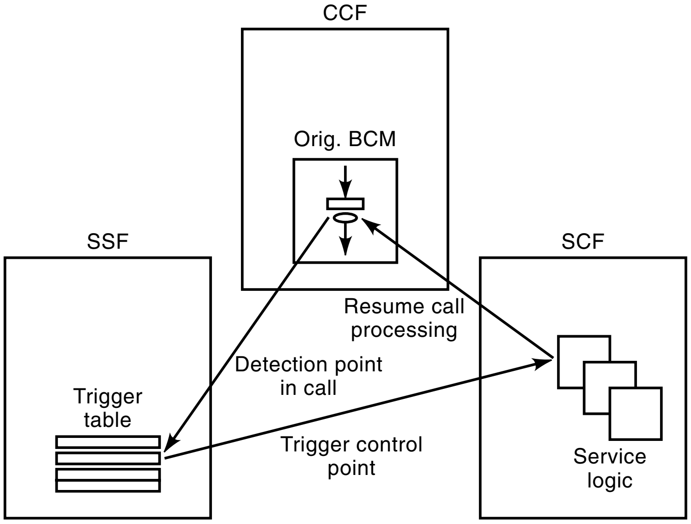


Figure 4. IN service process.

actual service provision takes place outside of the SSP, thus freeing it for other tasks related more closely to routing calls.

The PIC/TCP mechanism in the IN switch functions like a remote procedure call. Call processing in the switch is suspended while a service request message is transmitted across the CCS7 network to the appropriate service processor—either an SCP or an adjunct depending on the type of service requested and the speed of the connection.

The SLP in the service processor responds to the service request and creates a response message which is formatted and transmitted across the CCS7 network back to the AIN switch. The call resumes processing in accordance with directions provided by the SCP or adjunct.

A single PIC/TCP can be used to support a variety of services depending on the context of the call. At the PIC the SSP analyzes the data provided about the call and the switch requests service from a specific SLP. The SLP may request additional information from the subscriber such as a personal identification number. The SLP may evoke other process such as those that reside on an IP. The IP may be asked to play out specific message or to collect digits from the subscriber.

The notion of "backroom" processing by a network of service processors invisible to the subscriber allows the function of providing telecommunications services to be separated from the function of connecting calls because the service provision function has been off-loaded to other processors.

Aside from greatly reducing the work required in the switch and allowing switch cycles to be more tightly allocated to call connection processing, off-loading the service function makes it easier to define new services and the new services can be deployed much faster. The new service is deployed once on the SCP rather than in each switch in the PSTN. The catch is, of course, that there must be a substantial infrastructure that allows global signaling among IN components; but once the infrastructure is in place, the deployment of new national telecommunications services is much easier. However, although service deployment is now easier, we are required to manage an increasingly complex signaling infrastructure.

Using the 800/888 number translation example, when number translation is done at an SCP connected to the AIN switch over a CCS7 network, the switch and the SCP work in parallel. Plus new numbers can be added much more rapidly because all that is required is to update the SCP database instead of transmitting a new number translation table to *all* switches that make number translation.

For a new service to be deployed, its SLP is installed only on the SCPs that provide the service—not on every switch in the PSTN. Thus new services can be defined and deployed in an AIN environment in months instead of years.

Feature Interaction

A major IN problem is the unintended consequences caused by several features active together during one call. This is called *feature interaction* and refers to the problems caused when parties to a call have different feature sets active. For example, suppose a subscriber makes a call to the universal personal number (UPN) of another subscriber. Further, suppose the UPN translates to a number that is a toll call for the caller. Who pays the charges? The calling party expects to reach a local number thus does not expect to be charged for the call. The called party is not interested in paying toll charges for unwanted calls such as telemarketing calls to his/her UPN number. How are these feature interactions to be handled?

When the feature is introduced, its interaction with all existing features must be clearly defined. Thus when the UPN feature is introduced, the added complexity of possible toll charges must be included in the design of the feature. For example, if the called party UPN translates to a number resulting in toll charges, the UPN feature might notify the calling party that the call is a toll call and ask for billing acceptance. Additionally, the UPN feature may include a list of numbers for which the subscriber is willing to accept toll charges without notifying the calling party. Clearly, the creation of features from SIBs is greatly complicated by the requirement to deal effectively with feature interaction.

NEW TELECOMMUNICATIONS SERVICES AND THE IN

Personal Communications Services

Personal communications services (PCS) is a good example of an IN transaction-intensive service (33–41).

There are several generic functions necessary to support PCS. Several of those SCP functions are as follows:

- Analyze time-of-day, calling number, and called number for routing or access directions to the SSP.
- Collect and analyze user information such as personal identification number (PIN) for billing and call routing.
- Database access and billing control functions are used to verify and update user database information and to create and store billing information.

Bray (42) estimates that services, excluding PCS, will require SCPs to support query rates in the range of 1000 transactions per second.

Universal Personal Number

Personal number service or *universal personal number* (UPN) is expected to be a big component of PCS, with 4.5 million personal numbers projected for the year 2000 (43). While the implementation of UPN differs from vendor to vendor (44), the single number applies regardless of the type of call—that is, FAX, voice, or e-mail. UPN allows a subscriber to be reached (conditionally) regardless of his physical location from a single telephone number. UPN also implies that wireless, voice, data, and FAX calls be automatically routed to the appropriate device.

Clearly, the IN is critical to the development and deployment of UPN because as the service becomes available, an increasing percentage of called numbers require treatment. UPN will generally allow the subscriber to determine how he is to be reached and who is allowed access. Clearly, UPN depends on extensive and fast SCP processing.

IN EVOLUTION

The IN is a powerful mechanism for deploying telecommunications services. However, with this power comes great complexity. IN management is a critical component of the overall IN strategy. Management consists of operations, administration, maintenance, and provisioning (OAM&P). There are many IN component vendors each with their own operations systems (OSs) that want to place their equipment in the Bellcore version of IN in North America and the ITU version of IN in Europe and Asia. Clearly, for the sake of interoperability, there must be movement to a common IN reference model and there are several activities in this IN movement. These activities include the notion of an *international telecommunications management network* (TMN) (45) and an *open distributed processing* architecture (46). Bellcore is also developing a long-range view of IN in its *information networking architecture* (INA) (47,48) and its *telecommunications network architecture* (TINA) consortium (49–54).

Telecommunications Management Network

One approach to consistent management across network components within a network and networks themselves is called *Telecommunications Management Network* (TMN) (55,60). TMN emerged in the early 1980s as a mechanism to effectively manage diverse operations systems developed by component vendors to support OAM&P efforts. TMN included a set of standards to ensure component and network interoperability.

Conceptually, TMN produces a network of management systems. This overarching software system monitors and tunes entire telecommunications networks. Interfaces were standardized so that introduction of new components into the network was eased from the OAM&P perspective.

While some success in this grand vision has been achieved, TMN has not yet been fully realized. There are several very difficult issues with the TMN concept that have not yet been resolved. Development stumbling blocks include the following:

- *TMN Complexity.* Open Systems Interconnection (OSI) system management technology was selected as the basis for TMN interfaces; and while these systems are very powerful, they are also quite complex. Thus, TMN interfaces are being slowly deployed.

- *Legacy Systems.* Developing TMN interfaces is very expensive, and thus developers require a strong incentive to deploy TMN. Since there are few TMN systems currently deployed on legacy systems, the incentive to develop TMN interfaces for new systems is weak.
- *Alternative Protocols.* TMN relies on OSI management standards while the TCP/IP protocol suite uses Simple Network Management Protocol (SNMP). Because TCP/IP is so widely available, there is pressure to use SNMP. However, since SNMP is simpler than OSI management systems, it is perceived to be less powerful.

TMN concepts are critical to the effective management of complex INs. The ability to automate these functions is essential to smooth network interoperability. See Magedanz and Popescu-Zeletin (24, Chapter 4), and other articles referenced here for more details about TMN concepts.

Information Network Architecture

In 1990 Bellcore started working on a concept meant to be the successor to its AIN. The successor network concept was called *information network architecture* (INA). Basic INA concepts were specified by Bellcore in 1992 and 1993 and are described in Ref. 53. INA concepts require management software modules and service software modules to be separated and capable of working correctly anywhere in a distributed network of telecommunications service processors.

The distributed processing environment of the INA concept has a kernel that will be present in every node and a set of transactions servers that provide the telecommunications service delivery function. See also Ref. 24, Chapter 5 for an INA overview.

Telecommunications Information Networking Architecture

About the same time that Bellcore was developing the INA concepts, a group of network equipment vendors and network operators formed the Telecommunications Information Networking Architecture Consortium (TINA-C) (61) to specify an architecture that can support all network applications across all network types. Bellcore's INA concepts influenced the TINA-C, but they took the evolution of the IN further. Specifically, TINA-C focused on four areas (24):

- Computing architecture concepts for designing and implementing a distributed computing environment based on the open distributed processing reference model.
- Service architecture concepts for designing and implementing the delivery of telecommunications services.
- Network architecture concepts for designing and implementing a transport network.
- Management architectural concepts for designing and implementing an OAM&P system across the distributed architecture.

The TINA initiative is well underway. There exist several proposals for TINA trials most scheduled for mid-1998 (62).

CONCLUSION

Telecommunications service providers have dramatically expanded the services they offer to their subscribers. Also the environment in which they operate has become much more complex with competitive long distance, competitive local service, and competitive wireless service.

Couple this dramatic increase in complexity with an increasingly demanding subscriber and we have a situation that forces us to carefully examine the service provision architecture.

The evolution of the IN is in response to this growing complexity. The bright side of the IN is the speedy development of telecommunications services to sophisticated subscribers. The dark side of the IN is an increasing complex entity that must be maintained and must evolve.

BIBLIOGRAPHY

1. ITU, *Recommendation Q.1200: General series intelligent networks recommendations structure,* Int. TeleCommun. Union, Geneva, September 1997.
2. ITU, *Recommendation Q.1201/I.312: Principles of intelligent network architecture,* Int. TeleCommun. Union, Geneva, October 1992.
3. ITU, *Recommendation Q.1202/I.328: Intelligent network service plane architecture,* Int. TeleCommun. Union, Geneva, September 1997.
4. ITU, *Recommendation Q.1203/I.329: Intelligent network global functional plane architecture,* Int. TeleCommun. Union, Geneva, September 1997.
5. ITU, *Recommendation Q.1204: Intelligent network distributed functional plane architecture,* Int. TeleCommun. Union, Geneva, March 1993.
6. ITU, *Recommendation Q.1205: Intelligent network physical plane architecture,* Int. TeleCommun. Union, Geneva, March 1993.
7. ITU, *Recommendation Q.1208: Intelligent network interface recommendations for CS-1,* Int. TeleCommun. Union, Geneva, October 1995.
8. ITU, *Recommendation Q.1211: Introduction to intelligent network capability set 1,* Int. TeleCommun. Union, Geneva, March 1993.
9. ITU, *Recommendation Q.1213: Global functional plane for intelligent network CS-1,* Int. TeleCommun. Union, Geneva, October 1995.
10. ITU, *Recommendation Q.1214: Distributed functional plane for intelligent network CS-1,* Int. TeleCommun. Union, Geneva, October 1995.
11. ITU, *Recommendation Q.1215: Physical plane for intelligent network CS-1,* Int. TeleCommun. Union, Geneva, October 1995.
12. ITU, *Recommendation Q.1219: Intelligent network user's guide for CS-1,* Int. TeleCommun. Union, Geneva, April 1994.
13. ITU, *Recommendation Q.1221: Introduction to Intelligent Network Capability Set 2,* Int. TeleCommun. Union, Geneva, September 1997.
14. ITU, *Recommendation Q.1223: Global functional plane for Intelligent Network Capability Set 2,* Int. TeleCommun. Union, Geneva, September 1997.
15. ITU, *Recommendation Q.1224: Distributed functional plane for Intelligent Network Capability Set 2,* Int. TeleCommun. Union, Geneva, September 1997.
16. ITU, *Recommendation Q.1225: Physical plane for Intelligent Network Capability Set 2,* Int. TeleCommun. Union, Geneva, September 1997.

17. ITU, *Recommendation Q.1228: Interface Recommendation for Intelligent Network Capability Set 2,* Int. TeleCommun. Union, Geneva, September 1997.
18. ESTI, *ETSI ETR NA-61010: Intelligent network user's guide for CS-1,* European TeleCommun. Standardization Institute, May 1994.
19. ESTI, *ETSI ETR 300348: Intelligent network CS-1 physical plane,* European TeleCommun. Standardization Institute, November 1993.
20. ESTI, *ETSI TCR-TR NA-60502: Distributed functional plane for intelligent network CS-1 physical plane,* European TeleCommun. Standardization Institute, November 1993.
21. ESTI, *ETSI TCR-TR NA-60204: Guidelines for standards on intelligent network CS-1,* European TeleCommun. Standardization Institute, March 1923.
22. ESTI, *ETSI TCR-TR NA-60501: Global functional plane for intelligent network CS-1,* European TeleCommun. Standardization Institute, November 1993.
23. E. Carne, *Telecommunications Primer: Signals, Building Blocks and Networks,* Upper Saddle River, NJ: Prentice-Hall, 1995.
24. T. Magedanz and R. Popescu-Zeletin, *Intelligent Networks Basic Technology, Standards and Evolution,* New York: International Thompson Computer Press, 1996.
25. R. Berman and J. Brewster, Perspectives on the AIN architecture, *IEEE Commun. Mag.,* **30** (2): 27–32, 1992.
26. R. Robrock, The intelligent network evolution in the United States, *Conf. Rec. Int. Conf. Commun. (ICC) (Singapore),* vol. 1, 1990, pp. 11.4/1.5.
27. R. Robrock, The intelligent network-changing the face of telecommunications, *Proc. IEEE,* **79**: 7–20, 1991.
28. Bellcore, *Bellcore multi-vendor interactions compendium of 1989 technical results,* 1990.
29. ITU, *Principles of intelligent network architecture,* Q.1201/I.312, 1992, revised 1995.
30. W. Ambrosch, A. Maher, and B. Sasscer, *The Intelligent Network: A Joint Study by Bell Atlantic, IBM and Siemens,* Berlin: Springer-Verlag, 1989.
31. J. Garrahan et al., Intelligent network overview, *IEEE Commun. Mag.,* **31** (3): 30–36, 1993.
32. P. Russo et al., INrollout in the United States, *IEEE Commun. Mag.,* **31**: 56–63, 1993.
33. P. Bragwad and B. Coker, Advanced intelligent network requirements for personal communications services, *1st Int. Conf. Universal Personal Commun.* Dallas, TX, 1992, pp. 1–5.
34. R. Cochetti, Intelligent communications: The complete solution, *Telephony* **226**: 22, 26, 28, 1994.
35. G. S. Lauer, IN architectures for implementing universal personal telecommunications, *IEEE Netw.,* **8** (2): 6–16, 1994.
36. W. Lee, Applying the intelligent cell concept to PCS, *IEEE Trans. Veh. Technol.,* **43**: 672–679, 1994.
37. E. Lipper and M. Rumsewicz, Teletraffic considerations for widespread deployment of PCS, *IEEE Netw.,* **8** (5): 40–49, 1994.
38. R. Pandya, Emerging mobile and personal communication systems, *IEEE Commun. Mag.,* **33** (6): 44–52, 1995.
39. P. Rice, SS7 networks in a PCS world, *Telephony,* **230**: 138, 140, 142, 144, 146, 1996.
40. J. Stach and J. Place, A simulation study of hybrid SSP/IP architecture in the advanced intelligent network, *Int. J. Model. Simulation,* **16**: 111–117, 1996.
41. K. Takami et al., An application of advanced intelligent network technology to personal communication services, *IEEE Intell. Netw. Workshop* Melbourne, Victoria, Australia, 1996, p. 6.
42. M. Bray, Impact of new services on SCP performance, *Conf. Rec. Int. Conf. Commun. (ICC),* 1990, pp. 241–247.
43. K. Egolf, Single number expanding to multiple applications, *Telephony,* **230**, 1996.
44. J. Shih and C. Addison, Bellsouth telecommunications first step towards personal communications, *Proc. IEEE Int. Conf. Universal Personal Commun.* San Diego, 1994, pp. 607–611.
45. ITU, *Principles for a Telecommunications Management Network,* ITU Recommendation M.3010, 1992.
46. ITU, *Basic reference model for open distributed processing,* X.900/ ISO/IEC 10746-2.2 1-5, 1993.
47. Bellcore, *Cycle 1 specifications for information networking architecture (INA),* 1993.
48. H. Rubin and N. Natarajan, A distributed software architecture for telecommunication networks, *IEEE Network,* **8** (1): 8–17, 1994.
49. M. Appeldorn, R. Kung, and R. Saracco, TMN + IN = TINA, *IEEE Commun. Mag.,* **31** (3): 78–85, 1993.
50. W. Barr, T. Boyd, and Y. Inoue, The TINA initiative, *IEEE Commun. Mag.,* **31** (3): 70–77, 1993.
51. H. Berndt, P. Graubmann, and M. Wakano, Service specification concepts in TINA-C, *Towards a Pan-European Telecommunication Service Infrastructure, IS&N 94 2nd Int. Conf.,* 1994, pp. 355–366.
52. F. Dupuy, G. Nilsson, and Y. Inoue, The TINA Consortium: Toward networking telecommunications information services, *IEEE Commun. Mag.,* **33** (11): 78–83, 1995.
53. N. Natarajan and G. Slawsky, A framework architecture for information networks, *IEEE Commun. Mag.,* **30** (4): 102–109, 1992.
54. M. Wakano, M. Kawanishi, and L. Richter, Information model to support TINA service and management applications, *Proc. IEEE Conf. Global Commun. (GLOBECOM),* 1994, pp. 543–547.
55. H. Fowler, TMN-based broadband ATM network management, *IEEE Commun. Mag.,* **33** (3): 74–79, 1995.
56. R. Glitho and S. Hayes, Telecommunications management network: Vision vs. reality, *IEEE Commun. Mag.,* **33** (3): 47–52, 1995.
57. M. Kockelmans and E. Jong, Overview of IN and TMN harmonization, *IEEE Commun. Mag.,* **33** (3): 62–66, 1995.
58. D. Sidor, Managing telecommunications networks using TMN interface standards, *IEEE Commun. Mag.,* **33** (3): 54–60, 1995.
59. T. Towle, TMN as applied to the GSM network, *IEEE Commun. Mag.,* **33** (3): 68–73, 1995.
60. K. Yamagishi, N. Sasaki, and K. Morino, An implementation of a TMN-based SDH management system in Japan, *IEEE Commun. Mag.,* **33** (3): 80–85, 1995.
61. The TINA Consortium, About TINA-C, [Online], 1997. Available: http://www.tinac.com/
62. The TINA Consortium, The TINA trials, [Online], 1997. Available: http://www.tinac.com/

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