The Development of the Wireless Intelligent Network (WIN) and Its Relation to the International Intelligent Network Standards

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This paper summarizes the current International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) intelligent network (IN) standards in the context of the wireless intelligent network (WIN) and relevant parts of the ANSI-41 family of standards developed in the United States. In addition, this paper outlines the concepts on which the standardization of the IN support of wireless networks should be developed internationally. The principal observation of the paper is that, while the mobile networks based on different standards are substantially dissimilar, it is still feasible to define one standard that would allow these dissimilar mobile networks to access the IN to provide telecommunications services globally and seamlessly. WIN sets the direction for such a standard.

Introduction

The intelligent network (IN) is an architectural concept that enables the real-time execution of network services and customer applications in a distributed environment consisting of interconnected computers and switching systems. Beginning in the early 1980s, the IN was applied to the development of new services in wireline telephone networks. Notable successes were achieved in the United States long-distance telephone industry, where IN-based 800-number services and virtual private network (VPN) services contributed strongly to growth in traffic and revenue. Given the highly competitive nature of that industry beginning in that period, IN platforms became key competitive weapons for the rapid development of differentiating services. Also around this time, the local exchange carrier industry developed advanced IN concepts and began to apply them to specialized service development in local wireline networks.

Many of the desirable properties of the modern IN architecture are based on three major principles of independence:

- Service independence (meaning that a wide variety of services can be composed using a set of common building blocks),
- Separation of basic switching functions from service and application functions, and
- Independence of applications from lower-level communication details.

In the fast-growing world of wireless networks, IN platforms designed according to these principles are now being applied to two fundamental needs: 1) The independence from physical network configuration and geography inherent in the IN has made it a natural platform to support the basic mobility functions required in wireless mobile networks; and 2) Just as in its earlier application to wireline networks, the IN's ability to support the rapid development and deployment of differentiating services makes it a necessary weapon in the arsenal of wireless carriers operating in highly competitive environments.

In the beginning, individual large carriers or industry segments (such as the Regional Bell

Panel 1. Abbreviations, Acronyms, and Terms

ACF—authentication control function
ANSI—American National Standards Institute
ASE—application service element
BCM—basic call manager
BCP—basic call process
BCSM—basic call state model
BS—base station
CCAF—call control agent function
CCF—call control function
CS—capability set
CUSF—call unrelated service function
DFP—distributed functional plane
DP—detection point
EDP—event detection point
EIA—Electronic Industries Association
FE—functional entity
FIM—feature interaction manager
FSM—function state model
GFP—global functional plane
GSL—global service logic
GSM—Global System for Mobile Communications
HLR—home location register
IAF—intelligent access function
IF—information flow
IN—intelligent network
INAP—intelligent network application protocol
INCM—intelligent network conceptual model
IP—intelligent peripheral
ISDN—integrated services digital network
ISUP—integrated services digital network user part
ITU—International Telecommunication Union
ITU-T—International Telecommunication Union - Telecommunication Standardization Sector
LRF—location registration function
LRFSM—location registration function state model
MAP—mobile application part
MC—message center
MS—mobile station
MSC—mobile switching center
NAP—network access point
NE—network entity
NRM—network reference model
OA&M—operations, administration, and maintenance
OSI—open systems interconnection
PCS—personal communications services
PE—physical entity
POI—point of initiation
POR—point of return
RACF—radio access control function
RCF—radio control function
R/N—request/notification
ROSE—remote operation service element
RTF—radio terminal function
SCCP—signaling connection control part
SCEF—service creation environment function
SCF—service control function
SCP—service control point
SCUAF—service control user agent function
SDF—service data function
SDL—systems description language
SDP—service data point
SIB—service independent building block
SMAF—service management agent function
SME—short message entity
SMF—service management function
SN—service node
SRF—specialized resource function
SS7—Signaling System 7
SSCP—service switching and control point
SSF—service switching function
SSP—service switching point
TCAP—transaction capabilities application part
TDP—trigger detection point
TIA—Telecommunications Industry Association
UPT—universal personal telecommunications
VPN—virtual private network
WIN—wireless intelligent network

Operating Companies under Bellcore's technical leadership) specified their own IN systems, and there were no universally agreed upon *standards*. Then, an IN standards project was initiated in the International Telecommunication Union (ITU) in 1989. The first set of IN standards was approved by the World Telecommunication Standardization Conference in March 1993. This set, known as IN capability set 1 (CS-1), which was revised and reissued in 1995, provides only limited support to wireless services. Capability set 2 (CS-2), a much richer and broader set of IN standards, is expected to be approved in September 1997 and has provided a base for the development of both the American National Standards Institute (ANSI) IN standard (by the Committee T1) and the wireless intelligent network (WIN) standard (by the Telecommunications Industry Association [TIA]). The WIN provides the framework for the integration of the IN and previous work on wireless networks standards.

It should be noted that the wireless standardization had a different focus from the conventional IN trajectory. Whereas the focus of the IN standardization work was on value-added services in the fixed networks, the work on wireless networks was to assist service providers and end users with the ability to obtain telecommunications services regardless of their location and to be in motion while continually accessing telecommunications services. To this end, the family of network wireless standards, *ANSI-41* (formerly known as IS-41), has been developed by the TIA based on the rapid emergence of cellular and personal communications services (PCS) networks over the past decade. The *ANSI-41* standards, which have been widely implemented in the United States and internationally, provide the base on which WIN has been developed. (*ANSI-41*–based wireless networks are deployed in more than 85 countries.) In addition, WIN has incorporated the most recent developments in IN standardization. WIN is now being positioned by the United States as the principal driver for the future mobility standards in the ITU.

This paper presents the technical platform of the current international IN standardization, and it relates WIN to that platform, describing the common parts as well as similarities and differences. The concluding section of this paper outlines the direction for achieving global interworking of mobile networks and the IN. This direction should lead to successful international standardization of the IN support of wireless networks.

The Platform

In this section we first briefly review the present status of standardization efforts concerning the WIN and IN. One essential piece, common to both efforts, is the IN conceptual model (INCM), with its four planes. Next we systematically review the IN and WIN in light of the four IN planes.

Overview of the Existing and Evolving Standards

In support of the IN standardization effort, in addition to approving and publishing the refined International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) CS-1 Recommendations[1,2] in 1995, the ITU-T has finished the technical work on the draft IN CS-2 Recommendations, which are scheduled to be approved in September 1997. The draft IN CS-2 Recommendations also form the foundation of the ANSI IN standard,[3] the technical work on which has been also finished. (A recent monograph[4] provides a detailed overview of the existing and emerging IN global and regional standards.)

The work on WIN in the United States has progressed in parallel with that of CS-2 and the ANSI IN standard, and it is positioned to influence IN CS-3, the work on which has just started. Panel 2 summarizes the ITU-T IN Recommendations. Panel 3 summarizes the *ANSI-41 Cellular Radiotelecommunications Intersystem Operations* standards.

These standards existed before the WIN work started and recently were augmented in response to the WIN requirements. In addition, a draft standard, ANSI-41.7, *Cellular Radiotelecommunications Intersystem Operations: Distributed Functional Plane*, which defines the distributed functional plane for WIN, is currently under development.

In terms of the subject matter, it is relatively straightforward to observe the following similarities between the two sets of standards:

- ANSI-41.1 is parallel to ITU-T Recommendations Q.1201, Q.1205, Q.1215, and Q.1225,
- ANSI-41.2, ANSI-41.3, and ANSI-41.7 are parallel to ITU-T Recommendations Q.1204, Q.1211, Q.1221, and Q.1224, and
- ANSI-41.5 and ANSI-41.6 are parallel to ITU-T Recommendations Q.1208, Q.1211, Q.1218, Q.1221, and Q.1228.

Note that ITU-T Recommendations Q.1203 and Q.1223 have no WIN counterpart because WIN has not standardized service independent building blocks (SIBs). Note also that there is no IN standards counterpart to the material in ANSI-41.4. The IN-related network and service management issues are still at the starting point of studies in the ITU-T.

In the remainder of this paper we expand on this parallelism as we address the material in more detail.

Panel 2. Existing IN Recommendations Produced by the ITU-T

Below is a summary of the existing IN Recommendations produced by the ITU-T.

Recommendation Q.1200, *General Series Intelligent Network Recommendation Structure,* explains the naming conventions and provides the outline of the Q.120x Series.

Recommendation Q.1201, *Principles of Intelligent Network Architecture,* defines the objectives and provides the overall description of IN. In addition, this Recommendation contains high-level IN functional requirements, and it describes the IN architectural concept. To this end, the Recommendation presents the IN conceptual model, which is composed of four planes: the Service Plane, the Global Functional Plane, the Distributed Functional Plane, and the Physical Plane. Each of the remaining IN Recommendations (except Recommendation Q.1290) deals with an architecture related to one of the four planes.

Recommendation Q.1202, *Intelligent Network—Service Plane Architecture,* describes the IN Service Plane, making the point that all IN-supported services can be described to the end user or subscriber by means of a set of generic blocks called service features.

Recommendation Q.1203, *Intelligent Network—Global Functional Plane,* describes the architecture of the IN Global Functional Plane. To do so, it introduces the concept of service-independent building blocks (SIBs), which are modeling constructs that denote the network-wide capabilities needed to deliver service features.

Recommendation Q.1204, *Intelligent Network—Distributed Functional Plane,* defines the IN architecture in terms of IN functional entities (FEs), which are sets of functions that reside in a single piece of physical equipment. The FEs communicate with each other by exchanging information flows (IFs) over (logical) media called relationships. The SIBs are realized in the distributed functional plane through the distributed processing carried by the FEs. The Recommendation also defines the IN call modeling concepts and provides a general example of the basic call state model (BCSM), in the context of which the IN triggering concept is defined.

Recommendation Q.1205, *Intelligent Network—Physical Plane,* defines the architecture of the IN in terms of physical entities (PEs), which constitute the IN equipment, and their interconnections.

Recommendation Q.1208, *General Aspects of the Intelligent Network Application Protocol (INAP),* specifies the methodology for the development of INAP.

Recommendation Q.1210, *Q-Series Intelligent Network Recommendation Structure,* provides the outline for the entire series of CS-1 Recommendations.

Recommendation Q.1211, *Introduction to Intelligent Network Capability Set 1,* specifies the contents of CS-1 and defines its service- and network-related principles.

Recommendation Q.1213, *Intelligent Network—Global Functional Plane for CS-1,* specifies 14 CS-1 SIBs.

Recommendation Q.1214, *Intelligent Network—Distributed Functional Plane for CS-1,* forms the basis for the definition of the CS-1 INAP. The Recommendation defines CS-1 FEs and provides their models as related to service execution. In particular, the Recommendation defines the CS-1 BCSM. Recommendation Q.1214 also describes each of the CS-1 SIBs in terms of functional entity actions performed by all associated FEs and the IFs exchanged among them on behalf of those SIBs. Finally the Recommendation supplies detailed descriptions of all CS-1 IFs.

Recommendation Q.1215, *Intelligent Network—Physical Plane for CS-1,* lists the IN PEs and describes the allocation of IN FEs to these PEs as well as the associated interfaces.

Recommendation Q.1218, *Intelligent Network Application Protocol,* specifies the protocol to support the capabilities required by the CS-1 benchmark services.

Recommendation Q.1219, *Intelligent Network User's Guide for Capability Set 1 (CS-1),* reflects invaluable clarifications of many CS-1 issues, including identification of specific problems with proposals for their solution. In addition, it provides systematic descriptions of several service scenarios (most notably, the universal personal telecommunications (UPT) service scenario).

Recommendation Q.1290, *Glossary of Terms used in the Definition of Intelligent Network Recommendations,* defines IN terms and concepts and contains a list of acronyms, which makes it a necessary companion when studying other Recommendations.

The structure of the CS-2 Recommendations is parallel to those of CS-1. The CS-2 Recommendations to be issued are Q.1220, Q.1221, Q.1222, Q.1223, Q.1224, Q.1225, Q.1228, and Q.1229.

The Intelligent Network Conceptual Model

In proposing the INCM, ITU-T Recommendation Q.1201 notes that it "should not be considered in itself an architecture" but rather serve as "a framework for the design and description of the IN architecture." It is important to keep in mind that INCM is not an architecture but rather a set of *viewpoints* developed according to the open distributed processing (ODP) guidelines.[7]

The INCM is depicted in **Figure 1** (after Figure 20 of ITU-T Recommendation Q.1201) as a set of four planes: the service plane, the global functional plane (GFP), the distributed functional plane (DFP), and the physical plane. These planes represent different aspects of implementing services as follows:

- The *service plane* deals with service specification (or, conversely, an observation of a service in action). Services are described in terms of service features. The principles of service independence also apply here, since service features, which exist in the service plane, may be used within the context of other services. (For example, the service features typical for the fixed network may be used in wireless networks.) Further, since a service specification at that level does not take into account any aspects of the underlying network, the service plane represents a service designer's viewpoint. Conversely, a service user typically observes the service at this plane.
- The *global functional plane* is where the service is expressed in terms of SIBs. The SIBs are atomic instructions chained together to form service logic programs (SLPs). The network *executes* SIBs in the following way. Whenever the basic call process (BCP) (in turn executed by the switching nodes of Figure 1) passes the control to service logic (indicated by the arrow leaving the point of initiation [POI]), the SIBs are executed in the way they are connected in the chain. In the end, control returns to the BCP, which, however, may continue its execution at a different point from the POI, the point of return (POR). Service programmers, equipped with an ideal service creation package that shields them from the network, observe the IN at this plane.
- The *distributed functional plane* comprises computational objects called functional entities

> **Panel 3. TIA/EIA-41 Standards**
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> ANSI has approved the TIA/EIA-41 series of standards entitled *Cellular Radiotelecommunications Intersystem Operations.* (Before these standards had been approved, they were known to the industry as IS-41,[5,6] for interim standards.) The resulting standards are listed below.
>
> <u>ANSI-41.1,</u> *Cellular Radiotelecommunications Intersystem Operations: Functional Overview*, defines the Network Reference Model and describes the services supported by (and general assumptions for developing) this series of standards.
>
> <u>ANSI-41.2,</u> *Cellular Radiotelecommunications Intersystem Operations*: *Intersystem Handoff Information Flows*, describes the information flows between network entities in support of intersystem handoff scenarios.
>
> <u>ANSI-41.3,</u> *Cellular Radiotelecommunications Intersystem Operations: Automatic Roaming Information Flows*, describes the information flows between network entities in support of automatic roaming scenarios.
>
> <u>ANSI-41.4,</u> *Cellular Radiotelecommunications Intersystem Operations: Operations, Administration, and Maintenance Information Flows and Procedures*, describes the operations, administration, and maintenance (OA&M) information flows and procedures in support of intersystem handoff and automatic roaming as well as intersystem trunk maintenance.
>
> <u>ANSI-41.5,</u> *Cellular Radiotelecommunications Intersystem Operations: Signaling Protocols,* defines the mobile application part (MAP) operations and parameters based on the IFs specified in ANSI-41.2 and ANSI-41.3.
>
> <u>ANSI-41.6,</u> *Cellular Radiotelecommunications Intersystem Operations: Signaling Procedures*, describes the signaling and call processing procedures for intersystem handoff, automatic roaming, and other features.

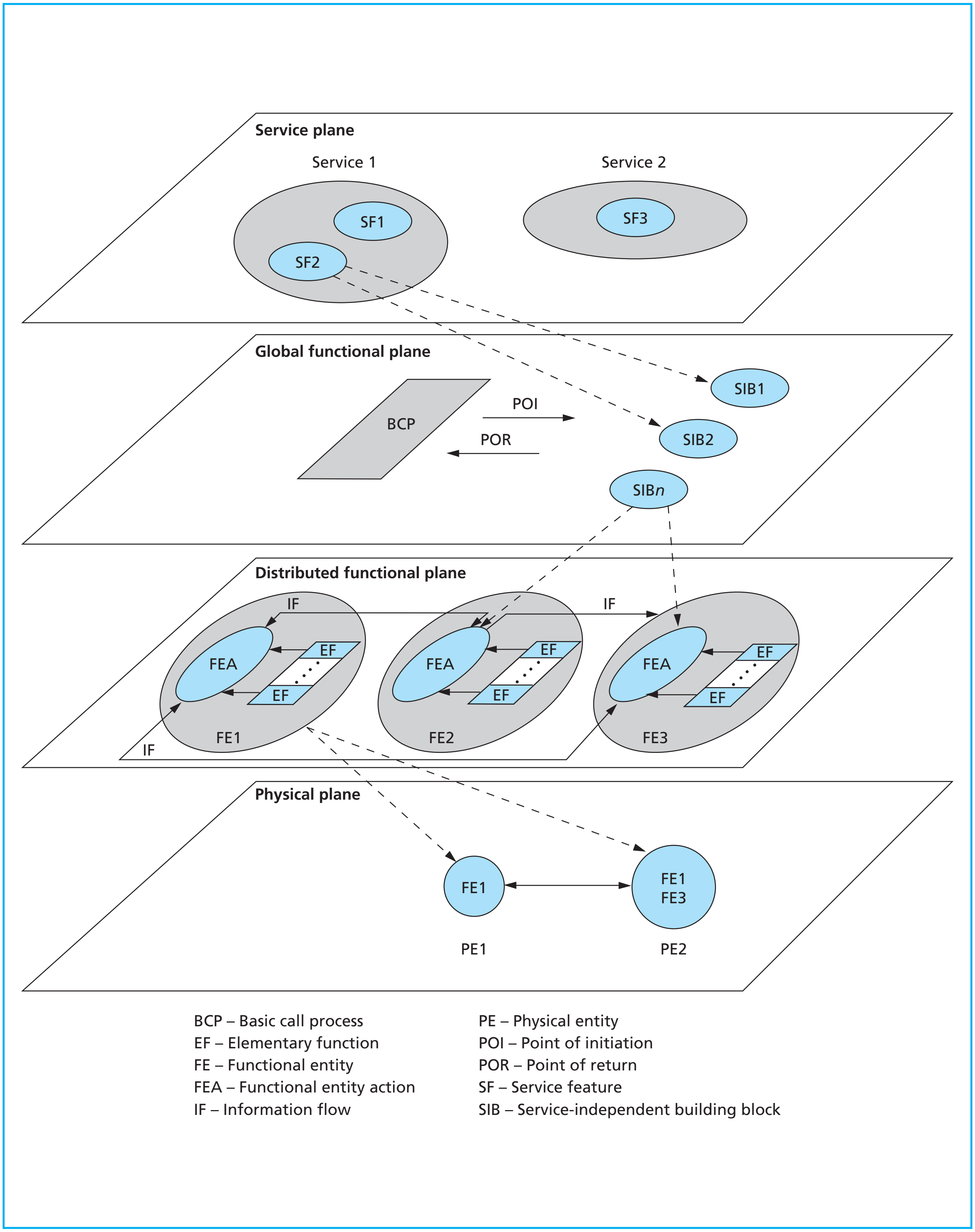

Figure 1.
Intelligent network conceptual model (after Figure 20 of ITU-T Recommendation Q.1201).

(FEs). (None of these objects is tied with any piece of physical hardware, which is why the word "functional" is used.) The FEs may exchange messages called information flows (IFs). An FE may send an IF only to those FEs to which it has a relationship (this is a place in the model where the physical network connections are reflected) and even then only in a specified direction. This plane represents the viewpoint of a network designer.

- The *physical plane* is where the real network hardware resides. The physical entities (PEs) (that is, the switches, general purpose computers that contain databases, specialized resources, and other elements), of which the network is composed, exchange *protocol* messages. The FEs of the DFP are assigned to PEs, and the IFs between the communicating FEs in different PEs are mapped into the protocol messages. Network and protocol designers observe the IN at this plane.

Finally, it should be noted that INCM is consistent with the ITU-T three-stage methodology, which was developed to describe integrated services digital network (ISDN) services and derive the protocols to support them. The methodology is carried out, for each service, in three stages as follows:

- Stage 1 describes the service as perceived by a user.
- Stage 2 defines the capabilities and processes within the network that are required to provide the service. The output of this stage is the functional decomposition of the network components into FEs as well as fully specified IFs to support the service.
- Stage 3 produces the protocol specification.

It is easy to see that these three stages correspond to, respectively, the service plane, the DFP, and the physical plane. In fact, the IN has simply adopted these concepts, including the terminology associated with them (such as FEs and IFs). Nevertheless, the GFP had no counterpart in the old terminology since it dealt with the individual services.

The pre-WIN wireless protocol work in the United States (that is, the former TIA/EIA/IS-41 standards) addressed the basic wireless service, and in doing so it was based on the three-stage methodology. This should explain in principle the essential similarity of the wireless protocol to the intelligent network application protocol (INAP), which is systematically explored in this paper.

In the remainder of this section, we briefly introduce relevant concepts and reports on standards developed for each plane. WIN builds on the INCM concept.

Service Plane

Technical publications often refer to "IN services." This term usually denotes services that are traditionally implemented using IN, but the term is misleading. There is simply no such thing as an "IN service," because IN is service-independent; any service, in principle, can be implemented using IN and any service can be implemented without using IN. IN does *not* standardize or define services, but it does define and standardize the means of supporting their introduction into networks. Therefore, a much better term to use when speaking of services in connection with IN is "IN-based" or "IN-supported."

It is important to assert at this point that each specific IN standardization effort (such as CS-1, CS-2, or WIN) starts with determining which services and service features should be delivered using IN means and which ones require no IN intervention and thus are assumed to be *basic*. In fixed networks, there has been a clear demarcation point (addressed in detail below) between the support of basic services (delivered by switches) and supplementary services (supported by IN). The development of WIN has resulted in a similar separation between the basic mobility services that require no IN support and supplementary services that may be (and are expected to be) delivered by the means of IN-to-mobility-network interworking.

The role of the IN service plane is to keep a repository of the services that can be supported by a given IN capability set. By the time IN standardization started, there had been several existing IN implementations (and several proposals for new ones) that had significant differences in the capabilities and their underlying protocols. An attempt to amalgamate these protocols into one, working "bottom-up," did not seem to foster agreements, for which reason the standardization process was re-organized to include the "top-down" approach. The latter—and it has proven to be successful—first builds an agreement on the services and service features to be supported in a given capability set and only then considers the lower-level capabilities needed for the support of the services chosen. Thus it is perfectly correct to speak about CS-1 services, CS-2 services (which, of course, include CS-1 services), and so forth.

Both CS-1 and CS-2 support service features (and, consequently, services) that are *single ended* and have a *single point of control*. Those criteria are defined in ITU-T Recommendation Q.1211 as follows:

- "A single-ended service feature applies to one party in a call and is orthogonal (independent) at both the service and topology levels to any other parties that may be participating in the call. Orthogonality allows another instance of the same or a different single-ended service feature to apply to another party in the same call as long as the service feature instances do not have feature interaction problems with each other."
- "Single point of control describes a relationship where the same aspects of a call are influenced by one and only one service control function at any point in time."

In other words, single-endedness means that a service process deals with only one *call party* (that is, either the calling or called party) and having a single point of control means that service control processes on different machines do not have to know anything about each other, including each other's existence.

WIN endorses both principles as shown in the draft standard ANSI-41.7.

ITU-T Recommendations Q.1211 and Q.1221 list the services and service features to be supported in CS-1 and CS-2, respectively. This material, however, is by no means a standard, since services are not a subject of IN standardization.

WIN, as described in the draft standard ANSI-41, introduces three types of services: *terminal mobility services*, *personal mobility services*, and *advanced network services* as its drivers. The latter two types of services are common for the fixed and mobile networks and are further explained below.

- The *incoming call screening* feature allows incoming calls to be treated differentially based on screening criteria set by subscribers. (In addition to normal call termination, possible treatments of incoming calls are *call forwarding*, *alternative routing*, and *call blocking*.) The screening criteria may be based on the calling or called party characteristics. (The originating directory number and the password provided by the caller are examples of the former, while the called party location, called party status, and time of the day are examples of the latter.)
- The *single number reach* service allows each user to have a single directory number. The user can be associated with and configure any terminal, mobile or fixed, to access customized telecommunications services according to personal needs.
- The *virtual private network* service provides to a subscriber (typically, an organization) the "touch and feel" of a private network with public network resources (wireless or wireline). Typical private network service features include dialing restrictions, private numbering plans, call hold, and call transfer.
- *Voice-controlled* services are actually not services but rather the means of accessing and controlling existing services using spoken commands that affect dialing, feature activation, user identification, and speech-to-text conversion. All these may share a common syntax and vocabulary.

All the above services and service features can be supported by present IN standards in the wireline network. Nevertheless, seamless interworking of wireless and fixed networks cannot be supported by either IN or basic mobile networks alone. WIN is developed to fill this gap.

The new draft ITU-T Recommendation Q.1222 (which has no CS-1 counterpart) also provides definitions of the following concepts: *feature interaction*, *feature cooperation*, and *feature interference*. *Feature interaction* is defined as a "situation that occurs when an action of one feature affects an action or capability of another." With that, it is noted that such a situation may be undesirable (that is, when it disrupts a service) or desirable (when features "cooperate" in achieving the expected result). A desirable feature interaction is called *feature cooperation*; an undesirable one, *feature interference*. In general, the interactions may occur not only among the *call-related* features (that is, the features of the services or parts of the services that are performed within a given call context) but also among the *non-call-related* features (which are particular to CS-2—especially, its mobility aspects—and include user authentication and registration). The Recommendation prescribes that the features of either type (as well as across both types) be examined in the context of interactions. To this end, the ANSI-41 standards examine specific scenarios where service interactions may be present and provide standard mechanisms to avoid them.

Finally, while CS-1 addressed only telecommunications services, CS-2 also addresses the service management services (which include service customization, service control, and service monitoring) and service creation services (which include service specification, service development, service verification, and service deployment). No specific IN standards, however, have been produced in that area, and the same holds for WIN.

Global Functional Plane

The GFP provides the view of service developers. To this end, the GFP *models* the IN programming environment. (The word "models" is used because the IN standards so far have intentionally avoided specification of such an environment.)

The major concepts considered here are those of the BCP, global service logic (GSL), and SIBs. Each of these is discussed in a separate section below. Keeping the needs of WIN in mind, it should be noted that the idea of the BCP is central to the WIN/IN future standardization, and it will be expanded later in this paper. On the other hand, the details of the model are irrelevant to WIN, for which reason the discussion of the model has been kept to a minimum. (It should be noted, however, that while not explicitly using SIBs for modeling, WIN illustrates network-wide building blocks and their protocol expansion for calling name identification presentation, voice controlled dialing with subsequent trigger processing, and other features.)

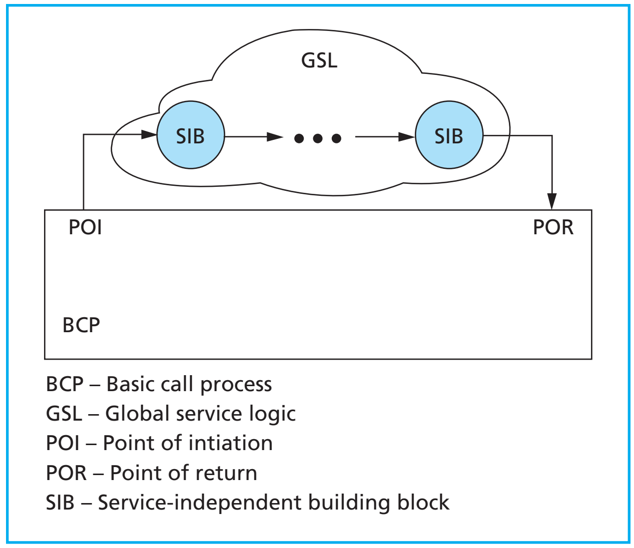

Figure 2.
Global functional plane architecture (after Figure 5 of ITU-T Recommendation Q.1203).

Basic call process. BCP represents a non-IN (that is, switch-based, as far as CS-1 and CS-2 are concerned) part of activities that support a single call. It is important to note that the word "process" is used here to denote a distributed activity. Consider a simple telephone call between two parties connected to the same switching exchange. When the calling party initiates the call, the exchange starts the *originating* process. When the exchange has enough information to ring the called party, it also starts the *terminating* process. In this case, the BCP actually combines these two processes. Of course, as far as the GFP is concerned, the distributed nature of the BCP is irrelevant; however, it is essential to be aware of it to fully understand the concept and appreciate its complexity.

Figure 2 (after Figure 5 of ITU-T Recommendation Q.1203) illustrates the modeling of IN at the GFP level. Whenever the BCP is unable to provide a requested service by itself, it initiates (invokes) a program called GSL, whose execution constitutes another process. This happens at a point in the BCP that is called the point of initiation (POI). Even though the call processing in the switching exchanges does not remain idle when the foreign logic is invoked, for the purposes of modeling of this activity (and relevant software design), the execution of the BCP is considered suspended at the POI. When the execution of GSL is completed, the execution of the BCP is resumed. According to the model, the BCP may resume at a point (POR) that is different from the POI. From the computing point of view, this is a flaw; the monograph[4] suggests a remedial interpretation.

Global service logic and service-independent building blocks. The GSL is defined in Recommendation Q.1203 as the "glue" that specifies the order of its instructions (SIBs) as well as the BCP's PORs to which to return. The GSL is responsible for holding the global data that relates to the call instance to be processed.

SIBs are symbols corresponding to atomic network-wide capabilities. Among the most important SIBs are those that correspond to call queuing, playing announcements, collecting user input, and charging. Similar to combining machine-level instructions to form machine-executable programs, SIBs are combined to form GSL. The CS-1 SIBs are described in ITU-T Recommendation Q.1213. In addition, Recommendation Q.1214 provides more information on the use and implementation of all 14 SIBs.

A word on implementation is warranted here, because rapid ubiquitous service introduction is an essential common goal of both the IN and WIN. It should be expected that service creation environments for fixed networks will seamlessly integrate into the wireless architectures. Most vendors have implemented all CS-1 SIBs, but they claim that many more are needed.[8,9,10,11] To this end, CS-2 has taken steps to define new SIBs as well as to improve the existing ones. In addition, CS-2 is adding new constructs that allow new SIBs (high-level SIBs) to be created from the existing ones and to support the concurrent execution of SIBs.

Again, in both CS-1 and CS-2, the primary role of SIBs has been to aid service modeling and service description. Service designers would spend much less time if they could specify services without deriving service-dependent protocols. Instead, they could use SIBs. Since the protocol to support each SIB is defined and standardized, the protocol to support the whole service can be derived automatically (for example, by a compiler).

Finally, ITU-T Recommendation Q.1219 contains superb self-explanatory examples of using SIBs for service description (for such services as universal personal telecommunications [UPT] set 1).

Distributed Functional Plane

The service and global functional planes deal with the *what* of service support; the DFP is where the *how* issues surface. The word *function* is used here in the sense of a more modern term *class (of objects)*, and the network is viewed as a set of objects, called *FEs*, which exchange messages called *IFs*, over the abstract media called *relationships*. By specifying the information exchange on the same level of abstraction as the FEs are specified, one gets the universal specification, which can later be implemented on a specific physical platform.

The description of protocol services (that is, the semantics of the protocol) indicates on whose behalf the protocol is executed and what has been achieved as the result of the execution. The DFP Recommendation addresses this item in several places. ITU-T Recommendations Q.1214 and Q.1224 describe the IFs in the context of each SIB (respectively, for CS-1 and CS-2). In addition, for each IF, they explain its role, pre- and post-conditions, as well as each of the information elements (IEs) that this IF carries.

Because the semantics of the protocol is the most essential part of any protocol standard, a standard (ANSI-41.7) is reserved for the WIN DFP, and that standard would be essentially the greatest common denominator of IN and WIN standards. (The protocol vocabulary and encoding can, in general, be adapted mechanically to ensure interworking as long as the semantics of the protocol is clear.)

The protocol procedures are specified, first of all, through the introduction of the *basic call state model (BCSM)*, whose two objects, *originating* and *terminating* calls, spur most of the IN traffic. (The BCSM is common to both IN CS-2 and WIN, but WIN augments the architecture by introducing the *location registration function state model [LRFSM].)* Call flows, and sometimes systems description language (SDL) descriptions as in IN Recommendations, are used to describe the

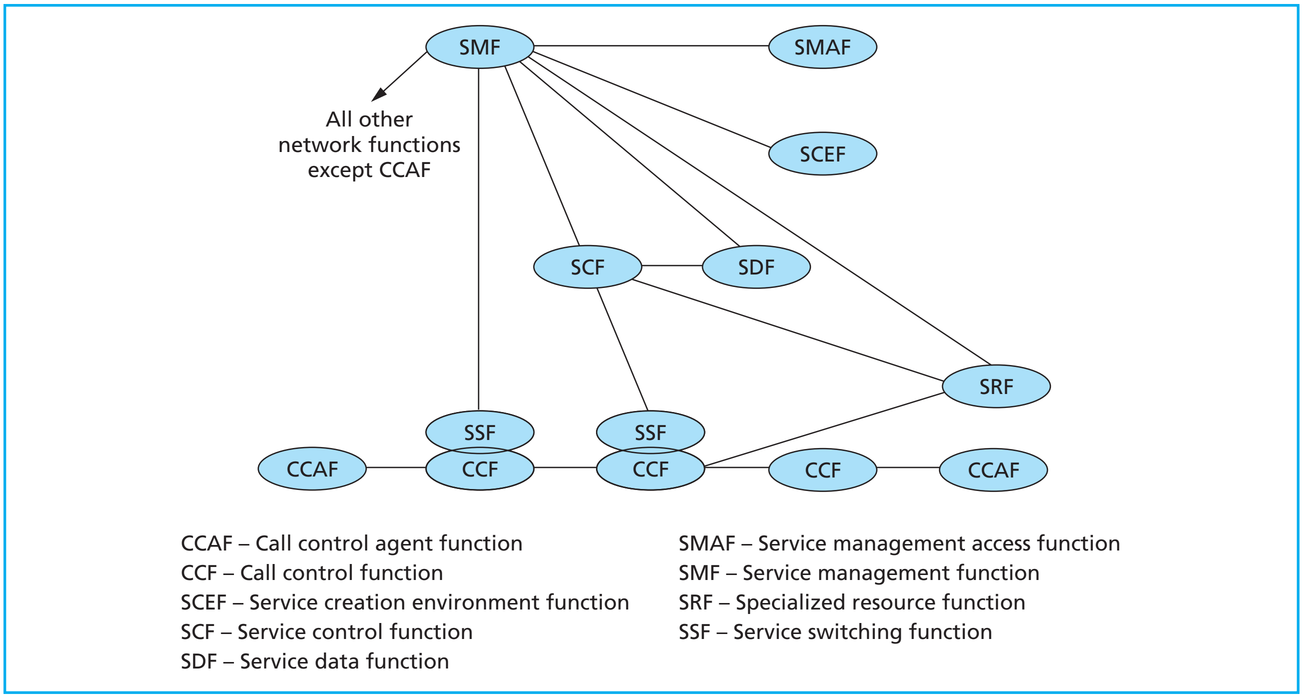

Figure 3.
Distributed functional plane architecture (after Figure 2-1 of ITU-T Recommendation Q.1204).

sequencing of the messages. Nevertheless, the encoding need not be specified because the messages at this level of abstraction are not actually destined to go over physical pipes.

The IN and WIN FEs and call models are presented in the following two sections.

Functional entities. The nine IN FEs (depicted in **Figure 3**, after Figure 2-1 of ITU-T Recommendation Q.1204) are grouped according to their role in supporting IN: those that are involved in service execution and those that are involved in service creation and management.

The six service execution FEs are listed below.

- The *call control agent function (CCAF)* provides user access capabilities. It may be viewed as a terminal through which a user interacts with the network.
- The *call control function (CCF)* provides the basic switching capabilities available in any (IN or non-IN) switching system. These include the capabilities to establish, manipulate, and release calls and connections. The CCF provides the trigger capabilities; however, another object, called the *service switching function*, is needed to support the recognition of triggers as well as interactions with the service control.
- The *service switching function (SSF)*, as mentioned in the previous paragraph, cooperates with the CCF in recognizing the triggers and interacting with the service control. Figure 3 depicts the CCF and SSF as overlapping ovals in order to signal that these objects are inseparable. For now, a network element containing the SSF must, by definition, also contain the CCF. For this reason, the notation SSF/CCF is used throughout all IN Recommendations to refer to a class of objects with switching capabilities.
- The *service control function (SCF)* executes service logic. It provides capabilities to influence call processing by requesting the SSF/CCF and other service execution FEs to perform specified actions. Implicitly, the SCF provides mechanisms for introducing new services and service features *independent* of switching systems.
- The *specialized resource function (SRF)* provides a set of real-time capabilities, which ITU-T Recommendation Q.1204 calls “specialized.” These capabilities include playing announce-

ments and collecting user input (either dual-tone multifrequency or voice, depending on the facilities). The SRF is also responsible for conference bridging and certain types of protocol conversion as well as text-to-voice conversion.

- The *service data function (SDF)* provides generic database capabilities to either the SCF or another SDF.

New FEs introduced by CS-2 are as follows.

- The *intelligent access function (IAF)* provides access to IN-structured networks from non-IN structured networks. (The IAF is actually located in a non-IN-structured network.) As far as the IN-structured network is concerned, the only FE there that has a relationship to the IAF is the SCF. The role of the IAF is pretty much that of a protocol converter.
- The *call unrelated service function (CUSF)*, which is coupled with the SSF and CCF, supports the call unrelated interactions between users and service processing.
- The *service control user agent function (SCUAF)* provides the user access to the CUSF (much as the CCAF provides the user access to the SSF/CCF).

The latter two FEs are not necessarily related to wireless service processing, and currently WIN does not refer to them.

The following three service creation and management IN FEs are defined in Recommendation Q.1204:

- The *service creation environment function (SCEF)* is responsible for developing (programming) and testing service logic, which is then sent to the service management function.
- The *service management function (SMF)* deploys the service logic (originally developed within the SCEF) to the service execution FEs, and otherwise administers these FEs by supplying user-defined parameters to customize the service and collect billing information and service execution statistics.
- The *service management agent function (SMAF)* acts as a terminal that provides the user interface to the SMF.

The relationships among the FEs are based on the client-server model. Under different circumstances, either of the two FEs involved may play the role of the client (for whom the other one becomes a server).

The following relationships have been defined in the IN:

- SCF with SSF/CCF, SRF, SDF, and SCF,
- SCUAF with CUSF,
- SDF with SDF, and
- SMF with SSF/CCF, SRF, SDF, SCF, SCEF, and SMAF.

IFs are exchanged across relationships; each IF is either a client's request or a server's response. The IFs, however, have not yet been standardized (or even defined) for all the above relationships. CS-1 has defined IFs only for the SCF-SSF/CCF, SCF-SDF, and SCF-SRF relationships; CS-2 specifies the IFs for the SDF-SDF and SCUAF-CUSF relationships.

The WIN DFP is based on the draft ITU-T Recommendation Q.1224, but it goes beyond the Recommendation in that it defines additional FEs and relationships. **Figure 4** depicts the WIN FEs and relationships being proposed for the draft standard ANSI-41.7.

The FEs listed below are complementary to the IN CS-2 FEs.

- The *authentication control function (ACF)* provides the capabilities for the authentication of terminals (mobile stations). Authentication typically occurs during terminal location registration, call origination, and page response.
- The *radio access control function (RACF)* supports service features and signaling that require handling of radio links. The RACF supports the wireless-specific interactions within a WIN-structured network. These interactions include terminal paging, radio-bearer setup, and handover. In addition, the RACF allocates specific network radio system elements and other network resources for use during calls, and it may support the acquisition of current terminal location information within the local radio system environment to support delivery of calls to the terminal.
- The *location registration function (LRF)* provides the service logic and data required for mobility

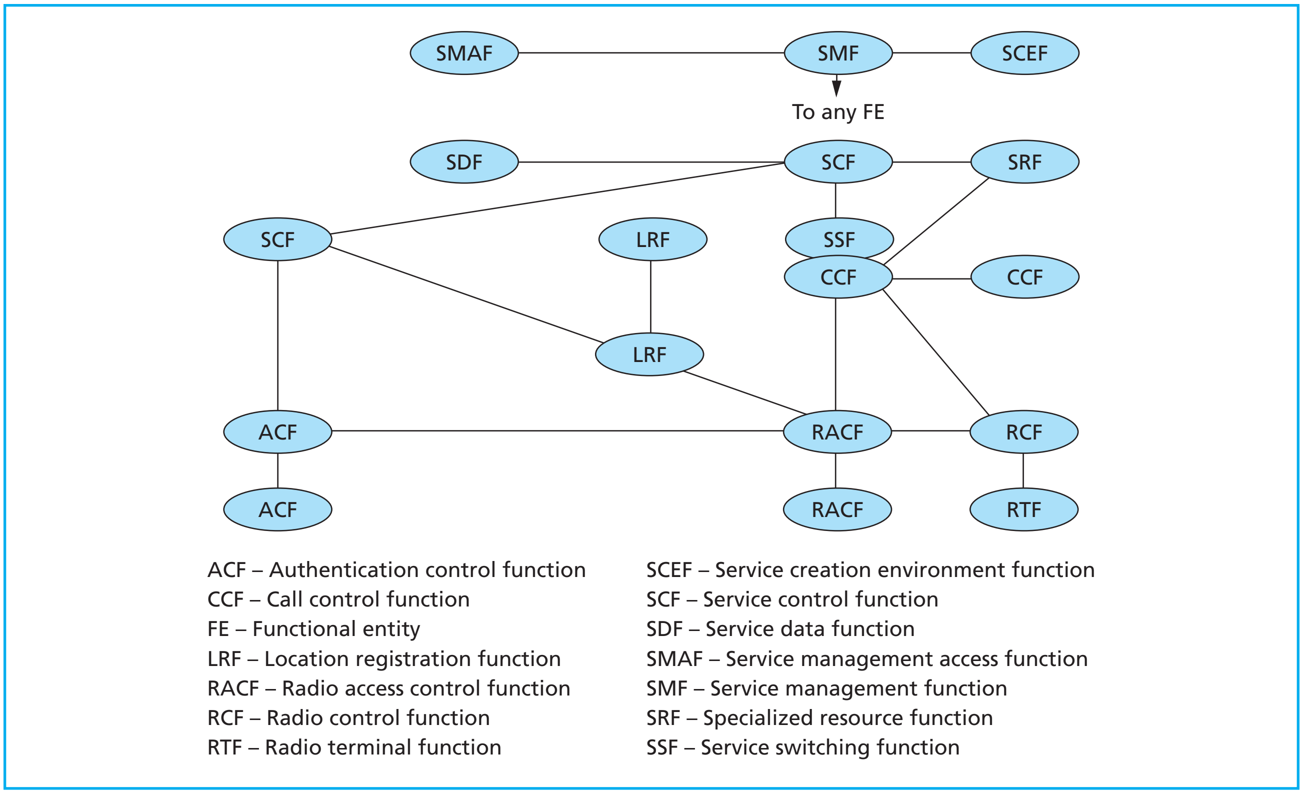

Figure 4.
Wireless intelligent network distributed functional plane architecture.

management. The LRF interacts with the RACF and other LRFs to maintain the location and status of mobile stations and provide mobile station notification information. In addition, the LRF supports interactions with the SCF and SSF/CCF in support of routing address resolution for establishing the information exchange path as well as transferring and updating subscriber profiles.

- The *radio terminal function (RTF)* is the gateway between the wireless user and network call control functions, taking the role of the CCAF in the fixed network case. The RTF supports interactions with the radio control function and the wireless users to establish, maintain, modify, and release calls. The RTF receives indications relating to the call or service from the radio control function and relays them to the user as necessary.
- The *radio control function (RCF)* establishes, maintains, modifies, and releases radio ports and provides interconnection between the radio and network bearer connections. To do so, it interacts with the CCF, RACF, and the RTF. In addition, the RCF provides radio control capabilities such as carrier generation, signal amplification, selective filtering, modulation and demodulation, radio channel assignment, and supervision.

The proposed relationships among these FEs are as follows:

- ACF with ACF, RACF, and SCF,
- LRF with LRF, RACF, and SCF,
- RACF with CCF, RACF, and RCF, and
- RCF with CCF and RTF.

Call models. In intelligent networks, the call is modeled with the aid of two objects within the CCF: the originating and terminating basic call state models (O_BCSM and T_BCSM). The behavior of these objects is described by the finite state machines named after them.

In general, O_BCSM and T_BCSM have to

exchange the information across the network. This information is carried via the ISDN user part (ISUP) protocol, a member of the Signaling System 7 (SS7) family of protocols.[12] Note that either object may interact with the SCF (through the SSF) independently of the other.

The description of the BCSM has its peculiarities, which are as follows:

- The states are referred to as *points in call (PICs)*. Graphically, the PICs are represented by rectangles.
- Some transitions are associated with *detection points (DPs)*, which correspond to such combinations of events that may (but do not have to) result in IN processing. If they do, the BCSM sends appropriate messages to the SCF and the processing may be suspended at the DPs. The present IN model, theoretically, supports transitions to any PIC from any DP, if so instructed by the service logic.

Each DP may be either *armed* or *not armed*. Only when a DP is armed is the external service logic (within the SCF) informed that the DP is encountered. A DP may be armed either *statically* (from the SMF, as the result of the service feature provisioning) or *dynamically* (by the SCF). In the former case, the DP stays armed until the SMF *disarms* it; in the latter case, the DP stays armed for no longer than the duration of a particular SCF-to-SSF relationship. A statically armed DP is called a *trigger detection point (TDP)*. A dynamically armed DP is called an *event detection point (EDP)*.

Even if a DP is armed, it has to satisfy certain *DP criteria* (which are associated with that DP) in order for the SSF/CCF to send an IF to the SCF. In the case of an EDP, such criteria are specified in the IF (from the SCF) that is arming the EDP. As far as the call processing is concerned, either of the two actions may be requested of the SSF/CCF when a DP is encountered. The request for instructions (to the SCF) is issued and the call processing is suspended until the response is received; or the call processing continues and notification of the event is sent (to the SCF).

Accordingly, two types, *R* (for "request") and *N* (for "notification"), are defined for the DPs. Both EDPs and TDPs must be assigned either type, but the assignment takes place *only* at the time a particular DP is armed. If a TDP is armed as *R*, it is denoted *TDP_R*; if it is armed as *N*, it is denoted *TDP_N*. Similarly, an EDP may be denoted *EDP_R* or *EDP_N*, depending on its type. It is important to remember that in order to arm or change a TDP, switches have to be re-provisioned (which is, again, outside the scope of the IN protocol, at least for CS-1), but arming or changing an EDP is comparatively easy—only one message from the SCF to SSF/CCF is required. Notably, WIN (in the draft standard ANSI-41.7) eliminates this restriction— in WIN, provisioning of TDPs may be performed dynamically.

Figure 5 (after Figure 4-10 of ITU-T Recommendation Q.1214) depicts different outcomes of the DP processing in view of the elements of the switching call model. The latter has two new entities—the basic call manager (BCM) and the feature interaction manager (FIM). The initial processing of a BCSM DP is performed by the BCM, which spans both the CCF and SSF. If the DP is not armed, the BCM resumes the processing of the call. Otherwise, the BCM determines the type of the DP and passes its processing to the FIM. The FIM determines whether a message should be sent to the service logic (within the SCF), and, if so, formulates that message. The FIM is also the first element to receive messages from the SCF. Certain call unrelated messages are not passed any further but are processed within the FIM. As mentioned before, the issue of feature interactions is particularly important in the case of WIN architecture because of the additional functional entities involved in service processing.

One more complexity with which the SSF/CCF has to deal is that a DP may be armed as both EDP and TDP. It is therefore necessary to devise certain precedence rules according to which the FIM can process all the "hats" a particular DP is "wearing." To this end, the standard postulates that

- Notifications are to be processed before requests,
- Events are to be processed before triggers, and
- If a DP is armed as both EDP_R and TDP_R, the latter may be processed only if the relationship between the SSF and CCF has been terminated as the result of processing EDP_R.

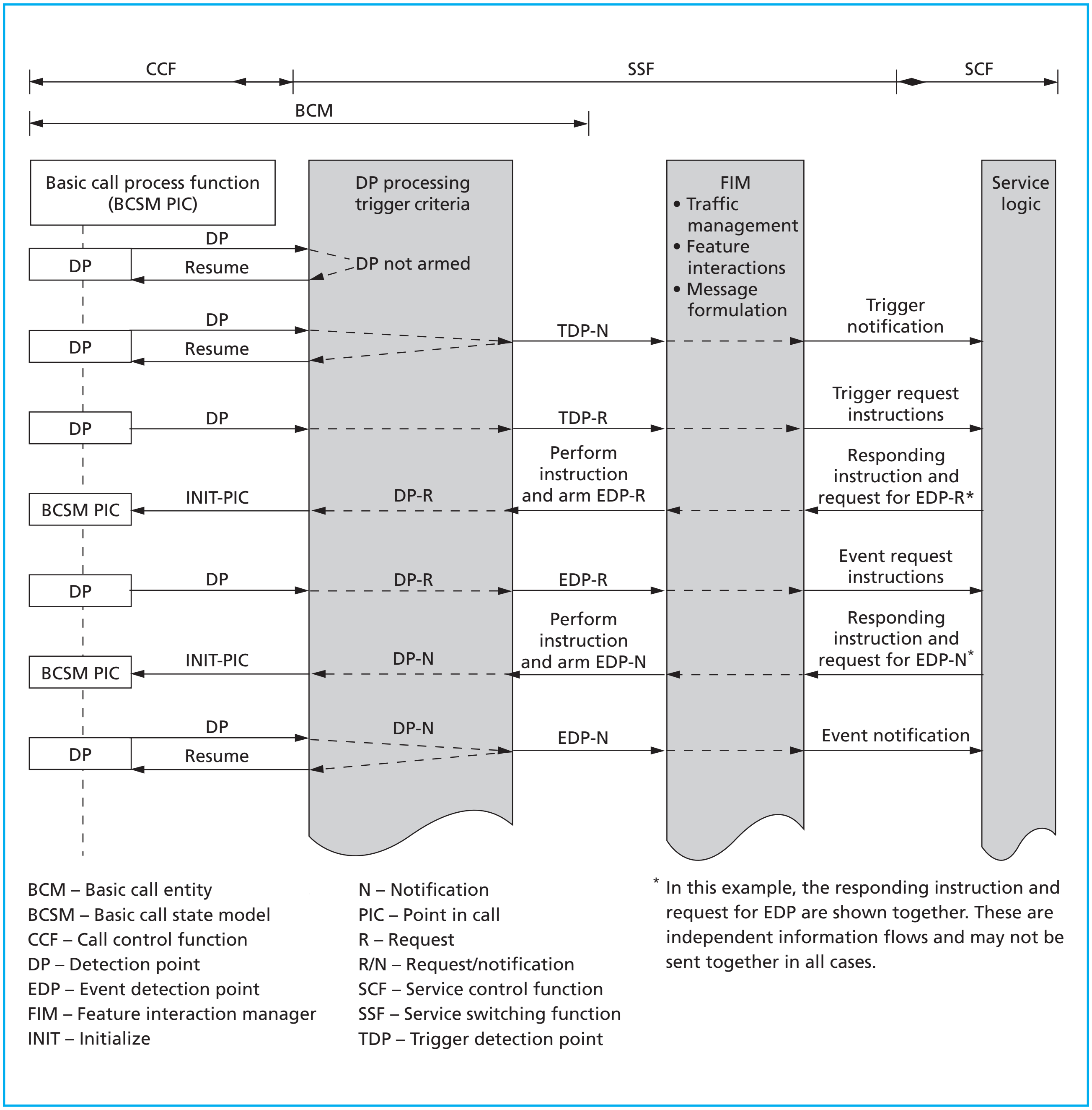

Figure 5.
Detection point processing (after Figure 4-10 of ITU-T Recommendation Q.1214).

These rules, together with the requirement that a specific trigger condition may result in an invocation of only one service logic process, enforce the single point of control principle.

Figures 6 and **7** present the IN CS-2 BCSM (described in ITU-T Recommendation Q.1224), which has been adopted by both WIN and the ANSI IN standard. (There are other call models in IN standards. The Annex A of the ITU-T Recommendation Q.1204 contains a sample BCSM, and Recommendation Q.1214 contains the CS-1 BCSM.)

There are, however, two major differences between the ITU-T and WIN call processing—the capability of WIN to set TDPs dynamically and the

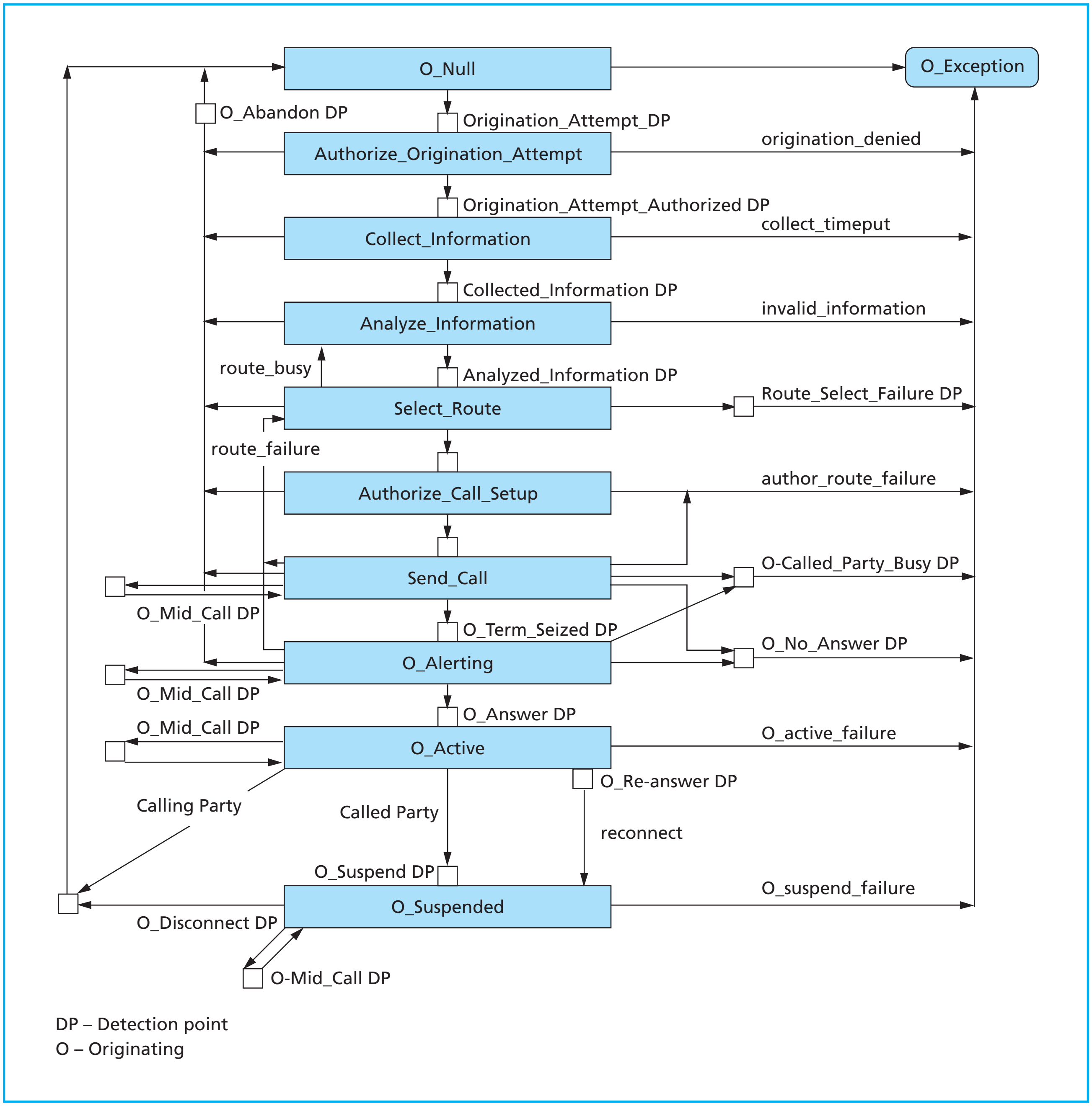

Figure 6.
Originating basic call state model for capability set 2 (after Figure 4-3 of ITU-T Recommendation Q.1224).

differences in trigger types (that is, classes of events, such as reception of specific digit sequences that are peculiar to mobile dialing). One other distinction of mobile networks is that the BCSM alone does not contain some information that is necessary for proper invocation of services. Other FEs have to be able to access IN entities.

Of these, the LRF is of the highest priority, as far as IN is concerned. **Figure 8** shows the LRF state model under discussion for WIN (in the annex, informative, of the draft standard ANSI-41.7). The present model maintains the registration process, which is open to IN intervention at six DPs.

Finally, it should be added that the IN CS-2 DFP

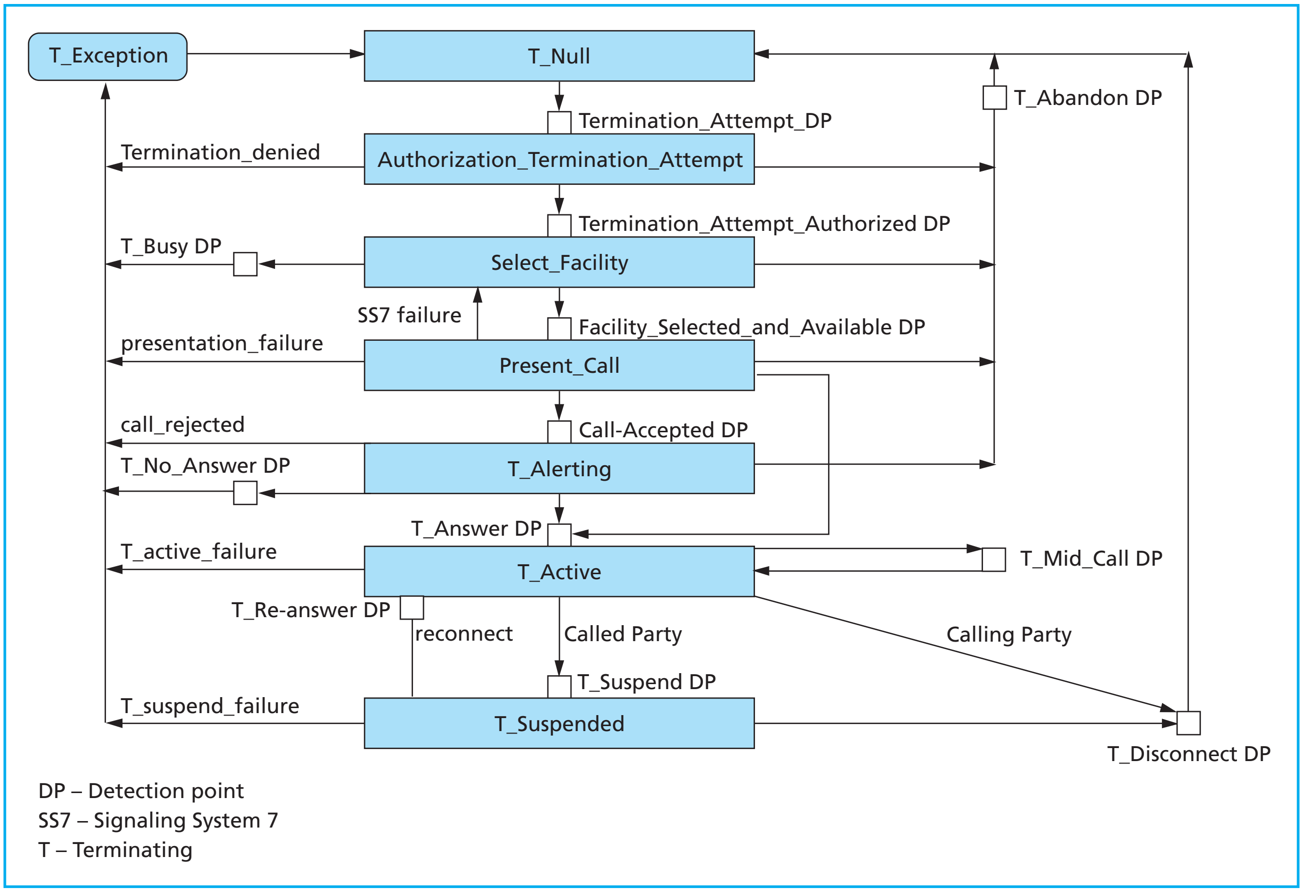

Figure 7.
Terminating basic call state model for capability set 2 (after Figure 4-4 of ITU-T Recommendation Q.1224).

(ITU-T Recommendation Q.1224) defines the semantics and abstract protocol for multi-party call handling.[4]

Physical Plane

There are two aspects to the physical plane material: the definition of the PEs (and their WIN counterparts called network entities [NEs]) and the assignment of the FEs to them. The other aspect is specification of the application protocol (*INAP*, in the case of ITU-T IN, and *mobile application part [MAP]*, in the case of WIN).

These two aspects are addressed in the following two sections.

IN physical entities and WIN network entities. Figure 9 (after Figure 1 of ITU-T Recommendation Q.1225) depicts the above entities and all associated interfaces, which are as follows:

- The *service switching point (SSP)*, a switch that provides access to IN capabilities. An SSP contains a CCF, SSF, and CUSF, all three coupled together. If it is a local exchange, it may also contain a CCAF. In addition, an SSP may contain an SRF. Finally, an SSP may contain an SCF or SDF (or both).
- The *network access point (NAP)*, another type of switch that includes only the CCAF and CCF (but not the SSF). As Recommendation Q.1225 explains, "the NAP supports early and ubiquitous deployment of IN–based services. This NAP cannot communicate with an SCF, but it has the ability to determine when IN processing is required. It must send calls requiring IN processing to an SSP."
- The *service control point (SCP)*, which contains an SCF and (optionally) an SDF. The SCP has access to the SS7 network, which it uses to communicate with SSPs and IPs.

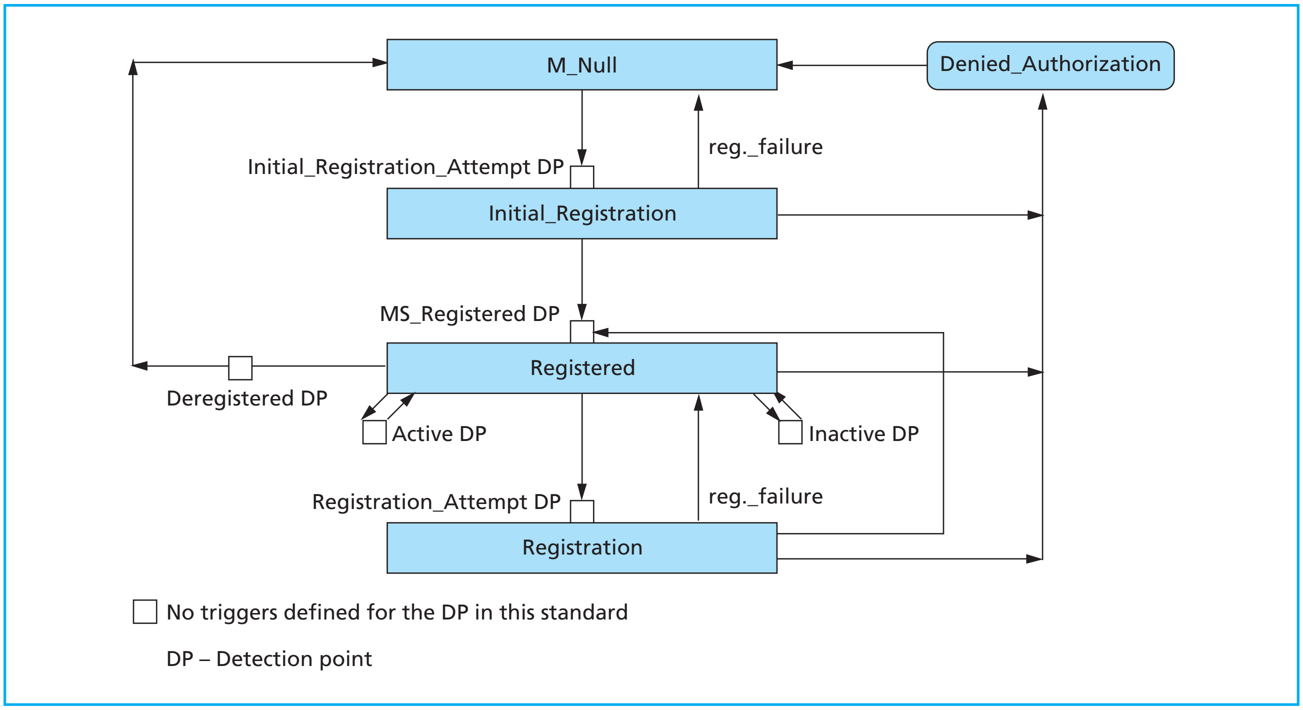

Figure 8.
Location registration function state model.

- The *service switching and control point (SSCP)*, which combines the SCP and SSP in one entity. It contains all the FEs that either PE may contain, but none of them are optional except the SRF. Furthermore, the interface between the SSF/CCF and SCF (internal) is proprietary as is the internal SCF-to-SDF interface; however, all the entities also support the external standard interfaces, and therefore the SSF/CCF within the SSCP may, for example, send a query to an SCP.
- The *service data point (SDP)*, which contains only the SDF. The SCP can access data in an SDP either directly or through a signaling network. The key to understanding the role of the SDP is in the Recommendation's statement that it "may be in the same network as the SCP, or in another network." In other words, the SDP is defined as an entity that can be accessed from another network. To this end, it is the only entity that has been *explicitly* specified for internetworking.
- The *intelligent peripheral (IP)*, which contains an SRF. The Recommendation provides a (non-exhaustive) list of the IP capabilities, which include customized and concatenated voice announcements, synthesized voice, speech recognition, dual tone multifrequency digit collection, audio-conference bridging, tone generation, text-to-speech synthesis, as well as protocol conversion.
- An *adjunct (AD)*, which is functionally equivalent to an SCP, but is connected to a single switch via a high-speed network rather than via an SS7 network.
- A *service node (SN)*, which is similar to an AD but, in addition to performing a role of an SCP, can perform that of an IP. The SN may communicate with more than one SSP, but it must have direct point-to-point signaling and transport connections to each SSP with which it is communicating. The SN contains the SCF, SDF, SRF, and the SSF/CCF/CUSF triad.

The above physical entities have been defined in CS-1 (although the inclusion of the CUSF is the CS-2 requirement). There is one new, CS-2 specific entity,

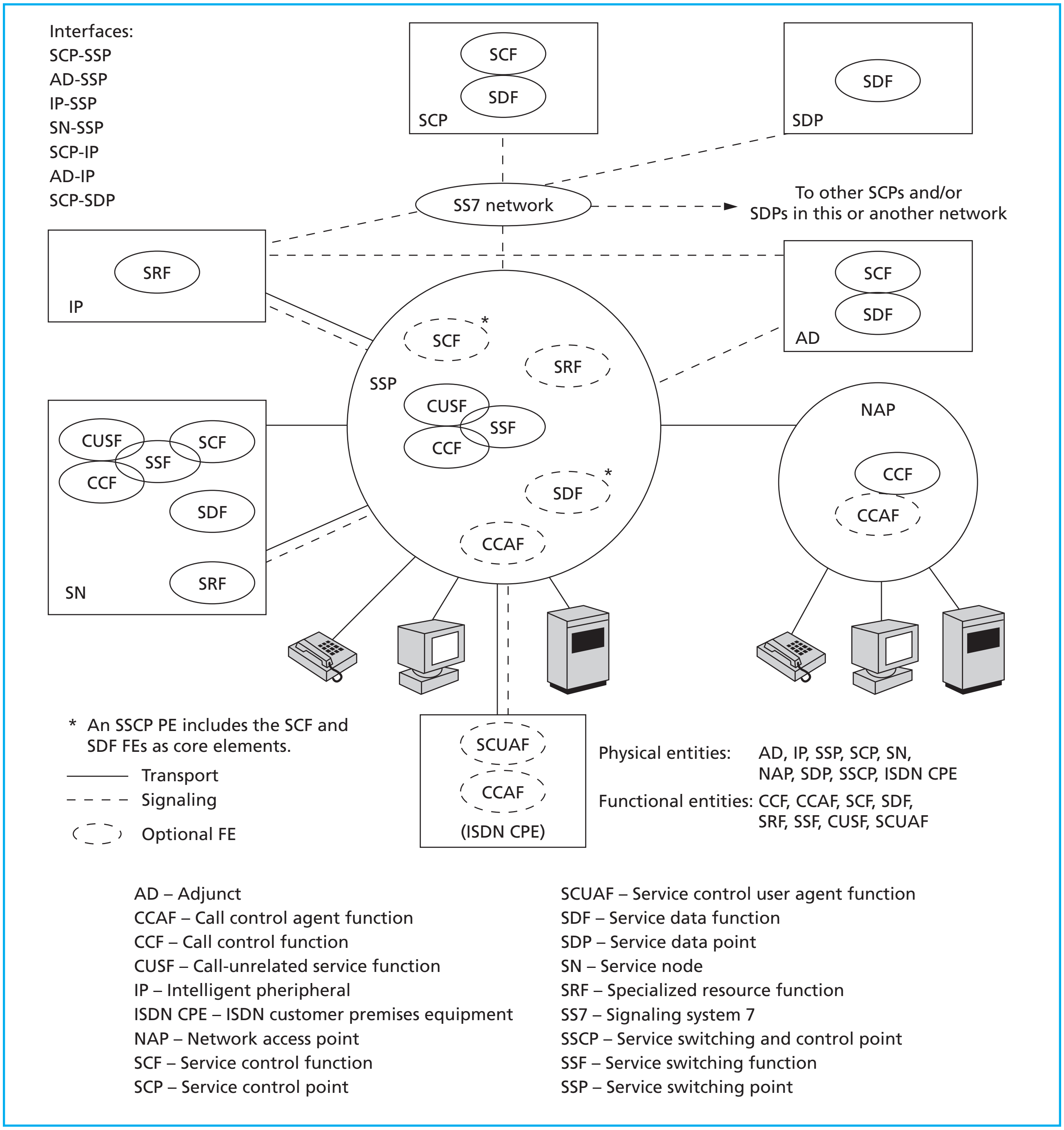

Figure 9.
Physical plane architecture (after Figure 1 of ITU-T Recommendation Q.1225).

the *ISDN customer premises equipment (ISDN CPE)*, defined as "a node that provides the functions necessary for the operation of the access protocols by the user." Functionally, the ISDN CPE can contain the CUSF (for the bearer-unrelated interactions) and, optionally, the CCAF. The ISDN CPE has one interface—to the SSP.

To provide the industry with the flexibility necessary for the evolution of future implementations, WIN does not define PEs. Instead, the NEs are identified in the network reference model (NRM) of ANSI-41.1. In addition to the IP, SCP, and SN, the NRM includes the following NEs:

- The *authentication center (AC)*, which contains the ACF, manages the authentication information for the mobile station. The AC may be located within and be indistinguishable from a home location register. In addition, an AC may serve more than one home location register.
- The *base station (BS)*, which contains the RCF, terminates the radio path.
- The *equipment identity register (EIR)*, where the user equipment identity information is stored. Its functionality as well as mapping to the DPE FEs is an area for further study.
- The *home location register (HLR)*, which contains the LRF, SCF, and SDF for management of the mobile subscriber information. The HLR may be located within and indistinguishable from a mobile switching center. The HLR may serve more than one mobile switching center or be distributed over more than one physical entity.
- The *message center (MC)*, which stores and forwards short messages.
- The *mobile station (MS)*, which contains the RTF, is the interface equipment for terminating the radio path on the user side.
- The *mobile switching center (MSC)*, which contains the CCF, SSF, and RACF (and may also contain the LRF and SRF), is a gateway system that passes the user traffic between a wireless network and a fixed network or other wireless networks.
- The *short message entity (SME)*, which composes and decomposes short messages. The SME may be located within and be indistinguishable from an HLR, MS, or MSC.
- The *visitor location register (VLR)*, which contains the LRF and ACF, maintains the visiting mobile subscriber information.

Technically, these NEs differ from PEs in that multiple NEs may still be combined into one PE. On the other hand, the NEs are similar to PEs in that an NE may contain several FEs. For example, the HLR may contain an LRF, SCF and SDF; and the MSC may contain a CCF, SSF, RACF, LRF, and SRF. The assignment of the FEs is not final.

Protocols. As mentioned in the previous section, the semantics of the services provided by both INAP and MAP are specified at the DFP. The role of the protocols is to carry the information defined in the IFs and their IEs exchanged among the FEs. Why FEs and not PEs? Recommendation Q.1208 stresses that "the protocols should be defined in such a way that the Functional Entities defined... may be mapped into Physical Entities in any way that operators and manufacturers desire." The same is true for WIN—MAP is specified for the interfaces among the NEs, which can be placed in different PEs.

Both MAP and INAP environments are provided by the application layer of the open systems interconnection (OSI) model.[12] To this end, both MAP and INAP provide to the application (and are, in turn, supported over) the *transaction services*.

Recommendation Q.1211 postulates that the IN application service elements (ASEs) in CS-1 be aligned with ITU-T Recommendation X.207 | ISO/IEC 9545 and be defined independent of the protocol stacks. The recommended protocol stacks are the SS7 transaction capabilities application part (TCAP) and various access protocols over Q.932. Each of the IN-specific interfaces (that is, SCF-to-SSF, SCF-to-SRF, SCF-to-SDF, and SDF-to-SDF) has a separate set of ASEs.

ASEs are grouped into *application contexts*. An application context is a set of ASEs and rules that is to govern the communications among application processes. A process that initiates the communications presents one or more contexts in a packet data unit and receives a response, which confirms the agreement to use the proposed context, denies it, or, in turn, proposes another context. For the latter option to take place, the association (or transaction) has to be closed—and the new one started—in order to propose another set of contexts. Recommendations Q.1218 and Q.1228 define the application contexts in a way that allows existing regional standards to be mixed and matched.

The vocabulary of the INAP consists of the remote operation service element (ROSE)-supported *operations* and their *parameters*, which respectively correspond to their DFP counterparts—the IFs and IEs. Rather than providing explicit encoding, INAP uses the *abstract syntax notation 1 (ASN.1)* language.[13,14] ASN.1 is a Pascal-like language for the encoding-independent definition of application layer protocol data units (which, as far as the computer languages are concerned, are data structures). The advantage of using ASN.1 versus performing detailed encoding is similar to the advantage of writing programs in a high-level language versus producing binary code.

In the ITU-T Recommendations, the protocol procedures are usually specified by the combination of the *call flows* (that is, specific exchanges among the communicating entities required to demonstrate the support of a given capability) and the SDL[15] descriptions (one for each communicating entity). The call flows are instrumental for illustrating the main idea behind the protocol, but they can only be illustrative because they cannot capture infinite aggregations of the message exchanges required to cover the error cases.

The SDL descriptions, on the other hand, can perfectly capture all the cases; furthermore, special tools can be used to verify the SDL descriptions. The disadvantage of the SDL descriptions is that they often tend to spread over many pages and thus are rather hard to grasp. During the initial work on the IN standard, a pithy BCSM-like function state model (FSM)-based description of the IN entities did the job. Presently, both CS-1 and CS-2 contain complete FSM-based procedure descriptions (in Recommendations Q.1218 and Q.1228, respectively), but Recommendation Q.1228 also contains the SDL-based procedure model (which is actually executable).

ROSE-based TCAP is used for the SCP-to-SSP, SCP-to-IP, SCP-to-SDP (for intranetworking purposes), AD-to-SSP, and AD-to-IP interfaces. For the SSP-to-IP interface, the ISDN basic rate interface (BRI) or primary rate interface (PRI) (or both) as well as the SS7 are specified. Recommendations Q.1215 and Q.1225 clarify that in the case the ISDN interfaces are used, the D-channel connecting an IP to an SSP is to be used for relaying the application layer information between an SCF and an SRF as well as for setup of B-channel connections to the IP. A similar arrangement (that is, the ISDN D-channel as the transport) is suggested by the Recommendation for the SN-to-SSP interface. Finally, the operations used at the (internetworking) SCF-to-SDF and SDF-to-SDF interfaces are carried via the directory protocol.[16,17,18]

The structure of MAP is much more straightforward than that of INAP. Unlike INAP, MAP has virtually eliminated options in the operations selection, for which reason it needs no application context negotiation (and, as the result, no application context definition). ANSI-41.5 specifies that ANSI TCAP be used by MAP for communications among all network entities. (The standard also allows the X.25 protocol to be used for data transfer services as an alternative to the SS7 data transfer services.) MAP uses ASN.1 for specifying operations and their parameters, but it also often presents specific encoding strings.

Unlike INAP, MAP has been assigned a set of subsystem numbers (SSNs) used within the signaling connection control part (SCCP). The SSN values are assigned for MAP, HLR, VLR, MSC, EIR, AC, and short message service.

The detailed MAP procedures are presented in ANSI-41.6, where they are grouped so as to address separately basic call processing, intersystem procedures, and individual and common voice feature procedures. The standard also defines a language for the procedure specifications, which are all written in a pseudo-code. The language is geared to specification of processes. In addition to the basic structured ALGOL-like constructs (such as *IF/ENDIF* and *CASE*), the language has a *WAIT* construct (for synchronous event processing) and a *WHEN* construct (for handling asynchronous events). With these constructs, the language is equivalent to SDL in its expressive power.

Conclusion: Toward Mobility and IN Integration

Although many similarities exist between the ITU-T INAP and MAP, these protocols are essentially different. The main difference is that MAP has been developed to support the basic wireless services (such as roaming and call delivery). The wireless protocol predates standardized wireline IN and there has been a plethora of implementations based on the standard. (As the tutorial[5] demonstrates, the first such standard, IS-41 Revision 0, was adopted in October 1987.) In fact, the success of multivendor implementations of the MAP protocol in the United States has proven that the standard is viable and mature.

Nevertheless, while MAP has succeeded in supporting the basic wireless service, it has not been designed (and was not required) to support supplementary services. In order to achieve the latter, something new needs to be done.

Hypothetically, MAP and INAP could be blended into some new "super INAP" protocol. However, this naive, brute force hypothesis would be very far from a viable solution for many reasons, of which the most important is dictated by the major principles of engineering: backward-compatibility and cost efficiency. Indeed, the investment in the existing wireless products by network operators precludes any massive replacement of the equipment.

Such replacement is not technically necessary. The development of WIN has resulted in an elegant solution, which, while solving the problem of delivering supplementary services in wireless networks, will maintain their integrity. This solution is rooted in the history of IN—as the basic call process in the switches was opened, so should be the set of processes involved in the basic wireless service!

In the case of the basic call in the fixed networks, the SSF/CCF is an FE that maintains the basic call process. In the case of wireless networks, the "basic wireless process" is maintained not only by the SSF/CCF but also by the ACF and LRF of Figure 4. Opening interfaces from these FEs to the IN SCF is sufficient for supporting any supplementary service that IN already supports. Thus, adaptation of the IN CS-2 BCSM and the definition of the LRF state model were decisive and fundamental steps toward full IN support of supplementary services in the wireless networks. Note that with this solution the existing IN service logic in the SCF needs only be augmented by the new modules; the service logic implemented for the fixed network should remain unchanged.

As often happens with elegant engineering solutions, they automatically solve additional problems that they were not originally intended to address. WIN has solved at least two such problems—opening of networks and multi-standard (not simply multi-vendor) compatibility.

The underlying idea of the open network access (ONA) initiative is that service providers should be separated from (and independent of) the network providers. This, in turn, creates new markets, increases the competition, and drives down the prices. With the WIN solution, the provision of supplementary services is separated from the basic wireless service provision. As a result, supplementary services can be provided by a party that does *not* own the wireless network. In fact, all the service provider needs to own is the SCP (which is a general computer), and, possibly, the IP.

As long as a service provider owns only these physical entities, the service provider may access the wireless networks that are built on standards different from the ANSI ones. (Although this paper focused only on international IN standards and WIN, it is time now to mention that the Global System for Mobile Communications [GSM] is yet another wireless network standard.)[19] The dissimilarities in standards reflect the differences in regional pre-standard implementations. Naturally, the mobile networks based on different standards are substantially dissimilar, but there is nothing to prevent these dissimilar networks from using the *same* standard for accessing IN.

Such a standard does not exist yet. Its creation, based on the WIN solution, is the focus of the United States position[20] to the ITU-T. Armed with that position, the authors are hopeful that the present study in ITU-T will result in global ubiquitous access to and provisioning of telecommunications and information services.

Acknowledgments

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