CTIA Logo To Be Inserted

The Open Wireless Network Architecture

CTIA

September, 1996

A. Contents

1. Executive Summary

An Open Wireless Network Architecture (OWNA) is a major goal of the CTIA, with the long term aim of providing totally seamless service to all wireless customers. This goal is shared by the CTIA, which generates requirements for OWNA interfaces based on their member company needs, the TIA which writes standards for many of the interfaces, and manufacturers and carriers that share this vision.

The CTIA has been promoting the development of seamless service and open interfaces since its inception, realizing that the success of the entire cellular industry depends increasingly on open architectures. Indeed, in the first CTIA UPR (User Performance Requirements), defining the need for digital wireless systems in 1988, the CTIA stated that "without the industry-wide adoption of cellular air interface standards, it is unlikely that the cellular industry would be successful to the extent experienced to date … The concept of a Cellular - Open Network Architecture is key to the future of the cellular industry. By providing a set of common interfaces at the mobile telephone switching office (MTSO) and base station levels, we ensure that technical innovation, reliability enhancement, network product availability and economic competition will not inhibit growth of the cellular industry as we move into a next generation system." This logic also applies to other wireless systems, such as PCS and Satellite. Beyond the provision of seamless service, OWNA will provide important economic benefits to carriers, including cost reductions and revenue enhancements.

As the CTIA OA&M sub-task group stated in their requirements for OAM&P standards (and their comments apply equally to other OWNA standards), any standards for the open wireless network architecture "should address important market scenarios such that wireless providers may build their network with equipment, such that different radio technologies may be deployed in networks."

The purpose of open wireless network architecture standardization can be summarized as a set of goals:

- Vendor independence.
- Radio Technology Independence.
- Minimization of Management Costs.
- Inviting Innovation.
- Cooperative benefits.
- Competitive benefits
- Regulatory pressures

Vendor Independence

Carriers require a greater choice of vendors to increase competition. This will lead to lower prices, a greater variety of features and more innovation. A classic example of a standard to support this goal is the "A" interface between a wireless switch (MSC) and a base station. Traditionally in AMPS based networks, a proprietary interface has been used, forcing the carrier to purchase base station and switch equipment from the same vendor. The European GSM system has proven the viability of having this as an open interface, and the provision of open A interface standards in North American systems will change the dynamics of traditional business practices substantially.

A similar dramatic change will occur when the Wireless Intelligent Network interfaces are successfully standardized. The goal of this CTIA initiative, as defined by the WIN sub-task group, is to “offload feature intelligence from switches and HLRs, based on a distributed architecture, using new MSC intersystem messaging capabilities in connection with service applications residing on external service platforms.” Today, these capabilities are tightly knit together. Opening this interface will open doors for innovative third party designers of niche equipment, such as voice recognition, one-number services, wireless internet access, short message generation and credit/debit billing services.

Radio Technology Independence.

Radio technology independence can only be achieved by a clean separation of the radio access methodology from network issues. The trend in this area is towards layered protocols, where the lower layers provide for management of the radio capabilities that distinguish one technology from another, while the upper layers provide a secure logical data channel that is independent of the radio technology. The TIA IS-95 standard for CDMA digital systems and IS-136 for TDMA digital are clear examples of this trend.

Minimization of Management Costs.

One of the concerns of carriers is the cost of managing subscriptions and their ever-growing, ever more complex networks. The cost of acquiring subscribers is still high, yet as wireless systems penetrate the marketplace more deeply, the revenue received from each subscriber is generally lower. The trend here is towards providing new interfaces that standardize previously manual operations. The most ambitious step in this direction is the definition of over-the-air activation protocols that will allow a phone to be completely programmed without manual intervention. Just as importantly, this activation will be more secure, and will protect personal information and the secret data that is required for authentication from possible leaks.

Management costs cannot be reduced if the price is reduced service. Today’s customers expect the level of service they receive to continually improve. Like customers everywhere, they are quick to find fault when the system does not meet their expectations. To achieve continuous service improvements without increasing costs will require more advanced network monitoring and management capabilities, and the ability to provide these capabilities remotely. Apart from reducing costs, this will allow potential trouble spots to be identified and rectified, will allow quick response to problems at any time of the day or night, and will allow better access to the carrier’s knowledge base by trouble-shooting staff on-site or at a monitoring location. Only a standard will be able to provide this information in a consistent format as the variety of equipment in the network increases. This is the goal of the recently initiated TIA TR-45 OA&M ad hoc group in its “O” interface standardization efforts.

Inviting Innovation.

There are many innovators in wireless communications. While yesterday’s innovators have turned into today’s big companies, tomorrow’s success stories are among the startups and small manufacturers of today. To these innovators, who often do not have the financial or marketing muscle to provide complete systems, every open interface is a challenge and an opportunity. Thinking hard and moving fast, they will be able to provide solutions for niche markets that bigger companies have not yet paid attention to. With more open interfaces, carriers will be able to put the “custom” back in “customer”, by providing their customers with a larger menu of features to choose from. In the process, carriers will provide a testbed for exciting new products. Those that succeed, will go on to be the everyman features of tomorrow, the standard against which future innovations will be measured. Without open interfaces, innovators will be shut out of many opportunities and niche markets will go unserved.

Cooperative benefits.

Automatic roaming is the most important benefit that has come from the cooperative implementation of standards by wireless carriers. The ability to go to any area of the US and Canada that has cellular service and receive calls almost the moment that one steps off the plane, used to impress people. Now, like microwaves and dishwashers, many people cannot live without automatic roaming. This important capability came about because wireless carriers, led by the CTIA, decided to cooperate with each other and make the development of the TIA IS-41 automatic roaming standard a priority.

Competitive benefits

Open interfaces will not necessarily lead to homogenization of systems, and the reduction of differentiation. It is possible to provide innovative services to consumers that distinguish each carrier from their competition. Both the TIA IS-41 standard for automatic roaming and the Wireless Intelligent Network effort now underway go a considerable way to allowing carriers to "have their cake and eat it too". The magic ingredient is the open network that keeps the "secret sauce" in the home carrier's HLRs, SCPs and IPs, while allowing call processing to proceed in the serving system. Consequently, some features can be provided by one carrier on behalf of a customer of another carrier in the same way as if the customer was at home. In some cases, this can even occur if the serving system does not support the feature for its own customers.

Regulatory pressures

Standards are not only required to relieve market pressures. In some cases governments put pressure on wireless carriers, and standardization is the most effective way for the industry to respond. Two examples of this type of pressure are the requirements for enhancing 9-1-1 service for wireless customers and the need to provide lawfully authorized surveillance (wiretaps) under the 1994 US Communication Assistance for Law Enforcement Act (CALEA).

Standards are important tools for responding to regulatory pressure because there is less incentive to 'do it differently' when your competitors are forced to adhere to similar minimum requirements. Given that there may be no motivation to go much beyond what is required, it makes a lot of sense for carriers to work together with manufacturers to minimize the time and costs of development. This approach is given further momentum with CALEA which explicitly states that "A telecommunications carrier [is] … in compliance … if the carrier, manufacturer, or support service provider is in compliance with publicly available technical requirements or standards adopted by an industry association or standard-setting organization."

This document describes the many interfaces that make up the OWNA vision. Each interface is summarized, including a list of the standards that make the interface open and the role of the CTIA, TIA and other organizations in developing the interface.

2. Impact of OWNA Standards on the Wireless Industry

The cellular industry grew from two systems in Chicago and Washington-Baltimore to a huge interconnected network that now spans national boundaries. The only standard at first was the AMPS air interface standard (initially called IS-3, and now known as EIA/TIA-553). Network standards were conceived of from the beginning, but seemed to be a luxury at first.

That changed with the advent of the first roamers. Not only did they demand service, and carriers start to provide it, but the first fraud started to hit the industry. Gradually, all participants in the industry realized that wireless network standards needed to become an essential part of doing business. This started the development of the first, and still the most important network standard in North America, IS-41.

IS-41 was first published in 1987 (as Revision 0), when it provided the first inter-system operations in a standard fashion - intersystem handoff, and a limited form of validation. Revision A followed in 1991, with automatic call delivery, remote access to subscriber features and full validation capabilities. Revision B and C, along with a number of TSB's (that add capabilities to a revision of a standard) have dramatically increased the capabilities of this standard. Although there will always be some features that can only be provided by proprietary interfaces, IS-41 has gone, in less than 10 years, from providing only a few services to a few carriers, to providing most inter-system services to most carriers.

The success and importance of intersystem operations, led to the desire to standardize other interfaces in the wireless network. Important developments have been the standardization of the "A" interface, which allows base station and mobile switching equipment to be connected in a standard way. The IS-124 ("DMH") standard has added several interfaces which allow the transmission of call detail and billing records, primarily to enhance fraud detection and billing capabilities. IS-93 has taken the in-band and common channel PSTN interfaces from a Bellcore technical recommendation to an industry standard. And there is much more to come, both in new network interfaces, and in steady enhancements to the existing interfaces.

The cellular radio interface was initially supported by a single standard. Now there are several, to provide new technologies to customers (e.g. TDMA and CDMA digital), to provide new capabilities (e.g. data, fax and in-building operation) and to provide terminal support for new network features (e.g. calling number identification, short message service and over-the-air activation).

The future of wireless telecommunications will be a combination of new innovations and the increasing penetration of standards. Sometimes innovations will precede standardization, and sometimes a standard itself will represent innovation. Some standards and technologies will find favour with consumers and others will eventually disappear. Competitive pressures will be the driving force, with consumer confusion and the goal of seamless service being an ultimate brake on the development of too many different standards. The end result will be a satisfying smorgasbord for carriers and consumers, stocked only with high quality choices.

3. CTIA OWNA Initiatives

The CTIA (Cellular Telephone Industry Association, phone +1-202-785-0081), formed in 1984, is the leading organization of the wireless communications industry. Although it started by representing only cellular carriers, its membership has expanded considerably in breadth , and now is open to all Commercial Mobile Radio Service (CMRS) providers, including cellular, personal communications services (PCS), enhanced specialized mobile radio (ESMR) and mobile satellite services.

The CTIA influences standards through its Advisory Group for Network Issues, which contains the following sub-task groups:

A-Z Cross Band Roaming	Defining requirements for roaming between the A and B cellular bands, between the A–F PCS bands, and between cellular and PCS. Chaired by David Mangini of SNET.
Authentication	Defining requirements to facilitate the introduction of authentication as a fraud preventative into the wireless network and into mobile stations. Chaired jointly by Jim McGarrah of BellSouth and Blair Kutrow of Vanguard.
Interoperability	Promotes the open wireless network architecture, particularly the IS-41 standard. This group completed the definition of an IS-41 Rev. B interoperability test plan in October 1995, and are currently defining a staged implementation of IS-41 Rev. C that will allow substantial subsets to be implemented in phases, without losing interoperability. Chaired by Bob Montgomery of the CTIA staff.
"O" Interface (OA&M)	Defined requirements for open Operations, Administration and Maintenance interfaces to wireless network elements. They were presented to TIA committee TR45 in March, 1996. Chaired by Huel Halliburton of AirTouch.
Wireless Intelligent Network (WIN)	Defines requirements for a network architecture and protocols to provide enhanced features, which are known as the Wireless Intelligent Network (WIN). These features will be provided outside the existing HLR and MSC network elements, to allow faster and more flexible feature definition. Chaired by Dick Gove of Ameritech.

The CTIA interfaces to the TIA through sending a representative to many TIA meetings, by exchanging liaison letters and through the publication of Standards Requirements Documents (SRD, previously known as User Performance Requirements (UPR)). The following SRD/UPR documents have been released by the CTIA and used by the TIA as input into the standards process:

Advanced Radio Technologies UPR	The UPR that kicked off the transition to digital cellular, and also proposed the Cellular Open Network Architecture (C-ONA) for the first time. Released in September 1988.
Cellular Open Network Architecture UPR	A UPR that defined the most important features and capabilities for a second generation mobility management network. Released in 1990.
Wireless Intelligent Network SRD	The requirements for the Wireless Intelligent Network were presented to TIA committee TR-45 in November, 1994. Subcommittee TR-45.2 set up an ad hoc group, which has been studying these issues since then.
CTIA Requirements for Wireless Network OAM&P Standards	Revision 3.0 of these CTIA requirements were presented to TIA committee TR-45 in March, 1996. An ad hoc group was immediately set up, and has begun to study these issues.

Prioritization of IS-53 Rev. B Candidate Features	While not an official SRD, this contribution from the CTIA Wireless Intelligent Network sub-task group to the TIA TR-45.2 subcommittee focused the development of IS-53 Revision B by listing the 9 priority features that a consensus of carriers most wanted standardized: 1. Calling Name Identification (see Cn interfaces) 2. Enhanced Emergency Services (see 911 interface) 3. Lawfully Authorized Electronic Surveillance (actually being standardized outside of IS-53) 4. Identity Confidentiality (see G interface) 5. Incoming Call Screening (see Cn interfaces) 6. Voice Controlled Services (see Cn interfaces) 7. Group III Facsimile Transmission (see L interface) 8. Broadcast Short Message Service (see M and N interfaces) 9. Over-the-air Activation (see Q2 and D2 interfaces)
CTIA IS-41 Rev. C Prioritization	The CTIA, in consultation with Chief Technical Officers of CTIA member carriers, grouped IS-41 Rev. C features into three groups, to facilitate a staged implementation of this standard while maintaining seamlessness.

4. TIA Participation in OWNA

The TIA (Telecommunications Industry Association) is a trade association representing manufacturers of telecommunications equipment. One of its roles is as an ANSI accredited standards setting organization, which has led it to set virtually all standards related to the AMPS family of cellular and PCS protocols. The TIA originated in 1988 as an offshoot of the EIA (Electronics Industry Association), with which it is still associated. It has the following technical committees:

FO-2	Optical Communications Systems
FO-6	Fiber Optics
TR-8	Mobile and Personal Private Radio Standards
TR-14	Point-to-Point Communications Systems (microwave)
TR-29	Facsimile Systems and Equipment
TR-30	Data Transmission Systems and Equipment (modems)
TR-32	Personal Radio Equipment
TR-34	Satellite Equipment and Systems
TR-41	User Premises Telephone Equipment Requirements
TR-45	Mobile and Personal Communications Standards (AMPS-based)
TR-46	Mobile and Personal Communications Standards (non-AMPS-based)

The most important committee for the development of standards to support the Open Wireless Network Architecture, is TR-45, which is divided into the following subcommittees:

TR-45.1	Analog air interfaces
TR-45.2	Network interfaces
TR-45.3	TDMA digital cellular and PCS air interfaces
TR-45.4	BS-MSC “A” interfaces for all AMPS based air interfaces
TR-45.5	CDMA digital cellular and PCS air interfaces

The Telecommunications Industry Association standards secretariat can be contacted at:

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5. ATIS Participation in OWNA

ATIS (the Alliance for Telecommunications Industry Solutions) has traditionally developed standards for wireline phone systems, through its ANSI accredited T1 standards committee. ATIS was founded in 1983 as ECSA (Exchange Carriers Standards Association) and received its new name in 1993. Since the development of PCS systems, committee T1 has started the development of network standards, in cooperation with TIA committee TR-46. The ATIS T1 standards committees are:

T1 Committee	Study Area
T1A1	Performance and signal processing.
T1E1	Interfaces, Power and Protection of Networks.
T1M1	Internetwork Operations, Administration, Maintenance and Provisioning.
T1P1	Systems Engineering, Standards Planning and Program Management (including PCS standards development).
T1S1	Services, Architectures and Signaling (including Signaling System Number 7).
T1X1	Digital Hierarchy and Synchronization

Committee T1 can be contacted at:

Committee T1

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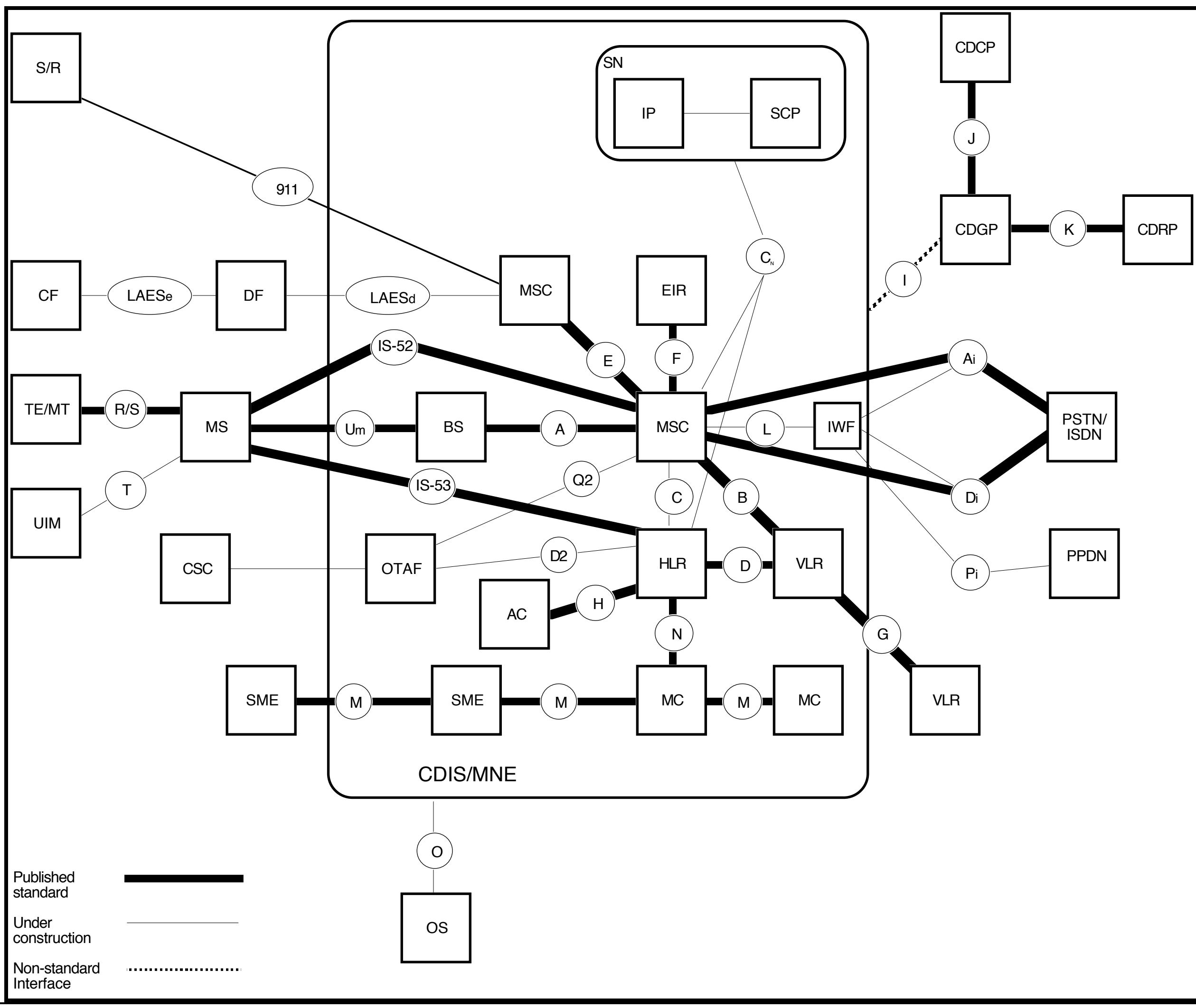
6. Network Reference Model

The network reference model shown below illustrates the logical network elements that are used within standards such as IS-41. This reference model is a simplified compilation of the TIA TR-45 reference model, the CTIA WIN reference model and other reference models being used for standards under development. The network elements are *logical* and not *physical*, and therefore can be combined in any fashion. If combined, some interfaces become internal and a standard need not be used. No standards are provided for interfaces between network elements formed by splitting a logical network element. A simplified version of the TIA network reference model (currently under review) is shown in Figure 1:

In some cases, an interface that is discussed in this document is not defined in the network reference model. In these cases, the interface is identified by its major standard (e.g. IS-52, IS-53).

Figure 1: Network Reference Model (Simplified)



6.1 Network Elements

The network elements shown in the network reference model are described below.

AC Authentication Center

The Authentication Center manages authentication and encryption information for a group of Mobile Stations. This includes the parameters required to operate the TIA authentication algorithm (CAVE), such as A-Key and Shared Secret Data. The AC is often physically contained within an HLR.

BS Base Station (BS)

The land side of the radio interface to mobiles, including cell-sites and base station controllers.

CDCP Call Detail Collection Point

Consumes call detail records, connected to an application such as fraud detection or real-time billing.

CDGP Call Detail Generation Point

Receives call detail records in a proprietary format, and forwards them in a standard format.

CDIS Call Detail Information Source

Generates call detail records in a proprietary format. Since almost any network element can perform this function, it is shown as a large box surrounding many other types of network elements.

CDRP Call Detail Rating Point

Puts a price on a call detail record, turning it into a settlement or billing record.

CF Collection Function

Records signaling, data and voice information for lawfully authorized electronic surveillance.

CSC Customer Service Center

Controls the activation and modification of subscriptions for wireless terminals and subscribers.

DF Distribution Function

Collects signaling, data and voice information from an MSC for standardized transmission to a law enforcement agency.

EIR Equipment Identity Register

Stores terminal identification information (as opposed to subscription information).

HLR Home Location Register

Stores information related to a subscription, both information about a subscriber, in the absence of an EIR, about the terminal or terminals associated with that subscription. Subscriber information includes a MIN and a profile (e.g. whether and type of call forwarding is subscribed to, activated). In the absence of an EIR, terminal information is also included, such as the ESN and terminal capabilities.

IP Intelligent Peripheral

Provides specialized functions, such as playing recorded announcements, collecting digits, converting speech to text (or vice-versa) and recording and storing voice messages.

IWF Inter-Working Function

Translates between two protocols, such as between a digital air interface data protocol and a landline modem. A modem pool can be considered a simple type of inter-working function.

MC Message Center

Stores and forwards short messages (whether coming from a mobile or going to a mobile).

MS Mobile Station

The end user's terminal device providing wireless voice and/or data services.

MNE Mobile Network Element

Any element of the wireless network that can provide OA&M information, or that can be controlled from a central point.

MSC Mobile Switching Center (MSC)

Provides wireless call processing, through internal switching, logic and external interfaces. The MSC contains switching functionality and extensive logic, but does not maintain databases, beyond the information required to process calls in progress.

MT Mobile Termination

The termination of the radio interface, within a mobile station (MS).

OS Operations Subsystem

Provides access to OA&M information and control from other network elements.

OTAF Over-the-air Activation Function

Manages the over-the-air activation and modification of wireless subscriptions within terminals.

PPDN Public Packet Data Network

A publicly accessible packet data network.

PSTN/ISDN Public Switched Telephone Network (PSTN)

Any telephony equipment outside the domain of the wireless network, including PABX's, local exchange carriers and inter-exchange carriers.

SCP Service Control Point

Provides realtime database and transaction processing related to enhanced features.

SME Short Message Entity

Consumes or produces short messages. The SME may be physically located within another network element (most commonly an MS).

SN Service Node

A combination of an IP and an SCP, which also may include a PSTN interface.

S/R Selective Router

A wireline switch capable of routing emergency (9-1-1) calls to the appropriate Public Service Answering Point (PSAP) based on the location of the caller. This is also known as a '911 Tandem switch'.

TE Data Terminal

A data terminal that may be connected to a wireless terminal to facilitate wireless communication.

UIM User Identity Module

A small device that contains the identity of a wireless phone subscriber, and some configuration and profile information. It is also known as a 'smart card' or SIM.

VLR Visitor Location Register

Stores information related to roaming subscribers, including the current location of the terminal within a subtending MSC, the profile, authorization information and authentication data.

7. Cross Reference of Standards and Interfaces

This is a list of interfaces, along with associated standards. Publication dates are listed as the month of publication (for already published standards) and as the estimated quarter of publication (for not yet published standards).

Interface Point	Between…	Purpose of interface	Primary Standards	Publication Date
A	BS-MSC	Coordination of Base Station and MSC call processing.	IS-634 IS-651 IS-653	01/96 07/95 *in press*
A_i	MSC-PSTN/ISDN	Wireless interconnection to PSTN using MF tone signaling.	IS-93-0 IS-93-A	10/93 4Q'96
B	MSC-VLR	Mobility management, including validation, authentication and feature processing.	IS-41-A IS-41-B IS-41-C IS-41-D IS-652	01/91 12/91 02/96 *development* 05/96
C	HLR-MSC	Retrieving redirection addresses	IS-41-A IS-41-B IS-41-C IS-41-D IS-652	01/91 12/91 02/96 *development* 05/96
C_1 C_2 C_3 C_4 C_5 C_6 C_7	MSC-SCP HLR-SCP IP-SCP HLR-SN IP-MSC MSC-SN SCP-SN	Wireless Intelligent Network (WIN) interfaces to support enhanced features with intelligence outside the HLR/MSC infrastructure	IS-41-D	*development*
D	HLR-VLR	Mobility management, including validation, authentication and feature processing. Very similar to B interface.	IS-41-A IS-41-B IS-41-C IS-41-D IS-652	01/91 12/91 02/96 *development* 05/96
D_i	MSC-PSTN/ISDN	Digital interconnection to PSTN (i.e. ISDN and SS7-ISUP).	IS-93-0 IS-93-A	10/93 4Q'96
D2	HLR-OTAF	Creating, querying and modifying HLR subscriber records	n/a	*development*
E	MSC-MSC	Intersystem handoff… …including path minimization. …including intersystem paging. …inter-system link protocol For GSM-based systems (e.g. PCS1800)	IS-41-0 IS-41-B TSB-51 IS-41-C IS-41-D IS-652	02/88 12/91 02/93 02/96 *development* 05/96

Interface Point	Between…	Purpose of interface	Primary Standards	Publication Date
F	MSC-EIR	Management of equipment identities.	IS-652	05/96
G	VLR-VLR	TMSI (Temporary Mobile Station Identity) management.	IS-41-D IS-652	*development* 05/96
H	AC-HLR	Authentication, voice privacy, data encryption and signaling message encryption.	TSB-51 IS-41-C IS-41-D IS-652	02/93 02/96 *development* 05/96
I	CDGP-CDIS	Proprietary call detail records.	n/a	
IS-52	MS-MSC	Dialing plan.	IS-52-0 IS-52-A TIA/EIA-660	11/89 03/95 *in press*
IS-53	MS-HLR (and others)	Subscriber features.	IS-53-0 IS-53-A TIA/EIA-664 IS-53-B IS-104-A	09/91 07/95 *in press* *development* *development*
J	CDGP-CDRP	Rating call detail records.	IS-124-0 IS-124-A	09/93 *in press*
K	CDCP-CDGP	Delivery of call detail and billing records to application processes.	IS-124-0 IS-124-A	09/93 *in press*
L	IWF-MSC	Interworking between protocols (e.g. from a wireless digital data standard to analog modem tones)	IS-658	08/96
$LAES_d$	MSC-DF	Delivery of signaling, voice and data information to a delivery function (DF) within the MSC premises, based on a lawfully authorized electronic surveillance intercept.	n/a	*development*
$LAES_e$	DF-CF	Delivery of signaling, voice and data information from a delivery function to a law enforcement agency collection function (CF)	n/a	*development*
M	MC/SME-MC/SME	Short message service.	IS-41-C IS-41-D IS-652	02/96 *development* 05/96
N	HLR-MC	Short message service address and routing management.	IS-41-C IS-41-D IS-652	02/96 *development* 05/96
O	MNE-OS	Centralized operations, administration, maintenance and provision.	n/a	*development*
P_i	IWF-PPDN	Delivery of packet data between a wireless and a fixed network	Non-wireless standards	*Existing*

Interface Point	Between…	Purpose of interface	Primary Standards	Publication Date
Q2	MSC-OTAF	Control of the over-the-air activation (and modification) of terminals.	n/a	*development*
R/S	TE/MT-MS	Delivery of data from a digital mobile station to an internal or external asynchronous data or facsimile device.	IS-99-A IS-130 IS-135 IS-657	07/95 03/95 03/95 08/96
T	MS-UIM	Interface between user identity module (UIM) and mobile station	n/a	*Under development by T1P1.2*
U_m	BS-MS	Radio interfaces (also known as air interfaces):		
		• Analog.	EIA/TIA-553-0 EIA/TIA-553-A	09/89 *In press*
		• Wideband analog (NAMPS)	IS-88	02/93
		• In-building/private system analog	IS-94	05/94
		• Integrated analog (including NAMPS)	IS-91-0 IS-91-A IS-91-B	09/94 11/95 *development*
		• TDMA digital	IS-54-B IS-136-0 IS-136-A J-STD-011	04/92 12/94 *development* *In press*
		• CDMA digital	IS-95-0 IS-95-A IS-95-B J-STD-008	07/93 05/95 *development* *In press*
		• PACS (Personal Access Communications System) for PCS band	J-STD-014	*In press*
		• PCS1900 (GSM adapted for PCS band)	J-STD-007	*In press*
		• Composite TDMA/CDMA for PCS band	IS-661	*In press*
		• Wideband CDMA for PCS band	J-STD-014	*In press*
911	MSC-S/R	Emergency service interconnection from wireless network to emergency services Selective Router (S/R)	IS-41-D IS-53-B IS-93-A IS-104-A	*development* *development* 4Q'96 *development*

8. Open Interfaces

The wireless network is extremely complex. Yet, based on the division of the network into logical network elements, interface points can be defined. Many have been standardized by TIA committees, often with requirements provided by the CTIA. Each interface is listed with a detailed description of its capabilities, benefits and champions, along with a list of standards associated with the interface.

A BS-MSC Interface

Summary

The Base Station (BS) to Mobile Switching Center (MSC) interface provides for management of mobile call processing, with the BS managing the radio interface and the MSC providing interconnect to another phone or services, wireless or not, through its external and internal interfaces.

An open "A" interface was first proved feasible by the European GSM system. The, so-called "A+" interface, developed by Motorola, was loosely based on this standard to support the variety of air interfaces possible in AMPS-based systems. Motorola and other companies proposed standardization to the TIA subcommittee TR-45.4, resulting in the development of TIA/EIA/IS-634.

Benefits

An open "A" interface will allow base station and switching equipment to be purchased separately. Traditionally, base station and switching equipment has to be purchased from a single supplier due to the proprietary nature of the interface.

Champions

The major champions of an open "A" interface are the GSM based equipment vendors, where an open "A" interface is necessary, and Motorola, which first promoted the idea of an open interface for use with "AMPS" standards.

TIA subcommittee TR-45.4 is responsible for the development and enhancement of A interface standards.

Standards

Standard	Status	Description
EIA/TIA-634	Published 01/96	A standardized "A" interface for use with AMPS-based air interface standards (e.g. EIA/TIA-553, IS-91, IS-54 and IS-95). Optionally, this standard will support a frame relay transport method.
IS-651-A	In press	A standardized "A" interface, based on SS7 protocols, for use with PCS-1900 (GSM) systems.
IS-653	In press	A standardized "A" interface, based on ISDN protocols, for use with PACS systems.

Ai PSTN Interface (MF based)

Summary

The Ai interface is the traditional in-band (MF tone) signaling interface to the PSTN, and any other telephony network that cannot be interfaced at a higher level of capability. The Ai interface provides the capability for originating and terminating calls and for identifying the calling party (using some variants of the interface). The related Di interface provides interconnect to the PSTN using ISDN/SS7 ISUP out-of-band signaling.

Traditionally, this interface has been standardized using the Bellcore TR-NPL-000145. However, this document does not have the status of a standard, and is controlled by PSTN, not wireless, carriers. The TIA has defined IS-93 to provide equivalent or greater capabilities, as deemed necessary by wireless carriers and manufacturers.

Benefits

An open Ai interface is necessary to ensure cost-effective interconnect to all other telecommunications network. It is likely that wireless telecommunications carriers will migrate to a Di interface, but this transition will take several years.

TIA subcommittee TR-45.2, Working Group VI is responsible for enhancements to the IS-93 standard.

Champions

Bellcore was the traditional developer of Ai interface recommendations. The development of the TIA IS-93 standard was spurred by AT&T Wireless Services (then McCaw) and Synacom.

Standards

Standard	Status	Description
IS-93-0	Published 10/93	Standardized PSTN interconnect (also includes the Di interface).
IS-93-A	Unscheduled	A second revision of this standard is planned when the need arises. It is likely that international roaming or enhanced emergency services will be the stimulus.

B MSC to VLR Interface

Summary

This interface provides communications between an MSC, which provides mobile call processing, and a VLR which stores records for registered roamers. In theory, an MSC contains data only for calls in progress and a VLR contains records for all registered roamers, including those not currently in a call.

Benefits

The benefits of an open B interface are not clear. Assumptions made in the development of IS-41 mandate the storage of information for all registered roamers at an MSC. Unless there are benefits of storing only partial information at an MSC (and complete records at a VLR) that outweigh the cost of inter-system messaging for every call, this interface will not be open in practice.

This interface can be used where a VLR is just a cache for multiple MSCs, to eliminate communication with an HLR when mobiles move between two MSCs within the domain of a single HLR. In this case, each roamer record would be stored in the VLR and also in at least one MSC.

TIA subcommittees TR-45.2 and TR-46.2 are responsible for standardizing this interface.

Champions

Major carriers and infrastructure manufacturers.

Standards

Standard	Status	Description
IS-41-A	Published 01/91	Automatic call delivery, remote feature control, profile transfer and networked validation.
TSB-55	Published 05/94	Forward compatibility to IS-41-B.
TSB-56-0	Published 03/93	Application level test plan for IS-41-A.
IS-41-B	Published 12/91	Support for TDMA digital cellular terminals
TSB-41	Published 11/94	Backward and forward compatibility and correction of errors in IS-41-B.
TSB-51	Published 02/93	Authentication, voice privacy and signaling message encryption for roamers.
TSB-56-A	Published 06/94	Application level test plan for IS-41-B.
TSB-64	Published 02/94	Support for CDMA terminal intersystem operations.
TSB-65	Published 04/94	Border cell problems

Standard	Status	Description
TSB-65	Published 04/94	Border cell problems
IS-41-C	Published 02/96	Numerous new features including extension phone services, preferred language service, 'IN'-like capabilities, short message service and incorporation of all previous TSB's.
IS-41-D	Development	PCS operation, advanced digital capabilities (including circuit-switched data and fax), international mobile identification, wireless intelligent network, and enhanced emergency services.
IS-652	05/96	MAP for PCS1900 systems.

C HLR-MSC Interface

Summary

This interface provides for call delivery to a roaming mobile from any gateway MSC. This also allows for call redirection to an HLR-provided destination from this gateway point, minimizing the use of trunks in this case.

Benefits

Allows least cost routing of calls to a mobile by avoiding call setup via the home system. Because the HLR is involved in the signaling, subscriber-specific services can be retained.

Champions

Supported by the major champions of IS-41 (major MSC manufacturers and large carriers).

TIA subcommittees TR-45.2 and TR-46.2 are responsible for the development of standards for this interface.

Standards

Standard	Status	Description
IS-41-A	Published 01/91	Included redirection during inter-system call delivery.
TSB-55	Published 05/94	Forward compatibility to IS-41-B.
TSB-56-0	Published 03/93	Application level test plan.
TSB-41	Published 11/94	Backward and forward compatibility and correction of errors in IS-41-B.
TSB-56-A	Published 06/94	Application level test plan for IS-41 Rev. B.
IS-41-B	Published 12/91	No further enhancements
IS-41-C	Published 02/96	Enhancements in the type of services that can be provided from a gateway (e.g. extension phone services)
IS-41-D	Development	Further enhancements to services, such as incoming call screening.
IS-652	05/96	MAP for GSM based systems (PCS1900).

Cn Wireless Intelligent Network Interfaces

Summary

Several interfaces are required for Wireless Intelligent Network capabilities, currently being defined by a TIA TR-45.2 Working Group II ad hoc group. In general these interfaces connect traditional cellular network elements (MSC and HLR) to IN network elements (IP, SCP and SN) using a protocol based on IS-41.

Benefits

The Wireless Intelligent Network will allow features to be defined and customized by carriers instead of always by vendors, with less load on traditional network elements, and with fewer and simpler software upgrades required. While the benefits of WIN may not be felt during development of the first release of a feature, they should allow customizations and local adaptations of features to be made more quickly.

Champions

The CTIA and member carriers have been the primary promoters of the Wireless Intelligent Network, particularly the CTIA staff and carrier representatives that have participated in the CTIA AGNI Wireless Intelligent Network sub-task group, chaired by Dick Gove of Ameritech.

The TIA has a TR-45.2 subcommittee ad hoc group dedicated to the development of WIN standards.

Standards

Standard	Status	Description
IS-53-B	Development	Defines meta-features that provide a scope for the initial WIN triggers: a. Voice controlled services. b. Incoming call screening. c. Calling name presentation.
IS-41-D	Development	To include signaling to standardize the implementation of WIN features.

D HLR-VLR Interface

Summary

The D interface, in conjunction with the B interface provides the all-important messaging connectivity between a wireless subscriber's home system HLR (containing profile, validation and other information) and the current serving system (VLR and MSC).

Benefits

The B and D interfaces together make roaming possible. All important inter-system automatic roaming capabilities rely on signaling messages carried on these interfaces.

Champions

Major MSC and HLR manufacturers and large cellular carriers.

The TIA subcommittees TR-45.2 and TR-46.2 are responsible for standardization of this interface.

Standards

See the description of the B interface standards.

D_i PSTN Interface (Common Channel Signaling)

Summary The Di interface provides common channel signaling interconnection to the PSTN and other telecommunications networks.

Benefits Common channel signaling on the Di interface, using ISDN or SS7 ISUP signaling, is much faster than traditional MF-tone based signaling (see Ai interface) and allows more data to be transferred, facilitating the efficient implementation of advanced capabilities, such as calling number identification.

Champions The first field trial of the Di interface in a wireless environment was a joint effort of BellSouth, BellSouth Mobility and AT&T Wireless Services (then McCaw).

TIA standards subcommittee TR-45.2, Working Group VI is responsible for enhancing the IS-93 standard.

Standards

Standard	Status	Description
TIA IS-93-0	Published 10/93	Standardized PSTN interconnect (also includes the Ai interface).
TIA IS-93-A	Unscheduled	A second revision of this standard is planned when the need arises. It is likely that international roaming or enhanced emergency services will be the stimulus.

D_2, Q_2 Over-the-air Activation Interfaces

Summary These interfaces will allow for wireless phones to be completely programmed over the radio interface, either activation for the first time, or when a change of service profile occurs.

Benefits This feature will reduce the cost of acquiring subscribers and the potential of fraud that occurs when sensitive subscriber information is manually entered. This is particularly important for handling the entry of authentication keys.

Champions Major wireless carriers are the chief proponents of this technology, which is primarily oriented at new TDMA and CDMA digital phones.

TIA subcommittees TR-45.2, TR-45.3 and TR-45.5 are responsible for standardization of this interface.

Standards

Standard	Status	Description
IS-41-D	Development	OTA capabilities, based on short message service, will be incorporated in this automatic roaming standard, to ensure that activation occurs in the desired system.
IS-136-A	In press	The air interface definition for TDMA terminal activation.
IS-683	Ballot	The air interface definition for CDMA terminal activation.

E MSC-MSC Interface

Summary

Interfaces between neighbouring MSC's provide wireless call processing enhanced capabilities such as inter-system handoff, inter-system paging and an inter-system link protocol for data calls.

Benefits

Inter-system handoff reduces dropped calls caused by mobiles that traverse a system boundary during a call. This capability will become steadily more important with the advent of in-building systems, micro-systems in tunnels, parking lots and other hard to reach public spaces and as the gaps between cellular and PCS systems are gradually filled in.

Inter-system paging can reduce the impact of certain 'border cell' problems that can result in problems such as mobiles getting lost, resulting in an a loss of incoming calls. These problems can significantly reduce the quality of service in some systems, especially those with a combination of high population density, several neighbouring systems and large bodies of water forming system boundaries.

The inter-system link protocol (ISLP) provides rate adaptation for bridging digital data information from the serving MSC (where a mobile is currently transmitting and receiving data over a digital air interface) to the anchor MSC (where the inter-working function is maintained). First implementations will probably map one data user to one 56/64 kbps DS0. Future implementations may provide sharing of this channel to multiple users.

Champions

Major MSC manufacturers and large carriers were the initial champions of inter-system handoff capabilities. Ericsson, Lucent, Nortel and Alcatel were the primary proponents of solutions to border cell problems. Qualcomm and Ericsson were prime motivators for the ISLP.

TIA subcommittees TR-45.2 and TR-46.2 are responsible for standardization of this interface.

Standards

Standard	Status	Description
IS-41-0	Published 02/88	Inter-system handoff forward and handoff back.
IS-41-B	Published 12/91	Path minimization (reducing facility usage in certain complex inter-system handoff scenarios), support for TDMA terminals and support for 3-way call/handoff interactions.
TSB-51	Published 02/93	Maintenance of voice privacy over an inter-system handoff.
TSB-56-A	Published 06/94	Application level test plan for IS-41-B.
TSB-64	Published 02/94	Support for CDMA terminal intersystem handoff.
TSB-65	Published 04/94	Inter-system paging to resolve border cell problems.

Standard	Status	Description
IS-41-C	Published 02/96	Numerous handoff and border cell enhancements, including enhanced authentication capabilities following an inter-system handoff.
IS-41-D	Development	Inter-system handoff within PCS bands, between cellular and PCS bands and for terminals in a data mode.
IS-652	05/96	MAP for GSM based systems (PCS1900)

F MSC-EIR Interface

Summary This interface provides access to an Equipment Identity Register for the validation of equipment.

Benefits This allows the separation of subscription and terminal identification and profile information, which is essential to UIM based systems (such as GSM and its derivatives). Although the EIR has never been standardized for AMPS based systems, it has existed as ESN databases.

Champions Proponents of GSM-based systems (i.e. PCS1900).

TIA subcommittee TR-46.2 is responsible for standardization of this interface (based on the original GSM MAP standard).

Standards

Standard	Status	Description
IS-652	05/96	MAP/F for GSM based systems (e.g. PCS1900).

G VLR-VLR Interface

Summary

Interfaces between VLR's are necessary to support wide area TMSI's (Temporary Mobile Station Identifiers). This interface is required because a TMSI only identifies the system that allocated it, and that system must be consulted to find the true identity of the mobile (and thus the network address of the home system). Since this information is transmitted on the signaling network it can be transferred securely.

Benefits

The TMSI concept can provide greater radio interface efficiency and security for mobiles. Since a TMSI is smaller than other mobile identifiers, less radio bandwidth is utilized to page or access using this identifier. Also, the TMSI does not identify a mobile, reducing the ability to perpetrate cloning fraud, as the TMSI can be reassigned at any time.

Champions

All GSM, D-AMPS and CDMA manufacturers and major carriers are proponents of the TMSI concept. However, only IS-95 (CDMA) and IS-652 (PCS1900) systems allow a TMSI to be maintained across a VLR boundary, and thus need the G interface.

TIA subcommittees TR-45.2 and TR-45.5 are jointly responsible for the standardization of this interface to support CDMA systems. TIA subcommittee TR-46.2 and TIA/ATIS TAG 5 are responsible for standardization in PCS1900 systems.

Standards

Standard	Status	Description
IS-41-D	Development	Definition of a VLR-VLR IS-41 message to obtain the MIN or IMSI and ESN or a mobile that has accessed with a foreign TMSI.
IS-652	05/96	MAP/G provides a VLR-VLR message to obtain the IMSI of a mobile that has accessed with a foreign TMSI.

H AC-HLR Interface

Summary

Network authentication depends on access to the Authentication Center network element, which has databases containing the secret keys required for authentication, voice privacy, data encryption and signaling message encryption.

Authentication is a process, using sophisticated encryption algorithms, that verifies that a mobile requesting service is in possession of a secret key (or 2 secret keys in the case of the TIA CAVE algorithm). The process never transmits the secret keys over the air interface, but validates their possession by a mobile by its ability to successfully execute the authentication algorithm. This validation is performed using a random number to provide a different challenge to each mobile on each access, resulting in a different response being required from the mobile.

The only type of authentication used in cellular systems is one based on the TIA CAVE algorithm. It is also used in PCS systems based on air interfaces in the AMPS family. The CAVE algorithm requires the mobile and AC to possess two secret keys, the A-Key (which is kept only by these network elements) and the Shared Secret Data, which can be transmitted around the network. Authentication can be restricted to use by the AC and MS only, or it can be distributed to the serving system to reduce network overhead.

PCS systems based on GSM technology (i.e. PCS1900) use an algorithm defined by the operator, known generically as A3. Only the AC and the MS execute this algorithm (as the serving system may not even have the capability of doing so). Voice encryption is provided by an operator specific A8 algorithm to generate the voice encryption mask and a single A5 algorithm to apply the mask to the digitized voice stream.

Benefits

With fraud losses by cellular carriers in the US estimated at $500 million per year, and technological fraud accounting for most of that, authentication is the *only* true solution.

Champions

The TIA standardization committees and, more recently, the CTIA are the biggest proponents of authentication.

The TIA TR-45 Ad Hoc Authentication Group (AHAG) is responsible for developing and approving authentication algorithms that are being designed for use in TIA wireless standards.

Standards

Standard	Status	Description
TSB-51	Published 02/93	Defined additions to the IS-41 Revision B protocol to allow authentication for roamers.
IS-41-C	Published 02/96	Authentication is incorporated, with some enhancements and corrections.
IS-41-D	Development	Authentication is included, with some enhancements to support new capabilities and features (such as data calls).
IS-652	05/96	Authentication for GSM based systems (e.g. PCS1900) is not based on the CAVE algorithm, but on an operator chosen algorithm (known generically as “A3”). Voice encryption uses algorithms known as A5 and A8.

I CDIS-CDGP Interface

Summary

This non-standard interface allows call detail records to be carried in a proprietary format from any network element (known as a Call Detail Information Source) to a Call Detail Generation Point, that can convert the information into the IS-124 format, and transport them over a call detail/billing record network.

While this is a non-standard interface, it is important that it be able to supply enough information to support a reasonably complete IS-124 record.

Benefits

Enhancing this interface will allow semi-realtime transmission of call detail records which enhances fraud detection and billing, and which will allow the provision of new billing and settlement services.

Future trends may be towards the elimination of this interface, as MSC's and other network elements become adapted to producing standardized call detail records conforming to the IS-124 standard directly.

Champions

There are no proponents of standardizing this interface at present.

IS-52 MS-MSC (Dialing Plan)

Summary

Conceptually, a dialing plan can be considered as an interface between a Mobile Station and an MSC. The TIA IS-52 standard defines a dialing plan that conforms to World Zone 1 (USA, Canada and much of the Caribbean), with some cellular extensions. These extensions are for providing feature codes (e.g. to activate or deactivate features such as call forwarding) and for short mnemonic abbreviated dialing codes (e.g. *AAA for roadside assistance).

Benefits

A standardized dialing plan is essential to provide seamlessness to roamers. Problems such as some systems requiring a 1 prefix on certain 10 digit numbers and some not allowing the prefix make it difficult for roamers to make calls, and make it impossible to program memory locations so that they work in all markets.

Wireless systems outside the North American numbering plan area use their own national numbering plans.

Champions

The major cellular carriers have been the proponents of the IS-52 standard.

TIA subcommittee TR-45.2 Working Group VI is responsible for the development of the IS-52 standard.

Standards

Standard	Status	Description
IS-52-0	Published 11/89	Original dialing plan standard
IS-52-A	Published 05/95	Same basic dialing plan, with some formatting and technical corrections, and adaptations to recent dialing plan modifications.
TIA/EIA-660	In press	ANSI version of IS-52-A.

IS-53 MS-HLR (Features)

Summary

The operation of features can loosely be considered an interface between an MS and an HLR (although the serving system is often also involved). The TIA IS-53 standard and the TIA IS-104 standard define the operation of features from a user perspective (i.e. how the features are operated and how they modify call treatment, not how they are made to work).

Benefits

Standardized feature processing makes roamers more comfortable. This has to be balanced against the competitive advantage of carriers designing their own unique features. To some extent, IS-41 allows carriers to “have their cake and eat it too” by allowing a serving system to operate a feature according to HLR rules, rather than strictly to IS-53.

Champions

The CTIA and the largest cellular and PCS carriers are the proponents of standardizing feature operation. Revision B of IS-53 was stimulated by the CTIA prioritization of 9 features (from a list of over 40 candidate features) in early 1995.

TIA subcommittee TR-45.2, Working Group I is responsible for developing the IS-53 standard. TIA subcommittee TR-46.2 is responsible for developing the IS-104 standard.

Standards

Standard	Status	Description
IS-53-0	Published 09/91	Basic features (3-way calling, call waiting and call forwarding)
IS-53-A	Published 04/95	Addition of 20 new features, including extension phone service, ‘intelligent network’ like capabilities, PIN validation features and short message service.
TIA/EIA-664	In press	ANSI version of IS-53-A.
IS-53-B	In development	Addition of the 9 CTIA priority features (with the exception of lawfully authorized electronic surveillance, which will be defined in a separate standard and broadcast SMS, due to a lack of interest).
IS-104-0	Published	Basic features for GSM-based systems (PCS1900).
IS-104-A	Development	GSM adaptations for the US marketplace, such as enhanced emergency services.

J CDGP-CDRP Interface

Summary

This interface allows call detail records to be rated, converting them into billing records.

Benefits

Access to a rating function will allow for the development of features based on semi-realtime access to billing information, such as rental phones and debit phones.

Champions

The major proponents of the IS-124 standard have been AT&T Wireless Services, CIBERNET Corporation (a subsidiary of the CTIA) and Synacom. Coral Systems, CBIS, Mobility Canada, Securicor, US West and Andersen Consulting have also made significant contributions to its development.

An important parallel development has been the development of NSDPBS subset of IS-124 for billing and settlement, spearheaded by CIBERNET Corp., a CTIA subsidiary.

TIA subcommittee TR-45.2, Working Group IV is responsible for developing the IS-124 standard.

Standards

Standard	Status	Description
IS-124-0	Published 09/93	Basic capabilities for the transmission of call detail records, including the J interface.
IS-124-A	In press	Corrections and enhancements to IS-124 Rev. 0, including internationalization and adaptation to different radio technologies.
IS-124-B	In development	Enhancements for intelligent network and data service call detail recording and billing.

K CDGP-CDCP Interface

Summary

This interface allows call detail and billing records to be transmitted to a destination application for use in areas such as fraud detection, customer satisfaction monitoring, settlement and billing.

Benefits

A standard way to communicate call detail and billing information, will gradually replace the more time consuming and expensive generation and transportation of CIBER billing tapes (and other related processes).

Champions

The major proponents of the IS-124 standard have been AT&T Wireless Services, CIBERNET Corporation (a subsidiary of the CTIA) and Synacom. Coral Systems, CBIS, Mobility Canada, Securicor, US West and Andersen Consulting have also made significant contributions to its development.

An important parallel development has been the development of NSDPF and NSDPBS subsets of IS-124 for fraud and billing/settlement, spearheaded by CIBERNET Corp., a CTIA subsidiary.

TIA subcommittee TR-45.2, Working Group IV is responsible for developing the IS-124 standard.

Standards

Standard	Status	Description
IS-124-0	Published 09/93	Basic capabilities for the transmission of call detail records, including the J interface.
NSDPF	Published by CIBERNET 03/95, with a revision in development.	Not a formal standard, but a corrected subset of IS-124 for fraud applications.
NSDPB&S	In development.	Not a formal standard, but a corrected subset of IS-124 for billing and settlement applications.
IS-124-A	In press	Corrections and enhancements to IS-124 Rev. 0, including internationalization and adaptation to different radio technologies.
IS-124-B	In development	Enhancements for intelligent network and data service call detail recording and billing.

L MSC-IWF Interface

Summary This interface provides access to a data interworking function that allows data being transmitted over a digital air interface (TDMA or CDMA) to be connected through the PSTN using analog modem tones.

Benefits This interface is essential to providing the at least the same level of data capabilities in digital cellular and PCS phones as are available from analog cellular phones.

Champions Qualcomm has been the major proponent of a standardized interface. Other major manufacturers, the CTIA and major carriers have also been supportive of standardization.

TIA subcommittee TR-45.5 is responsible for the development of IS-687.

Standards

Standard	Status	Description
IS-58	Published 08/96	Data services inter-working function for wideband spread spectrum (CDMA) systems.

$LAES_d$, $LAES_e$ - Lawfully Authorized Surveillance

Summary Together, these interfaces provide a mechanism for an MSC to provide lawfully authorized surveillance information to law enforcement agencies (signaling, voice and other traffic).

Benefits These interfaces are required by the US CALEA law. A standard may provide a ‘safe harbor’ in case of disputes about the actual requirements of the law.

Champions Major carriers and manufacturers who recognize the economic and legal benefits of a standard for at least the $LAES_e$ interface.

This standard (as yet unnamed) is the responsibility of a TIA TR-45.2 subcommittee ad hoc group.

Standards

Standard	Status	Description
n/a	Development	A combined wireless/wireline surveillance standard is under development.

M,N Short Message Service Network Interfaces

Summary

The M (MC-MC, MC-SME or SME-SME) interfaces allow for transmission of short numeric or text messages through the network to an SMS-capable terminal. The N interface (MC-HLR) allows for coordination of general terminal and subscription functions with the message center. In particular, routing information must be obtained by an MC via the HLR.

Note that the MC is known as SM-SC in GSM-based systems (e.g. PCS1900).

Benefits

Short message service allows for a virtual 2-way pager to be supported in wireless phones, without additional hardware. This service will be of obvious interest to customers who currently carry both a pager and a cellular phone.

Short message service contains capabilities beyond pagers, such as longer message capabilities (up to about 200 characters) and mobile originated messaging.

Champions

Lucent Technologies (previously AT&T Network Systems), AT&T Wireless Services (previously McCaw), Southwestern Bell, Synacom, Ericsson as well as the CTIA.

Standards

Standard	Status	Description
IS-41-C	Published 02/96	The first standard to contain short message network interfaces (point-to-point only).
IS-41-D	Development	May contain support for broadcast short message service.
IS-652	05/96	Short message transmission through the network is supported in the MAP/C, MAP/D and MAP/H protocols.

O Administrative Interface

Summary

The O interface, today just in the pre-natal phase of development, will provide standardized administrative interfaces to all network elements for operations, administration, maintenance and provisioning applications (known as OA&M or OAM&P). This is one of the greatest challenges that can be undertaken in any network, due to the variety of functions that must be supported.

Benefits

A standard O interface would allow for seamless central monitoring and lower training and network management costs.

Champions

Several major carriers, under the auspices of the CTIA AGNI ad hoc group on OAM&P have developed an initial standards requirements document (CTIA Requirements for Wireless Network OAM&P Standards), which was presented to TIA standards committee TR45 in March, 1996.

Standards

Standard	Status	Description
None	Development	Preliminary TIA activities are underway, which will probably result in the development of one or more standards for the “O” interface.

Q2 See D2

R/S Data Terminal Interfaces

Summary

Data terminals are increasingly being connected to wireless phones, or even being built in, to take advantage of the wireless communication capability of the phone. The S and R interfaces provide the capability of having a data terminal built into a voice terminal, or connected externally by a cable.

Benefits

Wireless data usage is steadily increasing. The transmission of data from a computer connected to a wireless phone, by a combined voice/data device and even by a data-only device are important capabilities.

Champions

Ericsson, Qualcomm and other major manufacturers and carriers are the major proponents of standardized S and R interfaces.

Standards

Standard	Status	Description
IS-99-A	Published 07/95	CDMA circuit switched data/fax interface
IS-130	Published 03/95	Radio link protocol for carrying data from TDMA digital phones
IS-135	Published 03/95	Circuit switched services (asynchronous data and fax) that ride above IS-130.
IS-657	Published 08/96	CDMA packet data

T User Identity Module Interface

Summary

The User Identity Modules (UIM), also known as a “Smart Card” or SIM (Subscriber Identify Module) allows the subscription identification to be separated from the terminal. A user can insert their identity into any phone compatible with the UIM, even if it uses completely different radio technology from their regular phone.

Benefits

UIM cards facilitate roaming between otherwise incompatible systems, and facilitate sharing of phones with separate billing.

Champions

GSM proponents have long promoted the Smart Card concept. The CDMA Development Group is now promoting the adaptation of this concept to phones built to the AMPS family of standards.

Standards

Standard	Status	Description
IS-652	05/96	PCS-1900 MAP protocols support the UIM concept.

U_m Radio Interfaces

Summary

The radio interfaces are the very basis of cellular, PCS and other wireless telecommunications systems. The major families of radio interfaces for telephone-like communication today are:

AMPS — A family of analog and digital cellular (and now PCS) air interfaces derived by evolution from the original AT&T Advanced Mobile Phone System. An offshoot of this family is the 900 MHz analog TACS system. AMPS systems are now found all over the world, increasingly with digital capabilities.

GSM — A digital air interface applicable to 900 MHz cellular bands and 1800-2000 MHz PCS bands, developed and first implemented in Europe, and now spread widely throughout the world. GSM is perhaps best known for its pioneering use of a smart card, which allows some subscriber information to be carried in a credit-card-sized device from phone to phone.

NMT — A pioneering 400 and 900 MHz analog cellular system, first applied in Scandinavia. While NMT systems are found in many countries, there are none in the Americas.

Others — During the development of PCS standards leading up to the auctioning of licenses by the FCC, several new interfaces were proposed. Those that appear likely to be commercially applied in North America are the Omnipoint combination CDMA/TDMA/FDMA interface and the PACS interface.

Benefits

Without radio interfaces there would not be wireless communications!

Champions

There are too many manufacturers and carriers with different preferences to list all champions of different technologies.

Standards

Standard	Status	Description
EIA/TIA-553-0 EIA/TIA-553-A	09/89 *ballot*	Analog cellular
IS-88	02/93	Narrowband analog cellular (NAMPS)
IS-94	05/94	In-building cellular.
IS-91-0 IS-91-A IS-91-B	09/94 11/95 *development*	Combined analog and NAMPS.
IS-54-B IS-136-0 IS-136-A J-STD-011	04/92 12/94 *development*	TDMA digital cellular and (in J-STD-011) PCS standards.
IS-130 IS-135	03/95 03/95	TDMA digital cellular and PCS data standards.

Standard	Status	Description
IS-95-0 IS-95-A IS-95-B J-STD-008	07/93 05/95 *development*	CDMA digital cellular and (in J-STD-008) PCS standards.
IS-99-A IS-657	07/95 08/96	CDMA digital cellular and PCS data standards for circuit switched and packet applications
IS-41-D	Development	May contain support for broadcast short message service.
IS-661	In press	Composite CDMA/TDMA air interface for 1.85-1.99 GHz licensed applications
IS-665	In press	Wideband CDMA air interface for 1.85 to 1.99 GHz PCS applications
J-STD-007	In press	PCS1900 (GSM based) air interface
J-STD-014	In press	Personal Access Communications System (PACS) air interface

Appendix A. Manufacturer/Standard Cross Reference

This table lists information that manufacturers of wireless equipment have provided to illustrate the availability of equipment that conforms to standards that define many of the interfaces of the open wireless network architecture. Each standard is listed, along with a list of interfaces that it standardizes and a list of manufacturers that claim to provide equipment that adheres to the standard. No attempt has been made to validate the claims of manufacturers or to distinguish between various levels of implementation for a standard.

Note: Many standards are highly complex, and complete adherence may be unlikely. An entry in this table indicates that, in a company's own opinion, they adhere to the most important sections of the standard, not necessarily adherence to the entire standard.

A.1 Air Interface Standards

Standard	Rev.	Description	Element	Company
EIA/TIA-553	0	Analog air interface	BS	Astronet Celcore Ericsson Lucent Nortel Panasonic Telos Watkins-Johnson Wavetek (test equipment)
			MS	Ericsson Lucent NEC America OKI telecom
	A	Analog air interface, with authentication	BS	Celcore Ericsson Lucent Nortel
			MS	Ericsson Lucent NEC America Wavetek (test equipment)

A.1 Air Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-54	B	TDMA digital cellular (first generation)	BS	Ericsson
				Lucent
				Nortel
				Wavetek (test equipment)
			MS	Ericsson
				Lucent
				NEC America
				Wavetek (test equipment)
IS-88		NAMPS air interface (narrowband analog)	BS	Nortel
				Wavetek (test equipment)
			MS	NEC America
				OKI telecom
				Wavetek (test equipment)
IS-91	0	Analog air interface (including NAMPS and authentication)	BS	Nortel
			MS	NEC America
				OKI telecom
				Wavetek (test equipment)
	A	Including in-building capability (IS-94)	BS	Celcore
				Panasonic
			MS	OKI telecom
IS-94	0	In-building analog air interface	BS	Astronet
				Celcore
				Hyundai
				Lucent
				Telos
			MS	Hyundai
				OKI telecom
				Wavetek (test equipment)

A.1 Air Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-95	0	CDMA digital cellular	BS	Hyundai Nortel Wavetek (test equipment)
			MS	Hyundai OKI telecom Wavetek (test equipment)
	A	…with enhanced features	BS	Lucent Nortel
			MS	Lucent (planned) OKI telecom
IS-99		CDMA circuit switched data	BS	Lucent (planned) Nortel
			MS	Lucent (planned) OKI telecom
IS-130		TDMA radio link protocol for data	BS	Ericsson Lucent (planned)
			MS	Ericsson Lucent (planned) OKI telecom
IS-135		Circuit data services for IS-130	BS	Ericsson Lucent (planned) Nortel
			MS	Ericsson
				Lucent (planned)

A.1 Air Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-136	0	TDMA with digital control channel	BS	Ericsson Lucent Nortel Telos Wavetek (test equipment) Watkins-Johnson
			MS	Ericsson Lucent (planned) OKI telecom Wavetek (test equipment)
	A	…with enhanced features.	BS	Ericsson Lucent (planned) Nortel Telos (pending)
			MS	Ericsson Lucent (planned) OKI telecom Wavetek (test equipment)
IS-657		CDMA packet data services	BS	Lucent (planned) Nortel (12-18 months after publication)
			MS	Lucent (planned) OKI telecom
IS-661		Composite CDMA/TDMA air interface	BS	Ericsson Nortel Telos (pending)
			MS	Ericsson
IS-665		Wideband CDMA air interface		
J-STD-007		PCS1900 air interface	BS	Ericsson Nortel
			MS	Ericsson Nortel

		Wavetek (test equipment)

A.1 Air Interface Standards (continued)

Standard	Rev.	Description	Element	Company
J-STD-008		CDMA digital cellular for 2 GHz PCS band	BS	Nortel
				Lucent
				Wavetek (test equipment)
			MS	Lucent (planned)
				Wavetek (test equipment)
J-STD-011		TDMA digital cellular for 2 GHz PCS band	BS	Ericsson
				Lucent
				Nortel
				Telos (pending)
				Wavetek (test equipment)
				Watkins-Johnson
			MS	Ericsson
				Lucent (planned)
				Wavetek (test equipment)
J-STD-014		PACS (Personal Access Communications System)	BS	Lucent
				Telos (pending)

A.2 Network Interface Standards

Standard	Rev.	Description	Element	Company
IS-41	0	Intersystem operations (handoff)	MSC	Astronet
				Ericsson
				Lucent
				Nortel
				Telos
	A	…including validation and call delivery	HLR	Alcatel
				Astronet
				Celcore
				Coral
				Ericsson
				HP
				Lucent (standalone planned)
				Nortel
				Telos
				Watkins-Johnson
			MSC	Alcatel
				Astronet
				Ericsson
				Lucent
				Nortel
				Telos
				Watkins-Johnson
			VLR	Alcatel
				Astronet
				Celcore
				Nortel
				Telos
				Watkins-Johnson

A.2 Network Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-41	B	…including TDMA digital and enhanced handoff	HLR	Alcatel
				Celcore
				Coral
				DSC (4Q'96)
				Ericsson
				Lucent (standalone planned)
				Nortel
				Telos
				Watkins-Johnson
			MSC	Alcatel
				Ericsson
				Lucent
				Nortel
				Telos
				Watkins-Johnson
			VLR	Alcatel
				Celcore
				Nortel
				Telos
				Watkins-Johnson

A.2 Network Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-41	C	…including enhanced features (e.g. extension phone, IN-like features, short message service, authentication, CDMA support etc.)	AC	Alcatel
				Ericsson
				Lucent (planned)
			HLR	Alcatel (SMS & Authentication)
				Coral (in progress)
				DSC (4Q'97)
				Ericsson (SMS & Authentication)
				Lucent (standalone planned)
				Nortel
				Telos (scheduled)
			MC	Ericsson
			MSC	Alcatel (SMS & Authentication)
				Ericsson (SMS & Authentication)
				Lucent (partial implementation)
				Nortel
				Telos (scheduled)
			VLR	Alcatel
				Nortel
				Telos (scheduled)
IS-52		Dialing plan	HLR	Alcatel
				Nortel
				Telos
			MSC	Alcatel
				Astronet
				Celcore
				Ericsson
				Lucent
				Nortel
				Telos
			VLR	Celcore
				Nortel

A.2 Network Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-53	0	Features (3 way calling, call waiting, call forwarding)	HLR	Alcatel
				Celcore
				DSC (4Q'97)
				Ericsson
				Lucent (standalone planned)
				Nortel
				Telos
				Watkins-Johnson
			MSC	Alcatel
				Astronet
				Celcore
				Ericsson
				Lucent
				Nortel
				Telos
				Watkins-Johnson
			VLR	Celcore
				Nortel
				Telos
				Watkins-Johnson
	A	Features support by IS-41-C	HLR	Coral (in progress)
				Ericsson
				Lucent (standalone planned)
				Nortel
				Telos
				Watkins-Johnson
			MSC	Ericsson
				Lucent (partial implementation)
				Nortel
				Telos
				Watkins-Johnson
			VLR	Nortel
				Telos
				Watkins-Johnson

A.2 Network Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-93		MSC-PSTN interface (MF/ISDN)	MSC	Alcatel Ericsson Lucent Nortel Telos
IS-104	0	Features for PCS systems (excluding AMPS based standards)	BS	Nortel
			HLR	Ericsson Lucent (standalone planned) Nortel
			MC	Nortel
			MSC	Ericsson Lucent Nortel
			VLR	Nortel
	A	Enhanced features for PCS systems	BS	Nortel
			HLR	Ericsson Lucent (standalone planned) Nortel
			MC	Nortel
			MSC	Ericsson Lucent Nortel
			VLR	Nortel
IS-124	0	Call detail and billing records	CDGP, CDCP, CDRP	Coral Ericsson (CDGP) Lucent (planned)
			HLR	Metapath
			MSC	Metapath
			VLR	Metapath

A.2 Network Interface Standards (continued)

Standard	Rev.	Description	Element	Company
IS-634		BS-MSC interface (AMPS)	BS	Telos Lucent (planned) Nortel Watkins-Johnson
			MSC	Lucent (planned) Nortel Telos Watkins-Johnson
IS-651		BS-MSC interface (PCS-1900)	BS	Ericsson Lucent (planned) Nortel
			MSC	Ericsson Lucent (planned) Nortel Telos (scheduled)
IS-652		Intersystem operations for PCS-1900 systems	AC	Nortel (later in 1996)
			HLR	Ericsson Nortel
			MSC	Ericsson Nortel
			VLR	Nortel
IS-653		BS-MSC interface (PACS)	BS	Lucent (planned)
			MSC	Lucent (planned) Telos (scheduled)
IS-680		ACRE (Residential cordless phone capability)	VLR	Celcore

A.3 Company Contacts

Company	Contact	Phone
Alcatel Engineering & Service Center	Bob Erdman	301-571-2626
Astronet	Norma Paine	407-333-4926
Celcore	Thomas Ginter	901-759-5155 x 296
Coherent Communications Systems Corp. Note: Coherent is not listed in the preceding tables. This company produces “voice enhancement products (echo cancellers) to assist with the implementation of air interface standards.”	Mr. Tushar Shah	703•729•6400
Coral Systems, Inc.	Nancy Laundy	303-772-5800
Digital Microwave Corporation Note: This company is not listed in the preceding tables. It produces “equipment to interconnect wireless systems together.”	Jimmy Hannan	408-943-0777
DSC Communications	Dan Allen	214-477-8475
Ericsson Inc.	A. Gains Gardner	214-952-8673
HP Note: “HP produces computer platforms and through HP and alliance partners, produces solutions as indicated.”	Garry Irvine	408-447-5509
Hyundai Electronics America	Inchul Kang	408-232-8731
Lucent Technologies, Inc. Note: Formerly known as AT&T Network Systems.	John A. Marinho	201-386-2886
Metapath Corporation Note: Previously called Securicor Wireless Networks	Karen Edwards	206-885-0088
NEC America, Inc.	Beth Anderson	214-751-7335
Nortel	Brian McNealy (AMPS/TDMA/CDMA) or Steve Horowitz (PCS-1900)	214-684-8864 214-684-2209

Company	Contact	Phone
Panasonic	Richard Nardone	201-392-6325
Raytheon E-Systems Note: This company is not listed in the preceding tables. It produces "adaptive smart antenna systems that may assist with the implementation of radio interface standards at BS network elements."	Debbie Jaudon or Richard Minthorne	703-560-5000
SCT Note: SCT is not listed in the preceding tables. This company "produces a tower-top receiver front end sub-system that is air-interface independent."	David Patton	303-384-0500
Telos Engineering Ltd.	Mr. Bradley W. Long	604-276-0055
Watkins-Johnson Company	Thomas Yang	301-948-7550
Wavetek Corporation	Jeffry H. Perrin	317-788-9351

Appendix B: Glossary of Acronyms

Acronym	Definition
AC	Authentication Centre
AHAG	TIA Ad-Hoc Authentication Group
AMPS	Advanced Mobile Phone Service (generic name for US cellular and PCS standards)
ANSI	American National Standards Institute
ATIS	Alliance for Telecommunications Industry Solutions. Parent organization of T1 committees for standardization.
BS	Base Station (includes BTS and BSC)
CAVE	Cellular Authentication and Voice Encryption Algorithm
CDCP	Call Detail Collection Point
CDGP	Call Detail Generation Point
CDIS	Call Detail Information Source
CDMA	Code Division Multiple Access
CDRP	Call Detail Rating Point
CF	Lawfully authorized electronic surveillance collection function.
CIBER	Tape format for wireless billing records
CSC	Customer Service Center
CTIA	Cellular Telephone Industry Association
DF	Lawfully authorized electronic surveillance distribution function.
EIA	Electronics Industry Association
EIR	Equipment Identity Register
ESN	Electronic Serial Number
HLR	Home Location Register
IP	Intelligent Peripheral *or* Internet Protocol, depending on context.
IS-	TIA Interim Standard
ISDN	PSTN utilizing SS7 interfaces
ISLP	Inter-system link protocol
IWF	Inter-working function (usually between two forms of data)
J-STD-	Standard produced by joint technical committees with TIA and ATIS participation.
MC	Message Centre
MF	Multi-frequency tone signaling.
MIN	Mobile Identification Number
MNE	Mobile Network Entity
MS	Mobile Station (i.e. phone)
MSC	Mobile Switching Centre (aka MTSO)
MT	Mobile Termination
NAMPS	Narrowband AMPS

Acronym	Definition
OAM&P	Operations, Administration, Maintenance and Provisioning
OTAF	Over-The-Air Activation Function
OWNA	Open Wireless Network Architecture
PN-	TIA project number
PSTN	Public Switched Telephone Network (utilizing R1 MF tone interfaces)
SCP	Signaling Control Point.
SME	Short Message Entity (logical SMS terminal)
SMS	Short Message Service
SM-SC	Short Message Service Center (see MC)
SN	Service Node
SP-	ANSI standards proposal number
S/R	Emergency services selective router.
SRD	CTIA Standards Requirement Document
SS7	Signaling System 7 inter-switch protocol
TAG	Joint TIA/ATIS technical ad-hoc group
TCAP	Message packaging standard used by IS-41 and defined in ANSI T1.114
TDMA	Time Division Multiple Access
TE	Data Terminal
TIA	Telecommunications Industry Association
TR-	TIA Technical Review standards committee prefix
TR-45	TIA Standards Committee responsible for AMPS-based cellular and PCS standards.
TSB-	TIA Telecommunications Systems Bulletin. Often used as an addendum or erratum to a published interim standard.
UPR	CTIA User Performance Requirements document. Now know as SRD.
VLR	Visitor Location Register
WIN	Wireless Intelligent Network

Appendix C: About the Author

David Crowe is editor of the Cellular Networking Perspectives monthly bulletin, and a wireless telecommunications consultant. He has been involved in the development of wireless standards since 1988, and in the development of wireless system software since 1984. He can be reached by phone at 1-403-289-6609 or by email at crowed@cadvision.com. The web page for Cellular Networking Perspectives is http://www.cnp-wireless.com/.