Inter-Standard Roaming White Paper

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Revision History

Date	Version	Description
1 August 2005	1.0	Initial release
5 December 2005	2.0	Second release

1. Introduction

1.1 Purpose

The objective of this white paper is to guide CDMA operators who want to launch inter-standard roaming services through the various steps required. Its aim is also to provide information related to inter-standard roaming that will be helpful as a reference.

1.2 Referenced Documents

Ref	Standard	Description
1.	C.S0024-0v4.0	cdma2000 High Rate Packet Data Air Interface Specification
2.	3GPP2 specification X.S0003-0	One-Way Roaming from X.S0004 to GSM
3.	3GPP2 specification X.S0023-B	Network Interworking between GSM MAP and TIA-41 MAP-cdma2000 Support
4.	3GPP2 specification X.S0004-000E	Introduction to TIA-41
5.	J-STD-038, Rev. B	Joint TIA/ATIS standard for ISR. The 3GPP2 equivalent is X.S0023-B v 1.0.

1.3 Acronyms and Abbreviations

Acronym / Abbreviation	Description
3GPP2	Third Generation Partnership Project 2
ARIB	Association of Radio Industries and Businesses
ANSI	American National Standards Institute
AuC	GSM Authentication Center
AC	CDMA Authentication Center
BID	Billing IDentifier

Acronym / Abbreviation	Description
CDG	CDMA Development Group
CDMA	Code Division Multiple Access
CIBER	Cellular Intercarrier Billing Exchange Roamer record
EDI	Electronic Data Interchange
GSM	Global System for Mobile
GSMA	GSM Association
HLR	Home Location Register
HUR	High Usage Reporting
IFAST	International Forum on ANSI-41 Standards Technology
IIF	Inter-standard Inter-working Function
IMF	International Monetary Fund
IMSI	International Mobile Subscriber Identity
IMSI-M	MIN-based IMSI
IMSI-T	True IMSI
INMSI	International Mobile Station Identity
ISR	Inter-Standard Roaming
ITU	International Telecommunication Union
Kc	Encryption key used in GSM encryption
MDN	Mobile Directory Number
ME	Mobile Equipment
MSC	Mobile Switching Center
MSIN	Mobile Station Identification Number
MSRN	Mobile Subscriber Roaming Number
NANP	North American Numbering Plan
NMSI	National Mobile Station Identity

Acronym / Abbreviation	Description
NPA	Numbering Plan Area
OEMs	Original Equipment Manufacturers
PIN	Personal Identification Number
PLMN	Public Land Mobile Network
PMN	Public Mobile Network
PSTN	Public Switched Telephone Network
PUK	Pin Unblock code
RAND	Random Number used in GSM subscriber authentication
R-UIM	Removable User Identity Module
SDR	Special Drawing Rights
SGSN	Serving GPRS Service Node
SID	System IDentification
SIM	Subscriber Identity Module
SN	Serial Number
SMS	Short Messaging Service
SRES	Signed Response used in GSM subscriber authentication
TADIG	Transferred Account Data Interchange Group (GSMA Working Group)
TAP	Transferred Account Procedure
TIA	Telecommunications Industry Association
TLDN	Temporary Local Directory Number
USIM	Universal SIM
USSD	Unstructured Supplementary Services Data
VLR	Visitor Location Register

1.4 Useful Links

The following are some links that operators will find useful when implementing ISR. Some of them contain general documents, white papers, standards, and components' information that can be referenced at all times.

1. www.cdg.org
2. www.tia.org
3. www.gsma.org
4. www.3gpp2.org
5. www.qualcomm.com
6. www.gemplus.com
7. www.syniverse.com
8. www.vodafone.com
9. www.worldcell.com
10. www.cibernet.com
11. www.sktelecom.com
12. www.lucent.com
13. www.fairisaac.com
14. www.verisign.com

1.5 Contributors

The following companies have been active contributors of this white paper. Thanks to all of them for their valuable support.

- Qualcomm Incorporated
- Gemplus Corporation
- SK Telecom
- Vodafone
- Syniverse
- WorldCell
- Cibernet
- FairIsaac
- Verisign
- Lucent

2. ISR Feature Description

2.1 Inter-Standard Roaming (ISR) Feature Description

ISR is roaming between different mobile technology standards. A quarter of the total mobile telephony market is non-GSM, with CDMA as the second most prevalent technology worldwide.

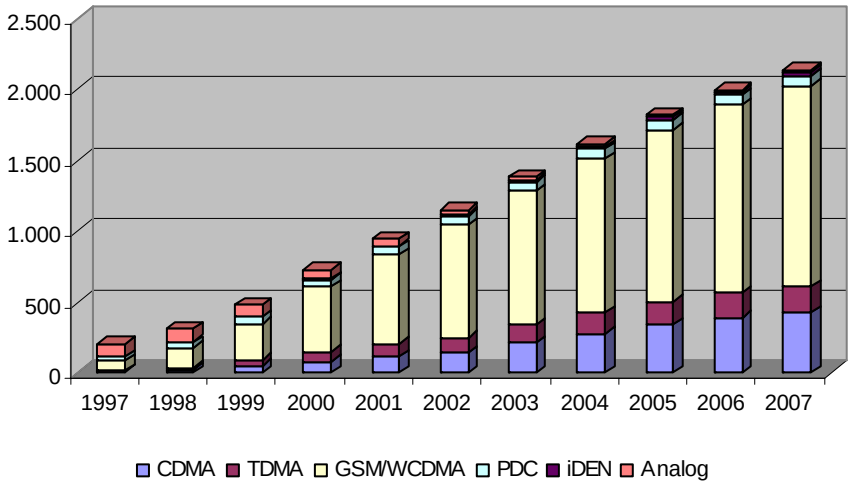

*Figure 2-1: Number of Subscribers (in millions) by Technology **

* Source: EMC Database (Informa, UK)

The most logical choice to interconnect mobile technologies is to implement seamless roaming between GSM and CDMA, since these two technologies represent 86% of the total mobile market size.

If we take a closer look at both technologies, we see that GSM was originally designed for roaming while CDMA was designed for high-speed data. Thus, both GSM and CDMA combined provide a myriad of opportunities for mobile users and operators alike.

2.2 Service Description

ISR allows CDMA wireless operators to offer their customers worldwide roaming. This international roaming solution is welcome news for international travelers who need to stay in touch, virtually anywhere in the world, instantaneously. This solution also gives

CDMA operators a competitive edge that protects their valuable global customers and helps them attract new ones.

CDMA operators who implement inter-standard roaming give their subscribers a very valuable productivity tool. Work never needs to stop while key players are traveling. And with all charges appearing on the company's regular monthly statement, business travel is easier to manage and budget. Leisure travelers also appreciate the convenience this service offers. Subscribers who can make and receive calls using their existing wireless numbers use their wireless service more often and talk longer than when they use a rental phone and do not keep their own number.

2.3 Added Value

The ISR service delivers added value to the home operator and to the end-users.

Added value for the home operators:

- Enhances their competitive position through connectivity to international markets
- Enables them to obtain new revenues from activations, airtime and monthly fees
- Lets them retain high-end corporate subscribers by satisfying the needs of this key customer segment
- Improves customer service and roaming management through timely online information
- Allows them to choose a roaming partner regardless of technology

Added value for end-users:

- Provides worldwide access: one number, one bill, one phone, same services
- Allows users to view all charges on one home operator bill in their currency
- Enables MO and MT calls independent of access technology
- Delivers calls automatically to the end users' existing home wireless phone number
- Enables them to communicate easily with no complicated dialing procedures or language barriers

2.4 Conversion Platform

The conversion platform (connecting GSM and CDMA networks) includes automatic call delivery on the home cellular number and home wireless system billing. It also provides technical interoperability that is transparent to the user, including the following:

- Location of roamers abroad
- Link between GSM SIM card and home cellular number
- Conversion from GSM-format (TAP) to ANSI-41-format (CIBER)
- Clearing house functionality

3. Network Infrastructure

3.1 Architecture

The CDMA operator or service bureau must be able to network both ANSI-41 (CDMA) and GSM. This may be done with network infrastructure or by partnering with network providers. For GSM, arrangements may also need to be in place to handle ITU-to-ANSI GSM conversion.

3.2 Signaling Conversion

The conversion device must be able to handle conversion of CDMA messaging to GSM and vice versa. However, there is not always a one-to-one mapping for each message.

Implementation of standards on the CDMA side is rather loose. Individual operators have implemented their networks with their own interpretation of the CDMA standards. This creates some difficulties with ISR and may require custom software development.

GSM standards are somewhat tighter, but there is still some implementation that is left to the operator's discretion. Voice mail is a good example of this. In GSM, a call to a phone that is busy or not answered is re-directed to the called subscribers own number for voice mail. Some CDMA operators also do this but some use a unique number. Depending on the home operator's voice mail set up, software must be adjusted to allow for different routing.

Some CDMA operators use "steering digits" to forward to voice mail. For example, if a subscriber's number is 888 555-1234, the call forward number in the signaling record is something like #8885551234. This will not work in GSM as the GSM VLR will not allow a registration with a non-numeric call forward number and won't be able to route it all back to the voice mail system if the forward-to number is not in the correct E164 format. Therefore, for these operators, software must be available to allow this implementation.

3.3 Numbering Plans

ISR must take into consideration both the international numbering plan and the North American numbering plan.

The international public telecommunication numbering plan (ITU-E.164)

Table 3-1: Number Structure for a Geographic Area

Country Code	National Destination Code (optional)	Subscriber Number
cc=1-3 digits	National (significant) number	
maximum 15-cc digits		
International public telecommunication number for geographic areas (maximum 15 digits)		

Table 3-2: Number Structure for Networks

Country Code	Identification Code	Subscriber Number
cc=3 digits	x=1-4 digits	maximum 12-x digits
International public telecommunication number for networks (maximum 15 digits)		

Table 3-3: Number Structure for Global Services

Country Code	Global Subscriber Number
cc=3 digits	maximum 12 digits
International public telecommunication number for global services (maximum 15 digits)	

For each of the categories, ITU-E.164 details the components of the numbering structure and the digit analysis required to successfully route the calls. This plan's Annex A provides additional information on the structure and function of E.164 numbers. Its Annex B provides information on network identification, service parameters, calling/connected line identity, dialing procedures, and addressing for geographic-based ISDN calls. Specific E.164 based applications which differ in usage are defined in separate recommendations.

International identification plan for mobile terminals and mobile users (ITU-E.212)

This recommendation defines an identification plan for land mobile stations in international harmonized PLMNs; it establishes the principles for allocation of INMSIs to mobile stations; and it defines an IMSI consisting of

- a mobile country code (MCC) of three digits
- a national mobile station identity (NMSI), consisting of:
  - a mobile network code (MNC)
  - a mobile station identification number (MSIN)

An IMSI is required for a visited network to identify a roaming mobile terminal or mobile user, e.g., in order to query a subscriber's home network for subscription and billing information.

Example: MCC 204 = the Netherlands, MNC 04 = Vodafone

North American Numbering Plan (NANP)

The NANP is the numbering plan for the PSTN in the United States and its territories, Canada, Bermuda, and many Caribbean nations, including Anguilla, Antigua and Barbuda, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos.

The area served by the NANP is divided into smaller areas, each identified by a three-digit NPA code, commonly called an area code.

TLDN/MSRN-ranges

For the ISR service to work, it is necessary that the CDMA operator makes sure that all the TLDN / MSRN ranges of the GSM markets, where the service should work, are configured in its network. Any type of international barring should be removed at the CDMA operator's network.

If it is not possible to route the TLDN/MSRN ranges from the CDMA operator to the visited country, then the ISR service will not work.

4. Network Services

4.1 Network Services and Features

The TIA/EIA standard J-038-B specifies the network services to be performed by the IIF in order to offer seamless voice and data roaming between ANSI and GSM networks. This section details service and feature support for one-way roaming from ANSI to GSM networks.

In the case of an ANSI subscriber roaming on GSM, the following services are supported:

- ANSI-41 VLR – The IIF emulates an ANSI-41 VLR to the subscriber's home network.
- GSM HLR - To the visited GSM network, the IIF emulates a GSM HLR.
- GSM AuC - The IIF can perform full subscriber authentication as required by the visited GSM network. GSM Authentication algorithm A3 versions 1 and 2 must be fully supported and possibly some proprietary algorithms. The algorithm would depend on the GSM operator's IMSI being used.

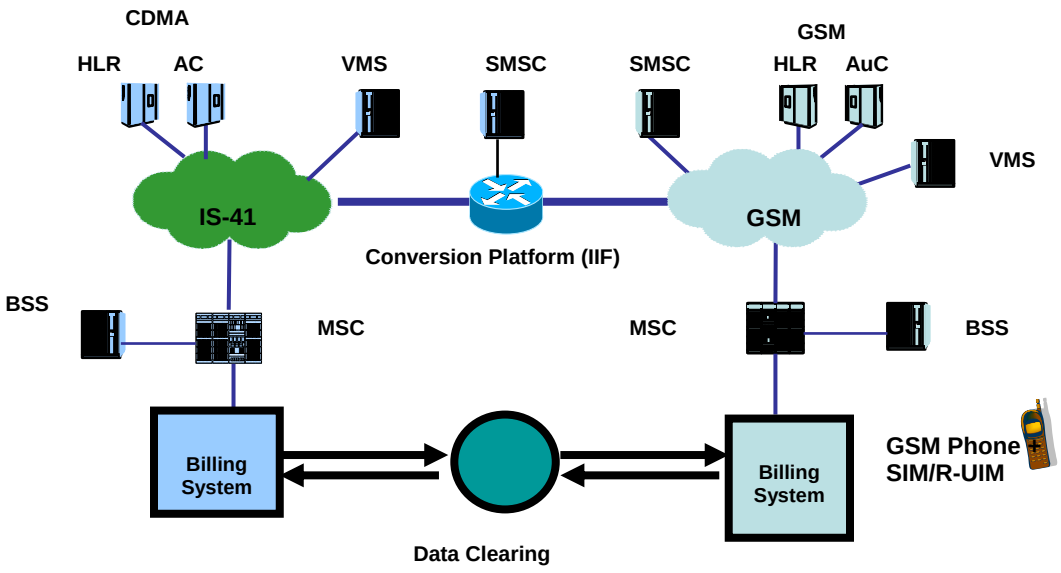

Figure 4-1: ISR Network Architecture

The IIF supports the following services and features in the above setup:

- **Authentication:** The IIF, acting as the GSM AuC, handles the subscriber's authentication when roaming in GSM. Upon receiving an authentication request from the GSM VLR, the IIF AuC generates the authentication triplets (RAND, SRES, Kc) and sends them to the GSM VLR. The GSM VPLMN performs the actual authentication using the GSM A3 algorithm COMP128. The GSM authentication is, typically, not translated back to CDMA authentication.
- **Location Management:** The IIF acting as the CDMA VLR and GSM HLR is responsible for the subscriber's location management in GSM. When a CDMA subscriber first roams into a GSM network, a "Location Update" message is sent from the serving GSM VLR to the IIF. The IIF translates this into an ANSI-41 MAP message "REGNOT" and sends it to the home HLR. From the CDMA home network's point of view, the CDMA subscriber is now located in a foreign CDMA VLR. When the subscriber roams back into the CDMA network, the subscriber's home CDMA HLR sends an ANSI 41 MAP message "REGCANC" to the last registered CDMA VLR, which is the IIF. This causes the IIF to de-register the subscriber from the last real GSM VLR that the subscriber was registered in.
- **Call routing:** The CDMA subscriber roaming in GSM appears to be roaming in another CDMA market. When receiving an incoming call, the CDMA home network requests a TLDN for call routing from the IIF. In turn, the IIF, acting as the GSM HLR, requests an MSRN from the visited GSM VLR. The IIF is responsible for handling the MSRN-to-TLDN conversion number formatting to accommodate both ANSI 41 A- and ANSI 41 C- compliant networks. The call is routed directly between the home MSC and the visited GSM MSC.
- **Voice Mail Deposit:** Due to different implementations of voice mail call delivery in GSM and ANSI markets as well as non-implementation of optimal routing in most GSM networks, the call delivery to voice mail in GSM can be a problem. The J-038 standard has left the implementation of the voice mail delivery solution up to the service provider and IIF vendor. Different solutions to address this issue are available from ISR service bureau providers. Contact the CDG for information.
- **Subscriber Profile Translation:** The IIF translates the CDMA subscriber's HLR service profile to the corresponding GSM profile. This is done during initial registration and upon any change in profile that is network- or subscriber-initiated. Below is a list of some the services supported in GSM and the corresponding features in CDMA.

CDMA Feature	Translated Feature in GSM foreign mode
Call waiting	Call waiting
Call hold	Call Hold
CFNA	CFNRy and CFNRc
Three-way calling	Multiparty
CFD	CFNRc and CFNRy

CDMA Feature	Translated Feature in GSM foreign mode
CNIP	CLIP
CNIR	CLIR

- **Subscriber Control of Supplementary Services:** In GSM, the IIF enables the subscriber control of supplementary services in two ways:
- Use of GSM or dual-mode phone menu functions where the IIF maps the GSM MAP messages “Register_SS”, “Interrogate_SS”, “Erase_SS” to corresponding ANSI MAP “FEATREQ”
- Use of CDMA-specific service codes (*codes) in GSM using USSD

  The IIF vendor or the service bureau provider should support both of the above in order to enable a seamless control of supplementary services in GSM.

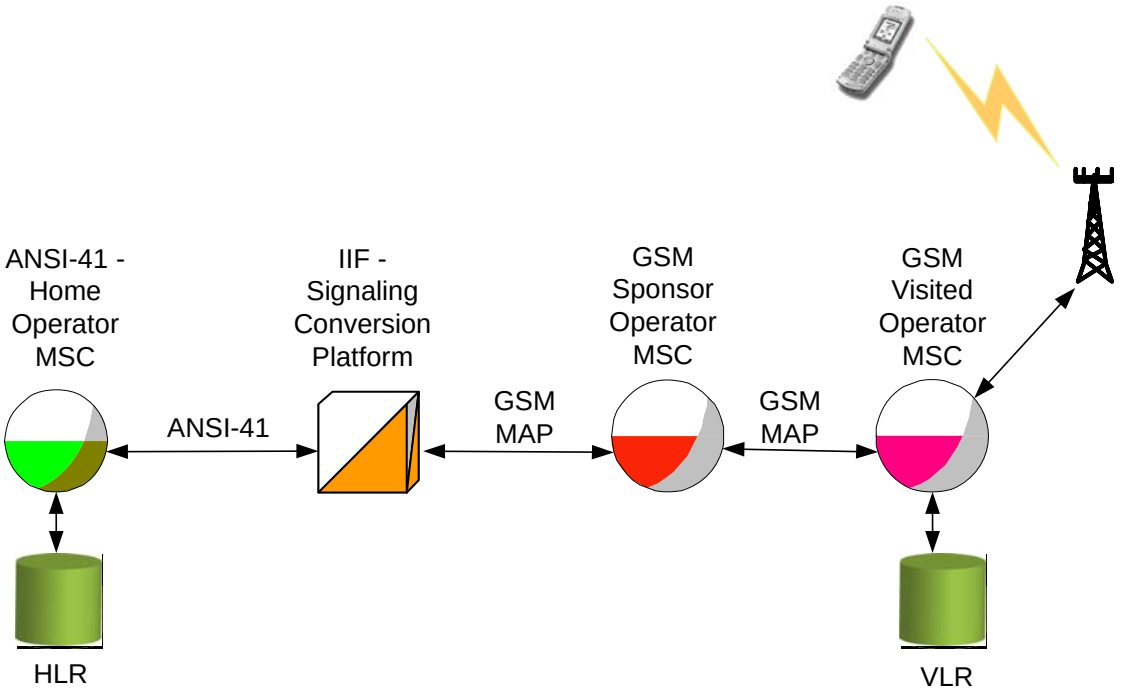

Figure 4-2: ISR Conceptual Diagram

For ISR, the CDMA operator should establish a business agreement with a GSM sponsor operator or with a service bureau that has access to GSM agreements. This agreement allows the CDMA operator to leverage the roaming agreements the GSM operator has already established with the many potential serving/visited carriers. It also simplifies the network architecture in that the CDMA operator need only establish a network link between the IIF and the GSM operator. The CDMA operator must also install its own signaling conversion platform or utilize a third party’s.

A network between the CDMA operator and the conversion systems, as well as between the GSM operator and the conversion systems, must be established for signaling messages to be routed between each of the parties. When in a GSM network, the CDMA operator's subscribers use the IMSI (GSM equivalent to MIN) of the GSM operator and look like an end subscriber of the GSM operator. To facilitate the air interface, the CDMA operator's subscribers must use a GSM-capable handset while in GSM countries.

When the CDMA operator's subscriber powers on the handset in the visited GSM network, the validation and authentication messages are routed to the signaling conversion platform (IIF) via the GSM operator. Signaling for validation is translated into ANSI-41 and the registration request is forwarded to the CDMA network while authentication occurs between the IIF and the GSM network. The subscriber must pass authentication and receive a positive registration acknowledgement from the CDMA network before being validated in the GSM network and allowed service.

5. Billing

5.1 Billing Record Exchange

CDMA operators use CIBER (Cellular Inter-carrier Billing Exchange Roamer) records for the exchange of subscriber roaming usage. GSM operators use TAP (Transferred Account Procedure) for the same purpose

The serving operator produces records in the format that its billing system uses. If the home operator cannot accept the format, then it is responsible for conversion into a format that it can process. Several vendors have the ability to convert between CIBER and TAP. The IIF service bureau providers usually include this service.

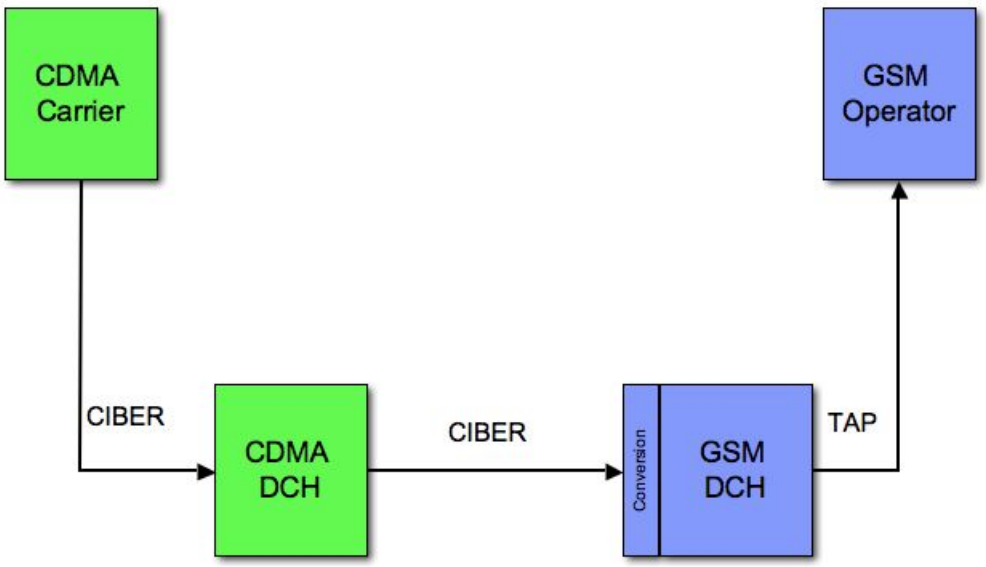

Figure 5-1: CIBER-to-TAP Conversion

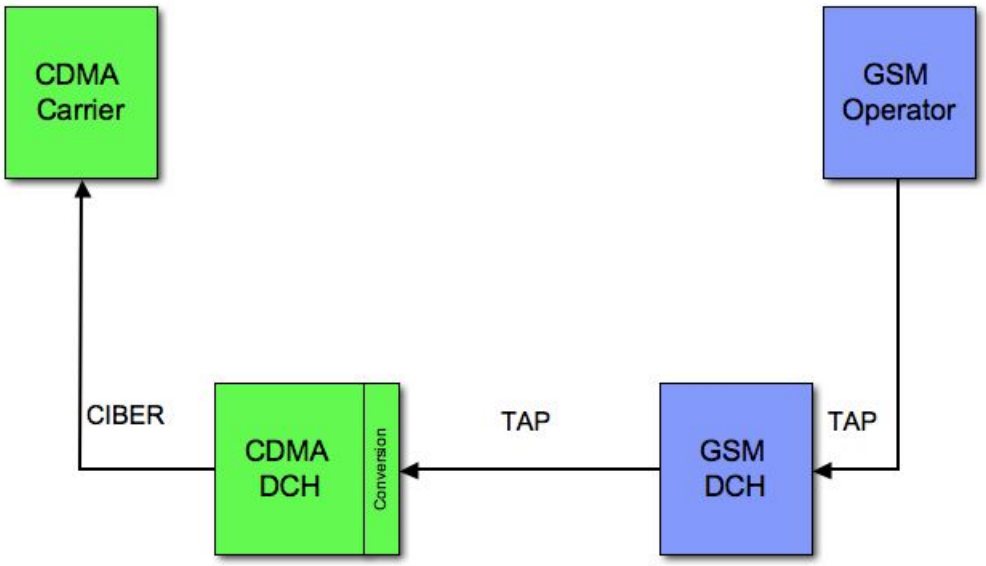

Figure 5-2: TAP to CIBER Conversion

Occasionally, information is lost during conversion from TAP to CIBER or vice versa. For example, many TAP records do not separate air and toll in the call records, so CIBER-using home operators may not be able to distinguish air charges from toll when the records arrive in their billing systems. During network testing, the CDMA and the GSM operators should exchange records to test their billing systems and ensure billing system compatibility with the conversions and formatting.

Many other differences between the TAP and CIBER formats and processing must be resolved in order for GSM and CDMA operators to exchange roaming billing information. For instance, the settlement cycle for GSM operators using TAP is from the 1st-31st of the calendar month; while the standard settlement cycle for CDMA operators exchanging CIBER records is the 16th- 15th of the calendar month. This means that the dollar value of a TAP settlement cycle will not be equivalent to the value of a CIBER settlement cycle, and balancing procedures must be implemented to accommodate this difference.

Another significant difference between TAP and CIBER is that CIBER supports only the US dollar as a valid currency; while TAP supports the US Dollar, the Euro and the SDR which is an exchange currency created by the International Monetary Fund (IMF). If a GSM operator uses either the Euro or the SDR, then the corresponding currency must be converted to US Dollars.

The following are some additional differences between the clearing and settlement of TAP and CIBER:

Frequency of processing – CIBER files are processed once per day, while TAP files are processed many times throughout the day.

Sequential Processing – CIBER files must be processed by sequence number, while TAP files are not required to be processed in sequence.

SID/BID vs. TADIG (PMN) – CIBER uses a SID/BID, which is a market-level identifier of the serving market. TAP uses a TADIG (PMN) code to identify the operator's network where roaming took place. The TADIG code generally indicates only the country and the network where roaming occurred (not the specific market). For example, the operator can see that a customer was on Bouygues, Orange, or SFR but not that the customer was in Marseille or Paris. Because GSM operators in North America also use SID/BID to identify the visited market, version TAP 3.0 and later include an optional field for SID/BID. For roaming outside of North America, a table must be maintained for conversion of TADIG (PMN) to SID/BID.

Flexibility of Validation – An industry-defined set of edits are performed on all CIBER records. GSM operators have defined a standard set of validations to be performed on TAP records. However, operators can bilaterally agree to different validation rules.

Billing records should be exchanged using EDI, unless otherwise agreed by the carriers or their vendor(s). Roaming agreements should describe fallback procedures for transfer failures or other delays in exchanging records.

TAP and CIBER allow record exchange of up to 30 days after the call date. However, according to generally accepted procedures for TAP processing, the record must be returned to the home operator within 36 hours of the end of the call. Most home operators, however, expect records more quickly. Therefore, operators should agree on file exchange timescales.

Rejected records or batches must be returned to the serving operator in its own record format.

5.2 Settlement

Invoicing requirements vary by country, so partners should agree on invoicing procedures when establishing the roaming agreement. (See Section 12)

The roaming partners must agree on whether settlement may be in direct payment or may involve netting bilateral positions. Payment will be in the receiver's currency as indicated in the invoice. In the case of records originally sent in TAP using SDR, the receiver's home currency will be converted from SDR using the rate on the GSM operator's invoice for the period. Roaming partners must also agree on whether to settle directly or via a financial clearinghouse or other agent. The invoice and the billing records will indicate applicable taxes according to the serving carrier's regulations.

6. Service Features

6.1 Feature Description

CDMA operators now consider many formerly optional features as part of their standard business and expect these features to work in GSM. These features are presented below:

- Call Forward Unconditional
- Call Forward Busy
- Call Forward No Answer
- Voice mail
- Call waiting
- Multi party calling
- Caller ID
- Message waiting indicator
- SMS
- Packet data

Some GSM operators do not allow features such as call forwarding and multi party calling while roaming. Blocking call forwarding also renders voice mail useless in those GSM areas. However, in general, it should be possible for a CDMA roamer to have access to most home services while roaming in GSM.

There is no standard testing of special features between GSM roaming partners; therefore, they must agree on this topic. The testing of special features is more common among CDMA operators.

Many different implementations of special feature codes in CDMA create special mapping problems. For example, some larger CDMA operators use different feature codes in different markets for the same feature. (CF B may be *71, *81, and *91 for different markets). The IIF provider or the service bureau generally offers the mapping between the CDMA feature codes and their GSM equivalents.

International operators do not pass caller ID information consistently Therefore, caller ID may not be available in some coverage areas or may be dropped by the international long distance carrier.

SMS is fairly straightforward between CDMA and GSM. One exception is the SMS for voice mail message notification. In CDMA, there is a “call back number parameter” that does not exist in GSM. Therefore, based on mapping standards, information in this parameter gets dropped.

Packet data roaming from CDMA 1x/EVDO for GPRS/UMTS requires a “dual registration” on the GSM side. In GSM, registration occurs both in the GSM VLR and the SGSN (AAA equivalent in GSM). IP networks must be connected (radius and bearer links) as well as signaling. For CDMA–GSM packet data roaming, there needs to be a connection between GRX and CRX.

7. Fraud Management

7.1 Introduction

The CDMA and GSM operator communities have chosen to adopt fundamentally different approaches to tackling roaming fraud. This has led to serious consequences for the GSM community that today is experiencing unprecedented levels of roaming fraud losses ($millions per month). By contrast, CDMA operators are largely protected from the exposure. However, the introduction of ISR means CDMA operators are opening themselves up to the same serious roaming fraud risk experienced by GSM operators today. As such, it is important that the CDMA community understands and addresses the new fraud risk introduced by ISR

7.2 What is Roaming Fraud?

In today's GSM world, the predominant method for fraudsters is to begin by using subscription fraud to gain access to the home network. Often fraudsters work with corrupt dealers or internal groups within the operator in order to create the subscriber accounts. They obtain roaming privileges, for example by posing as a small company or by behaving as a good paying customer for a period of time (known as a "sleeper"). The fraudster then roams to a foreign network and generates a high volume of lengthy calls in quick succession, usually on multiple handsets.

Typically, the delay in the home operator receiving the roamer call data to properly detect this activity can be anywhere from one to several days because roamer call records and HURs have to be processed by partner operators and the clearinghouse. This overall time delay insulates the fraudster from current detection technologies and leaves an exposure that is exploited to make as many high value calls as possible with no intention of paying.

Organized roaming fraud typically involves calling to international premium rate service numbers or revenue share numbers in obscure locations. These numbers are owned by the fraudsters themselves and they collect their money and disappear before they can be identified and captured. Taking advantage of the lack of visibility with methods like this are the primary reasons why roaming fraud has grown to as much as 50% of a GSM operator's overall fraud rate in recent times.

7.3 CDMA International Roaming Fraud Prevention

Most CDMA operators in North and South America tackle roaming fraud by exchanging roamer CDRs in near real-time. Raw CDRs are collected from the serving operator's network and delivered to the home network bypassing the clearinghouse. The roamer CDRs are automatically fed into the home operator's fraud management system, providing a holistic view of the subscriber's account and activity. This allows the home operator to analyze roaming call details for fraud and address suspicious behavior immediately. It eliminates the exposure of the delay in clearinghouse and HUR roaming data.

7.4 GSM International Roaming Fraud Prevention

The GSM community has chosen to implement High Usage Reporting (HUR) as the standard approach to addressing roaming fraud. Unfortunately, the HUR has a number of drawbacks, including an inherent fraud exposure. HURs alert the home operator when one of their roamers has exceeded a high usage threshold, indicating possible fraud. This HUR policy is a manual, cumbersome process that requires the exchange of hundreds of daily reports between operators, via faxes and emails, which contain only summary information that is difficult to diagnose without a detailed profile of the related account. It does reduce the clearinghouse delay from several days to between 24 and 48 hours. But the delay still exists and the fraudsters are aware of it. Using multiple handsets and the HUR delay, many roaming fraud incident losses over $500,000 have been reported. It is important to note that the home operator is liable for roaming fraud losses. The home operator still has to pay the serving operator for fraud incurred by the home operator's subscribers while roaming.

This situation makes roaming a hard dollar loss for the home operators since they actually have to pay the foreign operator for allowing the fraudster to roam. When a premium rate number is used, the foreign operator does not generate revenue from the fraud. The revenue ends up with the premium number provider who is working with the fraudster.

It is worthwhile noting that some GSM operators have tried to use SS7 MAP messaging to track visibility of their roaming subscribers. Unfortunately, this does not provide the call detail information that is provided by CDR exchange. Call detail information is important for detecting high roaming usage and roaming calls to suspicious destinations.

7.5 Revenue Impact

Operators often adopt measures to mitigate this type of fraud. These measures include operator determined barring, "touristic" roaming (roamers can call within a visited country and to the home network only), taking mandatory deposits or establishing good payment history prior to allowing subscribers to make international calls when roaming. All of these measures only serve to reduce a home operator's retail roaming revenues and serving operator's wholesale revenues, since they introduce restrictions on the vast majority of customers who are legitimate subscribers, wanting to make roaming calls and willing to pay for them. Eliminating these call restrictions for subscribers who roam can

increase roaming minutes of use by about 5% to 10%, which in turn, increases the revenues for roaming. Exchanging roamer CDRs enables the lifting of restrictions and the realization of these roaming revenues.

7.6 Inter-Standard Roaming Fraud

When CDMA operators negotiate roaming agreements with their GSM counterparts, the GSM operators will likely only be able to offer HUR reports for roaming fraud detection. CDMA operators need to understand that this creates a roaming fraud risk for their subscribers roaming on the GSM network.

In order to mitigate the risk, the CDMA operator has various options. One option is to implement call barring restrictions on roamers to GSM networks. While this prevents calls to fraudulent destinations, it also reduces revenues (for example, barring roaming calls to international numbers) and does not prevent calls to newly created fraudulent numbers. Another option is to request more frequent and faster delivery of clearinghouse roamer CDRs – known as “accelerated TAP”. While this is a good idea in principle, in practice not many serving operators can deliver TAP records much quicker than an HUR due to the mandatory billing and clearing processes that have to take place. The third and best option is to request that the GSM roaming partner delivers roamer CDRs back to the home operator in near real-time. This has proved to be the most effective method of addressing the roaming fraud problem in CDMA networks and will continue to do the same job preventing roaming fraud in the inter-standard roaming environment.

8. Subscriber Identification

Subscribers of a mobile network should be identified and authorized to use the network. The authentication process allows the operator to charge the right customer for the right service but also to prevent fraud.

Some CDMA operators currently authenticate their subscribers with a fixed subscriber module inside the handset. They use the MIN and ESN for this process. Other mobile technologies like GSM and iDEN, as well as over 40 CDMA operators in Asia, Eastern Europe, and Latin America, use a SIM or R-UIM (CDMA SIM) for the purpose of subscriber identification (IMSI) and authentication (Security algorithm and Ki). This allows the subscriber to easily swap the SIM/R-UIM between different handsets and maintain the same identity. Additionally, both GSM and CDMA operators can print an ICCID, or SIM serial number on the back of the SIM/R-UIM to provide the subscriber with a unique identifier to customer care in case of a mobile station issue.

The difference between a SIM card and an R-UIM is that the first is only used in GSM, while an R-UIM supports multiple technologies' operating systems, such as GSM and CDMA, iDEN, W-CDMA, etc.

8.1 SIM Cards

A SIM or R-UIM is a secure smart card specifically designed for wireless telecommunications

Like other types of smart cards, SIMs/R-UIMs are operator-owned, credit card-sized plastic cards embedded with small metal-coated microprocessor silicon chips capable of storing subscribers' data and applications securely. However, unlike other types of smart cards, SIMs/R-UIMs are inserted into mobile phones or terminals to provide secure user authentication, international or ISR (if dual mode, in the case of an R-UIM) and a platform for value-added services. The advantage of SIMs/R-UIMs is that they contain both the data and the means to process to-and-from a network without divulging the sensitive information stored on the card. The reason is that authentication keys and algorithms never leave the card.

8.2 SIM/R-UIM Functions

Providing a convenient platform that can be optimized for specific market requirements and configured to support multiple applications, SIMs/R-UIMs enable operators to plan and build new generations of services and applications. These include phonebook

storage, new menus, pre-recorded numbers for speed dialing, and the ability to query databases or secure transactions. SIMs/R-UIMs also enable operators to customize mobile phones for a full range of standards including GSM, CDMA, iDEN, GAIT, TETRA, or W-CDMA.

Today, SIMs/R-UIMs are available as open, Java-compatible high-memory cards with up to 1 GB capacity that perform mission-critical background network security and administration functions, enabling enhanced security, improved logistics, and new marketing opportunities. In summary, smart card functions include the following:

- Subscriber authentication-enabling secure usage of the wireless network
- Speech/data encryption-enciphering information on the radio path
- Personalization-storing subscribers' personal information
- Access to additional value-added features
- Support for international and inter-standard roaming

8.3 SIM Types

According to the Gartner Group, there are three basic types of SIM cards:

- GSM Subscriber Identity Module (GSM SIM) - smart card that supports access to the GSM network, including subscriber features and services
- Removable User Identity Module (R-UIM) - smart card that supports access to the CDMA and/or GSM networks as well as other technologies. It also supports storage of phonebooks, applications, and services.
- Universal SIMs (USIMs) - smart cards that support access to other 3G networks such as W-CDMA

8.4 Supporting Access to GSM Networks

The GSM provisioning data on the SIM contains a unique SIM serial number. In the subscriber's provisioning process, the SIM serial number will be linked to a unique subscriber number: the IMSI. This IMSI is used for international identification and cannot be changed once it is programmed in the card.

8.5 R-UIM Advantages for ISR

When used for ISR purposes, the R-UIM can support multiple technologies in one card: GSM, CDMA, iDEN, or W-CDMA. It also stores the subscriber's personal data such as phonebook, features, and services.

For example, a CDMA subscriber can insert a dual-mode R-UIM both into an R-UIM-capable CDMA handset or into a GSM phone. Nokia, Motorola, Kyocera, Samsung, and LG are only a few of the handset providers who offer R-UIM-enabled handsets as part of their device portfolio. Only Nokia's R-UIM-capable handsets support both the 800 MHz and the 1900 MHz bands today.

The R-UIM and SIM are both based on IS-835. Most GSM phones developed after 1999, which support phase 2+, can potentially work with R-UIMs except in cases where the wireless operator has locked the phones.

When using an R-UIM, CDMA end-users are independent of their CDMA handsets and have all of their subscription data available in a GSM network instantly. When used with a GSM handset, the R-UIM operates like a GSM SIM. For international travelers, the R-UIM could also allow roaming across CDMA and GSM networks with the same multimode terminal, or world mode handset.

With the evolution of 3GPP2 and 3GPP standards, it is possible to have SIM/R-UIM/USIM subscriptions on one single card, capable of handling different access technologies.

The R-UIM key benefits are as follows:

- Guarantees subscriber authentication on every network - if authentication is turned on in the operator's network.
- Enables users to program personal information one time and roam between different technology networks with a multimode device or through "plastic" roaming.
- Eliminates the need for consumers to program phones, Pads and other wireless devices multiple times with the same personal information.
- Provides operators with state-of-the-art security for applications such as mobile banking, mobile proximity and contactless.
- Offers consumers the added benefit of portability of subscriber data.
- Saves operators time and money at POS through easier handset upgrades and repairs.

8.6 Subscription-Related Information

The smart card plays a vital role in holding key subscriber information. Below is some of the information stored in the R-UIM:

- IMSI-M and IMSI-T: indicates whether the IMSI is MIN based or a true IMSI
- A-Key: key used in authentication and generation of shared secret data. The A-key can be dynamically generated during R-UIM personalization
- UIM-ID/ESN: identity of the terminal or the R-UIM
- CDMA Home SID/NID
- Preferred Roaming List (PRL)

The R-UIM specification (C.S0023-B) defined by 3GPP2 defines the structure and how to code each file for the CDMA portion of the R-UIM.

If an operator wishes to enable ISR for its subscribers, the R-UIM must contain two or more valid subscriptions from different technologies. The most common inter-standard roaming takes place between CDMA and GSM. In this case, the R-UIM would contain an IMSI and Ki for GSM and the IMSI-M/T, A-key, UIM-ID/ESN for CDMA. An IIF enables

inter-standard roaming on the network side by providing the services, information flows, and message mappings to support roaming between ANSI-41 MAP (CDMA) and GSM MAP networks.

8.7 Security

A SIM/R-UIM is protected against misuse or fraud by a PIN. The PIN consists of four (4) digits and can be activated or de-activated by the user.

The operator decides whether to deliver the SIM/R-UIM with an activated standard PIN code. If the PIN code is activated on the SIM/R-UIM, the handset will request the user to enter the PIN code on each power on. When a user enters a wrong PIN three times, the R-UIM is blocked for further use; consequently, no calls can be made (except for emergency calls) or received anymore. To unblock the R-UIM, subscribers require a PUK code that they can receive from the operator. The operator receives the PIN, PUK, and all other secret codes from the R-UIM in an encrypted output file. The R-UIM vendor stores the secret code information on the R-UIM in a proprietary manner to keep the data secure and unreadable.

The R-UIM performs some of the secured process of key generation and ciphering via a special crypto processor on board. Algorithms stored in the R-UIM and used in the above process also make the cards more secure since they are never sent over the air (OTA).

8.8 ME Personalization (SIM/R-UIM Lock)

The ME, or handset, personalization feature allows operators to protect their investments by restricting the handsets to operate with an R-UIM containing operator-specific personalization parameters. This feature is used to “lock” a handset to a particular R-UIM, or set of R-UIMs. The locking feature works by storing personalization information in the handset that limits the R-UIMs with which it will work and by checking this information against the R-UIM upon power-up or insertion.

Each R-UIM/SIM is identified by unique numbers, including a mobile phone number, and it enables services to be delivered by the issuing operator. ‘SIM-lock’ is the practice whereby handsets are locked so that they can only be used to obtain the services of the operator who issues the SIMs/R-UIMs. It is more accurately termed ‘handset locking’. The SIM card itself is not actually locked, as it can be used with other handsets (that are not locked to other networks). SIM cards can be bought separately from handsets, though generally only for pre-pay tariffs. Consult your smart card provider for more details.

Handsets are locked by handset manufacturers, at the operators’ request. The manufacturers also provide codes to unlock handsets. The following are some pros and cons of handset locking.

Pros

- This feature locks the handset to a specific operator’s MNC, so that it cannot be used with a competitor’s R-UIM or SIM card

- The subscriber must contact the home operator to obtain the unlock code. Once unlocked, the handset can be used with any R-UIM/SIM regardless of the MNC value
- The subscriber is forced to stick to the home operator
- If stolen, the handset will not work once the R-UIM is reported stolen and is disconnected. This discourages thieves.

Cons

- There must be a central database containing unlock codes or a method for calculating unlock codes
- Support staff must be educated on the topic
- The operator must have a company policy in place concerning distribution of unlock codes

3GPP2 anticipates publishing the ME Personalization specification before the end of 2005. R-UIM Lock is a work item in progress at 3GPP2; therefore, it is not standardized yet.

8.9 Potential Issues

By providing a separate GSM SIM card for ISR, CDMA operators expose their networks to the potential of having two devices active simultaneously for the same subscription in the network (HLR). The CDMA handset could be active in the CDMA network, while the GSM SIM card with a GSM handset could be active in a visited GSM network at the same time. This is an undesirable situation, as the two devices will independently perform Location Updates or Registrations, and overwrite each other's data to the same record in the HLR in the CDMA network. It will double or multiply the signaling traffic for registrations in the network. More importantly, it will cause anomalies for MO and MT calls. The last device to perform Location Update will cause Cancel Location for the other device, potentially purging it from its VLR and rendering it incapable of originating calls. An MT call will be delivered to the device that last performed Location Update, while it may be intended for the other device.

One way to address this is to provide the ISR GSM SIM card on a different MDN and different entry in HLR, whereby the two devices can be independently active; but then the subscriber will not receive mobile-terminated calls on his/her primary MDN while roaming in GSM networks.

The other way to address the above situation is to have a **single R-UIM** for both GSM and CDMA that can be used only in one device at a time. The device can be a CDMA handset, a GSM handset, or a World Mode phone.

9. Provisioning

9.1 R-UIM/SIM Provisioning

To provision service on the R-UIM/SIM, it is necessary to enter the correct settings per subscriber on the R-UIM/SIM in order to make the service available to a specific subscriber. The provisioning is executed in three phases:

1. Pre-activation (linking the R-UIM/SIM number and the IMSI)
2. Activation of the R-UIM/SIM in the conversion platform
3. Connection (or disconnection) of the individual R-UIM/SIM by the home operator

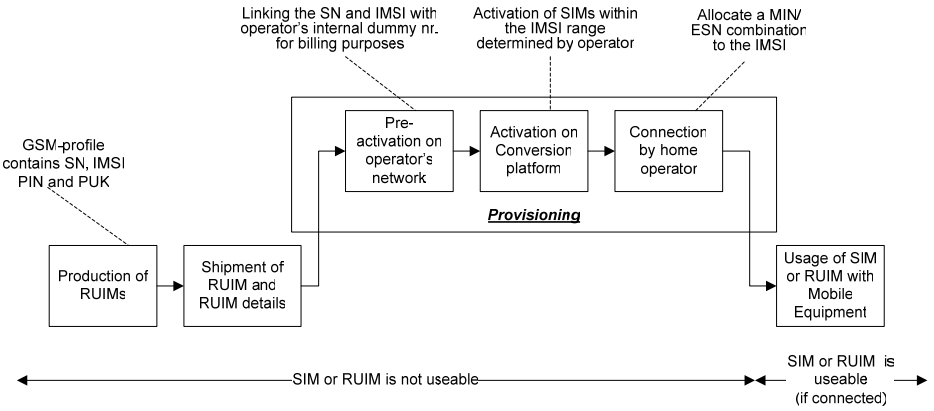

Figure 9-1: R-UIM/SIM Provisioning

9.2 Pre-Activation

After the smart card manufacturer produces the smart cards, the R-UIM/SIM contains the card's serial number, the IMSI and the PUK-code. The ISR provider pre-activates the R-UIM/SIM in batches before shipping. This pre-activation means that the R-UIM/SIM serial number and the IMSI will be linked to a GSM operator's internal dummy number according to the NANP. This dummy number is used for billing purposes. After this batch process, the GSM operator will send a file to the conversion platform administrator and

the home operator containing security codes (for conversion platform only) and PUK-codes. At this stage the R-UIMs/SIMs cannot be used.

9.3 Activation

After the conversion platform administrator has received the security codes, the platform administrator activates the R-UIMs/SIMs. The cards to be activated are within the IMSI range determined by the GSM operator. The conversion platform is now ready to accept subscribers' connections and disconnections from the home operator.

The GSM operator does not need to load the NPA-NXX of the home operator in its, or its partners', network. The GSM operator must assign an IMSI range to the home operator. In this phase, the SIMs still cannot be used.

9.4 Connection and Disconnection

The home operator uses the conversion platform to make the final connection of the individual subscriber. In the connection process, the home operator allocates a MIN/ESN combination to the IMSI in the conversion platform. The result is that the home operator's subscriber keeps one number in both technologies.

9.5 Provisioning Types

The CDMA operator may choose to implement ISR using SIM or R-UIM. When using the SIM, the CDMA-specific information resides in the CDMA handset, and the GSM-specific subscription is pre-provisioned on the SIM by the card manufacturer.

In CDMA, the R-UIM can be provisioned using the following options:

- Pre-provisioning by the card manufacturer: This method is used when the operator has a definite set of data to personalize on the card and does not intend to change it after card issuance. In this procedure, the operator supplies all the provisioning card details to the card vendor and the card manufacturer provisions the card in a secure environment and then ships it to the operator. Information such as ICCID and UIM-ID are pre-provisioned in the card.
- Provisioning at POS: this simple method of provisioning is the most commonly used. It involves provisioning the R-UIMs/SIMs at the operator's premises. The subscriber approaches the operator at specific outlets and submits his personal details. The operator then personalizes the R-UIMs or SIM cards in a secure environment and hands them over to the subscriber, ready to use.
- Provisioning through OTAF: OTAF is an over-the-air functionality embedded in the network and terminals to securely provision R-UIMs. This type of provisioning is normally followed when the terminal and R-UIMs have to be sold at retail outlets where the operator does not need to be involved. During this procedure, the subscriber has to dial a hotline number (e.g., *288) that hooks on to the operator's IVR. He is then asked to enter the password or SSN related to this subscription. After successful verification, information related to the subscription such as IMSI, Preferred Roaming List (PRL), SID/NIDs, etc., is securely downloaded on the card. After this step, the subscriber is ready to use his subscription

- Secured SMS-based provisioning: widely adopted in GSM/3G networks, this type of provisioning involves all the parameters inside the smart card used over the air. This procedure is still under study for R-UIMs. Once this feature is standardized in 3GPP2, wireless operators can use OTA to manage information remotely on R-UIMs to provide their subscribers with new services and updates to existing services. These OTA services go from the remote OTA platform via the Short Message Service Center (SMSC) to the R-UIM in the mobile phone. The subscriber never has to return to the POS, and the wireless operator does not have to re-issue the R-UIM.

9.6 Entities Provisioned on R-UIMs

Using OTAF, the following entities are provisioned on R-UIMs:

- MIN
- PRL
- ACC-OLC
- SID/NID
- MDN

Using POS and other methods, the following entities are provisioned on R-UIMs:

- All other subscription-related information
- Authentication keys

10. Testing on ISR

10.1 Overview

CDMA networks based on the ANSI-41 signaling system operate in a completely different manner from GSM networks; thus, technical limitations exist when introducing one-to-one mapping between these two technologies.

This section establishes a comparison between CDMA roaming testing and GSM roaming testing; proposes a practical approach which can be used in CDMA-to-GSM one-way roaming test; and describes network inter-working issues and test items.

MMS and Packet Data roaming are not covered in this document.

10.2 Testing Environment

To test CDMA-to-GSM roaming, it is assumed that an IIF with the signal conversion functionality and the signal link between CDMA point code routing and GSM SCCP routing are in place. The handset functions or interoperability issues are not covered or tested in this section.

10.3 Comparison between CDMA and GSM test items

- Governing Organization for Roaming test documents

CDMA	GSM
CDG	GSM Association

- Reference Document

CDMA	GSM
CDG Reference Document #52 Ver 1.5 (For Voice, Supplementary Services, SMS) • 104 Pages • 146 Test Items	GSMA IR-24 (For Voice, Supplementary Services, SMS) • 42 Pages • 15 Test Items

- Test Items Covered

CDMA	GSM
MS Location Management Auth/Profile Info Change Call Forwarding Call Forwarding to VMS SMS Call Waiting Three way calling	Common Tests • Location Update • Cancel Location • ODB (Operator Determined Barring) Individual Tests • Mobile Origination and Termination • Barring Control • Call Forwarding (CFNRc, CFNRy) • SMS

- Test call CDRs to be re-used for billing tests

CDMA	GSM
No	Yes

10.4 Recommended Test Items

The GSMA IR-24 is a document available to use for GSM roaming tests. Based on this document, the following items should be tested.

- Common Tests
  - Location Update
  - Cancel Location
  - ODB (Operator-Determined Barring)
    - ANSI-41 doesn't have exactly equivalent parameters to GSM ODB data. However, the ANSI-41 parameter "Origination Indicator" should be appropriately translated to GSM ODB data by IIF.
- Individual Tests
  - Mobile Origination and Termination
  - Barring Control
    - ANSI-41 doesn't have an equivalent function to support Barring Control from the mobile.
  - Call Forwarding (CFNRc, CFNRy)
  - SMS
  - Voice Mail Deposit and Retrieval (Not part of IR-24 but should be tested)

GSMA IR-24 can be used as a guideline to create a comprehensive test plan. The CDMA operator should add feature test items depending on the features and functionality they intend to implement with ISR. For example, call waiting, three-way/multi-party calling, and voicemail deposit and retrieval are "standard functionality" with most CDMA operators. If these features are going to be used in ISR, then they should be included in the test plan.

10.5 Other Topics

Test documents to support MMS, Packet Data in CDMA-to-GSM roaming are not part of this white paper.

11. Handsets

11.1 Handset Fulfillment

A major consideration for inter-standard roaming is handset fulfillment. CDMA/GSM roaming requires two handset technologies: GSM air interface and CDMA air interface. This can be achieved in several ways:

- With two separate handsets with separate subscriptions
- With two separate handsets with the same subscription
- With a single handset with a dual mode chipset.

In the past, and even now, operators who had subscribers traveling to countries where only one technology was present provided “loaner” phones. These mobile phones were used in that particular region or countries. Enabling this type of service proved complicated as customers had additional phone bills, a new phone number and were required to carry two phones with them.

That concept seemed to prove quite profitable and had significant operator interest. Therefore, the “twin” concept for ISR continues to allow operators to provide their subscribers with two handsets with one subscription and one phone number. Figure 11-1 shows an example in which each of these phones is SM/R-UIM capable and supports AMPS/CDMA at 800 and 1900 MHz. They are also SMS, MMS, and WAP 2.0 capable and include camera and hands-free kits.

Figure 11-1: Twin Phone Concept (example)

The availability of multimode chipsets (CDMA 2000 1x, EV-DO and GSM/GPRS) affords handsets providing “true” ISR features. The multimode chipset developed by QUALCOMM is unique in that it provides a seamless cost effective solution for OEMs to build a handset that enables both the CDMA and GSM air interfaces to be accessed with a single chipset.

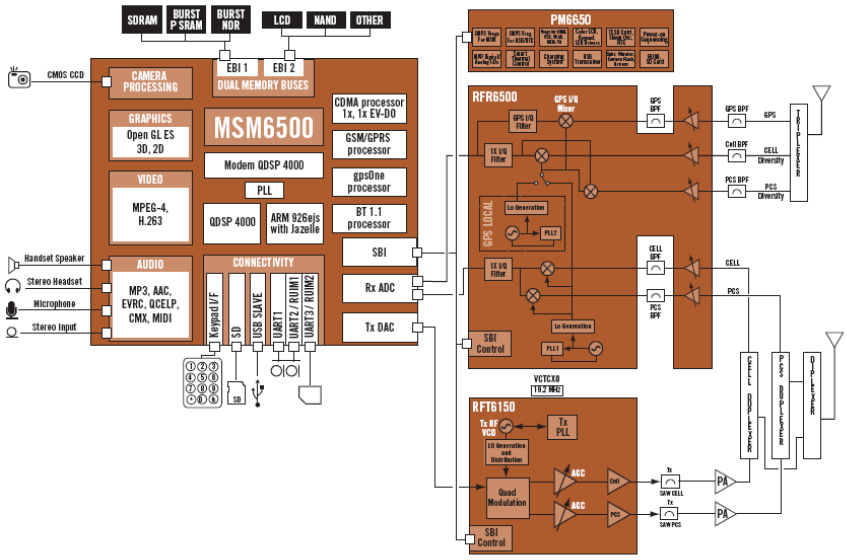

Figure 11-2: QUALCOMM’s MSM6500™ Chipset Diagram

The issues around acquisition and system selection still remain and are discrete when each technology is in operation. Preferred roaming lists still need to be formed for each technology. By providing more convenience, dual-mode devices introduce the new issue of which technology mode to select when both are present - although this is user- or operator-controlled by means of geographic region menu or mode selection. In addition, GSM handsets use the SIM for user subscription management. Most CDMA handsets retain user information internal to the handset. These differences lead to the need for multiple handset provisioning methods. The use of R-UIMs in CDMA handsets help address some of these provisioning and subscription management issues. The R-UIM follows the same specification as the SIM, so both a CDMA and a GSM profile can be put in one card.

11.2 World Phones

The following true inter-standard handsets are available today and afford the subscriber one phone, one subscription and one phone number that can be accessed by multiple technologies anywhere in the world (except Japan).

Samsung A790 - This phone supports CDMA 2000 1x at 800 and 1900 MHz as well as GSM at 900 and 1800MHz. It is SIM/R-UIM capable and supports SMS, MMS, WAP 2.0,

and BREW applications. It includes a VGA 600k pixel camera and camcorder with MPEG4 including flash capability for pictures or movies taken in dark spaces as well as a hands free kits which allows for speech recognition without having to teach the phone speech patterns. The later model, Samsung A795, offers GPRS functionality as well.

Samsung's A790 is currently used by Verizon Wireless, Sprint PCS, and China Unicom. Verizon Wireless and Sprint PCS versions of this handset do not support R-UIM. China Unicom's version, the SCH-W109, does support R-UIM and GPRS.

Figure 11-3: Samsung A790

Motorola A840/A860 – This phone supports CDMA 2000 1x at 800 and 1900 MHz as well as GSM at 900 and 1800MHz. It is SIM/R-UIM capable and supports SMS, EMS, MMS, WAP 2.0, and BREW applications. It includes a 1.2 Mega pixel camera and flash capability for pictures taken in dark spaces. It has an integrated CDMA/GSM picture phonebook which allows you to associate phone numbers to pictures. It also offers an MP3 player with removable flash memory card as well as a hands-free kit with voice recognition and speaker phone.

Verizon Wireless uses the A840 (no R-UIM support) while China Unicom uses the dual-slot A860 (supports R-UIM but no GPRS).

Figure 11-4: Motorola A840/A860

LG W800 – This phone supports CDMA 2000 1x at 800 and 1900 MHz as well as GSM at 900 and 1800MHz. It is SIM/R-UIM capable and supports SMS, MMS, and WAP 2.0 applications. It includes a VGA 300k pixel camera and supports a hands- free kit.

Figure 11-5: LG W800

CMA8301 – This phone is a dual-mode, four-band clamshell. It has a rotational camera and the following features:

- 1.3M pixels CMOS Sensor: --1280 x 960 DC, QCIF Camcorder (MPEG 4)
- Internal: 176 x 220 pixels, 2.0", 262k colors TFT
- External: 96 x 64 pixels, 1.0", OLED
- USB, Bluetooth 1.1
- TransFlash Card (T Card) Slot
- Audio & Video streaming (MP3 & MPEG4)
- WAP 2.0, M-IMAP, BREW
- gpsOne

Figure 11-6: CMA8301

The issue of service access remains. The significant point is that although a single handset makes roaming more convenient for the user and service appears to be more transparent, all the issues of GSM versus CDMA network interfacing remain the same irrespective of whether the handset is single or dual mode.

12. Roaming Agreements

12.1 Access to GSM PLMNs

The IIF as specified in the J-038 standard is the central piece for providing ISR; however, the commercial agreements providing access to GSM coverage are an equally essential part of the service. CDMA operators can proceed in one of the following ways:

1. The ISR provider offers both GSM roaming and the required GSM agreements. This is true in cases where the ISR service is hosted by a GSM service provider. The CDMA provider signs the standard CDMA roaming agreement with the ISR provider which acts as a CDMA operator and then uses its own GSM roaming agreements as a GSM operator to provide end-to-end CDMA-to-GSM roaming. The CDMA operator gets immediate access to GSM networks without having to sign individual roaming agreements. This also creates a single point of contact for both the ISR service and the GSM roaming agreements. The ISR provider maintains direct control over GSM roaming technically and commercially.
2. The CDMA operator has an agreement with an ISR provider and another commercial agreement with a GSM sponsor network allowing access to an IMSI pool and network identity. The ISR operator is responsible for provisioning the service using the IMSI and other network resources provided by the GSM sponsor network. The ISR provider typically does not have a direct commercial relationship with the GSM sponsor operator in this scenario. This option also gives the CDMA operator immediate access to GSM roaming but may require them to manage multiple commercial agreements.
3. The CDMA operator signs its own individual roaming agreements with GSM operators and is responsible for implementation and maintenance of these agreements. This path may be chosen by a CDMA operator opting to build its own IIF and end-to-end ISR service. However, this requires a much longer implementation and does not give the CDMA operator immediate access to GSM roaming, unlike cases 1 and 2. There is no standard template available today for an ISR agreement but the CDG International Roaming team (IRT) is working to make one available for those operators who might choose to use it.

13. Trouble Resolution

13.1 Introduction

In spite of the differences between GSM and CDMA, the IIF takes most of the complexity out of the ISR. The IIF makes roaming into GSM networks look like CDMA roaming by acting as an umbrella CDMA market. From a CDMA operator's perspective, most troubleshooting tools, tips, and practices used for CDMA-to-CDMA roaming are still applicable to ISR troubleshooting. The operation and maintenance of the IIF itself may be left to the IIF service provider.

However, ISR does create an additional layer of concerns for trouble resolution among CDMA operators, as described below.

The following are some key items to keep in mind when dealing with trouble resolution:

- Phones/SIM cards
  - CDMA operators will have to stock or have third-party arrangements for GSM phones or dual-mode phones.
  - SIMs/R-UIMs also have to be stocked and distributed.
  - Testing a newly provisioned phone and SIM card is recommended prior to shipping it to the subscriber. This can be easily arranged with your SIM card provider and is currently done at the operator's request.
- Provisioning
  - The IMSI, MSIDSN/MIN, MDN, and ESN relationships must be maintained for signaling and billing conversion. This presents additional opportunities for human error when provisioning.
  - Interfaces from the CDMA operators' provisioning system to the IIF or service bureau system may have to be created.
  - Tools must now be available to view and correct errors for these provisioning items.
  - Provisioning errors can account for a large number of trouble tickets
  - Provisioning errors can also cause unsuccessful registrations when the subscriber roams to GSM
- Signaling
  - If the CDMA operator has its own IIF, signaling network connections must be established to the GSM sponsor operator.

  - The CDMA operator's troubleshooting organization(s) must now have intimate knowledge of GSM signaling as well as ANSI.
  - Resolution of signaling issues now requires a view of both the CDMA signaling and the GSM signaling with the ability to see mapping on both sides

- International long distance issues
  - The CDMA carrier must now ensure adequate international long distance service for its subscribers roaming in GSM. These subscribers will typically be roaming in Europe or Asia. For a call to reach them will require additional international long distance service. Failure in this area could result in a low percentage of terminated calls
  - Some international service providers do not pass Caller ID.
- GSM issues
  - If a GSM roamer/broker relationship is used, the GSM operator may be responsible for troubleshooting issues with GSM roaming partners/
  - Some GSM operators do not allow call forwarding while roaming. This means that voice mail will not work.
- Interoperability Issues
  - GSM and CDMA have different voice mail implementations. Most GSM networks do not support, or have not implemented, optimal routing whereas optimal routing is used in CDMA roaming for calls diverted to voice mail. Voice mail may not work if a custom solution is not implemented at the IIF for call-forward number mapping etc.

14. Appendix A. Standardization Bodies

A.1 TIA

The Telecommunications Industry Association (TIA) is the leading trade association in the communications and information technology industry with proven strengths in market development, trade promotion, trade shows, domestic and international advocacy, standards development and enabling e-business. Through its worldwide activities, the association facilitates business development opportunities and a competitive market environment. TIA provides a market-focused forum for its more than 1,100 member companies that manufacture or supply the products and services used in global communications.

TIA represents operators of communications and information technology products and services for the global marketplace through its core competencies in standards development, domestic and international advocacy, as well as market development and trade promotion programs. The association facilitates the convergence of new communications networks while working for a competitive and innovative market environment. TIA strives to further members' business opportunities, economic growth, and the betterment of humanity through improved communications.

A.2 TR-45.2 Wireless Inter-system Technology

This sub-committee's goal is to develop service definition and network interface standards for support of interoperability and intersystem operations, for interfaces between those network elements that comprise the infrastructure, in support of seamless service to wireless subscribers, other mobile and personal communication network systems, auxiliary systems, and to other networks.

Subcommittee TR-45.2 shall coordinate, for the purpose of consistency, and to promote efficient and timely development of standards, with other Subcommittees within TR-45, other TR Committees, other international, foreign, or national standards bodies and appropriate industry organizations as their work requires. Subcommittee TR-45.2 shall support efforts to promote standards developed within the Subcommittee at international, foreign, or national standards fora.

Subcommittee TR-45.2 operates within the Mission Statement of the Telecommunications Industry Association and under the direct supervision and guidelines of Committee TR-45.

The Standards development programs of Subcommittee TR-45.2 operate under the accreditation awarded to the Telecommunications Industry Association by the American National Standards Institute. Subcommittee TR-45.2 operates under the guidelines of the Telecommunications Industry Association.

A.3 ITU-T

The ITU Telecommunication Standardization Sector (ITU-T) is one of the three sectors of the International Telecommunication Union (ITU). ITU-T was created on 1 March 1993 within the framework of the "new" ITU, replacing the former International Telegraph and Telephone Consultative Committee (CCITT) whose origins go back to 1865.

Also created were the ITU-R, Radio communication Sector (former CCIR and IFRB) and the ITU-D, Telecommunication Development Sector.

The ITU-T mission is to ensure an efficient and on-time production of high-quality standards covering all fields of telecommunications except radio aspects.

The Telecommunication Standardization Bureau (TSB) provides secretarial support for the work of the ITU-T Sector and services for the participants in ITU-T work, diffuses information on international telecommunications worldwide and establishes agreements with many international Standards Development Organizations.

A.4 American National Standards Institute (ANSI)

ANSI is a private, non-profit organization (501(c)3) that administers and coordinates the U.S. voluntary standardization and conformity assessment system.

The Institute's mission is to enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.

A.5 IFAST

The International Forum on ANSI-41 Standards Technology (IFAST) is not a standardization body. IFAST coordinates the global assignment of IRM (International Roaming MIN) and SID codes. IFAST also facilitates the identification and resolution of issues to enable the interoperability of systems between countries, operators, technologies, and standards, thereby protecting the investment made by the industry in the ANSI-41 family of standards while evolving to a seamless global network.

The mission is to increase the awareness and value of ANSI - 41 networks to operators and their customers.

A.6 Association of Radio Industries and Businesses (ARIB)

ARIB is a Japanese standardization body. The objectives of ARIB are to conduct investigation, research & development and consultation of utilization of radio waves from the view of developing radio industries, and to promote realization and popularization of

new radio systems in the field of telecommunications and broadcasting. Thus, ARIB aims at promotion to public welfare.

Apart from a lot of other activities ARIB establishes technical standards for radio systems in the field of telecommunications and broadcasting. For the CDMA standard in Japan, ARIB developed the standard T-53 for radio transmission for the CDMA mobile system. The main difference with IS-95 is the reversal of receiving and sending radio channels.

A.7 CIBERNET

CIBERNET, a subsidiary of CTIA, is the global leader in wireless transaction financial settlement for voice, data, and m-commerce. Since 1988, CIBERNET has provided the wireless industry with inter-company billing protocols, roaming administration tools, and financial settlement programs. CIBERNET serves over 300 customers in more than 80 countries across all interface technologies and settles $6 billion annually in wireless service revenues. With offices in Washington, DC, London, UK, and Hyderabad, India, CIBERNET's products are positioned to meet inter-carrier and inter-company billing and settlement requirements in the emerging mobile Internet world.

A.8 GSM Association

The GSM Association’s goal is to make wireless work globally. As a global trade association, GSMA focuses on many areas, where it aims to accelerate the implementation of collectively identified, commercially prioritized operator requirements and to take leadership in representing the global GSM mobile operator community with one voice on a wide variety of issues - nationally, regionally and globally.

The GSM Association is serving the world’s GSM mobile operator member community by promoting, protecting, and enhancing their interests and investments. GSM has already become one of the technological success stories of our age, ranking proudly alongside other wonders of the modern era such as mass air travel, television and the Internet – and in fact, more people now have GSM mobile phones than are online globally.

A.9 CTIA

The Cellular Telecommunications and Internet Association (CTIA) is the international organization that represents all elements of wireless communication - cellular, personal communication services enhanced specialized mobile radio, and mobile satellite services - serving the interests of operators, manufacturers, and others.

CTIA is the voice of the wireless industry - representing its members in a constant dialog with policy makers in the Executive Branch, in the Federal Communications Commission, and in Congress. CTIA's industry committees provide leadership in the area of taxation, roaming, safety, regulations, fraud, and technology.

A.10 3GPP2

The Third Generation Partnership Project 2 (3GPP2) is a collaborative third generation (3G) telecommunications standards-setting project comprising North American and Asian interests developing global specifications for ANSI/TIA/EIA-41 "Cellular Radio Telecommunication Intersystem Operations" network evolution to 3G, and global specifications for the radio transmission technologies (RTTs) supported by ANSI/TIA/EIA-41.

3GPP2 was born out of the International Telecommunication Union's (ITU) International Mobile Telecommunications "IMT-2000" initiative, covering high speed, broadband, and Internet Protocol (IP)-based mobile systems featuring network-to-network interconnection, feature/service transparency, global roaming, and seamless services independent of location. IMT-2000 is intended to bring high-quality mobile multimedia telecommunications to a worldwide mass market by achieving the goals of increasing the speed and ease of wireless communications, responding to the problems faced by the increased demand to pass data via telecommunications, and providing "anytime, anywhere" services.

A.11 CDG

Although not a standards' body, the CDMA Development Group (CDG) is included here for its key role in international and inter-standard roaming in the CDMA industry. Founded in December 1993, the CDG is an international consortium of companies who have joined together to lead the adoption and evolution of 3G CDMA wireless systems around the world.

The CDG is comprised of CDMA service providers and manufacturers, application developers and content providers. By working together, the members help to ensure interoperability among systems, while expediting the availability of 3G CDMA technology to consumers.

Its mission is to lead the rapid evolution and deployment of 3G CDMA-based systems, based on open standards and encompassing all core architectures, to meet the needs of markets around the world.