PRL Enhancements for International Roaming

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Revision History

Date	Version	Description
14 November 2003	1.0	Initial CDG release
1 April 2004	1.0	Reformat only
14 June 2005	1.0	Updated reference of TSB-29D to TSB-29E

1. Introduction

1.1 Summary

This document specifies the system requirements and enhancements to the Preferred Roaming List (PRL) to support International Roaming. The enhancements affect both the base station and mobile station.

1.2 Acronyms and Abbreviations

Table 1-1: Acronyms and Abbreviations

Acronym	***Meaning***
ANSI	American National Standards Institute
AMPS	Advanced Mobile Phone Service
EIA	Electronics Industry Association
IFAST	International Forum on ANSI-41 Standards Technology
IMSI	International Mobile Subscriber Identity
IRM	International Roaming MIN
ITU	International Telecommunications Union
MAP	Mobile Application Part
MCC	Mobile Country Code
MIN	Mobile Identification Number
MNC	Mobile Network Code
MS	Mobile Station
MSIN	Mobile Subscriber Identification Number
NID	Network Identifier
NMSI	National Mobile Subscriber Identity
NPA	Number Plan Area
OTASP	Over The Air Service Provisioning

Acronym	***Meaning***
PRL	Preferred Roaming List
SID	System Identification
SS7	ANSI Signaling System 7

1.3 Technical Assistance

For any questions or comments regarding this document, contact CDG at the address on the cover of this document.

2. Background and General Description

2.1 Feature Summary

The Preferred Roaming List (PRL) contains information to assist the mobile station system selection and acquisition process, particularly when the mobile station is roaming.

The preferred roaming list can be sent to the mobile station using Over-The-Air Service Provisioning (OTASP). The mobile station retains the preferred roaming list when power is turned off.

The preferred networks to be used by a mobile station are identified by SIDs (System IDs) and NIDs (Network IDs).

A “SID” typically covers the area of a city or large town. There are currently no strict guidelines for the size of SIDs. Their definition is left to the operators and national authorities. The range of SID assignments per country can be found in ANSI/TIA/EIA-TSB-29E.

A “NID” is an optional subdivision of a SID. NIDs can identify, for example, different rating areas, toll areas, private networks, MSC boundaries, or any other subdivision the operator may want to distinguish within a SID.

A national operator may have coverage over an entire country. For certain countries, this can amount to tens, and sometimes hundreds of cities/regions being covered, which in turn implies tens or hundreds of SIDs for a single operator.

When two operators would like to offer international roaming service between each other, PRL information should be exchanged and reviewed to ensure mobile stations will correctly find the preferred system. If the operators are national operators covering a large number of SIDs, the PRLs get significantly larger due to the inclusion of the roaming partner’s SIDs.

Therefore, to support international roaming, the following key issues are identified:

- **PRL Management:** CDMA operators need to collect the roaming partner’s configuration information to construct PRLs. If one of the roaming partners changes its network configurations, such as adding/changing a SID or NID, all other operators may need to update the PRL based on the new configuration. PRL maintenance is complex. This discourages some operators from roaming.
- **Size of PRL:** The present design of the PRL only allows a single entry per SID /NID pair. For a large CDMA network with many roaming partners, this design is sub-optimum, as it requires a large number of (SID,NID) entries to be present in the PRL,

which causes a significant impact on the memory requirements of the handset and download times.

The enhancement described in this document involves using existing overhead channel information elements to identify a carrier's network identification.

By having each carrier broadcast its own network code, a mobile station can determine if the current network is within its PRL, and a corresponding behavior and/or priority can be assigned.

A mobile station would then only need (in most instances) a single PRL entry to describe an operator, instead of the tens or hundreds of entries that would be required if it had to enter each partner's individual SID and NID.

Describing a roaming partner by its network code also alleviates the management and coordination of updating a customer's PRLs when the roaming partner decides to change, delete, or add SIDs.

3. Detailed Description

3.1 Base Station

The intended mode of broadcasting a carrier identification is by using the Mobile Country Code (MCC) and IMSI_11_12 parameters in the *Extended System Parameters Message*.

- MCC is the Mobile Country Code assigned by ITU E.212
- IMSI_11_12 is to be defined for each operator and is generally controlled by a national regulatory body or their agent.

Initially, the IMSI_11_12 can define up to 99 distinct carriers per MCC. The IMSI_11_12 could also be described as the two most significant digits of the Mobile Network Code (MNC), assuming a three-digit MNC. These fields are already broadcast by CDMA operators. They are Mandatory parameters in the *Extended Systems Parameters Message*.

However, not all carriers have had formal national assignments of IMSI_11_12, and some may not even be broadcasting valid information. The MCC and IMSI_11_12 were originally designed in the air interface to reduce the bandwidth required for paging and access. (See Section 3.3 for more information on Paging/Access.)

3.2 Mobile Station

The Mobile Station is required to support the new PRL record as described above. This record conforms to the IS-683 formats, but it allows an MCC and IMSI_11_12 as identification of the system.

Older mobile stations will not be able to use this enhancement, since they are not able to process the new PRL record.

There are no changes to the existing behavior to the PRL as it relates to SID,NID; that is, an operator may continue to use SID,NID if it is the preferred method.

Note that SID/NID entries and MCC, IMSI_11_12 entries can be combined in a single Geographic Area. In this case, a SID/NID match is first attempted. If no SID,NID is found, then an MCC, IMSI_11_12 match is attempted. In other words, a foreign roaming partner can be defined from a minimum of one entry (MCC, IMSI_11_12) covering its whole region, to a more defined and granular list of SID,NIDs used, or a combination of the above.

3.3 Mobile IMSI Programming, Paging, and Access

The mobile IMSI stored in nonvolatile memory (or R-UIM) is 15 digits in length. Due to lack of support of true-IMSI in current CDMA systems, only International Roaming MINs (IRMs) are being supported.

Operators have the choice of programming the MCCp and IMSI_11_12p of the subscriber's IMSI or leaving them unused. It is recommended that the MCCp and IMSI_11_12p are actually programmed in the mobile station. Specifically, both the MCCp and IMSI_11_12p programmed should match the broadcasted MCC and IMSI_11_12 from the *Extended System Parameters Overhead Message* of the home network.

When a page is received by a mobile station, the algorithm described by CDMA-2000 requires the mobile to perform a full 15-digit IMSI match to declare a "page match." However, this 15-digit match is not required if the MCC and IMSI_11_12 broadcast by the network matches the MCCp and IMSI_11_12p programmed in the handset.

In other words, the service provider can page all the subscribers that are "Home" with a shortened version of the IMSI (only the IMSI_S, i.e., the least significant 10 digits), thereby saving considerable bandwidth on the paging channel.

The access channel has a similar algorithm: The mobile station is allowed to send only the 10-digit IMSI_S if the overhead and programmed MCC/IMSI_11_12 match. When they don't match, the mobile is forced to send a full 15-digit IMSI. Again, having these values set correctly can imply savings on the air interface.

3.4 Other Possible Uses

In addition to being able to use this scheme for international roaming, there are also cases where an operator may want to have certain service providers be negative listed.

Negative system entries prevent the mobile station from accessing these systems.

The same rules would apply, as before, where a single entry can describe the operator identifier and the entry would be negative listed.

In cases where there are exceptions, that is, where "most" of the geographic areas of a certain operator are to be negative listed but a few areas would be permissible, then a combination of a negative entry of MCC, IMSI_11_12, with an acceptable set of entries of SID,NIDs for exception areas, can be constructed for a certain geographic region.

This method of managing the PRL is also more compatible with the GSM scheme, making it possible for operators to use the same structure for CDMA and GSM modes within a multimode terminal.

4. Network Code Number Administration

4.1 Mobile Network Code

The MNC has been defined to distinguish operators within a certain country code. It is suggested that a formal regulatory entity be defined to administer MNCs in the respective countries.

In the United States, Telcordia (http://www.imsiadmin.com) has been selected to define MNCs for GSM operators. Telcordia has also assigned MNCs to certain CDMA operators, but the list is not comprehensive.

MNCs are defined by ITU as three-digit numbers. Currently, the CDMA-2000 air interface can only support a two-digit MNC to be broadcasted in the IMSI_11_12 field. It is recommended that, as an interim solution, the assignment of MNCs that correspond to IMSI_11_12 be limited to two-digit numbers. These two-digit numbers could be of the form **nnA** where **A** is a fixed number and **nn** is a set of 99 distinct numbers to be assigned.

Once the air interface and products are updated to support a full three-digit MNC, then the **A** digit can be changed to support additional sets of MNCs. Telcordia has already used a similar scheme for assignment of two-digit MNCs to GSM operators (currently using A=0).

Note: These network codes only need to be distinct within a country code (MCC). Each country can administer and assign these codes without needing to coordinate with other countries.

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5. Backward Compatibility: Existing Mobiles and PRLs

5.1 Backward Compatibility

Backward compatibility with existing PRLs is required in order to promote the adoption of the solution.

The backward compatible solution consists of encoding the MCC and IMSI_11_12 in existing SID and NID fields. Since all versions of IS-683 support SID and NIDs, this proposal is compatible with all versions of IS-683. (See Appendix 1.)

Two unique SIDs need to be assigned for this purpose. The mobile station algorithm for system determination and selection will look for these special coded SIDs and will decode the SID,NID fields and interpret them as MCC and IMSI_11_12. These specially coded SIDs must be allocated and not currently used by any operator worldwide.

Older model phones that do not have the detection algorithm software can receive these special entries; however, since there will never be a SID match (because these SIDs are not used), the entry would be of no consequence. Newer model phones can interpret this entry and decode accordingly.

This backward-compatible solution also allows current OTASP and OTAPA systems to be used.

If deemed necessary by the industry, a new PRL format can be created for a time in the future when these systems can be updated. This new PRL format would be able to fully describe an MCC and IMSI_11_12 without needing special encoding.

For discussion purposes, we can call these two SIDs **SIDOPER-0** and **SIDOPER-1**. These two special SIDs would indicate that there is an “Operator Code” described in the NID field.

- The SIDOPER-0 entry represents the ‘0’ bit
- The SIDOPER-1 entry represents the ‘1’ bit.

IFAST has assigned SIDOPER-0 and SIDOPER-1 the values described in Table 5-1.

Table 5-1: IFAST SID Allocations for PRL Enhancement for International Roaming

Special SID	***SID Value***	***Comment***
SIDOPER-0	15904	Operator escape code '0' for ANSI/TIA/EIA IS-683 PRLs
SIDOPER-1	15905	Operator escape code '1' for ANSI/TIA/EIA IS-683 PRLs

6. Implementation

There are two tables in the PRL, an Acquisition Table and a System Table. Figure 6-1 shows a conceptual representation of a PRL divided into Geographical areas.

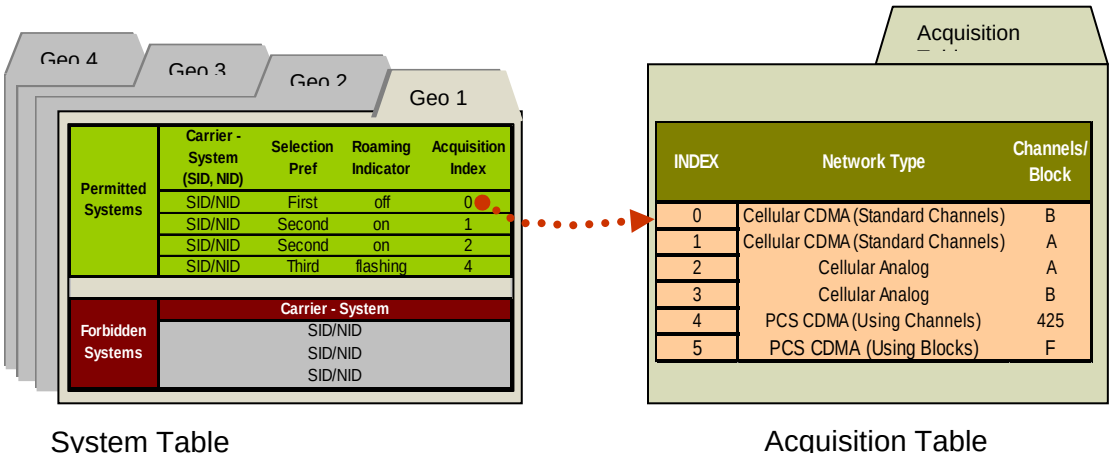

Figure 6-1: Conceptual Representation of PRL organization

The PRL enhancements described in this document require no changes in the Acquisition Table.

The System Table, however, will now be able to understand a special record, which is identified with the two special SIDOPER values.

Note: This system record is no different in format from the existing PRL. The current OTAF platform should treat this as a regular SID.

The only element that will understand the special SIDOPER value and act accordingly is the handset.

Figure 6-2 shows a sample PRL with the SIDOPER fields entered as part of the system table, one as a permitted system and the other as a forbidden system.

The IFAST assigned values of 15904 for SIDOPER-0 and 15905 for SIDOPER-1 have been used.

	Carrier - System (SID, NID)	Selection Pref	Roaming Indicator	Acquisition Index
Permitted Systems	15904/4632	First	off	0
	SID/NID	Second	on	1
	SID/NID	Second	on	2
	SID/NID	Third	flashing	4
Forbidden Systems	**Carrier - System**			
	SID/NID 15905/44556 SID/NID			

Figure 6-2: Sample PRL representation using the enhancements

The encoding of MCC and IMSI_11_12 into the SID/NID fields shall be performed as follows:

If the Most Significant Bit of the MCC is '0', then SIDOPER-0 should be placed on the SID field. The remaining 9 bits of MCC plus 7 bits of IMSI_11_12 (for a total of 16 bits) shall be placed concatenated in the NID field. For example, since SIDOPER-0 = 15904, then:

Table 6-1: Encoding when MSB of MCC is 0

SID (15 bits)	*NID (16 bits)*
15904	MCC (9 bits) + IMSI-11-12 (7 bits)

If the Most Significant Bit of the MCC is '1', then SIDOPER-1 should be placed on the SID field. The remaining 9 bits of MCC plus 7 bits of IMSI_11_12 (for a total of 16 bits) shall be placed concatenated in the NID field. For example, since SIDOPER-1 = 15905, then:

Table 6-2: Encoding when MSB of MCC is 1

SID (15 bits)	*NID (16 bits)*
15905	MCC (9 bits) + IMSI-11-12 (7bits)

All the existing rules and features of an existing system table entry will apply to this record (e.g., roaming preferences, forbidden, priority within a GEO, etc.). For existing handsets that do not support this feature, the entry will have no effect.

7. Conclusion

International roaming brings substantial economical benefits to an operator and gives subscribers a very important feature. Many CDMA operators are now implementing international roaming with partners around the world.

The information in this document is intended to improve the implementation and management of PRLs for international roaming. It is hoped that these enhancements will be promptly implemented by all CDMA operators.

8. IS-683C Support

8.1 IS-683C Support

This PRL Enhancement uses SIDs and NIDs to represent MCC and IMSI_11_12 values. Since SID and NIDs are used in all versions of IS-683, this proposal is by definition compatible with all versions.

IS-683C PRL is a new format of PRL that adds support for IS-856 (1xEV-DO systems). Another enhancement that IS-683C provides is the extensibility of the protocol for future revisions.

In IS-683C, Acquisition Records have been enhanced from IS-683A/B versions to allow IS-856 frequencies using band class and channel number pairs. These records are not affected by this proposal.

The IS-683C System Table has been enhanced (from IS-683A/B), to allow an IS-856 entry. An IS-856 entry contains the same information as the existing IS-2000 record type, except that the SID and NID fields are not used, and Subnet-ID fields are used instead. These Subnet-IDs are only meaningful to IS-856 and while operating in an IS-856 mode. The IS-856 record is not affected by this proposal.

A terminal supporting both CDMA 1x and 1xEV-DO, which supports the hybrid mode of operation, will first look for a CDMA 1x system based on the PRL preferences. Once the CDMA 1X system has been acquired, the search and acquisition of the 1xEV-DO network will be performed. The 1XEV-DO network is only searched if there is an association between the IS-2000 system record and the IS-856 system record in the PRL.

For this proposal, a special international roaming record with the unique SID would also support having an association with an IS-856 system. If a record with the unique SID and encoded NID has an association, the IS-856 system will be searched and acquired per IS-683C rules. If this is not the desired behavior, then the Association field should be set to “N” and IS-2000-only behavior would be performed on that system.

9. Example

9.1 Example

Let's assume an operator uses the following PRL System Table:

Table 9-1: Sample PRL Existing Format

*************SystemTable*************

INDEX	SID	NID	NEG/PREF	GEO	PRI	ACQ	ROAM
0	5205	65535	Pref	NEW	MORE	0	1
1	218	65535	Pref	SAME	SAME	1	0
2	4151	65535	Pref	NEW	SAME	0	0
3	5116	65535	Pref	SAME	MORE	1	0
4	4654	65535	Pref	SAME	SAME	1	0
5	1	65535	Pref	SAME	SAME	0	1
6	3	65535	Pref	SAME	SAME	0	1
7	5	65535	Pref	SAME	SAME	0	1
8	7	65535	Pref	SAME	SAME	0	1
9	1234	65535	Pref	SAME	SAME	0	1
10	5678	65535	Pref	SAME	SAME	0	1
11	9876	65535	Pref	SAME	SAME	0	1

If records 5 through 11 represent an international roaming partner whose MCC and IMSI_11_12 broadcasted are 310 and 21, respectively, and SIDOPER-0 and SIDOPER-1 are 15904 and 15905, respectively, then:

For the MCC $_{10bit}$
= 10LSB (Dec2Bin(MCC))
= 10LSB (Dec2Bin(310_{dec}))
= 10LSB (0001 0011 0110 $_{bin}$)
= 01 0011 0110 $_{bin}$

For the IMSI_M_11_12 $_{7bit}$
= 7LSB (Dec2Bin(IMSI_11_12))
= 7LSB (Dec2Bin(21_{dec}))
= 7LSB (0001 0101 $_{bin}$)
= 001 0101 $_{bin}$

17 bit MCC/MNC = concatenate(MCC $_{10bit,}$ IMSI_11_12 $_{7bit}$)
= concatenate (01 0011 0110, 001 0101)
= 0 1001 1011 0001 0101

SID-PART = MSB (17 bit MCC/MNC)
= MSB (0 1001 1011 0001 0101)
= 0
= SIDOPER-0
= 15904

NID-PART = BIN2DEC(16LSB (Combined MCC, MNC))
= BIN2DEC(1001 1011 0001 0101)
= 39701

Thus, the above PRL could be rewritten as:

Table 9-2: Sample PRL with enhancement encoding

*************SystemTable*************

INDEX	SID	NID	NEG/PREF	GEO	PRI	ACQ	ROAM
0	5205	65535	Pref	NEW	MORE	0	1
1	218	65535	Pref	SAME	SAME	1	0
2	4151	65535	Pref	NEW	SAME	0	0
3	5116	65535	Pref	SAME	MORE	1	0
4	4654	65535	Pref	SAME	SAME	1	0
5	15904	39701	Pref	SAME	SAME	0	1

Record index 5 represents the network, which broadcasts the above-mentioned MCC/IMSI_11_12.

10. References

1. ANSI/TIA/EIA IS-683C, Over-the-Air Service Provisioning of Mobile Stations in Spread Spectrum Systems.

2. ANSI/TIA/EIA Standard 41-D, Cellular Radiotelecommunications Intersystem Operation.

3. ANSI/TIA/EIA-TSB-29E International Implementation of Wireless Telecommunication Systems Compliant With ANSI/TIA/EIA-4.