Cellular Networking Perspectives

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New Chair for TR-45.2

Terry Watts of Cingular has been appointed the new chair of TIA standards subcommittee TR-45.2, replacing Cheryl Blum who resigned after being appointed chair of committee TR-45.

US FCC and Emergency Services Callback for Unsubscribed Phones

On May 25, 2001 the US FCC (Federal Communications Commission) proposed the development of rules to allow callback by unsubscribed phones (they use the term uninitialized, but unsubscribed is more accurate). Comments on their proposed rulemaking (NPRM) are due by July 9, 2001.

The FCC report is available at:

hraunfoss.fcc.gov:8835/edocs_public/attachmatch/FCC-01-175A1.pdf

Public Safety wants to solve this problem much more than wireless carriers, who only see more costs and possible erosion of their customer base when more people realize that they do not need a subscription to dial 911 from a wireless phone.

However, wanting to find a reasonable solution is probably not enough, as three significant problems have to be solved first:

- Assigning a unique MSID (Mobile Station Identifier) to an unsubscribed phone.
- Assigning a unique phone number (MDN).
- Correlating the MSID and MDN.

Assigning a Unique MSID

Every phone must have a unique MSID in order to make calls. The FCC is considering a proposal to assign a special number to 911-only phones, but the ability to make or receive calls is not guaranteed if two or more phones in the same cellsite have the same MSID, which would often be the case if this system gained widespread use.

If a distinct identifier is assigned to each phone, they will then have to be programmed, and the number assignment will need to be tracked. This is equivalent to giving these phones a free subscription, with many of the costs of real subscriptions, but without any of the revenue.

GSM phones, or others equipped with a SIM card, have a similar problem. If there is no SIM card in the phone, there is no MSID available to be transmitted. Therefore, no method exists to uniquely identify the phone; radical network changes would be required (e.g. using the IMEI as an alternate identifier).

Assigning a Unique MDN

When a PSAP (Public Safety Answering Point) calls back to a mobile, it dials the phone number (MDN), not the MSID. For this reason, when an MSC routes an enhanced 911 call, the ANI should be set to the MDN, not the MIN. This point is overlooked because currently, most US phones have a MIN that is the same as

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their MDN. However, this will change quickly once wireless local number portability (WNP) is implemented (a different FCC mandate).

WNP introduces another problem the FCC has not yet considered. Callback to a ported mobile is not possible if the phone is roaming in a non-WNP service area that has not implemented at least IS-41 Revision C. This is because the MDN is not transferred to the Serving MSC, and therefore the MSC has to assume the MIN is the same as the MDN. So far, the FCC has not indicated a willingness to fund the necessary upgrades to MSCs in small towns and rural areas likely to be affected.

There are two possible ways to provide a unique MDN:

- Assign a permanent, unique MDN.
- Assign a temporary MDN, like the TLDN used for call delivery.

Permanent MDN

Assigning a permanent MDN to an unsubscribed phone is equivalent to giving it a free subscription. Apart from the issue of who should pay for this and which carrier should have the privilege of having these non-paying customers, it will be difficult to track numbers when no bills are sent out. Phones can be reprogrammed or destroyed, and the carrier would never know. This would result in many stranded phone numbers, which is directly opposed to the FCC mandate to conserve phone numbers.

TLDN

The TLDN (Temporary Local Directory Number) is universally used in ANSI-41 and GSM systems (where it is called a Routing Number) for call delivery. It seems like a good fit for use in callback…at first glance. The problem is TLDNs are engineered to be used for a very brief period of time (a few seconds at most). Consequently, a small number of TLDNs can service thousands of customers.

TLDN requirements for E911 callback would be much more severe. Enough TLDN's would have to be provided to support the maximum expected number of E911 calls from unsubscribed mobiles within the time window within which callback is allowed. If callback is allowed within a 24 hour period, then a 911 callback TLDN would have to be assigned for that length of time.

Even if the required parameters could be guessed at, there is still the possibility that the TLDN pool will become exhausted, at which point callback would stop working for unsubscribed mobiles anyway. Attacking a wireless system to disable the entire pool of TLDN's would be quite easy.

Furthermore, callback beyond the time window would not work, nor would it work if the mobile roamed to another system.

A Waste of Time?

It appears the FCC NPRM may be a waste of time. All of the technical issues with callback to unsubscribed phones were examined by TIA TR-45.2 and ATIS T1P1 several years ago, and none of the barriers have been eliminated. In fact, the FCC mandates for WNP and number conservation are in direct opposition to this pending rule-making. The problem is not really technical; it is financial and political. Creating a subscription for every unsubscribed phone, and requiring that owners have them provisioned is a simple solution. But, who pays?

Roamer Agreement Tables, Part I: Validation

One of the most time consuming management activities at an MSC is maintaining the roamer agreement table. This table ensures roamers are not given service unless a business agreement exists between the Serving System (containing the MSC) and the Home System (containing the HLR). These tables also identify information about the home system — most notably its network address (e.g. an SS7 point code), which allows network communication using the ANSI-41 protocol.

Roamer agreement tables must be indexed by a prefix of the MSID of the mobile (usually a MIN). Usually, this is the first 6 digits of a North American MIN and the first 4 of an IRM. Consequently, these tables usually contain several thousand records. There is not just one record per carrier, but one per MIN-block. North American MIN codes are assigned to carriers implicitly in blocks of 10,000. A large carrier with 10 million subscribers — and a 50% utilization of their numbers — would require 2,000 database entries!

The number of database entries is not the biggest problem. The work required to maintain them, and the certainty that errors will creep in is more serious. Assuming that roaming is allowed in 1,000 MSC's, every assignment of a new number block will require 1,000 communications by fax or email to provide the new information. Entry of the information is often manual, giving much opportunity for errors creeping in.

In 2000, there were 14,245 net number block assignments in the USA alone. Only a minority of these were wireless, but even assuming 5,000 annual MIN block assignments affecting 1,000 MSC's, there will be 5 million individual roamer agreement table updates.

When a roamer agreement update is missed, or when it is performed incorrectly, roamers are denied service. Tracking down these problems is time consuming, which results in an unknown amount of lost revenue, particularly from roamers who do not realize they can call customer service to rectify the problem.

Standards for Roamer Database Validation (RDV)

Clearly a better system is needed. One small step in that direction is TR-45.2's new standard IS-847. It allows for the HLR to validate information stored in roamer agreement tables at VLR's, although it does not allow for automatic correction of problems detected.

A revision of this standard is being developed to extend beyond HLR validation of VLR data.

IS-847: VLR Roamer Database Verification

IS-847 adds one new message to TIA/EIA-41 to allow an HLR to verify the information stored at a VLR (see Figure 1). This message, *RoamerDatabaseVerificationRequest*, identifies the sending HLR, the first

MSID (MIN or IMSI) in the desired range and the number of MSID codes in the range (usually 10,000 for North American MIN blocks). For example, the editor's MIN (4038703736) is in a block identified by a starting MIN of 4038700000 and a range of 10,000. By contrast, the international MIN 1225123456 (Unifon Argentina) is in a block identified by a starting MIN of 1225000000 and a range of 1,000,000.

Successful Response

If the VLR verifies that the MSID range is exactly correct, it responds with a RETURN RESULT message, containing either no parameters, or just the TransactionCapability parameter, which indicates some of the TIA/EIA-41 capabilities of the MSC.

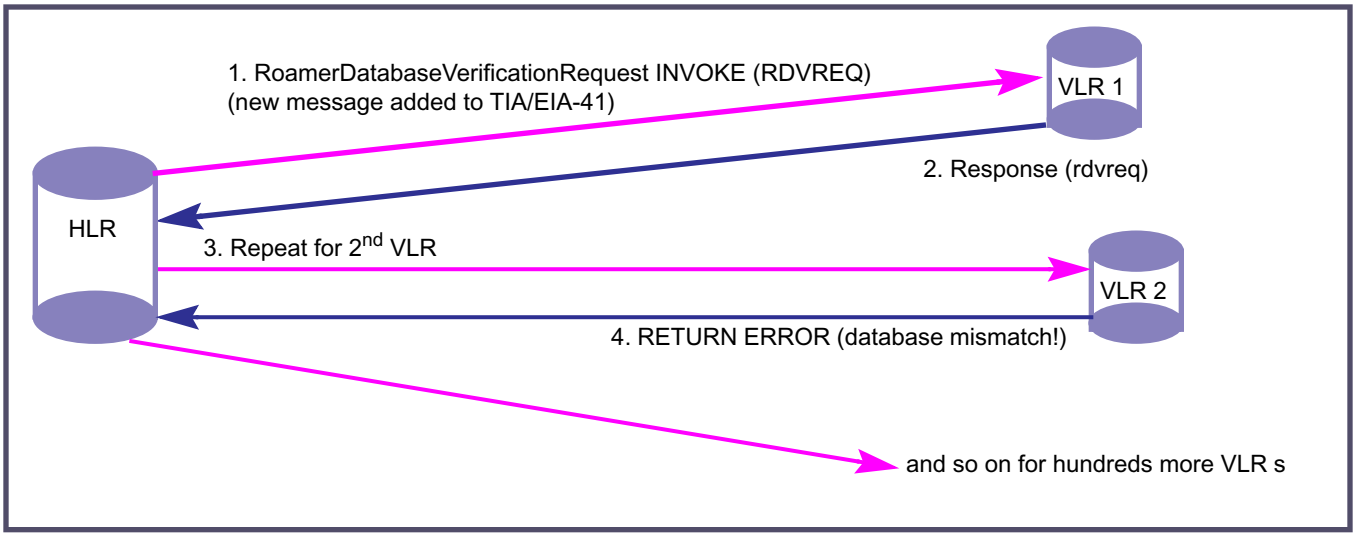
Unsuccessful Response

Unsuccessful verification of an MSID block is indicated by returning a RETURN ERROR message with an error code set to *MSID/HLR Mismatch*. There are several different reasons for this error code:

- Start of range matches, but HLR and VLR ranges differ in size. This could be a spurious error if two adjacent ranges have been merged in the VLR database.
- There is no VLR roamer agreement table entry that matches even part of the range.
- The HLR and VLR ranges are the same, but the VLR has recorded that ownership lies with a different HLR.

The response to a reported error must be manual. Assuming that the error lies with the VLR, and not the HLR, a correction to the information must be reported through the normal roamer agreement table update process.

Figure 1: Roamer Database Verification Using TIA/EIA/IS-847



Other errors can occur (as with most TIA/EIA-41 messages), including:

- Time-out (no response)
- *OperationNotSupported*. VLR has not been upgraded to understand this message.
- *ResourceShortage* or *SystemFailure*. VLR is overloaded, and cannot process this message.
- *ParameterError*. Message is formatted incorrectly.
- *UnrecognizedParameterValue*. Contents of parameters are incorrect.

Oops: No International Support

IS-847 supports verification of MSID blocks as large as 10,000 numbers, the largest size allocated within the North American Numbering Plan. Unfortunately, IRM codes are used by most international TIA/EIA-41 carriers and by several data systems within North America. IRM codes are assigned in blocks of 1 million numbers.

There is no reason why the protocol cannot support MSID blocks of any size. The restrict is totally arbitrary. However, unless the standard is modified, a strict interpretation of the standard would result in *UnrecognizedParameterValue* being returned if verification of a block with more than 10,000 MSID codes is specified.

IS-847-A: More than just HLR s and VLR s

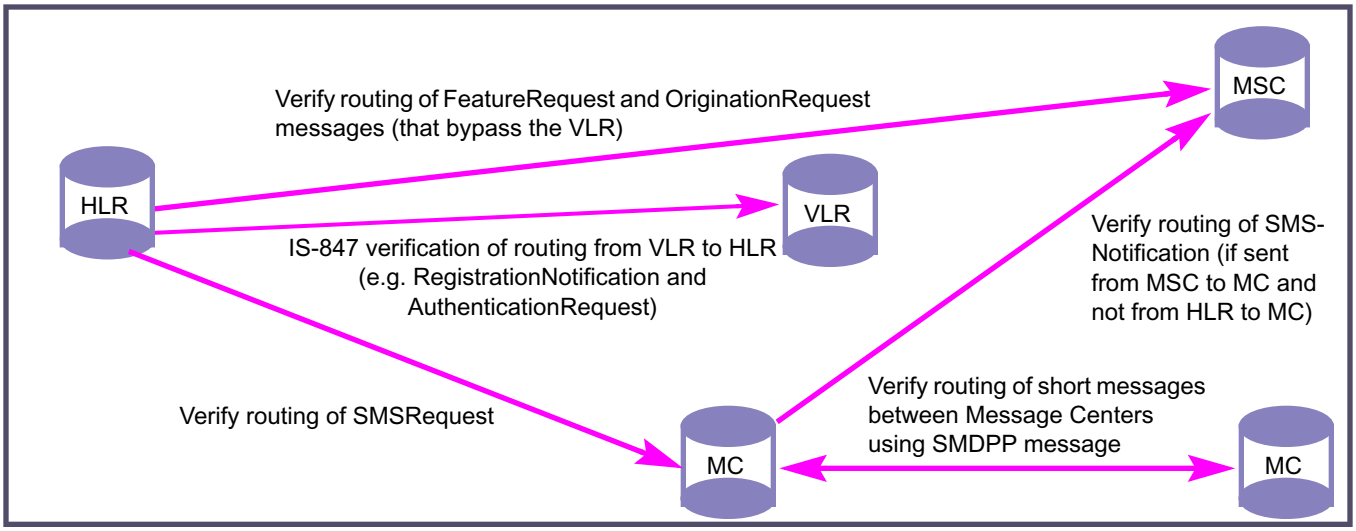
IS-847 solves the problem of an HLR verifying information about its subscribers, stored in various VLR's, but there are similar roaming and routing tables in other network elements. A revision to IS-847 is being developed to allow other network elements to participate in this validation.

Most of the validation will be initiated from the HLR. For example, it may be programmed to check MSC databases to determine whether routing of OriginationRequest and FeatureRequest messages is correct. These messages may be sent directly from an MSC to an HLR, and therefore they could be routed incorrectly, even if the VLR database is correct. The HLR may also check whether the Short Message Centers that it supports are properly routing SMSRequest INVOKE messages. Message Centers may check the routing of other message centers to ensure routing of short messages between them (using TIA/EIA-41 SMDPP) can be accomplished.

The Message Center may verify routing information stored in partner MSC's to ensure that SMSNotification INVOKE messages are routed correctly. Errors in routing of this message could result in suspension of delivery of short messages to a mobile until it registers in another system.

Revision A verification possibilities are illustrated in Figure 2.

Figure 2: Enhanced Verification with TIA/EIA/IS-847 Revision A



Efficiency Problems Multiply

One of the problems with RDV is that the number of TIA/EIA-41 messages required to do a full verification of every HLR–Number Block–VLR quickly becomes immense. Table 1 illustrates the size of the problem, based on various numbers of HLR's, VLR's and MSID blocks per HLR. With implementation of IS-847 Revision A, this problem will potentially increase by 2 or 3 times.

Table 1: Estimated Number of Roamer Database Verifications

		Number of Roaming Partner VLR s								
		100			1,000			10,000		
Number of HLR s		Blocks of MSID s in HLR								
	100	100	1,000	10,000	100	1,000	10,000	100	1,000	10,000
		1 million	10 million	100 million	10 million	100 million	1 billion	100 million	1 billion	10 billion
		Blocks of MSID s in HLR								
	1,000	100	1,000	10,000	100	1,000	10,000	100	1,000	10,000
		10 million	100 million	1 billion	100 million	1 billion	10 billion	1 billion	10 billion	100 billion
		Blocks of MSID s in HLR								
	10,000	100	1,000	10,000	100	1,000	10,000	100	1,000	10,000
		100 million	1 billion	10 billion	1 billion	10 billion	100 billion	10 billion	100 billion	1 trillion

To be continued...

If the use of IS-847/RDV was to become widespread, it would generate a large amount of traffic, which would only reduce the verification problem, not eliminate it. Roamer agreement tables would still be managed semi-automatically. In our continuation of this article, we will explore other alternatives, including the use of SS7 global title translation (GTT), querying a centralized database, and new ideas based on Domain Name Server concepts. Is it possible to reduce the number of places where roamer agreement and routing information needs to be managed without significantly increasing the amount of network traffic?

Identifying 3GPP and GSM Specifications

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ETSI GSM Specification Identification

ETSI GSM standards were identified as AA.xx, where AA represents a 2 digit series number from 01 to 13, and xx a 2 digit specification number.

3GPP GSM Specification Identification

In July, 2000, responsibility for GSM standardization was handed over to 3GPP TSG-GERAN. The series number was increased by 40 (e.g. 01 became 41 and 13 became 53), and the specification number expanded to 3 digits.

3GPP UMTS Specifications Identification

Many 3G specifications from 3GPP are based on GSM specifications. The series number is derived by adding 20 to the GSM number (e.g. 01 becomes 21). The specification number is simply prefixed with 0 if it is carried over from GSM without major changes (e.g. 02.93 becomes 22.093) or incremented by 100 if it is significantly different (e.g 09.08 became 29.108).

Series	ETSI GSM Series	3GPP GERAN Series	3GPP UMTS Series
Requirements	01.xx	41.xxx	21.xxx
Service Aspects	02.xx	42.xxx	22.xxx
Technical realization	03.xx	43.xxx	23.xxx
User equipment (phone) to Network signaling protocols	04.xx	44.xxx	24.xxx
Radio aspects	05.xx	45.xxx	25.xxx
CODECs (voice coders)	06.xx	46.xxx	26.xxx
Data	07.xx	47.xxx	27.xxx
Radio Subsystem (RSS) to Core Network signaling protocols (e.g. “A” interface)	08.xx	48.xxx	28.xxx
PSTN Interconnect signaling protocols	09.xx	49.xxx	29.xxx
Program management	10.xx	50.xxx	30.xxx
User Identity Module (aka SIM, USIM, “Smart Card”)	11.xx	51.xxx	31.xxx
Operations and Maintenance (O&M)	12.xx	52.xxx	32.xxx
European access requirements and test specifications	13.xx	*European regional requirements have been transferred to ETSI TC MSG. Other regions may define their own specifications in this area.*	
Security aspects			33.xxx
Test Specifications		*No GSM equivalent*	34.xxx
Security algorithms			35.xxx

TIA TR-45.6 and TSG-P 2G and 3G Wireless Packet Data Standards

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Note: 1. IS- Interim Standard, TSB- Telecommunications Systems Bulletin, P.Sxxxx - 3GPP2 TSG-P Specification, P.Rxxxx - TSG-P Report, PN- Project Number, SP- ANSI Standards Proposal.
2. Bold Type indicates a modification since the previous publication of this information.
3. Published TIA standards can be obtained from Global Engineering Documents at 1-800-854-7179.

Thanks to Ed Campbell (3Com) and Raymond Hsu (Qualcomm) for their assistance compiling the information in this table.

CDPD - Cellular Digital Packet Data

Standard	Project	Description	Status
IS-732	PN-4033	Cellular Digital Packet Data (CDPD) - multiple parts	Published 02/98
TSB-87	PN-4001...	CDPD Support Services (Directory, Authentication, DNS, Testing, Identifiers, Numbering)	Published 02/98

CDPD - Cellular Digital Packet Data (Revised)

Standard	Project	Description	Status
TIA/EIA-732	**SP-4033-UG**	**Revisions to CDPD and upgrade to ANSI**	**In press**

3G Packet Data

Standard	Project	Description	Status
IS-835	**PN-4732**	**cdma2000 Wireless IP Network Standard**	**Published 12/00**
IS-835-1	**PN-4732-1**	**Addendum for IS-835**	**In press**
IS-835-A	**PN-3-4732-RV1**	**cdma2000 Wireless IP network standard (ballot estimated 10/2001)**	**Development**
TSB-115	**PN-4286**	**cdma2000 wireless IP architecture based on IETF protocols. Waiting for RFC number from IETF**	**Published 12/00**

3GPP2 TSG-P Projects

3GPP2	Description	Status
P.R0001	**Wireless IP Network Architecture based on IETF protocols**	**Published 07/00**
P.S0001	**Wireless IP Network Standard based on IETF protocols (same as IS-835)**	**Published 12/99**
P.S0001-A	**Wireless IP Network Standard based on IETF protocols (same as IS-835-A)**	**Published 07/00**
P.S0001-A-1	**Addendum to P.S0001-A (same as IS-835-1)**	**Published 12/00**
P.S0001-B	**Wireless IP Network Standard (V&V estimated 09/2001)**	**Development**