



# Cellular Networking Perspectives

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## In This Issue ...

Location information is grist for the cellular mill. Without it, call delivery would be impossible. However there are other uses for location information which are described in this issue, along with mechanisms for obtaining this information.

The TIA TR45.2 sub-committee has published very little since IS-41 Rev. B, in 1991 and has missed most of its deadlines since then. Perhaps the group had taken on so many tasks that it was impossible to focus on any single task for long enough. But, whatever the reason, they are about to deliver several new standards and TSB's over the next few months. Two have already been approved: the DMH standard for transmission of call detail records and the Border Cell TSB, and two more may be approved as early as July. By the end of the year TR-45.2 may be looking for new work!

Working Groups are aptly named, as this is the level in standards committees where real technical work gets done. We have described the mandate and activities of each of the seven Working Groups of TR-45.2, and their Task Forces, in earlier issues. On Page 5 of this issue we have included a summary of all of the Working Groups and Task Forces, along with the projects that they are responsible for. ♦

### Comments Welcome

We welcome comments on the format of this newsletter, suggestions for future topics, corrections or additional information.

## Wireless Terminal Location Management, Part I

Mobile location tracking is a fundamental building block of the seamless cellular network. Based on autonomous registration of cellular phones when they recognize a boundary between groups of cells, it allows call delivery services to work for roamers, permits adherence to legal and business restrictions and provides the raw data for fraud detection and location tracking services.

But location tracking in cellular using autonomous registration is not without its challenges. If not properly controlled it can result in an excessive processing load on MSC's and HLR's and excessive air interface and network traffic. However, if used too little, it will result in excessive paging and inaccurate location information. On top of this balancing act, the initial analog cellular standard, IS-3 (now EIA/TIA-553) contained several bugs in the definition of autonomous registration, bugs which have not all been eliminated even in new TDMA (IS-54) and CDMA (IS-95) digital cellular standards.

### Definitions

Some technical terms that will be used during this discussion are:

**REGID** • Registration ID. A number transmitted by each control channel that is used by each terminal to help it decide when to register.

**Location Area** • A group of cells that force terminals to register going in or out, but not between cells in the group.

**SID** • System ID. A number that uniquely identifies a cellular MSA or RSA.

## Call Delivery

When terminating to a roamer, location tracking powered by autonomous registration is essential. Calls coming into a home system have to be directed to the appropriate visited system. In some cases incoming calls have to be directed to different parts of the visited system to avoid violating legal restrictions on inter-exchange traffic. In other cases, the treatment of roamers may vary in different parts of a visited system because of different ownership of MSC's or cells. In extreme cases agreements may exist to deliver calls to some areas, but not others. In cases where the location of a mobile has legal or business implications, location areas have to be configured to force registration to occur when mobiles move across such a boundary.

## Legal Requirements

Inter-exchange carriage restrictions cause serious complications for location tracking when used for call delivery. The restrictions are based on the prohibition against providing inter-exchange (long distance) service that the Regional Bell Operating Companies (RBOC's) agreed to during the AT&T divestiture. The main restriction resulting from these considerations is that calls to roamers outside their home area (LATA) have to be delivered across LATA boundaries by the subscriber's preferred inter-exchange carrier. Under these restrictions location areas must be restricted to a single LATA.

One open question dealing with inter-exchange restrictions applying to RBOC's is whether signaling data going across a LATA boundary needs to be transferred over the data network owned by a subscriber's preferred inter-exchange carrier. If mandated, this could affect location tracking because the Registration Notification

messages from the Visited to the Home system are sent before the Preferred Inter-Exchange Carrier is known, and therefore might have to be carried by a different data network than the response.

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### Business Restrictions

When different parts of cellular systems have different ownership, they may also have different business agreements with other systems in the cellular network. Roamers may get different treatment depending on which part of the system they are in. In the most extreme case they may get full service in one cell, and no service in a neighbouring cell because no business agreement exists. In these cases registration has to occur when a mobile crosses between cells with different ownership.

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### Vehicle Positioning

Using the cellular network to perform positioning for vehicles might seem ineffective when compared against the accuracy provided by high-tech satellite based systems, such as GPS. However, if a cellular terminal is already in a vehicle for other purposes, the location tracking comes almost for free, and coverage, at over 92% of the US population, is extensive. For applications where accurate location information is not required, cellular systems can provide the most cost-effective solution. Not only can cellular systems gather the information but, equally as important, they already route it to a central database, the HLR, for customized processing.

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### Location Tracking Mechanism

There are two conflicting goals for a location tracking mechanism that have to be balanced to achieve the best system:

- Getting accurate information
- Minimizing Resource Usage (Radio, Network and Processor)

The balance between the first two goals is straightforward. When cells are lumped into a location area mobiles will not normally register when moving between cells within the group, but paging will have to occur in all cells in the group, because the precise location of the mobile is not known. The larger the location area, the greater the paging load and the fewer the number of registrations. A balance should be achieved

through intelligent design of location area boundaries to minimize the total registration and paging load.

Accuracy of location information is also an important factor in designing new services, most obviously those involving vehicle positioning. It is safe to predict that location areas will become smaller over time, as there are more advantages to minimizing paging and getting accurate location information than there are to minimizing registrations.

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### Inter-System Operations

IS-41 Rev. A first defined inter-system operations for location tracking. The basic operations are illustrated in Figure 1. The Registration Notification Invoke (REGNOT) informs the VLR of a new registration in an MSC. The VLR may forward the REGNOT to the HLR if necessary. At the HLR the mobile will be validated, its location updated and a Registration Notification Result (regnot) returned to the VLR and MSC. At the same time a Registration Cancellation Invoke may be forwarded to the previous visited system, to allow it to release resources allocated for the roamer record in the VLR.

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### Role of the VLR

The VLR acts as a cache for roamer location information. If the VLR controls multiple MSC's it can track roamers on behalf of the HLR, passing only the first registration through to the HLR. However, this may be a simplistic design if location tracking information is used for fraud detection, vehicle positioning or for determining roamer privileges based on business agreements. In these cases the HLR may need to be updated more frequently to enable it to control decisions about the roamer.

Intelligent filtering of registrations at the VLR is an area that the TR-45.2 standards committee is not currently studying, although some informal discussions have occurred. This may be an area where more attention needs to be paid, and one that may provide future business opportunities, just as the HLR market currently is doing.

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### Air Interface Considerations

Autonomous registration is the mechanism used by cellular air interfaces to gather location information. Registrat-

ion is controlled by information transmitted by the control channel in each cell. Mobiles may register because of a change in location or a change in time:

- Geographic

Loss of synchronization on the current control channel causes a rescan to a control channel with a different System ID (SID) or a Registration ID (REGID) that differs by at least 450 from the value on the old control channel. Configuration of SID and REGID allows groups of neighbouring cells to be formed into Location Areas.

- Time Based

The Registration ID (REGID) transmitted by each control channel can be incremented at regular intervals. Terminals will normally register whenever the value differs by at least 450 from the value at the last registration. By controlling the rate of increment of REGID, mobiles can be forced to register at regular intervals, even when stationary.

IS-54 dual-mode Analog/TDMA terminals will also register under the following circumstances:

- Location Area (Geographic)

Rescanning to a control channel with a different Location Area ID, a new parameter in IS-54.

- Power Up/Down

Turning a mobile on or off. This allows call delivery to be suppressed while a mobile is off while retaining subscriber profile data at the VLR.

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IS-95 dual-mode Analog/CDMA terminals can also register under a dizzying array of new circumstances. Most of them are simply variants of the schemes listed above, but interesting new triggers for registration are:

- **Zones**  
CDMA terminals can store a list of Location Areas that have most recently registered in. They will then not re-register until the zone is removed from the list because the list gets full or because it has been too long since the last appearance in the location area. This method may cause similar network problems as the "Stack of 4 SIDs" feature did in analog mobiles prior to IS-3 Rev. C.
- **Distance**  
CDMA terminals can register when they have moved a specified distance from their point of last registration. This is based on the capability of CDMA systems to accurately locate active terminals.

### Validation & Authentication

Location management must occur after a mobile has been validated and, for authenticating mobiles, after authentication has been completed. Otherwise, fraudulent mobiles could cause the loss of location information for valid subscribers.

### Handoff Interactions

An intersystem handoff does not reflect a change in the logical location of a mobile, even though it does physically. Neither the mobile nor the network considers a handoff to be cause to register (unlike call origination and termination that are treated as implicit registrations). The logical location of a mobile throughout a call is always the Anchor MSC, which is where calls will be directed if Call Waiting is activated. At the end of each call the mobile will scan for a control channel and will likely register at this time.

### Profile

Retrieving profile information from an HLR does not interact with location management except that the time of registration is a convenient time to get profile without requiring a separate transaction. It is, however, also possible to retrieve profile information while setting up the first call by a roamer in a new area. This trades off a longer first call setup time against less waste of resources by mobiles that are just passing through a system.

### Fraud Management

Location information is a useful input to fraud management algorithms. Location can be used simply to track calls

more carefully that are made in high fraud areas. More sophisticated algorithms look at the change in location of a mobile, and the speed that would be necessary to make that change. For example, if a call is made at 9:00 AM in Los Angeles and at 9:01 AM in New York City with the same MIN, it can safely be said that a clone is present. Combined with other information, such as call destination and call duration, mobile location information is an important piece of the fraud detection puzzle.

### Summary

Location information can be used for many purposes, including Call Delivery, Fraud Management and Location Tracking. In this respect it is similar to Call Detail Records that can be used for much more than just billing. A good understanding of the possible uses of location information, and good planning to balance accuracy of location tracking against system and air interface overhead, can result in enhanced depth and breath of service to all subscribers. In the next issue of *Cellular Networking Perspectives* we will continue the discussion of location tracking by sketching out some of the challenges that the AMPS air interfaces used in the Americas and elsewhere provide to network designers.

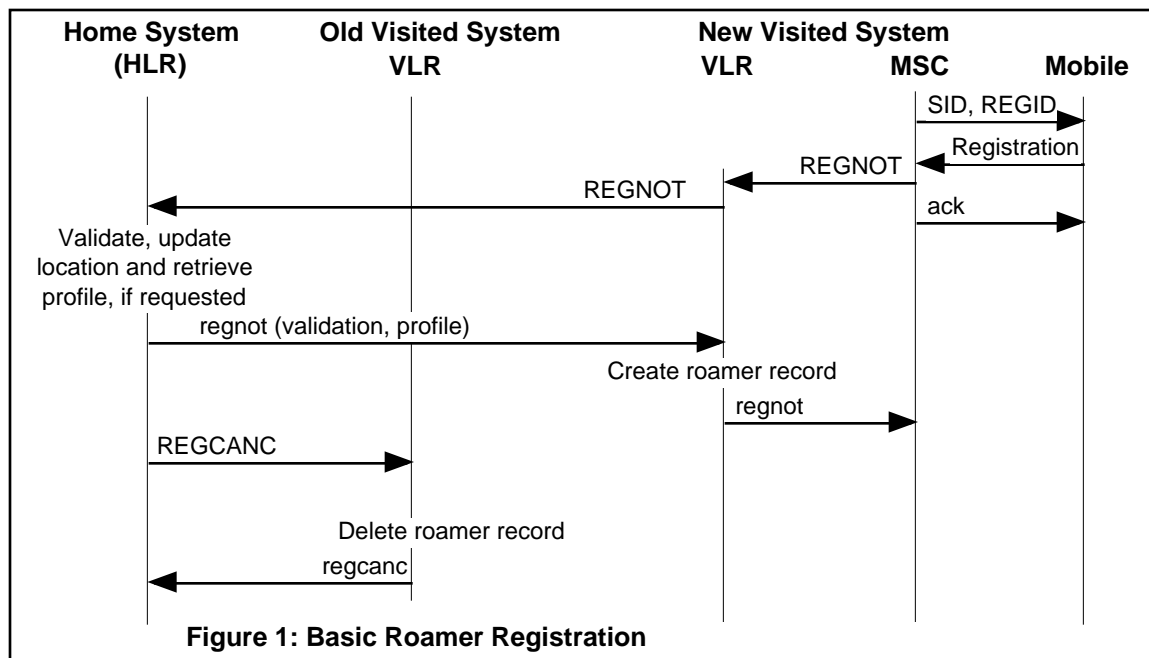


Figure 1: Basic Roamer Registration

## Brace for the Standards Flood

The TR45.2 standards sub-committee has had great difficulty completing standards and TSB's over the past two years, sliding many publication targets monthly. But finally the log jam appears to have burst. At the June meeting the DMH standard and the Border Cell TSB were both approved for ballot. At the July or August meetings, the IS-41 test plan TSB, the IS-41 Rev. A Forward Compatibility TSB and the IS-41 Rev. B Technical Notes TSB will be approved for ballot, barring unexpected delays. A large part of this push is from companies that are anxious to see IS-41 Rev. C published, particularly those that are committed to CDMA. They may not be particularly interested in all the IS-41 TSB's being developed, but recognize that they must be completed before IS-41 Rev. C. Another factor spurring progress may be the rapid progress that the DMH standard proponents have made over the past 6 months.

The status of all documents that the TIA TR-45.2 sub-committee has in progress is listed below in order of estimated publication date.

**Intersystem Non-Signaling Data Communications (DMH)** • This document describes record layouts and protocols for online transmission of cellular call detail records for billing, fraud detection and other purposes. This document was **approved for ballot** as an Interim Standard at the June meeting.

**Border Cell TSB** • The draft document to resolve several problems that occur on the border of cellular systems was **approved for ballot** as a TSB at the June meeting, pending finalization of approved changes by the editor and review by an editing team.

**IS-41 Rev. B TechNotes** • Will resolve several ambiguities in IS-41 that have resulted in incompatibilities between implementations of IS-41 Rev. A. A complete baseline document will be circulated at the July meeting, for **ballot in July or August** as *TSB-41*.

**Rev. A Compatibility** • Procedures to allow IS-41 Rev. A implementations to be forward-compatible with Rev. B. Remaining open issues are being resolved by WG II. The document will probably be recommended for **ballot in July or August** as *TSB-55*.

**IS-41 Rev. B Test Plan** • An application level test plan for IS-41 Rev. B is being developed by a WG II task force. Assignments for remaining tests are due in July. The test plan will be approved for **ballot as TSB-42 in July or August**.

**CDMA TSB (New)** • Approval for the development of a CDMA inter-systems operation TSB was given at the June meeting. It will not necessarily be published before IS-41 Rev. C which will also include support for CDMA.

**IS-41 Revision C** • An initial draft of this revision will be available as a working document in July. All the IS-41 Rev. B TSB's being published, and Stage 3 descriptions of features will be merged in as they become available. Publication is **scheduled for December, 1993**.

**Subscriber Features** • Draft text for a major revision to the cellular Features Description standard is still being reviewed by WG V. This document will be published as *IS-53 Rev. A*.

**PSTN Interface** • A definition of both the analog (i.e. MF signaling) and digital (SS7 signaling) interfaces required to connect MSCs to the PSTN is being developed. Detailed scenarios for most interfaces were reviewed in June. The intent is to produce only the minimum text required to describe the interfaces, referencing existing standards as much as possible. Publication is **scheduled for December, 1993**. After a slow start, fast progress is being made.

**Cellular Dialing Plan** • Plans are being made to revise the cellular dialing plan standard, IS-52 Rev. 0, including moving the recommended feature activation and deactivation codes from

IS-53. This document will also describe the recommended treatment for ANI. This standard will be published as *IS-52 Rev. A*.

**International Applications** • There are several recognized problems with the use of AMPS cellular outside North America. WG VI of TR45.2 is studying solutions to these problems. These recommendations will be published as *TSB-29 Rev. B*. The schedule for publication is December, 1993, but it is recognized to have a lower priority than other documents and its deadlines will probably be allowed to slip.◊

### Back Issues Available

Back issues are always available. Major topics in recent issues are:

#### November, 1992

Inter-System Handoff, part I - Handoff Forward/Back.

#### December, 1992

Inter-System Handoff, part II - Path Minimization.

#### January, 1993

Inter-System Handoff, part III - Feature Interactions

#### February, 1993

Inter-System Handoff, part IV - New Air Interfaces. IS-41 Rev. 0 Field Trials

#### March, 1993

Wireless '93 in review. IS-41 Rev. A Field Trials

#### April, 1993

IS-41 in Summary.

#### May, 1993

IS-41 Rev. A Status Report. IS-41 Rev. B Status. NovAtel. DMH. IS-41 Enables Innovation. TR45.2 Project Status.

The price of a back issue is:  
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# TIA TR-45.2 Working Group Report

## Cellular Networking Perspectives

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WG	TF	Mandate	Chair	PN	Title	Editor
Plenary		Cellular System Operations	John Marinho			
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				2985	Technical Notes for IS-41 Revision B (TSB-41)	Arzu Çalis
				2991	Cellular Radio Telecommunications Intersystem Operations (IS-41 Rev. C)	Terry Watts
				3063	IS-41 Rev. A/B Forward Compatibility (TSB-55)	Charles Ishman
II		Automatic Roaming	Cheryl Blum	*	CDMA Intersystem Handoff	
	1	IS-41 and IS-53 Test Plan	Kirk Carlson	2978	Application Level Test Plan (IS-41-B, TSB-51, IS-53-0). (TSB-42)	David Crowe
	2	Network Based Fraud Management	Rob Mechaley		<i>disbanded June, 1993</i>	
	3	IS-41 Rev. B Technical Notes Decision Points	David Crowe		<i>disbanded June, 1993</i>	
III		Inter-system Handoff	Thomas Ginter		<i>meets jointly with WG II</i>	
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VII		Interfaces to Other Telecommunications Networks	P.J. Louis	3098	Ai and Di Interfaces (PSTN/MSC) (IS-*)	Mike Buhrman
				3166	Uniform Dialing Procedures for use in Cellular Radio-telephone Systems (TSB-29 Rev. B)	Steve Jones
	1	Ad-Hoc Editing Group	Huel Halliburton		<i>disbanded June, 1993</i>	

For the phone numbers of any Working Group or Task Force Chair, or the editor of any Standard or TSB, please phone the editor of Cellular Networking Perspectives at 403•289•6609.

\* - Interim Standard, TSB or Project number not assigned.