Cellular Networking Perspectives

In This Issue ...

The status of IS-41 Rev. 0 inter-vendor trials is reported this month. This first release of the IS-41 standard provided only inter-MSC handoff and limited validation capabilities (MSC to clearinghouse). IS-41 Rev. 0 was first put into commercial service in 1989 and, as our report shows, most pairs of vendors have by now completed field trials and have IS-41 Rev. 0 in commercial service in at least one location.

Bellcore recently issued the second draft of their proposal on the future of numbering in North America. Their first draft was heavily criticized and, as our discussion of the second draft shows, they have not changed their proposals enough to stave off further criticism. Cellular and inter-exchange carriers and groups representing phone users will probably continue to complain that numbers are being managed exclusively for the benefit of the big wireline carriers that own Bellcore.

We conclude our series on IS-41 inter-system handoff by discussing the impact of new and emerging air interface technologies. We discuss the relatively new TDMA digital cellular air interface (TIA IS-54 Rev. B) and upcoming standards for CDMA digital cellular and digital cellular data terminals. We even wade into a discussion of handoff in PCS networks.

Standards for cellular implementations of features such as call forwarding and call waiting, are developed by Working Group V of the TIA TR-45.2 sub-committee. We discuss the history and current priorities of this group.

Bellcore has your numbers ... And they want to keep them

Bellcore has a problem. They have inherited administration of the North American Numbering Plan (NANP) from AT&T but this power is now a hot potato. They want to keep this control but get burned whenever they try to assert it. Everyone agrees that the NANP is close to running out of numbering resources, yet many companies, particularly cellular and inter-exchange carriers, oppose the solutions being proposed by Bellcore's NANP Administrator (NANPA). These carriers do not want the RBOC's, the owners of Bellcore, to be in control of numbering resources that are critical to their provision of current and future services.

The NANPA first attempted to revamp the numbering plan in early 1992, an attempt which met with strong criticism from many organizations,. The NANPA has attempted to alleviate some of those criticisms through a second draft of their "Proposal on the Future of Numbering in World Zone 1" and an open series of forums on numbering. Through this the NANPA will attempt to produce a solution to the NANP numbering shortage by their 1995 deadline.

Unfortunately, Bellcore's NANPA has not substantially changed its position with their new proposal.s The NANPA is still trying to ccontrol the discussion boundaries. They do not discuss, for example, conservation of existing numbering resources by Local Exchange Carriers and they define personal/non-geographic numbering very narrowly. They do not consider how non-geographic numbering could help solve the numbering crisis, which is an artifact of the current highly structured, geographically based numbering system. It is rather unusual to start an open discussion process with so many areas of discussion marked off limits!

The day seems ever closer that the FCC will take away responsibility for the NANP from Bellcore's NANPA and give it to a more independent body. For a detailed discussion of the initial version of this Bellcore NANP report, see the September and October issues of Cellular Networking Perspectives

Inter-System Handoff Part IV - New Air Interfaces

We complete our discussion of inter-system handoff by looking toward the future of cellular and the challenges raised by new air interfaces such as TDMA and CDMA. We even speculate on the impact PCS might have on inter-system handoff. While not much about the future can be predicted, it is safe to say that, no matter which air interface technologies prove most successful, there will be many more cells, many more wireless terminals and many more calls. Handoff procedures must be carefully designed and managed because, along with registration, handoff can be a heavy load on an MSC while not directly raising any revenue for carriers.

Both the TDMA standard (IS-54) and the upcoming CDMA standard support Mobile Assisted Handoff (MAHO) that can reduce the system overhead of handoff, and particularly of inter-system handoff, significantly. We will describe how it is possible to reduce the system overhead even further, although whether this is necessary for PCS services remains to be seen.

IS-41 supports TDMA inter-system handoff procedures in Revision B and the TR-45.2 sub-committee is planning to support CDMA and TDMA data terminal procedures in IS-41 Revision C. There has been no work on supporting inter-system operations for PCS, as the TIA TR45.4 sub-committee and the TIA TR46

committees have not proceeded far enough in the development of standard air interfaces.

TDMA Handoff

TDMA inter-system handoff requires changes to IS-41 parameters and message scenarios. Parameters were added over those existing for EIA-553 analog handoff for the new capabilities and characteristics of TDMA digital cellular terminals. Message scenarios for the handoff measurement phase changed from those used with analog cellular terminals (see Figure 1a) to those required to accomodate MAHO (see Figure 1b). These changes were incorporated in IS-41 Rev. B.

Modified IS-41 Parameters

The most obvious parameter that had to be modified for TDMA inter-system handoff is the channel identification. With TDMA dividing a single channel into 3 timeslots (and 6 in the future), the timeslot number must be added to the channel number to uniquely identify a traffic channel. In addition, there are several other new parameters:

- *CallMode* describes the capabilities of a terminal to handle an analog channel, full rate digital timeslot (3 slots per channel) or a half rate channel (6 slots per channel). Although today all terminals are either analog-only or analog and full rate capable, this parameter allows for digital-only and tri-mode phones in future. *CallMode* is sent from the Serving MSC to the Target MSC to ensure that a compatible traffic channel is allocated.

- *DMAC* replaces *VMAC* (EIA-553)to reflect the greater number of power levels available in IS-54 digital cellular. The power level is required to adjust signal strength measurements and to reset the power of the mobile after handoff.

- *DVCC* replaces *SCC* (EIA-553). This parameter allows greater discrimination amongst mobiles and base stations than provided by the fixed number of control channels. Each base station broadcasts a Colour Code (either SCC or DVCC) and will only accept messages from mobiles transmitting the same value. The increased number of colour codes in IS-54 reflects the problems of interference that are common in analog cellular systems today.

Mobile Assisted Handoff (MAHO)

MAHO bucks the normal trend that sees standards getting more complex with time by actually simplifying existing procedures. The handoff measurement phase, necessary in an analog handoff, can be eliminated by sending an IS-54 compliant terminal a list of neighbouring channels to measure. Inter-system operations are then not required unless a handoff is actually attempted. This reduces the system load of handoff greatly because most often the measurement phase does not result in an inter-system handoff attempt.

CDMA Handoff

If you guessed that CDMA complicates handoff even further, you would be right. However, because the new "soft" handoff procedures in CDMA are timing sensitive, they cannot be easily used for inter-system handoff. Thus, CDMA inter-system handoff is very similar to TDMA, allowing the use of MAHO or the older EIA-553 style handoff. CDMA does require the use of some new parameters in IS-41 messages, reflecting the major differences between the TDMA and CDMA air interfaces.

CDMA inter-system handoff procedures are being defined jointly by TR45.5 and TR45.2, with an intention to incorporate them in IS-41 Rev. C, due out later in 1993.

Handoff and Voice Privacy

IS-54, the TDMA air interface specification, also includes provision for terminal authentication and voice privacy using encryption. Authentication does not affect inter-system handoff, because it should be completed before a handoff occurs. Voice privacy, on the other hand, has had a major impact on IS-41 inter-system handoff procedures. The changes in IS-41 to accommodate voice privacy are described in TIA TSB-51. The major changes are passing encryption masks from the serving MSC to the target MSC and to negotiate the state of voice privacy between the serving and target MSC This ensures that a handoff does not result in loss of intelligible conversation when voice encryption cannot be maintained across a handoff. The upcoming CDMA standard will also include a very similar form of voice privacy. and will therefore require the use of inter-system handoff procedures described in TIA TSB-51.

The size of the voice mask used for voice encryption (66 bytes) will cause the size of IS-41 inter-system handoff messages to double in size, and because of the need to carry the voice masks for any call for which voice privacy could be used , the usage of inter-MSC datalinks will increase substantially. The number of links or link speed may have to be increased in some systems.

Data Terminal Handoff

Data terminal standards are currently under development by both the TDMA (TR45.3) and CDMA (TR45.5) committees. These terminals will have significantly different handoff requirements than voice terminals. Even within data terminals, some services are strongly circuit oriented, such as facsimile and some, such as dial-in computer access, are more packet oriented. The TR45.3 data services task force is currently taking the simple approach of supporting only a circuit oriented data protocol and assigning a single 64 kbps inter-MSC trunk for each data terminal handed off. While certainly the simplest approach, it is not efficient to use a 64 kbps channel to carry 2400 bps of data. More sophisticated handoff algorithms will have to be designed if packet oriented protocols are to be supported.

PCS Handoff

What follows is pure speculation. But then, everything about PCS is pure speculation. If PCS follows the trend of handoff evident in cellular it will place more of the handoff burden on the mobile and less on the system. The next logical step in this direction beyond MAHO would be to have the mobile select the cell to handoff to. Because this cell happens to be in a different system, IS-41 procedures will have to be defined to set up the connection between the Target MSC and the Serving MSC using a transaction looking like a reverse *FacilitiesDirective*. How such a procedure can avoid unacceptable breaks in conversation, and how the Target MSC will identify the Serving MSC are significant hurdles Whether the benefits of the reduction in system processing that would ensue are necessary is another important issue. Figure 1c shows how such a handoff measurement procedure might work.

WG V - Subscriber Features

Working Group V of TIA sub-committee TR-45.2 is responsible for the definition of cellular subscriber features. This group first defined 3 Party Conferencing, Call Waiting and three types of Call Forwarding in IS-53 Rev. 0, published in 1991. They are now finalizing an extensive revision of IS-53 that will incorporate more exotic features such as Calling Number Identification Restriction and Presentation and control over inter-system Call Delivery. The work of WG V in producing IS-53 complements the production of IS-41 by WG I, II and III. In many cases provision of a standard feature requires extensive support in IS-41 (as was the case with all features in IS-53 Rev. 0) and in some cases a feature of IS-41, such as fully automatic call delivery while roaming, requires subscriber control to be defined in IS-53.

WG V has defined cellular features as closely as possible to the local exchange definition. However, this has led to some complications. In several cases a feature that is easy to provide in a wireline switch is difficult to provide in cellular. A good example is ringing a phone that is hung up with an unanswered party on call-waiting hold. A cellular system has to re-page the mobile before alerting it, and contend with the possibility that the mobile will not respond to the page, or will respond in a different cell, or even a different system. In such cases, WG V has to choose practicality over consistency.

Another conflict with the ways of the wireline industry has been in the assignment of feature codes to services, such as *72 for Call Forwarding - Unconditional. The TR-45.2 proposals for the cellular industry were rejected by Bellcore several years ago. While ongoing discussions have failed to define a mutually acceptable set of feature codes, the cellular industry has been defining feature codes and convenience codes (e.g. *AAA for emergency road service or *CG for the Coast Guard) without central coordination or standardization. Persuading the cellular industry to accept a standard set of codes remains a formidable future challenge.

The chair of WG V is Terry Watts, one of the longest serving and hardest working members of TR-45.2. He is not only chair of this working group, but also the editor of IS-41 and IS-53. His priority for 1993 is to get IS-53 Rev. A completed and published.

Glossary

Bellcore•A research organization owned by the RBOC's. Among its many other functions is responsibility for administration of the **NANP**.

Candidate MSC•An **MSC** with cells bordering on the **Serving MSC** for a mobile needing a handoff.

CDMA•Code Division Multiple Access. A broadband digital cellular air interface being standardized by the TIA TR45.5 committee.

DOJ•US Department of Justice. Through their responsibility in handling the divestiture of AT&T they impose many regulations on the **RBOC**'s, created from that divestiture.

IS-41•The TIA standard for cellular inter-system operations. It exists in three different revisions; 0, A and B, each with successively greater functionality.

MAHO•Mobile Assisted HandOff. Handoff with signal strength measurement performed by the mobile instead of the system. Introduced in the **TDMA** digital cellular standard TIA IS-54. Also to be used in the upcoming **CDMA** standard.

MSC•Mobile Switching Centre. Synonymous with MTSO.

NANPA•NANP Administrator. A branch of **Bellcore**.

NANP•The North American Numbering Plan, covering the area known as **World Zone 1**.

PCS•Personal Communications Services. It has as many definitions as there are competing organizations trying to get into the business. All that can be said is that it is everything that Cellular is, and more, at a lower cost to the subscriber.

RBOC•Regional Bell Operating Company. A **LEC** formed from the breakup of AT&T. Each RBOC and their cellular subsidiaries are restricted from providing long distance service by the **DOJ**.

Serving MSC•The **MSC** currently serving a mobile.

Target MSC•The **MSC** to which a mobile is being handed off

TDMA•Time Division Multiple Access. A new digital cellular air interface standardized in TIA IS-54 Rev. B by the TR45.3 sub-committee.

TIA•Telecommunications Industry Association.

WORLD ZONE 1•The USA, Canada and several Caribbean countries that use the North American Numbering Plan (**NANP**)

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The Evolution of
Inter-MSC Handoff
Measurement Procedures

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1. MSC determines that
mobile signal is weak

2. Candidate MSC
measures signal in
cells near MSC-A

**MSC-A
(serving)**

3. HandoffMeasurementRequest

4. Signal Strength and best Cell ID.

**MSC-B
(candidate)**
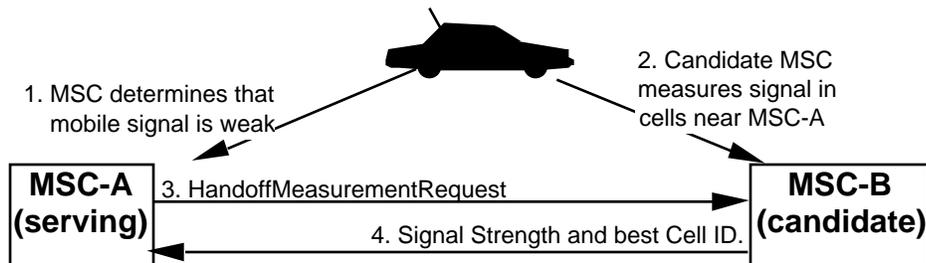
Figure 1a: Handoff Measurement Phase (Analog Cellular, EIA-553)

1. List of candidate channels

2. Mobile measures
signal for each
channel in list

3. Signal strength
for each channel

**MSC-A
(serving)**

**MSC-B
(candidate)**
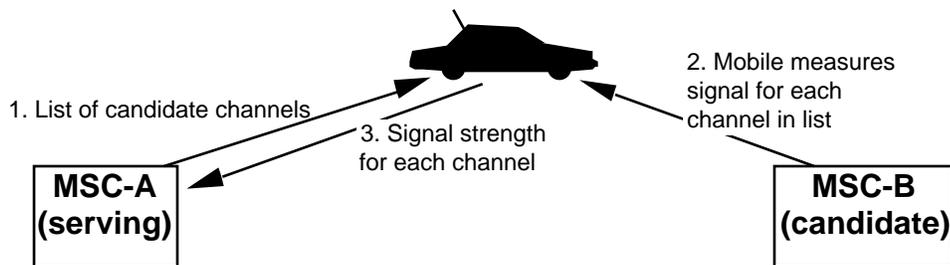
Figure 1b: Mobile Assisted Handoff Measurement (MAHO)

2. Mobile requests a
channel in the
chosen cell

1. Mobile determines that
handoff is needed and
measures the signal of all
control channels

**MSC-A
(serving)**

**MSC-B
(candidate/
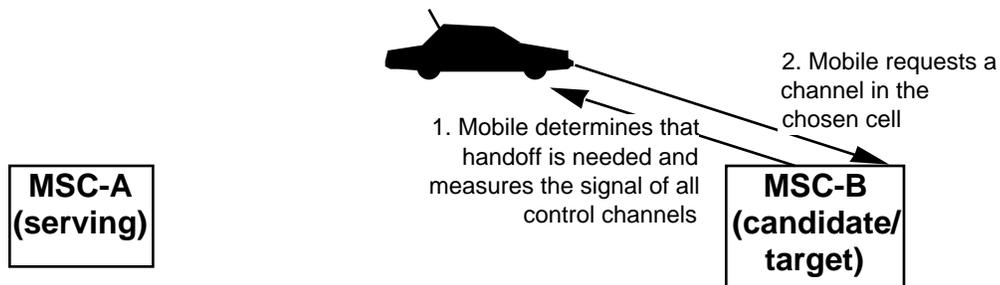target)**

Figure 1c: Mobile Controlled Handoff Measurement (speculation)

Status of
IS-41 Rev. 0
Inter-Vendor Trials

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IS-41 Revision 0 Status (Standard Published February, 1988)					
Vendor1	**Vendor 2**	**Status**	**Completion**	**HV**	**Location**
Astronet	AT&T	Commercial	03/92	H-	Abilene, TX (SBMS)
	NTI	Commercial	10/91	H-	TX-3(ENMR)
AT&T	Astronet	Commercial	12/91	H-	Dallas (SBMS)
	GTE TSI	Commercial		-V	Multiple locations
	Motorola	Commercial	02/91	H-	San Antonio(SBMS)
	NovAtel	Commercial	02/91	H-	Detroit(Ameritech)
	NTI	Commercial	06/91	H-	Detroit(Ameritech)
EDS	NTI	Commercial	08/92	-V	Ft. Meyers (Palmer)
Ericsson	Motorola	Commercial	06/91	H-	New York (Metro One)
	NovAtel	Field Trial	3Q'91	H-	Sacramento, CA (McCaw)
GTE TSI	Astronet	Commercial		-V	Lubbock, TX (SBMS)
	AT&T	Commercial		-V	Several Systems
	Motorola	Commercial		-V	Los Angeles (Pactel)
	NTI	Commercial		-V	Toronto/Cambridge, Ont. (Bell Cellular)
Motorola	AT&T	Commercial	02/91	H-	Austin(GTE Mobilnet)
	EDS	Commercial		-V	Los Angeles (PacTel), USWest (San Diego)
	Ericsson	Commercial	06/91	H-	New Brunswick, NJ (Comcast)
	GTE TSI	Commercial		-V	Los Angeles (Pactel)
	NovAtel	Commercial	07/90	H-	Beaumont, TX (GTE Mobilnet)
	NTI	Commercial	02/91	H-	Philadelphia (Metrophone)
NovAtel	AT&T	Commercial	02/91	H-	Grand Rapids, MI (Century)
(now NTI	Ericsson	Field Trial	3Q'91	H-	Chico, CA (GCC)
CM-800)	Motorola	Commercial	07/90	H-	Lake Charles, LA (Mercury)
	NTI	Commercial	12/89	H-	Calgary, AB (AGT)
NTI	Astronet	Commercial	10/91	H-	NM-4(ENMR)
	AT&T	Commercial	06/91	H-	Windsor(Bell Cellular)
	EDS	Commercial	08/92	-V	
	GTE TSI	Commercial	06/91	-V	Roamer Validation
	Motorola	Commercial	02/91	H-	Allentown, PA (Vanguard)
	NovAtel	Commercial	12/89	H-	Edmonton, AB (Edmonton Tel)

Explanation: Status: Development, Planning, Lab Trial, Field Trial or Commercial
              Completion: Date of actual or expected completion of phase of testing.
              HV: Type of Test ("H" - Includes Handoff, "V" - Includes Roamer Validation)
              Location: Location of Vendor1 Equipment (usually listed for first trial only)

Note: • All IS-41 Rev. 0 Field Trials used the X.25 datalink protocol.
           • IS-41 Rev. 0 procedures include Handoff and Validation.