

Cellular Networking Perspectives

Editor David Crowe • Phone 403-289-6609 • Fax 403-289-6658

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In This Issue ...

The war over North American numbering is far from over, judging from a recent blunt CTIA press release and a Bellcore rebuttal. There are indications that the FCC will be removing numbering administration responsibilities from Bellcore.

The "Seamless Network" is a misnomer. There will always be seams in the cellular network, it is more a question of whether they are noticeable. Boundaries between cellular systems form one of the seams that can be sewn together by inter-system handoff. This issue starts a series of articles which describe the progress towards ubiquitous inter-system handoff using the TIA IS-41 standard.

This issue continues a discussion of the TIA cellular networking sub-committee, TR45.2, this month examining the activities of Working Group II, which is responsible for Automatic Roaming procedures.

CTIA has Bellcore's Number

The CTIA, in a recent blunt press release, accused Bellcore's NANPA of biased assignment of numbering resources. The CTIA is concerned that Bellcore is about to assign the 1-200 series of numbers for personal communications services while refusing to assign 1-200 (or any other 1-N00 code) for cellular. The CTIA complains that Bellcore "is talking about assigning numbers for a service that doesn't exist yet, but is dragging its feet in assigning N00 codes to cellular, which has 9 million subscribers". Bellcore replied that the NANPA was just being cautious in the assignment of 1-N00 codes due to "the limited availability of area codes until 1995 when the present supply will be augmented". Thomas Wheeler, President and CEO of the CTIA responded curtly: "NANPA has delivered an irrelevant and confusing history lesson in its reply to my letter. Unfortunately, it has not addressed the serious numbering issues affecting customers. And that's what our complaint is all about".

The real target of the CTIA letter was not Bellcore, but the FCC, which the CTIA hopes will take NANP management responsibilities away from Bellcore.

Inter-System Handoff Using the IS-41 Standard

Handoff between cells is one of the original features of cellular systems, critical to maintaining calls in a low power, mobile environment. Handoff between different systems is another matter, however. While certainly important, it is not critical, and it required major technical and regulatory hurdles to be overcome before it was even possible. It was not until 1989 that the first commercial handoff between two cellular MSCs occurred, in Alberta Canada between an AGT/NovAtel and an Ed-Tel/NTI system. Since then most MSC vendors have implemented IS-41 Rev.0 or IS-41 Rev. A handoff. Soon the first implementations of IS-41 Rev. B, which contains new handoff features, will occur. On the horizon, in IS-41 Rev. C, is handoff between analog and digital MSCs (TDMA or CDMA). Inter-exchange carriers keep pushing for support for handoff across LATA boundaries using inter-exchange carrier trunks, while regulated carriers are slowly but surely reducing the MFJ barriers that prevented inter-system handoff in many places in the past.

Inter-MS-C Handoff Basics

Handoff, whether inter-system or not, occurs in two phases: measurement, then actual handoff. The measurement phase determines the best cell to handoff to, while the subsequent handoff phase allocates a voice facility and commands the mobile to handoff to it. The procedure for a basic inter-MS-C handoff using IS-41 is illustrated in Figure 1.

Configuration Requirements

Facility requirements for inter-MS-C handoff include datalinks (X.25 level 2 or SS7) to carry TIA IS-41 handoff and trunk signaling messages and trunks to carry voice after a handoff. The datalink is usually paired for redundancy, although X.25 implementations may only support active/standby redundancy. Both inter-MS-C trunks and datalinks are usually carried as timeslots on one or more T1 facilities directly connecting the two neighbouring MSCs.

Compatibility "Gotcha's"

Possible incompatibilities that may complicate the implementation of IS-41 handoff between two MSCs include the datalink protocol, particularly confusion between X.25 Level 2 and Level 3, the type of T1 framing, the modem speed (X.25 only), trunk and cell identifiers and the version of IS-41 used by each MSC.

IS-41 Revision 0 is incompatible with other versions of IS-41, a situation that is not likely to ever be rectified. IS-41 Revision A implementations may be incompatible with Revision B and C implementations. The TR45.2 committee is aware of the IS-41 Rev. A compatibility problems and is developing rules, taken from IS-41 Rev. B, to allow Rev. A systems to be compatible with later versions. IS-41 Rev. B, Rev. C and later implementations should not have compatibility problems.

Testing IS-41 Handoff

Rigorous testing of IS-41 protocols is performed by equipment vendors in lab and field trials before software is released to their customers. However, many cellular operators may wish to perform their own acceptance testing. An IS-41 functionality test will soon be available as a TIA Telecommunications Systems Bulletin (TSB-56). This document is currently being balloted and should be published early in 1993. Like all official TIA documents it will be available from Global Engineering Documents, 1-800-854-7179.

The Measurement Phase

The first stage of any handoff is to measure the signal strength of the mobile on its current frequency in neighbouring, *candidate*, cells. Usually most of the candidate cells are local, and measurement in those proceeds according to proprietary protocols. For candidate cells in another MSC the IS-41 *HandoffMeasurementRequest Invoke* message is transmitted to request a signal strength measurement.

A handoff is only potentially an inter-MS-C handoff during the measurement phase. It is only when a cell in a neighbouring system reports receiving the strongest signal (RSSI) from the mobile that an inter-system handoff is initiated by transmission of an IS-41

FacilitiesDirective Invoke message.

The Handoff (Forward) Phase

The IS-41 *FacilitiesDirective* contains all the information required for its recipient, the Target MSC, to accept a handoff from the Serving MSC. This information includes the identity of the mobile and the inter-MSC trunk that will be used. It is explicitly *not* assumed that the Target MSC retains any information from its time as a Candidate MSC because, back then, it had no idea whether it would later become the target of a handoff or not.

When the Target MSC receives a *FacilitiesDirective Invoke* it allocates a radio channel and responds with its identity (channel number, SAT colour code and Voice Mobile Attenuation Code for EIA/TIA-553 analog cellular) in a *ReturnResult*. The Serving MSC commands the mobile to handoff to the new channel as soon as it receives this message. When the mobile appears on the assigned channel the Target MSC transmits a *MobileOnChannel Invoke* message to the old Serving MSC which then releases the now unneeded radio channel.

This entire complex process is usually completed in under a second, hopefully without the subscriber even noticing that they have traversed a seam in the network.

"Shoelacing" and Handoff Back

One of the concerns of the original developers of IS-41 was that a mobile on the boundary of two systems could handoff back and forth several times, using a new inter-MSC trunk every time. This "shoelace" effect would result in excessive use of inter-MSC trunks. This concern led to the development of "Handoff Back" procedures in the very first edition of IS-41, Revision 0.

Handoff Back, illustrated in Figure 2, recognizes shoelacing as a special case and eliminates one inter-MSC trunk instead of allocating another, thus saving two trunks each time the procedure is invoked. If, as an example, MSC-A hands off a mobile to MSC-B and the mobile requires a handoff back to MSC-A, then MSC-B, recognizing this, can invoke the IS-41 Handoff Back procedures.

When a Serving MSC recognizes that Handoff Back is possible to the Target MSC it sends an IS-41 *HandoffBack* message instead of a *FacilitiesDirective*. The messages are very similar in content, except for information that can be omitted because the Target MSC is already involved in the call. The reaction of a Target MSC to a *HandoffBack* is to allocate a channel and then respond with a *ReturnResult* to the Serving MSC. As in a handoff forward, this causes the Serving MSC to command the mobile to move to the new channel.

The most significant difference between handoff forward and back procedures occurs

after the mobile has moved to the new channel. Instead of sending a *MobileOnChannel* message to the Serving MSC, the Target MSC sends a *FacilitiesRelease* message, as both the inter-MSC trunk and the channel in the old Serving MSC are no longer needed.

Handoff to December

We will continue our discussion of inter-system handoff by considering several more inter-system handoff issues in future editions of *Cellular Network Perspectives* 3 Party Calling, Path Minimization, TDMA and CDMA handoff, Inter-Exchange Carrier involvement in handoff and problems with low power cells. Then we will indulge in some speculation about further improvements to handoff that may be possible or necessary in the future.

TR45.2 Working Group II

Working Group II of the TR45.2 sub-committee is responsible for defining procedures for Automatic Roaming. According to the chair, Cheryl Blum of AT&T, its major goal for 1993 is to develop procedures for automatic roaming by CDMA terminals, TDMA terminals using the Digital Control Channel and terminals in border areas. These procedures will then be incorporated in Revision C of IS-41, due out in mid-1993. WG II will also develop procedures to allow the use of features defined in Revision A of IS-53 (e.g. Voice Mail Notification) while roaming. After Working Group II develops procedures it feeds them to WG I to be integrated into IS-41.

Working Group II is chaired by Cheryl Blum of AT&T. Her telecommunications experience began with the design and development of software for the AT&T 1ESS electronic switching system. Prior to her TR45.2 assignment Cheryl worked on requirements definition and software version planning for the AT&T Autoplex cellular system.

Glossary

Candidate MSC•One of possibly several MSCs in which signal strength measurements are taken when a handoff in an area bordering two systems is required.

ErrorResult•The IS-41 message type used to respond to an *Invoke* with an error indication.

FacilitiesDirective•The IS-41 message used to initiate an inter-MSC Handoff Forward.

FacilitiesRelease•The IS-41 message used to release an inter-MSC trunk following a Handoff Back, handoff failure or the end of a call.

HandoffBack•The IS-41 message used to initiate the Handoff Back procedure, which eliminates "shoe-lacing".

Inter-Exchange Carrier•A carrier licensed to carry public long distance traffic.

Invoke•The IS-41 message type used to

initiate an operation. The response is normally an **ErrorResult** or a **ReturnResult**.
IS-41•The cellular inter-system protocol for AMPS-compatible cellular (e.g. EIA/TIA-553 analog, TDMA and CDMA digital).

LATA•Local Access and Transport Area. Regional Bell Operating Companies, including their cellular subsidiaries, can provide service between points within this area, but must use an Inter-Exchange Carrier to connect to points outside.

MFJ•Modified Final Judgment. The US Department of Justice decision that broke up AT&T in 1984. It constrains the operations of the Regional Bell Operating companies, including their cellular subsidiaries, across LATA boundaries.

MobileOnChannel•The IS-41 message used to complete a Handoff Forward operation, informing the Serving MSC that the Target MSC has received the mobile and that the radio channel in the Serving MSC can now be released.

MSC•Mobile Switching Centre. A cellular switch, also known as an MTSO.

NANPA•North American Numbering Plan Administrator. Currently a department within Bellcore.

ReturnResult•An IS-41 message type that indicates successful completion of the operation requested in an *Invoke*.

Serving MSC•The MSC currently serving a mobile that requires an inter-MSC handoff.

SS7•A data communications protocol commonly used between telephone switches.

Target MSC•The MSC chosen to receive a handing-off mobile.

TSB•Telecommunications Systems Bulletin. An informational document from the TIA that does not have the status of a standard.

X.25•A data communications protocol commonly used in online services such as electronic mail.

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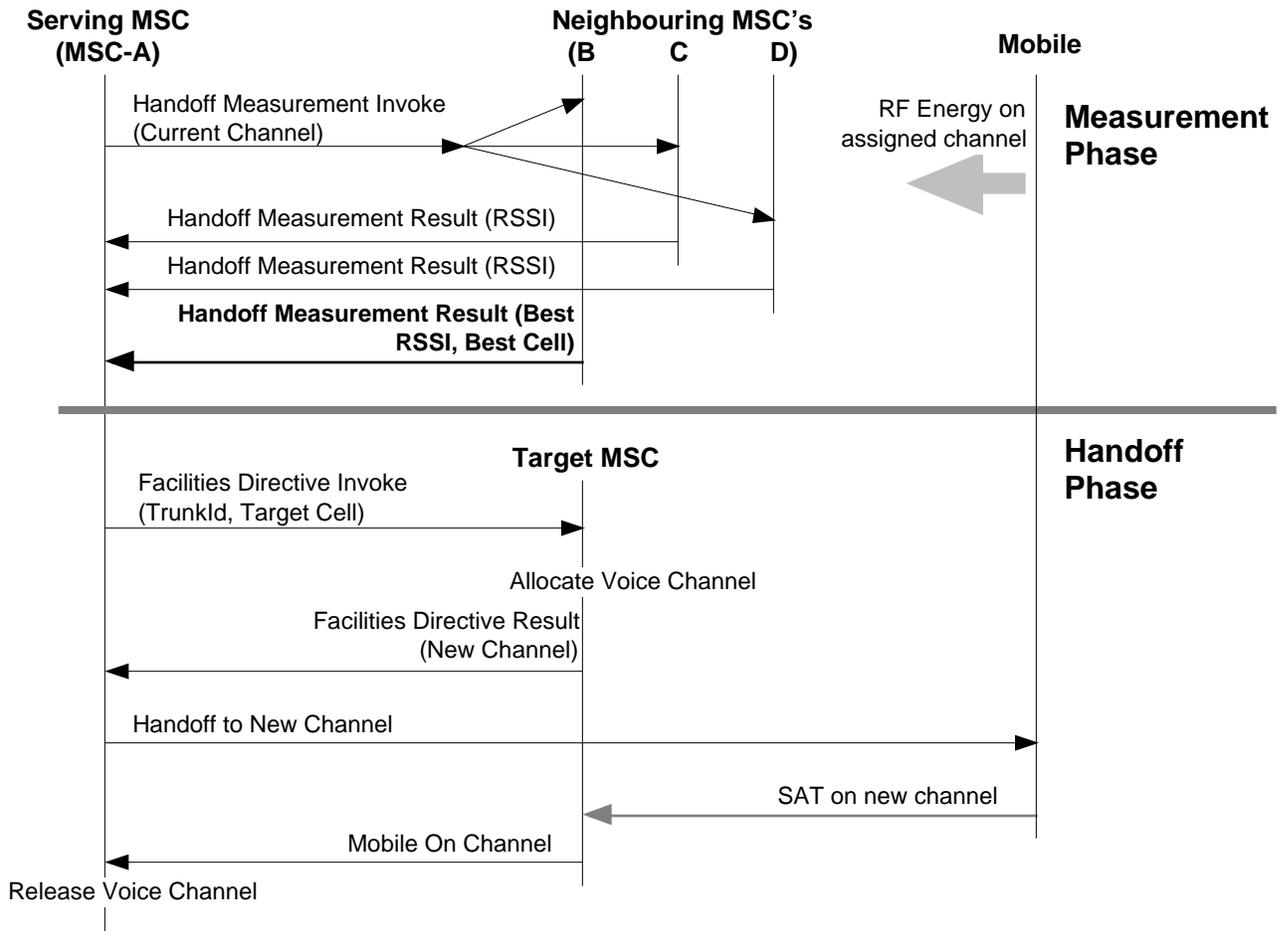


Figure 1: Inter-MSC Handoff Forward using TIA/IS-41 Protocols

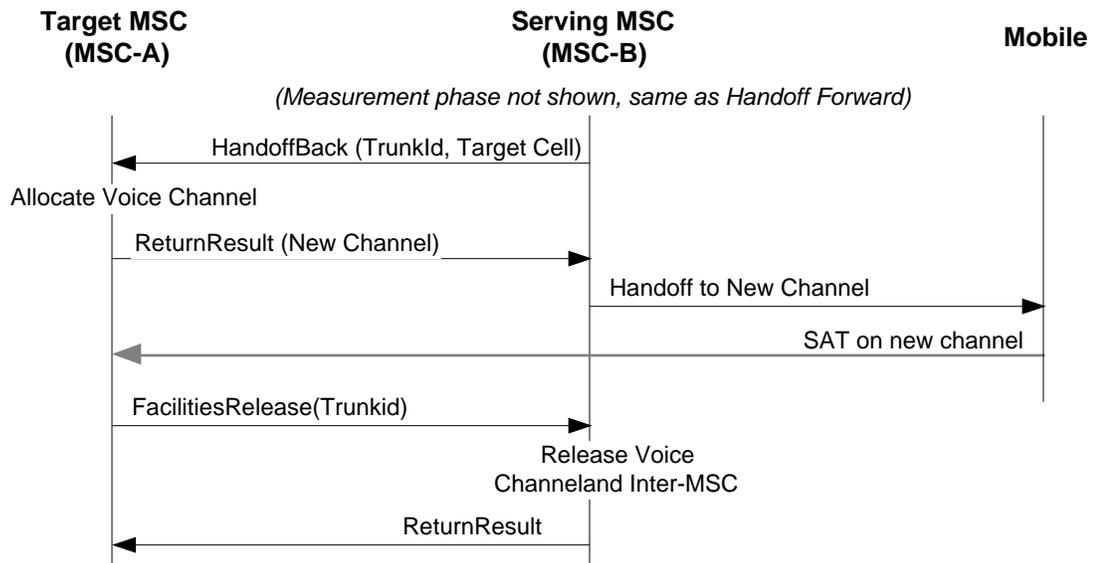


Figure 2: Inter-MSC Handoff Back using TIA/IS-41 Protocols