Cellular Networking Perspectives

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Next issue: March 4, 1998

Australia to Annihilate AMPS?

Australia currently has four cellular systems, one AMPS analog system by Telstra, and three GSM digital systems by Telstra, Optus and Vodafone. According to the Australian Telecom Act, the AMPS system is to be turned off by January 1st 2000. This may not please the AMPS customers who, on one system, number 2,700,000 (according to Cellular Business (April 1997) using US Dept. of Commerce statistics) while the three GSM systems had a combined total of only 1,800,000 customers.

An Australian group of angry mobile phone users, known as APUMP (Association for the Protection of Users of Mobiles Phones, www.apump.com) is fighting the pending demise of their system being planned by the Australian Communications Authority (www.sma.-gov.au/aca.htm). APUMP believes that not only have more Australians chosen AMPS than GSM, but they have the right to continue to make that choice.

APUMP also claims that AMPS provides up to ten times the coverage area than GSM from a single cellsite in rural areas, and that Telstra's AMPS coverage maps are overly conservative to obscure this advantage. GSM phones are also more expensive when mandatory service agreements are considered. There have been signs from the government that rural areas would be allowed to keep their AMPS systems after the year 2000, with only metropolitan areas being forcibly transferred to GSM. This, however, creates a compatibility problem, and would force many people to purchase two cellular phones: AMPS for the outback and GSM for the city.

APUMP is not opposed to digital cellular, but would clearly prefer a system that is compatible with AMPS, such as IS-95 CDMA or IS-136 TDMA. These systems would allow a migration to digital, with nobody being forced to purchase a new phone, and with nobody with a digital phone being denied coverage in rural areas. With a federal election scheduled for 1998, this issue could become a hot political potato.

If AMPS is given a reprieve, the decision could give new life to the analog system, perhaps allowing the development of international roaming agreements between Australia and other worldwide AMPS-based systems, something that is pointless when the very existence of the system is in doubt.

Website Upgrades

The *Cellular Networking Perspectives* website is continually upgraded and improved. It's not flashy, but it is fast and useful. Try out some of our new links by surfing to:

www.cnp-wireless.com/pointers.html

We have new and improved links for:

- GSM
- APUMP (see previous article)
- IFAST (see January 1998 issue)
- North American Numbering Plan

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International Applications of TIA Wireless Standards, Part II: Born in the USA

The TIA cellular and PCS network interoperability standard, TIA/EIA-41, still bears the stamp of its US heritage. "AMPS" emerged from a single country environment (for telephony purposes, the networks of Canada and the Caribbean are integrated with the US network), with a relatively huge number of licenses. GSM, by comparison, grew up in Europe, with many countries, but few wireless licenses within each country. Consequently, international roaming has only recently received adequate attention from the "AMPS" industry.

Part I of this article (see January 1998 issue) described the problems caused by the reliance of many wireless networks on a US directory-number based MIN, and the international challenges of SS7 signaling. We conclude by considering the influence of the North American Numbering Plan on TIA/EIA-41 and by describing some additional problems with IMSI in GSM, CDMA and D-AMPS systems. We have also included a list of current International Roaming MIN assignments (Table 1 and www.ifast.org).

North American Numbering Plan

The North American numbering plan (NANP) is a 10 digit dialing plan that applies to the US, Canada and many Caribbean nations, sharing the Country Code "1". Until January 1998, the allocation of NANP resources (e.g. area codes) was performed by Bellcore. Now, however, this function is being performed by Lockheed Martin (www.nanpa.com).

NANP numbers are used by many wireless systems not only for Mobile Directory Numbers (and unfortunately, usually also for Mobile Identification Numbers), but also for Temporary Local Directory Numbers (TLDN's) and for some internal TIA/EIA-41 purposes. Wireless systems outside the US have made their own accommodations to national numbering plans. However, interworking between these systems is not guaranteed at present.

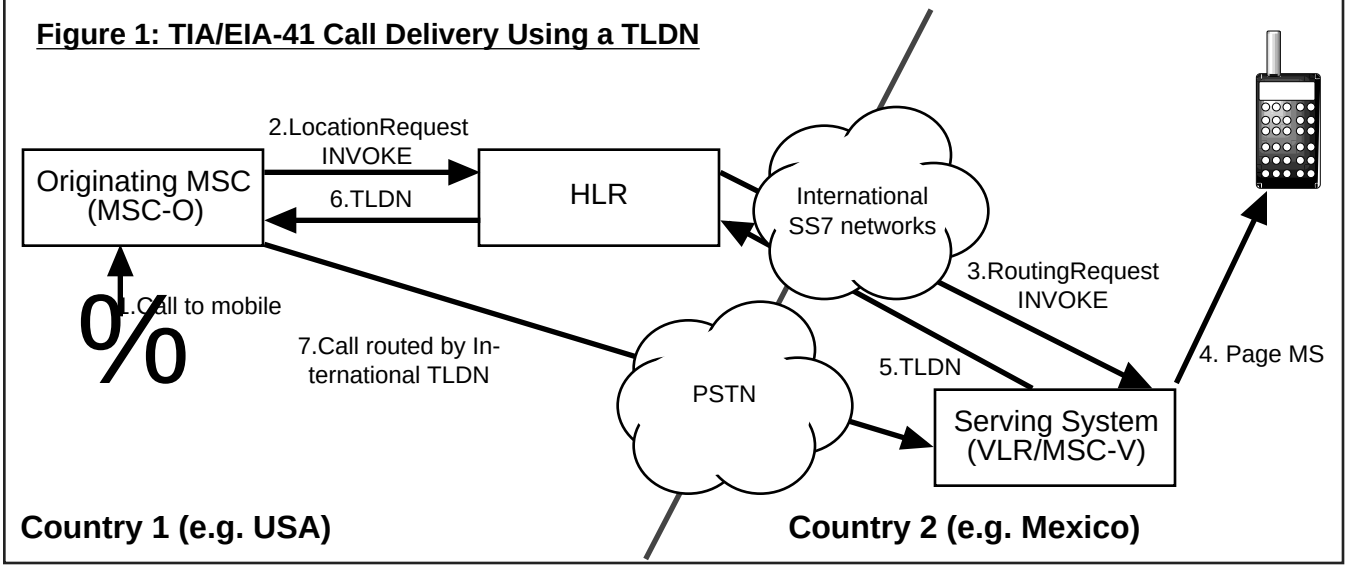
TLDN: Temporary Local Directory Number

The TLDN concept is critical to wireless call delivery (see the March 1994 issue and Figure 1). TIA/EIA-41 uses signaling messages to determine whether a call can be terminated to a mobile (LocationRequest and RoutingRequest). If it can, the MSC currently serving the mobile provides a directory number that belongs to that system (i.e. local). This number is returned to the originating switch, which can then launch a regular call through the Public Switched Telephone Network (PSTN). Because a directory number that is local to the serving MSC was provided, the PSTN will route the call to that system. When the call arrives, the incoming TLDN digits are cross-referenced with the MIN or IMSI and ESN that identifies the mobile, allowing the call to be terminated to the mobile. At this point, the TLDN can be released (hence the name "Temporary" Local Directory Number).

This process relies on the Originating switch being able to recognize the TLDN. What if the Originating Switch is in a difference country from the current Serving MSC? Currently, many systems will provide a national directory number as the TLDN, which may be misrouted by the Originating Switch, unless special accommodation is made (e.g. Mexican systems may recognize 10 digit TLDN's as being from the NANP, and insert the Country Code "1"). Alternatively, based on knowledge of the Serving MSC, systems could reformat the directory number. However, these are not desirable, long term solutions.

Standards have recently addressed this problem. TSB41, in essence an erratum to IS-41 Revision B, provided for a National/International indicator (with

Figure 1: TIA/EIA-41 Call Delivery Using a TLDN



"1" in the low order bit of the Nature of Number field in the Digits parameter indicating an international number, for those who really care!). IS–41 Revision C took a step sideways by defining the National/International indicator incorrectly, and in a way that would have be incompatible with IS–41 Revision B if implemented. The first ANSI version of IS-41 (TIA/EIA-41 Revision D) is due for publication soon, and has corrected this error.

This solution means that systems can choose to provide a national TLDN number when routing between two systems in the same country, using the international format in other situations. In the US context, a national number is 10 digits long (3 digit area code + 3 digit office code + 4 digit line number). The same TLDN in the international format (known as ITU-T Recommendation E.164) would be 11 digits long, the 10 digit national number prefixed with Country Code "1'. Other countries will have national formats that are usually not 10 digits long, and international formats that are often not 11 digits.

Even with the ability to encode a TLDN as an international number, software in many MSC's will have to change to accommodate international numbers. Routing an international TLDN may require the use of special prefixes (e.g. 011 from the NANP), special trunk groups or special signaling formats, depending upon interconnect arrangements and national signaling formats. Not only that, but when a national number is encoded in the international format (a perfectly legitimate thing to do), the special handling should *not* be applied or the call will likely fail within the PSTN.

Other NANP Influences

Apart from the TLDN, the NANP has had several other corrupting influences on IS–41 and TIA/EIA–41:

i. Hotline numbers were defined as 10 digit NANP numbers up to IS–41 Revision C, but are unconstrained in TIA/EIA-41, and may be formatted as international numbers.

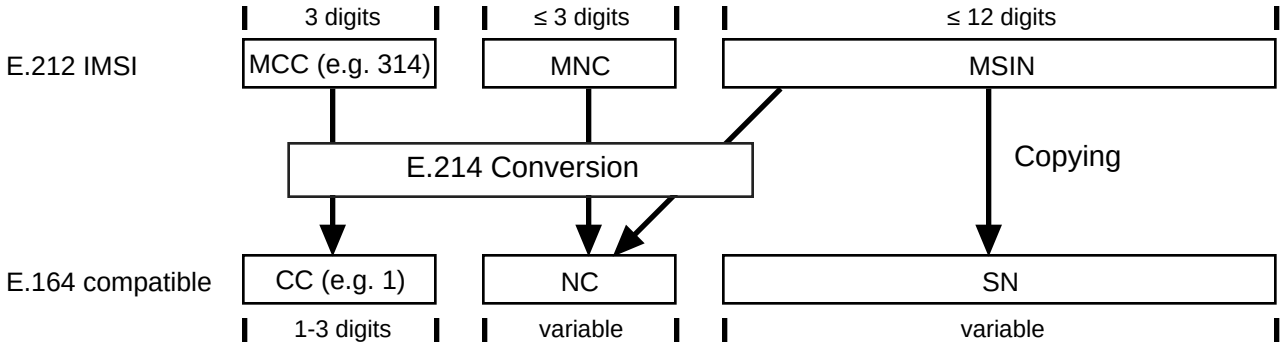
ii. Similarly, it was possible to restrict callers to dialing a specific 6 digit NPA-NXX code in IS–41 Revision A, B and C. TIA/EIA-41 allows prefixes of other lengths to be specified, although the issue of how to determine where the prefix is in the dialed digits is not defined, as a user of this service would have to prefix their local number with an international access code.

iii. Some TIA/EIA-41 messages allow specification of preferred carrier digits – Digits(Carrier). This parameter was first applicable in the US, to convey the identity of a roamer's preferred long distance carrier in their profile. This concept is needed in any country with long distance competition, where wireless carriers support a choice of carriers. However, the carrier digits are generally national in scope and cannot be used internationally. This may require either the HLR, VLR or Serving MSC to filter out this information.

iv. Two TIA/EIA-41 parameter types differentiate between intra-LATA and inter-LATA calls. The LATA concept is foreign to non-NANP dialing systems, so it is not clear how best to handle a roamer in these situations. One parameter is the OriginationIndicator that can constrain a roamer from making Intra-LATA Toll and Inter-LATA Toll Calls. Another is the OriginationTriggers parameter, which can provide special treatment for either or both of these call types.

A LATA is a geographical area within which a Bell Operating Company (RBOC) was restricted to offering its services by the Modified Final Judgment that resulted in the breakup of AT&T. Because some calls within a LATA may be toll calls, a distinction must be made between intra-LATA toll (handled by the RBOC) and inter-LATA toll (handled by an inter-exchange carrier, such as AT&T, MCI or Sprint). Because of this history, the LATA concept is not applicable to wireless systems outside the US. The best solution for wire-

Figure 2: E.214 Global Title Conversion



Note: Once one of the 25 North American MCC codes has been translated to the shared E.164 Country Code "1", it is impossible to route to the correct country within the NANP area.

less systems outside the US is to ignore any intra-LATA parameters and parameter values, and treat inter-LATA as synonymous with National Long Distance.

Triple Trouble with IMSI

Three major cellular and PCS technologies support IMSI today: GSM, CDMA (IS–95 Rev. A) and D-AMPS (IS-136 Rev. A TDMA). While the IMSI concept definitely has international roaming benefits, the idiosyncrasies of the individual implementations must be understood.

GSM

GSM systems have two troubles with IMSI. The first is that the SIM (Subscriber Identity Module – "Smart Card") contains a list of Preferred and Forbidden systems, identified by the first 5 digits of an IMSI (MCC + 2 digit MNC). This limits the number of systems per Mobile Country Code to 100, more than adequate for Europe, but not for the United States, which has hundreds of PCS licenses that could potentially use GSM technology. Luckily, these lists contain a spare digit, that can be used in phones adapted for the US market. However, for the foreseeable future, IMSI codes for GSM mobiles will have to be distinct in the first 5 digits.

A second problem is that GSM MAP network routing relies on the ITU-T E.214 global title. This global title is essentially a kludge, mapping the E.212 IMSI onto a pseudo-E.164 number to reach the home country using standard E.164 ("phone number") translations (see Figure 2). This works well in Europe, where there is virtually a 1-to-1 relationship between E.212 Mobile Country Codes and E.164 Country Codes. However, it does not work at all when routing messages to North America, where about 25 MCC's map onto a single E.164 landline Country Code.

The only long term solution to this problem is to migrate GSM networks to a true E.212 global title.

Table 1: International Roaming MIN Assignments

IRM	Carrier
000X	TDMA Carriers (Over-the-Air Service Provisioning)
0XX1	BellSouth Cellemetry, USA
0112-8	Korea Mobile Telephone, Republic of Korea
0128	Piltel, Philippines
0172-8	Shinsegi, Republic of Korea
0188-9	Mobikom, Malaysia
038X	NACN GSM Gateway, USA
05XX	Wireless carriers, Mexico
0658	SingTel Mobile, Singapore
0659	MobileOne (Asia), Singapore
0732	Comcel, Colombia
0733, 0737	Wireless carriers, Colombia
0886-7	Iridium, International Satellite
0972-3	Pele-Phone, Israel
0998	HighwayMaster, USA
1XX0	BellSouth Cellemetry, USA
109X	GTE Mobilnet, USA
110X	Rogers Cantel, Canada
1119	Telefonica del Peru, Peru
1221	Unifon, Argentina
1276, 1286, 1292, 1294	Cellular One of Boston (Southwestern Bell)/ HighwayMaster
1311	ReadyCom, USA
1471	USA-TELL, USA
1519	CRT, Brazil
1540-9	Miniphone and Movicom, Argentina
1585-7	Movilnet, Venezuela
1627	Mobility Canada, Canada
1692	Startel, Chile
1751	GTE Mobilnet, USA
1982, 1987	Mobility Canada, Canada
1991-9	HighwayMaster, USA

CDMA

The CDMA standard IS-95 was the first to be adapted to the IMSI concept. At that time, it was believed to be more beneficial to keep the MIN and IMSI aligned than to take advantage of the MNC concept. Consequently, the IMSI format for IS-95 is:

MCC+00+MIN

For a registering IS-95 mobile, it is only possible to recognize the home country, not the specific home system (unless the digits of the MIN are analyzed, which is unlikely). This should still result in correct routing, but not optimal routing, as an intelligent choice of signaling network cannot be made.

D-AMPS (IS-136 TDMA)

TDMA systems also have an anomaly with IMSI, relating to authentication. If an IS-136 terminal has both a MIN and an IMSI programmed in, and it uses the IMSI as an access identifier, it will still use the MIN for authentication calculations. This puts the Serving MSC in the awkward position of requiring a piece

of information from the mobile that is not made available in the access. Luckily, it is easy for the network to fix this problem. PN-3892, which was approved for publication as IS-751 in December 1997, allows the MIN to be provided in the AuthenticationRequest RETURN RESULT to allow the Serving MSC to obtain this critical piece of information.

Conclusions

There are many challenges on the road to totally seamless international roaming using phones based on TIA cellular and PCS standards. However, given the extensive global market penetration of these standards, and a growing awareness of the benefits of international roaming, it is only a matter of time before these challenges are overcome.

Glossary

AMPS	Advanced Mobile Phone Service (Analog).
CDMA	Code Division Multiple Access (digital). The IS–95 version has an AMPS compatibility mode.
D-AMPS	TDMA digital cellular with AMPS compatibility mode.
GSM	Global System for Mobility. TDMA digital cellular of European heritage.
HLR	Home Location Register
IMSI	International Mobile Station Identity (defined by ITU-T E.212).
IS-	TIA Interim Standard
ITU	International Telecommunications Union
LATA	Local Access & Transport Area
MCC	E.212 Mobile Country Code (first 3 digits of IMSI).
MNC	E.212 Mobile Network Code (part of IMSI, up to 3 digits long).
MSC	Mobile Switching Center.
NANP	North American Numbering Plan
NPA	NANP Numbering Plan Area (“Area Code”)
NXX	NANP Office Code (3 digits)
PN-	TIA Project Number.
PSTN	Public Switched Telephone Network.
TDMA	Time Division Multiple Access (see D-AMPS, GSM)
TIA	Telecommunications Industry Association
TLDN	Temporary Local Directory Number
VLR	Visitor Location Register

TIA TR-45.2 Cellular/PCS Network Standards Report

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Superseded Interim Standards and TSBs

IS/TSB	Description	Published
IS-41-B	Cellular Radiotelecommunications Inter-System Operations	12/91
IS-52-0	Cellular Subscriber Dialing Plan and Service Codes	11/89
IS-53-0	Cellular Features Description	09/91
TSB29-A	**International Implementation of Cellular Systems Compliant with TIA-553**	**09/92**
TSB41	Technical Notes for IS-41 Revision B	11/94
TSB51	Inter-System Authentication, Signaling Message Encryption and Voice Privacy	05/93
TSB55	IS-41 Rev. A/B Forward Compatibility	05/94
TSB64	Wideband Spread Spectrum Intersystem Operations	02/94

ANSI Standards and Annexes

ANSI #	SP #	TIA IS-	Subject	Published
TIA/EIA-41	**SP-3588**	**IS-41-C**	**Intersystem Operations**	**12/97**
TIA/EIA-660		IS-52-A	Dialing Plan	09/96
TIA/EIA-664		IS-53-A	Features	09/96
n/a	**SP-3580A**	**J-STD-025**	**Lawfully authorized electronic surveillance**	**ANSI review**
J-STD-034	**SP-3581**	**n/a**	**Enhanced Wireless 9-1-1, Phase I**	**in press**

Published TIA/EIA Interim Standards

IS-	Description	Published
IS-41-C	Cellular Radio Telecommunications Intersystem Operations	02/96
IS-52-A	Uniform Dialing Procedures for use in Cellular Radiotelephone Systems	03/95
IS-53-A	Cellular Features Description	04/95
IS-93-0	Ai and Di Interfaces Standard (PSTN/MSC)	12/93
IS-124-0	Cellular Inter-System Non-Signaling Data Communications	11/93
IS-124-A	**Cellular Inter-System Non-Signaling Data Communications**	**09/97**
IS-725	**IS-41 support for Over-the-air Service Provisioning (OTASP)**	**12/97**
IS-728	Inter-System Link Protocol	in press
IS-730	**IS-41 Support for IS-136 DCCH (TDMA digital control channel)**	**10/97**
IS-751	**TIA/EIA-41 support for IMSI (International Mobile Station Identity)**	**in press**
J-STD-025	**Lawfully Authorized Electronic Surveillance (joint with ATIS T1)**	**12/97**

Published Telecommunications Systems Bulletins (TSBs)

TSB	Description	Published
TSB29-B	**International Implementation of Wireless Systems**	**10/97**
TSB29-B-1	**Updated MIN assignment and SID conflict tables for TSB29-B**	**in press**
TSB56-A	Application Level Testing for IS-41 Rev. B, IS-53 Rev. 0 and TSB51	06/94
TSB76	PCS Multi-Band Support	09/96

Balloting TR-45.2 Projects (PN = TIA Project Number)

PN/SP	Description	Status	WG	Standard
PN-3295	**Ai and Di Interfaces Standard**	**ballot**	**VII**	**TIA/EIA-93-A**
PN-3619	IS-41 Support for IS-95-A (advanced CDMA)	pre-publication	II	TIA-41 annex
PN-3770	**IS-41 support for data services for digital terminals (TDMA and CDMA)**	**pre-publication**	**II**	**IS-737**
PN-3980	**Wireless Number Portability, Phase I (database query)**	**reballot**	**II**	**n/a**

Developing TR-45.2 Projects (PN = TIA Project Number)

PN/SP	Description	Editor	Standard
PN-3362	Cellular Features Description (Rev. B)	Terry Watts	TIA/EIA-664-B
PN-3590	Intersystem Operations	Terry Watts	TIA/EIA-41-E
PN-3661	Wireless Intelligent Network	Terry Jacobson	TIA/EIA-41-E
SP-3816	**Call detail/billing record transfer for data and enhanced services (e.g. WIN)**	**Peter Larsen**	**TIA/EIA-124-B**
PN-3890	Enhanced 9-1-1, Phase II (125 m. location accuracy)	Terri Brooks	n/a
PN-4081	**Authentication enhancements**	**Nick Mazzarella**	**TIA/EIA-41-E**
PN-4103	**Calling Name Presentation/Restriction**	**Terry Jacobson**	**TIA/EIA-41,-664**
PN-4104	**Broadcast/Multicast Short Message Service**	**Michel Houde**	**TIA/EIA-41,-664**
PN-4117	**International Implementations of Wireless Systems**	**Steve Jones**	**TSB29-C**
PN-xxxx	**TSB29-B addendum, including IFAST #7 updates (02/98)**	**Steve Jones**	**TSB29-B.2**
PN-xxxx	**Law enforcement support beyond CALEA**	**n/a**	
PN-xxxx	**Wireless Number Portability, Phase II: portable mobile directory numbers**	**Chuck Ishman**	
PN-xxxx	**Wireless Intelligent Network (WIN) Phase II: charging capabilities, etc.**	**n/a**	

Note: 1. IS- Interim Standard, J-STD- Joint ATIS/TIA Standard, PN- Project Number, SP- ANSI Standards Proposal , TSB– Telecommunications Systems Bulletins.

2. **Bold Type** indicates modification since previous publication.

3. Published TIA standards can be obtained from Global Engineering Documents at 1-800-854-7179.