# Cellular Networking Perspectives

Editor David Crowe • Phone 403-289-6609 • Fax 403-289-6658 Vol. 4, No. 8 August, 1995


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### Comments Welcome

We welcome comments on the contents and format of this newsletter, suggestions for future topics, letters, submissions and corrections. You may phone in your comments to 1–800–633–5514 (1–403–289–6609) or fax them to 1–403–289–6658.

**Next issue: Sept. 5, 1995**

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## TIA Standard IS-136 Part I: Advanced TDMA Digital Cellular and PCS

IS-136 is the second generation digital cellular standard based on TDMA (Time Division Multiple Access). It adds the features that its proponents hope will allow it to compete with its major rivals in the PCS frequency band; European GSM cellular and Qualcomm's CDMA (Code Division Multiple Access).

### Development of IS-136

IS-136 is built atop the first generation TDMA cellular standard: IS-54 which, in turn, was built on the EIA/TIA-553 analog cellular stan-

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*Cellular Networking Perspectives* (issn 1195-3233) is published monthly by Cellular Networking Perspectives Ltd., 2636 Toronto Cr. NW, Calgary AB T2N 3W1, Canada. Phone: 1-800-633-5514 or 1-403-289-6609. Fax: 403-289-6658. **Subscriptions**: CDN$250 in Canada (incl. GST), US$250 in the USA and US$300 elsewhere. Payment by cheque, money order or American Express Card. Issues are faxed or mailed 1st class. **Copies:** Each subscriber may make up to 10 copies of each issue. Rates are available for more copies. **Discounts:** Educational and small business rates: CDN$150 (incl. GST), US$150 and US$200, by mail only. **Back Issues:** Phone for contents and prices.

dard. IS-136 was developed by the TIA TR-45.3 standards subcommittee, and was approved for publication in December, 1994. An enhanced version (IS-136 Rev. A) is already under development. IS-136 is being promoted by the "TDMA Forum", a loose consortium of companies with an interest in AMPS-based TDMA wireless standards (namely IS-54 and IS-136). John McQueen, TDMA Forum project manager, claims that over 1,000,000 IS-54 TDMA cellular telephones are in service worldwide. His hope is that these customers, and more, will turn to IS-136 phones as soon as they are available.

IS-136 is actually one of a series of standards, and is loosely used to refer to the entire set. See Table 1 for a list of the family of DCCH TDMA standards and Table 2 for a list of other cellular standards. Members of the TDMA forum are listed in Table 3.

**Table 1: The IS-136 Family of Standards**

| Standard | Description |
|---|---|
| **IS-136** | TDMA Air Interface using Digital Control Channel (DCCH) |
| IS-130 | TDMA data radio link protocol |
| IS-135 | TDMA asynchronous fax and data air interface |
| IS-137 | DCCH mobile performance standards |
| IS-138 | DCCH base station performance standards |
| PN-3466 | Digital hands-free performance standards |
| PN-3467 | ITU-R G.729 based voice coder |
| PN-3474 | IS-136 Revision A |
| PN-3486 | Addendum to IS-136 (included with copies of IS-136) |

## A Channel By Another Name ... Could be Something Else Again

The most confusing term used in IS-136 and other air interface standards is 'channel'. By itself, it means nothing. Only when qualified by another word does it have meaning. Some of the 'channel' words used in this article are:

| Channel Type | Description |
|---|---|
| Cellular | A pair of 30 khz radio channels used to transmit and receive a single analog cellular conversation, or multiple TDMA conversations. |
| Control | A cellular or TDMA channel that is dedicated to the transmission of signaling data (e.g. mobile registrations, originations and page responses) |
| Logical | A stream of related data messages transmitted in multiple packets on a control channel |
| Radio | A single allocation of contiguous spectrum (30 khz in cellular). |
| TDMA | A sequence of timeslots (1 out of 3 or 1 out of 6) within a cellular channel |
| Traffic | A TDMA channel used to carry voice (or user |
| Voice | A 30 khz channel used for a single analog conversation. |

## What is TDMA?

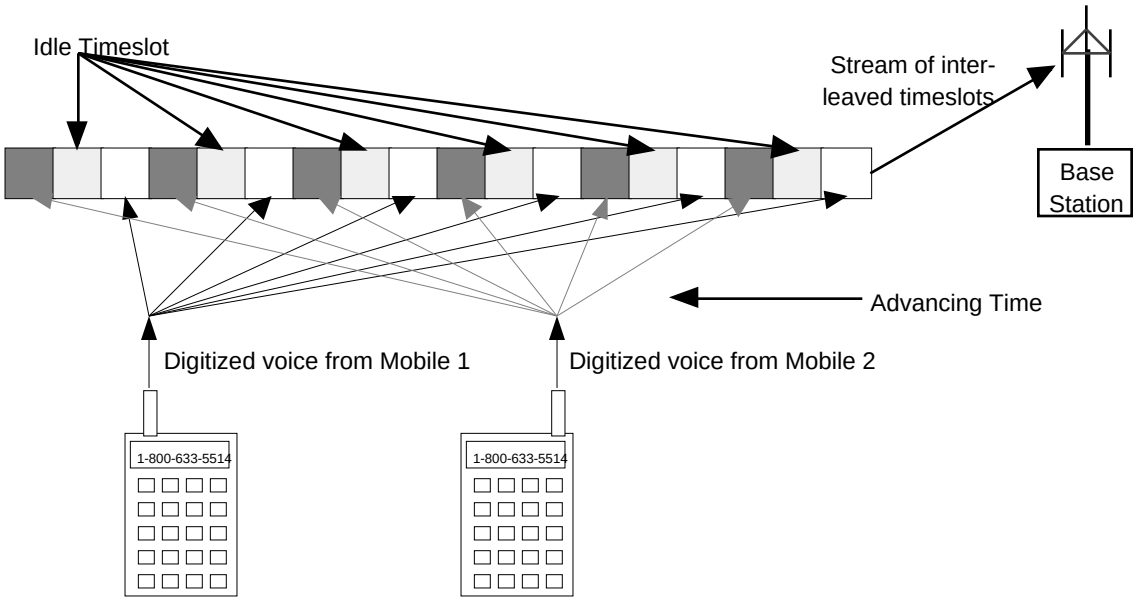
TDMA technology divides a single radio channel into a number of time slots ("Time Division") allowing it to be shared ("Multiple Access"), and thereby increasing the capacity of the channel. In the first generation TDMA digital cellular standard, IS-54, time division multiplexing applies only to voice, but in IS-136 this technique has been extended to control channel messages as well. Voice is carried over a TDMA channel by first digitizing and compressing the voice in a way that it can be transmitted in one-third of its actual time duration. Each terminal then transmits each tiny packet of coded voice in a strict rotation. The base station performs a similar function, taking in three conversations, digitizing them and transmitting at the same frequency to each of the three terminals in strict rotation. Both IS-54 and IS-136 support TDMA with three voice conversations on each 30 KHz cellular channel, although there are plans for supporting six or more users in separate TDMA channels in the future.

**Table 2: Other Cellular Air Interface Standards**

| Standard | Description |
|---|---|
| EIA/TIA-553 | Standard analog air interface |
| IS-54-B | First commercial TDMA air interface standard |
| IS-88 | NAMPS analog air interface |
| IS-91 | New analog air interface, including NAMPS and authentication |
| IS-95 | CDMA air interface standard |

An analogy (adapted, with thanks, from Tom Farley of *Private Line*) to illustrate the time division concept is to imagine 3 spies on a carousel trying to pass a message to their compatriot operating the carousel . On each turn, a spy gets one-third of the time to talk. Their compatriot on the ground has to separate out the three interleaved conversations before passing the message on to the spy master. To

**Figure 1: The Time Division Concept in Cellular and PCS**




complicate matters, if the spies want to converse at their normal speed, they will have to invent a shorthand or compression scheme.

TDMA is not the only multiplexing scheme that has been applied to cellular and PCS to squeeze more capacity out of a radio channel. NAMPS (TIA IS-88), in contrast, uses an analog frequency division scheme to also allow a channel to be used simultaneously by three different users. CDMA (TIA IS-95) uses a spreading code to transmit many conversations simultaneously over a much wider bandwidth (1.25 MHz), using the unique code to separate out the conversations.

## Control Channels and Traffic Channels

Cellular systems require both Traffic and Control channels. Traffic channels carry voice or data between a mobile phone and a base station, along with a small amount of signaling data required to process in-call events (such as disconnect, answer, handoff and flash requests). Control channels require a much more complex protocol to support the allocation of traffic channels for mobile originated and mobile terminated calls, to track mobiles and to perform numerous system management tasks. Control channel protocols are made even more complex by the necessity to resolve the contention inherent in multiple phones attempting to access this shared resource.

On analog and on IS-54 TDMA systems, the control channel is in a separate cellular channel from the traffic channels. IS-136 however, introduces a Digital Control Channel (DCCH) that occupies only a single TDMA channel.

As an aside, the name “Digital” Control Channel is somewhat of a misnomer as the so-called “Analog” Control Channel is also quite clearly digital. The analog connotation comes from its association with analog traffic channels, although this control channel was extended in IS-54 to also support digital traffic channels. But, as Shakespeare probably is tired of hearing repeated, “A rose by any other name would smell as sweet”.

## Signaling on Voice and Traffic Channels

The most common traffic on cellular systems is voice. Analog systems transmit an analog representation of voice in a full 30 khz channel or, in NAMPS, through frequency division into three 10 khz analog sub-channels. Signaling information can be transmitted across an analog voice channel either as special tones or as “blank and burst” messages that disrupt the voice traffic for a fraction of a second. IS-54 (and IS-136) digital traffic channels convert and compress the voice signal to 1’s and 0’s using a standardized voice coder. The digitized voice is inserted into frames that also include error correction and a low speed control channel (SACCH). Each frame fits into a single timeslot. A high speed control channel (FACCH) can also be invoked in a “blank and burst” mode, discarding a few voice frames in favour of the FACCH frames. While analog traffic channels have inferior in-band control channel capabilities, they can be used directly for modem-based fax and data applications. Digital channels cannot generally transmit data using standard or even special cellular modems, as the voice coder is not suited for use with modem tones.

## Digital Control Channel (DCCH)

The digital control channel is the heart and soul of IS-136. It melds some aspects of the IS-54 digital traffic channel with some of the "analog" control channel and introduces some new concepts in a 3 layered protocol. Intersystem operations, defined by IS-41, can be considered as a fourth layer. This layered structures makes the addition of new capabilities easier, allows moresharing of hardware and software between different applications and should allow greater control channel throughput. The layers, which will be discussed in more detail later, are:

1. Physical Layer
2. Link Layer
3. Call Processing Layer
4. Network Layer

## Finding a DCCH

One of the challenges with a Digital Control Channel is finding one! Unlike analog control channels which occupy the full bandwidth of cellular channels at designated frequencies, digital control channels may be at any frequency, and only occupy one TDMA channel. To assist with the search for a DCCH, analog control channels and digital traffic channels point to the approximate location of a DCCH. Given this hint, and knowing that digital traffic channels can be distinguished from control channels based on the bit pattern found in a particular field in each timeslot, a DCCH can be quickly found. If there are multiple digital control channels, once any DCCH is found, the mobile will perform a hashing algorithm to find its DCCH. This technique allows the number of digital control channels to be configured to meet traffic needs.

## To be continued ...

This article on IS-136 will be continued in the September, 1995 issue. We will address the new services that have been facilitated by the IS-136 standard, including:

- Short Message Service.
- Sleep Mode
- Higher speed data.
- Private & Residential Systems
- User Groups
- International Mobile Station Identification

We will also describe the three protocol layers in some detail.

**Table 3: The TDMA Forum Companies**

| Business Category | | Company |
|---|---|---|
| Carrier | Canada | Bell Mobility |
| | | Rogers Cantel |
| | International | Filipino Telephone Company |
| | USA | BellSouth Cellular |
| | | McCaw Cellular |
| | | Southwestern Bell Mobile Systems |
| | | Vanguard Cellular |
| Manufacturer | Chip Sets | DSP Communications Inc. |
| | | NEC Electronics Inc. |
| | | PCSI |
| | Infrastructure | Aldiscon (Message Center) |
| | | Astronet |
| | | AT&T Network Systems |
| | | Ericsson |
| | | Hughes Network Systems |
| | | Nortel |
| | Terminals | Carillon Corp. |
| | | Ericsson |
| | | Hughes Network Systems |
| | | JRC International |
| | | Megahertz Corp. (modems) |
| | | Mitsubishi International |
| | | Motorola |
| | | NEC America |
| | | Nippondenso |
| | | Nokia Mobile Phones |
| | | Oki Telecom |
| | | Sharp |
| | | Sony |
| | | Telephonics |
| | | Texas Instruments |
| | Test Equipment | IFR Systems Inc. |
| | | Hewlett-Packard |
| | | Wavetek |
| | Other | ISOTEL Research Ltd. |


## Acknowledgements

We would like to acknowledge the assistance of Dave Wenk of Hughes Network Systems and John McQueen of the TDMA Forum with this series of articles.◊

## TR-46 Standards Update

Standards activities in TR-46 are proceeding with some uncertainty, with the pending move of all development of AMPS based standards into TR-45. TR–46 projects are listed in order of their assigned Project Number (PN):

**MAP Interworking (PN–3212)**
An attempt to integrate IS-41 and DCS-1900 inter-system operation networks. A high priority in TR–46.2 WG I, with development continuing.

**Service Descriptions (PN–3369, IS-104-A)**
A project to go beyond the IS-53 cellular features standard and add PCS-specific features.

**IS-41 MAP (PN–3341, TSB-68)**
Approved for publication, this TSB adopts IS-41 as a PCS MAP, to be used with IS-136 TDMA and IS-95 CDMA PCS systems.

**DCS-1900 MAP (PN–3342, IS-652)**
Undergoing final editorial corrections, this document, when published, will define inter-system operations for DCS-1900 ("GSM") networks.

**SS7 "A" Interface (PN–3343, IS-651-0)**
In press as IS-652, this standard describes a BS to Switch interface for DCS-1900 and CDMA systems.

**ISDN "A" Interface (PN–3344, IS-653)**
Ballot comments are being reviewed.

**SS7 Signaling Network Routing (PN–3513)**
SS7 global title translation types (GTT) for use in DCS-1900 MAP. The E.212 (IMSI) based GTT has been approved by T1S1. A liaison is in development to try a second time to persuade ATIS committee T1S1 to support an ITU-T E.164 based ANSI SS7 global title translation type.

**DCS-1900 MAP, Revised (PN–3567, IS-652-A)**
Development is underway for this revision to the DCS-1900 (GSM) MAP (Mobile Application Part). This standard is equivalent to the IS-41 standard for AMPS based cellular and PCS networks.

**Frame-Relay "A" Interface (PN–3568)**
Development is underway on a frame relay interface between a BS and PCS Switching Center (PCSC). Frame relay packetizes voice and thus may allow inter-mixed voice and data.

**Additional Transport for MMAP on ISDN A-Interface (PN–3585)**
Intersystem roaming and handoff messaging.

**SS7 A Interface (PN–3596, IS-651-A)**
A revised version of the SS7 "A" interface, supporting DCS-1900 and CDMA, is being developed.

**Emergency Services (PN–xxxx)**
This project will be developed in cooperation with TR-45.2 (see PN-3581 in the adjacent column). It will accommodate both 1800 MHz PCS and 800 MHz cellular system requirements which are very similar.

**Law Enforcement Intercept (PN–xxxx)**
This project will also be developed in cooperation with TR-45.2 (see PN-3580 in the adjacent column). It will accommodate both 1800 MHz PCS and 800 MHz cellular system requirements, which are very similar.

**Privacy & Authentication (no PN)**
Internal, controlled distribution document set on authentication and voice privacy.◊

## TR-45.2 Standards Update

TIA subcommittee TR-45.2 is wading through almost 500 pages of ballot comments on IS-41 Revision C. It is expected that they will complete this task in September, allowing publication of Revision C once approved ballot comments are incorporated and reviewed.

The status of each major outstanding TR–45.2 project is listed below, in approximate order of completion:

**Cellular Dialing Plan (IS-52 Rev. A, PN-3544)** • ANSI Ballot Completes August, 1995.

**Subscriber Features (IS-53 Rev. A, PN-3545)** • ANSI Ballot completes September 11, 1995.

**IS-41 Revision C (PN-2991)** • Ballot comments are being reviewed.

**International Applications (TSB–29 Rev. B, PN-3173)** • TR–45.2 WG VI is studying the implementation of E.212 mobile identification (IMSI), international SS7 global title translation requirements and other issues, for incorporation in TSB-29 Rev. B, scheduled for ballot in January, 1996, and other documents.

**Multiple HLR Queries (PN-3528)** • The need for this project is under review as Mexican carriers have indicated that they prefer other solutions.

**Online Call Record Transfer (IS-124 Rev. A, PN-3293)** • Undergoing revisions, with a ballot scheduled for 1Q'95.

**Subscriber Features (IS-53 Rev. B, PN-3362)** • Task groups are developing Stage I descriptions for the 9 CTIA top priority features. Ballot is scheduled for January, 1996.

**IS-41 Rev. D (PN Pending)**• Task groups will develop Stage II and III descriptions of features and capabilities. Ballot is scheduled for January, 1996 but may be delayed by IS-41-C delays.

**Interconnection (IS-93 Rev. A, PN-3295)** • Balloting is scheduled to start in November, 1995 (if changes are proposed).

**Emergency Services (PN-3581)** • Stage I and II text is being developed for enhanced wireless 9-1-1 service.

**Law Enforcement Intercept (PN-3580)** • Stage I and II text is being developed to support US law enforcement requirements for lawfully authorized interception of wireless phones.

**Wireless Intelligent Network (PN pending)** • Changes to IS-41 to support the wireless intelligent network (WIN) are under development.

**Network Support for CDMA (PN pending)** • Changes to IS-41 to support the features of the IS-95-A second generation CDMA air interface standard are under development.

**Network Support for TDMA (PN–3579)** • Changes to IS-41 to support the features of the IS-136 standard for a TDMA air interface incorporating the so-called Digital Control Channel are under development.

**CDMA/TDMA Data Support (no PN)** • A task group is developing modifications to IS-41 required to support digital cellular asynchronous fax and data services.◊