Cellular Networking Perspectives

Editor David Crowe • Phone 403-289-6609 • Fax 403-289-6658 Vol. 4, No. 9 September, 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 or 1–403–274-4749 or fax them to 1–403–289–6658.

Next issue: Oct. 3, 1995

All Mexican Phones to be Reprogrammed

Mexican carriers are planning to reprogram all cellular phones in their country with a new MIN to solve their international roaming problems. The new MIN will be a non-dialable number (starting with "05") and thus will not conflict with any future North American based cellular phones.

Currently all Mexican phones have a MIN starting with their landline country code (52). This will be changed to a 05 prefix, according to the plans of Mexican cellular carriers stated at the third meeting of the Joint Committee on Cellular Roaming in Acapulco on August 28-29, 1995.

The Mexican carriers recognize this as only a mid-term solution, which will be required following the expiration, in 1997, of the short term solution (the North American Numbering Plan agreement to hold back 52X area codes from assignment until at least 1997). They also recognize that the use of IMSI (International Mobile Station Identifier) is the best long term solution.

The use of this solution may not assist other countries with MIN-based cellular systems, as few non-dialable MIN ranges exist and there is no recognized authority to allocate them.◊

Correction

Texas instruments was erroneously reported as an IS-136 terminal manufacturer on page 4 of the August, 1995 issue. They are actually designing IS-136 chip sets.◊

TIA Standard IS-136 Part II: New Capabilities

IS-136 supports a number of new capabilities on the DCCH (digital control channel). Most have significant inter-system requirements if roaming is to be supported. Apart from the Short Message Service, intersystem support will not be standardized before the release of IS–41 Rev. D at the earliest, which is currently scheduled for publication in 1996.

PCS and Cellular

IS-136 can operate in either the 800 MHz cellular bands or any of the six licensed 1800-2200 MHz PCS bands. The standard will even allow handoff

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between bands. This could facilitate the extension of cellular systems into PCS bands, although this will require a new capability to allow a terminal to pick the best of up to eight bands that might be offering IS-136 service in one location.

Short Message Service (SMS)

This service allows a mobile to receive short (up to approximately 200 characters) messages of text (including letters, digits and punctuation). Messages can be sent to only a single mobile at one time ("point-to-point" short message service). The standard also allows mobile stations to generate short messages, but the usefulness of this is limited due to the primitive nature of the average mobile keypad and the lack of addressing support for common destinations such as the Internet. Future revisions of IS-136 may support a broadcast short message service.

Inter-system support for the short message service is included in Revision C of IS-41 (currently under ballot review). For more information on this service, consult the February and March, 1995 issues of *Cellular Networking Perspectives.*

Sleep Mode

Sleep mode allows a mobile to turn off most circuitry most of the time. Designers of IS-136 hope that they will reach the CTIA goal of a 10 times increase in standby time.

When a mobile goes into a sleep mode the mobile turns off all circuitry except that necessary to wake it up at a prearranged time later. The base station will postpone any messages destined to the mobile until the short wakeup interval. If the mobile is not paged it can go back to sleep. Otherwise it can stay awake and will receive the buffered command (such as a page due to an incoming call or short message) a little later. There are 8 different sleep levels that allow a mobile to sleep for periods of about one second to about 2 minutes.

Idle IS-136 mobiles are always in at least the lowest sleep mode, needing to be awake for only 6 milliseconds out of every 1.28 seconds (less than 1% of the time) to check for incoming pages.

Sleep mode may delay incoming calls and will, if set for too long an interval, make it unlikely that callers will want to wait. Redirection of incoming calls to voice mail, combined with a short message containing the calling number is a more likely application for mobiles in a 'deep' sleep. This technique will be especially useful for mobile users that prefer to initiate calls themselves.

Double & Triple Rate Traffic

Traffic channels normally use 2 out of 6 time slots in a basic TDMA frame (full-rate) or, in future, 1 out of 6 (half-rate). For higher speed data applications, IS-136 allows 4 out of 6 or all 6 slots to be assigned to a single user.

Private & Residential Systems

Private and residential systems can be supported, under the umbrella of a public cellular or PCS system. While there is considerable flexibility of implementation, a residential system will likely borrow spectrum that is not currently being used by the surrounding public system for each call, and use it at low power. This service will allow an IS–136 phone to be used with the advantages of a cordless phone at home (i.e. no airtime charges) and as a regular cellular or PCS phone elsewhere.

A private system (e.g. Wireless PBX) is more likely to use permanently assigned frequencies at a low power within its coverage area, or exist just as a virtual system within a public system. Standalone private systems will provide service to authorized users, and possibly public service as well. In this case, authorized users will get special privileges, such as no air time charges or PBX features, that are not available to public users.

An IS-136 mobile can have a built-in list of Private System Identifications (PSIDs) and Residential System Identifications (RSIDs) that it is allowed to access. PSIDs and RSIDs supplement the assigned SID (System ID), they do not replace it. Mobiles that do not contain a matching PSID and RSID in their 'Preferred PSID/RSID List' can perform a 'test' registration. The response to this message indicates whether the mobile will be allowed access.

User Groups

IS-136 mobiles can be paged by a User Group Identification Number (UGID) instead of by an individual number. The first member of the group to respond will receive the incoming message (of whatever type) in each cell. This capability is designed to provide extension phone services. User groups will not allow the broadcast or multi-cast of information to several phones, such as short messages, because only one member of the group would receive the message. Location management for user groups may also be problematical, as members of the group may be spread around many cells in many systems.

While there are some efficiency benefits to the user group concept, the IS–41 Revision C network standard will allow similar user group services to be provided to any phone, independently of the type of air interface. In particular, IS-41 Rev. C provides two extension phone services: Flexible Alerting (first phone to answer gets the call) and Mobile Access Hunting (phones paged one at a time until one answers). IS-41 has also solved the location management problem, by tracking each mobile in the group separately.

Broadcast of short messages to a group could be handled simply by maintaining a list of group members at a message centre and distributing the message that number of times.

See the November, 1993 issue of *Cellular Networking Perspectives* for a description of Flexible Alerting and Mobile Access Hunting.

Control Channel Encryption

IS-136 allows the digital control channel to be encrypted for some mobiles, which could protect against fraud, eavesdropping and tracking and identification of phone users.

Implementation of this capability will require a definition of the fields to be encrypted in the authentication document known as "Appendix A".

International Mobile Station Identification

IS-136 supports the International Mobile Station Identification (IMSI) that is also used by the European GSM cellular standard and Revision A of the CDMA IS-95 standard. This identifier, defined in ITU-T Recommendation E.212, can replace or supplement the traditional Mobile Identification Number and has several advantages:

a. It identifies the home country for the mobile (unlike the MIN).

b. It identifies the home carrier in a straightforward way for each country (e.g. first six digits).

c. It is not associated with a directory number, so a change in one (e.g. change in area code) does not affect the other.

d. It has been adopted by the USA as the single future standard for mobile identification.

A mobile may have a MIN, an IMSI or both. Mobiles with both will still transmit a MIN in their home country, and will transmit IMSI outside. Further definition of IMSI requirements may indicate the need for a change in this algorithm. For more information on IMSI see the June, 1995 issue of *Cellular Networking Perspectives*.

Temporary Mobile Station Identification (TMSI)

A new form of identification in IS-136 is a Temporary Mobile Station Identification (TMSI). This identifier, either 20 or 24 bits long, is assigned by a base station to a mobile only while it is operating in one system, and then only for a limited time. The advantages of TMSI are that it enhances privacy (it is more associate air interface messages with a particular user) and, because it is smaller than either a MIN or IMSI, it increases the available control channel capacity. With DCCH encryption, identifying the mobile that transmitted a message may be virtually impossible. A mobile with a valid TMSI will always use it as its identification in preference to a MIN or IMSI.

Subaddressing

A mobile may have a subaddress that may be transmitted to and from the base station. The meaning of a subaddress is not defined in IS-136, and is left to the system and terminal to define.

Data

Transmission of data over digital traffic channels assigned by a DCCH is defined in TIA standards IS–130 and IS–135. Modems cannot be used, due to distortion of modem tones by the IS-54 voice coder.◊

TIA Standard IS-136 Part III: A 3 Layer Cake with Icing

IS-136 can be seen as a three layer cake with icing on top. The layers are 1) Physical, 2) Link, 3) Call Processing. The icing is the IS-41 standard for intersystem operations that enable IS-136 systems to operate in a coordinated fashion to enhance seamless roaming. The interaction of the layers is shown in Figure 1.

Layer 4: The IS-41 Icing

The IS-41 inter-system operations standard can be considered as a protocol layer above the air interface layers. Due to the number of different air interfaces that must be supported in AMPS based cellular, IS-41 messages are not carried directly by IS–136 but must be converted between these two very different formats.

It is useful to consider IS-41 as a layer above IS-136, or any other air interface for that matter, as many of the features and services supported by IS-136 imply significant network support.

Layer 3: Call Processing

Layer 3 consists of messages that allow call processing negotiations between a base station and a mobile, and also allow a variety of system management functions. These messages are carried in one of a number of logical channels.

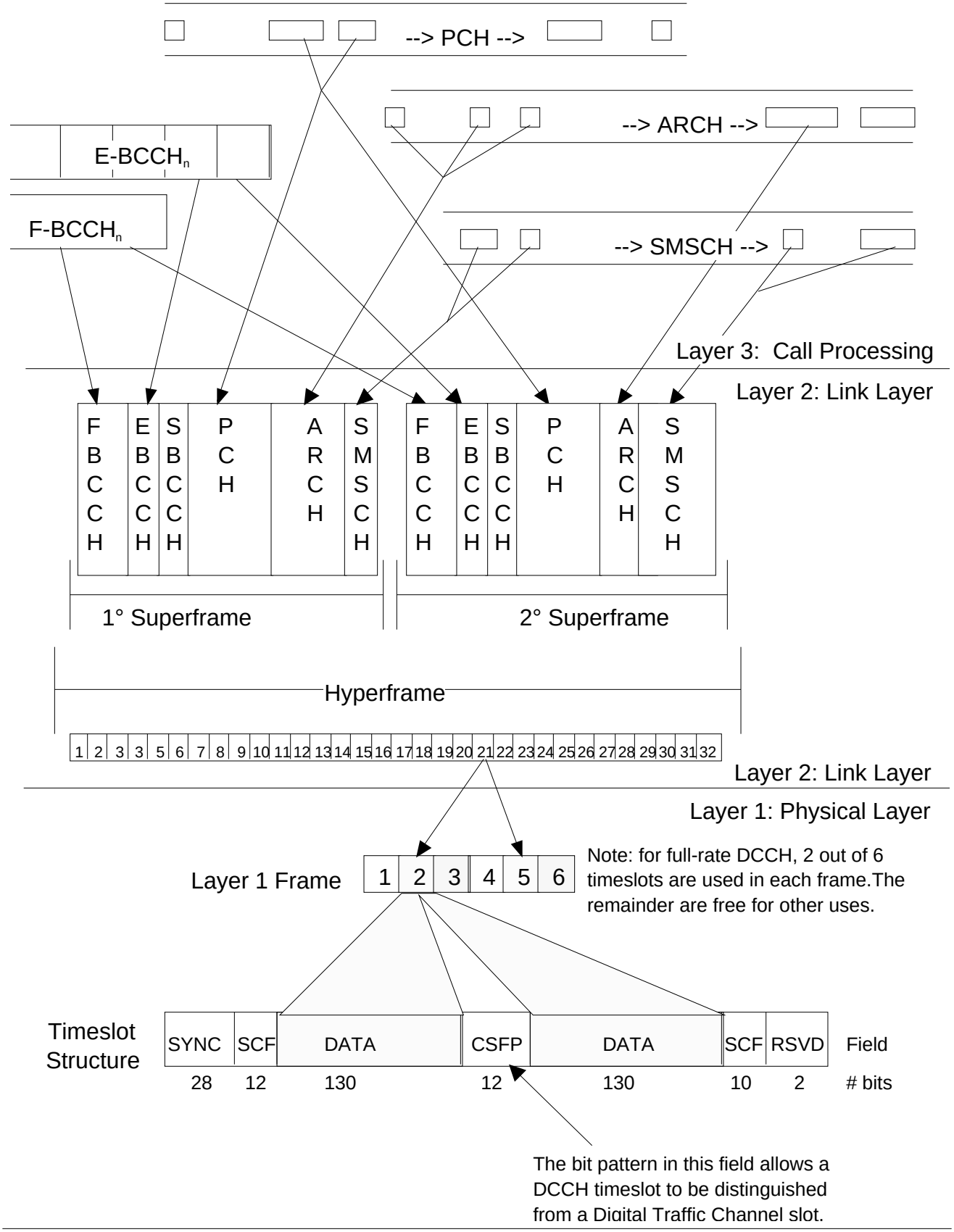
Broadcast Control Channels

Three broadcast control channels are listed in IS-136, carrying messages from the base to all mobiles:

F-BCCH — Fast Broadcast Control Channel. This channel consists of a number of messages, containing time-critical cell parameters, that are repeated continuously. Messages may change over time. The F-BCCH is always transmitted once in every Layer 2 superframe.

E-BCCH — Extended Broadcast Control Channel. This channel consists of messages containing non-time-critical information, such as about neighbouring systems. The E–BCCH may be transmitted over several Layer 2 superframes.

Figure 1: Digital Control Channel Layers (Base to Mobile)



S-BCCH The SMS Broadcast Control Channel is not defined.

SPACH: SMS, Paging & Access Channel

This logical channel carries messages related to a single mobile or a small group of mobiles. SPACH messages are transmit continuously, as needed, and at a maximum rate defined by the amount of space left over in each Layer 2 superframe by the broadcast control channels.

ARCH and SMSCH messages use an ARQ (Automatic Repeat ReQuest) protocol to allow large messages to be transmitted in pieces, in any order, with retransmission only of pieces that have not yet been successfully received.

PCH The Paging Channel contains page messages to indicate to a mobile that some action is required (such as receiving an incoming call or a short message). This channel is monitored periodically by idle mobiles. Consequently, incoming pages have to be buffered to ensure they are transmitted when the mobile is listening. For efficiency, a single page message may contain up to five mobile station identifiers. Pages are always repeated once (by Layer 2).

ARCH The Access Response Channel contains responses from a base station to an earlier mobile initiated message (such as an origination attempt).

SMSCH The Point-to-point Short Message Service Channel is used to transmit short messages to mobiles.

RACH: Random Access Channel

There is only a single logical channel allocated to mobile initiated messages. The channel can be used in two modes, using contention for autonomous mobile messages (such as an origination attempt) or in a reserved mode for replying to a base station command.

A potential problem with the RACH in large diameter cells, is due to the different distances that mobiles may be from the cell, which will skew the time of arrival of messages. To avoid overlap of messages on the RACH, smaller ("abbreviated") messages may need to be used, resulting in 25% to 50% lower throughput.

Layer 2: Link Layer

Layer 2 of IS-136 takes messages from the Layer 3 logical channels and multiplexes them on Layer 1 frames. The basic structures of Layer 2 are the Superframe and the Hyperframe. A Hyperframe consists of a Primary Superframe and a Secondary Superframe. This distinction is relevant to the F-BCCH and PCH channels which are repeated in each superframe. Other channels transmit different information in the two superframes.

A Hyperframe is composed of 32 Layer 1 Frames each of which, for a full-rate DCCH, contain 2 timeslots dedicated to the DCCH. Layer 2 processing (in the base to mobile direction) distributes information from the logical channels over 64 available timeslots in each Hyperframe. The first priority is transmission of the F–BCCH which is always transmitted completely in each superframe. The E–BCCH may be transmitted in many (up to 256) superframes, using no more than 8 timeslots in each superframe. The remaining timeslots are used by the SPACH channels.

IS-136 Layer 2 processing ensures that the logical channels can transmit relatively independently. The multiplexing makes it easier to transmit lengthy messages in one logical channel (e.g. an SMS message on the SMSCH) while transmitting higher priority, but shorter messages on another (e.g. the F-BCCH).

It is the presence of Layer 2 processing which most importantly distinguishes the DCCH from the "analog" control channel. Layer 2 multiplexing, contention resolution and the ARQ protocol significantly enhance the flexibility of Layer 3, making new services and capabilities easier to implement.

Layer 1: Let's Get Physical!

The physical layer for both IS-54 voice channels and the IS-136 DCCH is similar. Layer 1 divides a single 30 khz cellular channel into 6 timeslots each containing 260 data bits surrounded by framing bits (to allow synchronization on the channel). This layer can operate in either full rate mode (where timeslots 1 and 4, 2 and 5 and 3 and 6 are assigned to three different users), or in half rate mode (6 users with a single timeslot each). IS-136 even supports double and triple full-rate mode (e.g. assigning 4 or 6 timeslots to a single user).

The framing bits encapsulating the data portion is common for digital traffic and control channels, but a field in the centre of the timeslot (CSFP) allows a traffic channel and a control channel to be distinguished.

The basic pattern of 6 timeslots repeats continuously in TDMA. Each of the six timeslots may be assigned as a control channel, as voice traffic or as data (as defined by IS-130).

Summary

IS-136 is the best that the AMPS TDMA proponents have to offer today for Cellular and PCS systems. The TIA TR-45.3 standards subcommittee is already working on Revision A, which will contain major enhancements.

In future issues we will report on the competing IS-95 standard for CDMA systems, and also on the many changes to be found in IS-136 Revision A. Meanwhile, carriers and customers will be voting on the many cellular and PCS choices with their wallets.◊