Personal Communications Service (PCS)

Definition

PCS is a new generation of wireless-phone technology that introduces a range of features and services surpassing those available in analog- and digital-cellular phone systems. PCS provides the user with an all-in-one wireless phone, paging, messaging, and data service having a greatly improved battery-standby time.

Topics

1. Overview of PCS Technology

The Telecommunications Industry Association (TIA) IS–136 specification is the basis of the time-division multiple access (TDMA) PCS air-interface technology. IS–136 is designed to operate in both the 800-MHz and the 1900-MHz frequency bands, thus providing seamless operation on cellular and PCS systems.

The Digital Control Channel (DCCH)

The DCCH forms the core of the IS–136 specification and is the primary enhancement to TDMA digital-wireless technology. It is a new control-channel mechanism added to the analog control channel (ACC), the analog voice channel (AVC), and the digital traffic channel (DTC) of the TDMA air interface. The IS–136 DCCH TDMA technology provides the platform for PCS, introducing new functionalities and supporting enhanced features that make PCS a powerful digital system.

Dual-Band Dual-Mode Operation

PCS dual-band phones operating at 800 MHz and 1900 MHz enable users to receive full PCS features and services for IS–136 systems wherever they roam. The dual-mode capability provides service continuity and interoperability between analog and digital networks. As a result, a PCS phone can provide access to all outdoor wireless services, be used in a private in-building system, and serve as a flat-rate digital cordless phone at home.

Features and Capabilities

Table 1 shows important PCS features and capabilities.

Table 1. PCS Features and Capabilities

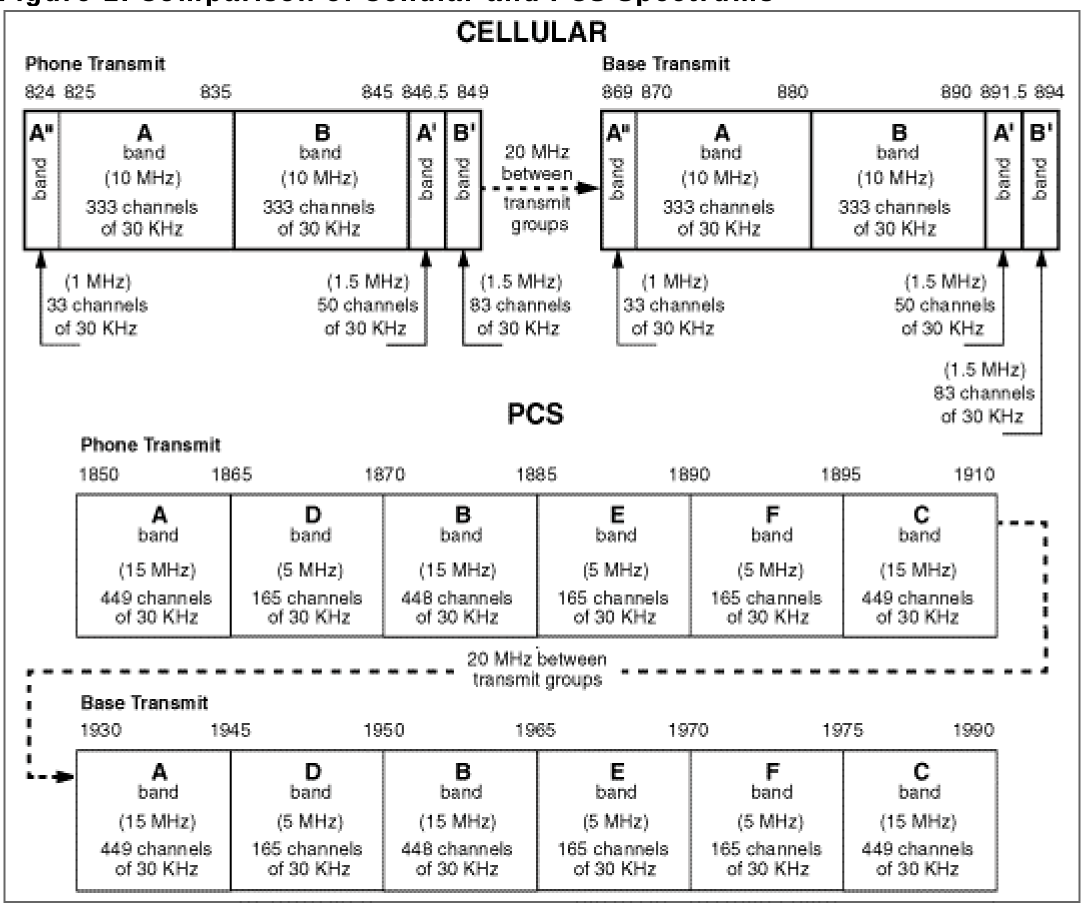
Feature	Capability
sleep mode	extends phone standby time and enhances battery life
short message service (SMS)	transfers alphanumeric messages to and from cellular and PCS phones
voice and data privacy	increases resistance to eavesdropping
superior voice quality	results in less background noise and fewer dropped calls
hierarchical environment	provides support for macrocell-microcell operation
intelligent rescan	allows tighter control of system selection
private and residential system IDs	provide more simplified and controlled wireless office service (WOS) and personal base station (PBS) features
seamless roaming	enables roaming between frequencies using dual-band phones and provides support for international roaming
circuit-switched data	provides highly reliable data transmission for

support	wireless e-mail, faxing, and Internet access
authentication	increases phone security and resistance to cloning
calling number identification (CNI)	allows callers to be identified before answering
message waiting indicator (MWI)	notifies users that they have voice-mail messages
text dispatch service	Live operators take caller messages and send text messages to the PCS phone.

Comparison of Cellular and PCS Spectrums

Figure 1 illustrates the wireless cellular 800-MHz spectrum and the PCS 1900-MHz spectrum.

Figure 1. Comparison of Cellular and PCS Spectrums



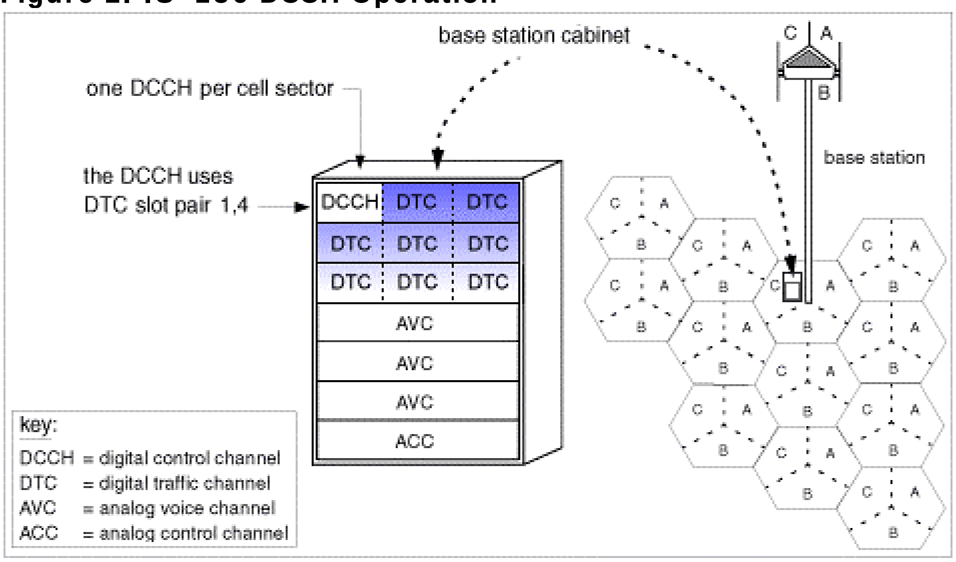
2. The DCCH Environment

A radio channel consists of two frequencies within the radio-frequency (RF) spectrum that are separated by a fixed distance. These two frequencies allow a cell site and wireless phone to transmit and receive signals simultaneously. Cell sites communicate with wireless phones using two different radio channels: a voice channel and a control channel.

In TDMA systems, each digital-radio channel can carry up to three voice calls by time-multiplexing voice traffic into time slots. A DCCH is introduced into the TDMA system by reprogramming one of those traffic channels, called DTCs, to become the DCCH on a frequency that contains the existing DTCs.

Figure 2 depicts the DTC slot pair (1, 4) used for a DCCH, and shows each cell divided into sectors (A, B, C). Only one slot pair is required for a DCCH in each cell sector regardless of the number of digital radios in the sector.

Figure 2. IS–136 DCCH Operation



Operating Principle

Information carried on the DCCH flows in two directions over the air interface: from the system to the phone (downlink), and from the phone to the system (uplink). In *Figure 2*, the base station represents the system.

DCCH–capable and PCS phones monitor (camp on) a DCCH in each sector of a wireless system that supports IS–136 services. A PCS phone will scan for this channel, gain synchronization, and begin to decode the information provided over a broadcast-control channel on the DCCH. The DCCH serves as the phone's control channel until the phone finds another cell that is more appropriate.

PCS phones receive pages, send originations, and communicate with the system on the DCCH. After receiving a page or performing a call origination, a traffic channel is then designated for the call, and the phone will hand off from cell to cell as it moves around the system. At call completion, the phone returns to the DCCH to await further interaction.

3. The Air Interface: Multilayered Protocol

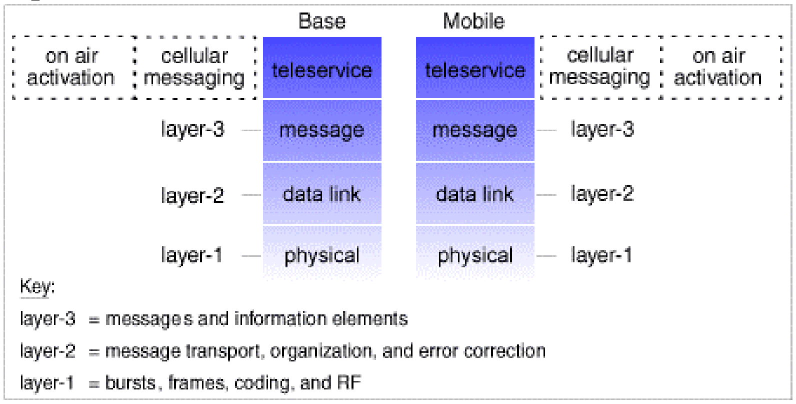
The air interface used in PCS is structured in different layers, each with specific purposes. This conceptual split makes it easier to understand the interactions between the base station and the phone across the air interface. There are four layers:

- **physical layer (Layer-1)—**deals with the radio interface, bursts, slots, frames, and superframes
- **data-link layer (Layer-2)—**handles the data packaging, error correction, and message transport
- **message layer (Layer-3)—**creates and handles messages sent and received across the air
- **upper application layers—**represent the teleservice currently being used, such as voice and messaging transactions, or future services like on-air programming

The Air-Interface Model

Figure 3 shows the air-interface model. This structure simplifies the introduction of current and future services using the IS–136 DCCH platform because the lower layers in the air-interface protocol (the radio interface, data management, messages, and so on) remain unchanged.

Figure 3. The Air-Interface Model

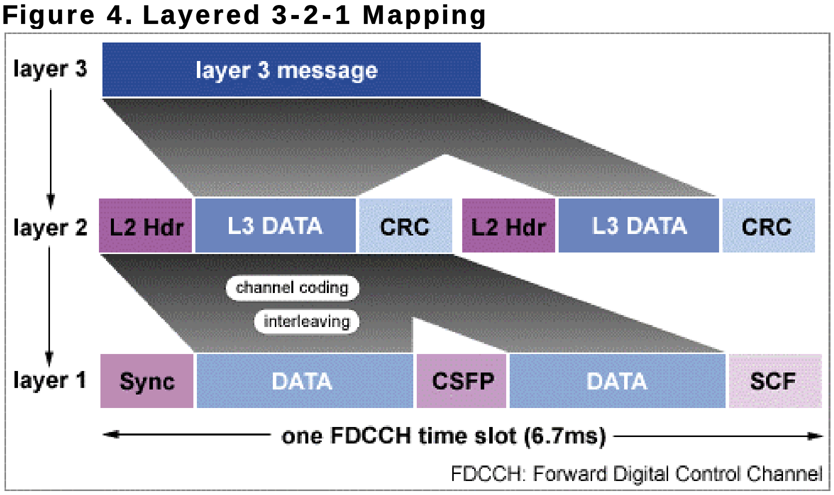


Operating Principle

Figure 4 shows how one Layer-3 message is mapped into several Layer-2 frames and how a Layer-2 time frame is mapped onto a time slot. The time slot is further mapped onto a DCCH channel. The figure shows how information is passed from layer to layer down through the stack until a burst is created, ready for transmission. At the receiving end, information is stripped off as needed as the message is passed up to the application.

The Layer-3 message shown in *Figure 4* can be an uplink registration, a downlink PCS message, a page response, or a broadcast message. The Layer-3 message is packaged into a Layer-2 frame where header and error-correction fields are added. The packet is then coded and the individual bits interleaved (mixed and distributed) to counteract errors introduced in the radio environment.

Figure 4. Layered 3-2-1 Mapping



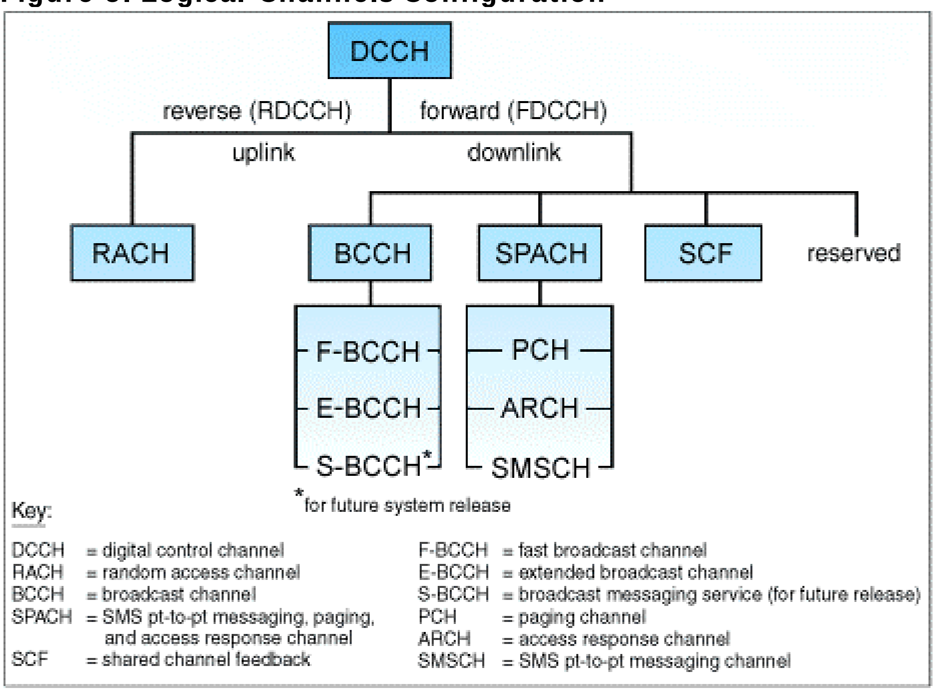
4. Logical Channels

Logical channels were developed in the IS–136 DCCH technology to organize the PCS and other digital information flowing across the air interface.

Logical-Channels Configuration

The logical channels are depicted graphically in *Figure 5*. The figure shows how the forward DCCH (FDCCH) consists of many logical channels carrying information from the system to the phone. The reverse DCCH (RDCCH), carrying information from the phone to the system, consists of one logical channel.

Figure 5. Logical-Channels Configuration



Operating Principle

Logical channels sort and prioritize signaling information by functional use. The data is then mapped onto a DCCH, which is a physical channel. Physical channels are the actual portions of electromagnetic bandwidth consisting of frequencies and time divisions. Logical-channel data flows on the DCCH in both directions: from the system to the phone (downlink), and from the phone to the system (uplink).

Logical Channels Functions

The multiplexed broadcast channel (BCCH) shown in *Figure 5* is designed to carry information about the system configuration and the rules that phones must follow at system access. Its primary logical channels are the following:

- **fast broadcast channel (F–BCCH)**—carries information that phones need immediately, such as the system ID and registration information

- **extended broadcast channel (E–BCCH)**—carries information that is not as time critical, such as neighbor cell lists

The system uses the multiplexed SMS point-to-point messaging, paging, and access-response channel (SPACH) shown in *Figure 5* to communicate with a specific phone. Its logical channels are the following:

- **short message service channel (SMSCH)**—carries PCS messaging and over-the-air activation and programming (OAA/P)—PCS information is carried on the logical channels at both 800 MHz and 1900 MHz

- **paging channel (PCH)**—carries system pages to the phone

- **access-response channel (ARCH)**—provides system response to phone queries and administration information

Table 2 outlines the logical channels.

Table 2. Description of Logical Channels

Logical Channel	Description
BCCH	This is a downlink multiplexed channel comprised of F–BCCH and E–BCCH.
SPACH	This is a downlink multiplexed channel comprised of SMSCH, PCH, and ARCH.
RACH	This is a single uplink channel with all time slots used for system access.
SCF	The SCF fields in the downlink are used to provide a collision-prevention mechanism for the uplink.

5. Sleep Mode and Standby Time

PCS uses the DCCH to provide a sleep mode during which phones can turn off much of their circuitry until they need to wake up, at predetermined intervals, to receive system messaging. This feature greatly increases the battery life, thereby increasing the standby time of phones. Standby time is the time a wireless phone is idle; that is, the phone is on, but no calls are being placed or received.

Operating Principle

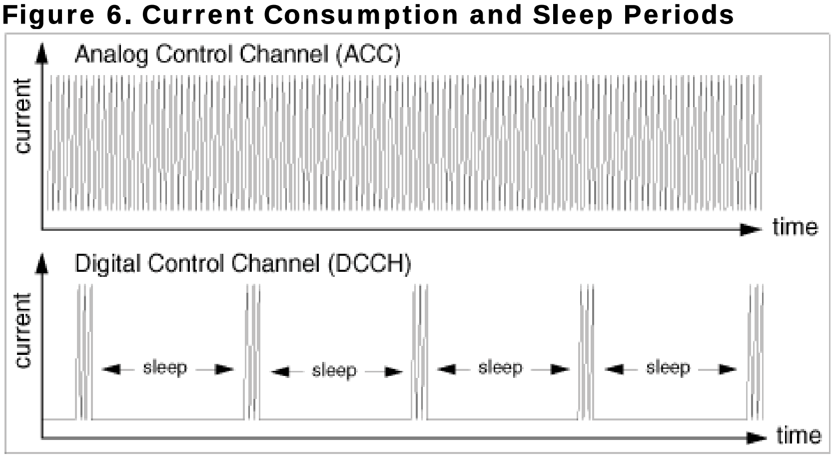
An idle phone camps on the DCCH. The phone checks for incoming calls every few milliseconds and then reenters the sleep mode. This differs from a phone using an ACC, where an idle phone must monitor the control channel constantly, wearing down the battery.

The system messages received by the phone can be pages (for either a voice call or PCS messaging) or broadcast messages (for example, updates about cell changes or neighbor lists) carried on the downlink DCCH. The phone needs to decode the downlink information only at intervals on its predetermined paging slots or on the broadcast slots if the broadcast information changes. In this manner, the phone has extended periods of time in which it can power down some of its circuitry and sleep between paging opportunities.

Current Consumption and Sleep Periods

Figure 6 depicts ACC versus DCCH battery current consumption and indicates the phone's sleep-mode periods on the DCCH. The time spikes in the DCCH segment of the drawing are representative of the predetermined paging slots.

Figure 6. Current Consumption and Sleep Periods



6. PCS Messaging

PCS messaging is a digital SMS feature that allows a wireless phone to receive numeric pages and short text messages. This lets one device do the work of both pager and phone. Users can receive messages on their phone's display screens from a variety of sources: computers, telephones, e-mail, voice mail, and text dispatch (live operators take caller messages and send text messages to the PCS phone).

PCS uses the DCCH and DTCs to deliver the alphanumeric messages to and from the wireless phone. The messages are sent and received via a message center, which is a node on the wireless intelligent network. The messages contain a variety of attributes controlling their delivery, storage, and display behavior.

Message Architecture

Each network-originated PCS message consists of the following three basic elements:

- **addressing information—**tells the system to which phone the message is to be delivered
- **alphanumeric text—**the characters that make up the actual text message
- **message attributes—**tell the phone how to handle and display the message when it is received

Message Types

PCS messaging can deliver numeric-callback messages from a phone and alphanumeric messages sent via modem and computer. Examples of PCS messaging include paging and notification of new voice messages and e-mail messages. Messages of up to 239 characters can be sent over the air interface.

Operating Principle

The PCS messaging feature uses a dedicated paging terminal. When the network receives a PCS message, it locates the target phone and delivers the message. The phone notifies the user with a message icon, a beep, or both. The message can then be displayed and read. If users leave a PCS messaging area, the network stores any messages until they return. The network will repeatedly try to deliver a message until the phone is able to receive it.

Message Generation

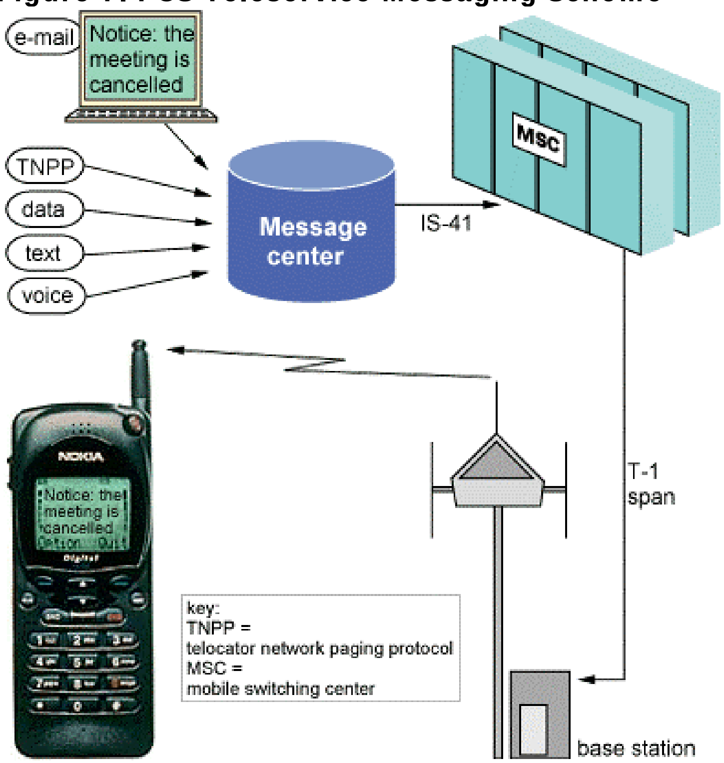
The following entities can be used for PCS message generation:

- networking from existing paging terminals

- voice-response unit
- live operator text-dispatch service
- dial-up modem
- e-mail gateway
- data information source
- voice-mail system

Figure 7 shows a PCS teleservice messaging scheme in which a message is formulated in a personal computer (PC) and sent to the phone of the message recipient. Phone-screen displays differ depending on model and manufacturer, but they all show the number of new messages.

Figure 7. PCS Teleservice Messaging Scheme



Message Delivery

PCS messaging is designed to operate in practical, everyday situations.

- **power on**—If the phone is powered on, the message is available immediately just like a pager.

- **phone engaged**—If the phone is engaged in a voice conversation, the network delivers the message to the phone using the same DTC being used for the conversation.

- **power off**—If the phone is powered off, or the phone is out of a service area, the network message center stores the message for later delivery. As soon as the phone is powered on, the messages are delivered. This way messages are not missed if a phone is off, out of a service area, or in an area with poor reception.

- **voice mail**—When a caller reaches a user's voice mail, the system provides the option to send a callback-number message to the phone or to send an alphanumeric message using special Message Flash software.

- **roaming**—If the user is roaming in an area not supporting PCS messaging, the message center will store the message and deliver it when the phone reenters a PCS–supported area.

7. Hierarchical Cell Relationships

Cell sites have traditionally existed as macrocells on towers that cover areas up to several miles in diameter. Macrocells are typically public cells, serving all wireless-phone users. IS–136 DCCH TDMA technology enables the use of much smaller cells called microcells. Microcells provide customized service within the coverage of existing macrocells. Microcells typically provide WOS features to specific phones within a private building or campus environment.

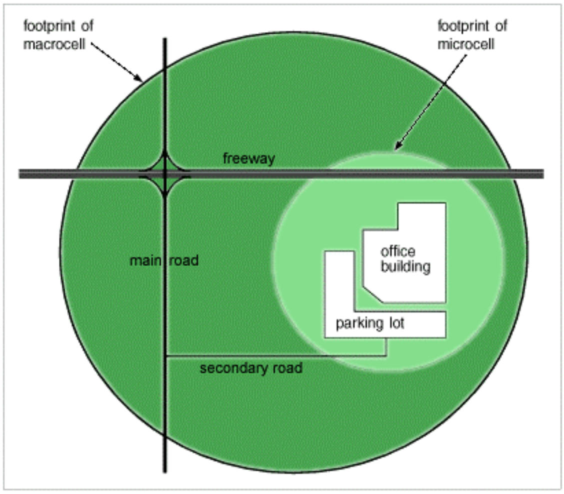
Hierarchical Cell Coverage

The combined coverage of both macrocells and microcells is called hierarchical cell coverage, with the microcells creating a second level of coverage under the existing level. Although macrocells are usually public and microcells are usually private, they can reverse roles.

For example, a public macrocell can also provide private WOS services to offices within its coverage area. Conversely, a microcell can provide public coverage to fill in geographic gaps due to topography or to enhance coverage in high-density areas.

Figure 8 shows a private-system microcell within a public macrocell.

Figure 8. Macrocell / Microcell Configuration



Hierarchical Cell Structures

In a PCS environment, a geographic area might be covered by a mix of macrocells and microcells as well as public and private systems. A PCS phone must therefore assess the most suitable control channel on which to provide service, even if the signal strength of a neighboring cell is not the highest signal being received by the phone, but is of a sufficient level to provide quality service. PCS uses hierarchical cell structures (HCS) to accomplish this by identifying neighboring cells as preferred, regular, or non-preferred.

- **preferred neighbor cell**—A preferred cell has the highest preference. The phone reselects it even if its signal strength is lower than the serving cell. The main criterion here is that the preferred neighbor cell must have signal strength sufficient to provide quality service.

- **regular neighbor cell**—A regular cell has the second-highest preference. The phone reselects it if the cell's signal strength is greater than the serving cell (plus a hysteresis value) and there is no eligible preferred cell available.

- **non-preferred neighbor cell**—A non-preferred cell has the lowest preference. The phone reselects it only if the signal strength of the serving cell becomes insufficient to provide service and the signal strength of the non-preferred neighbor is greater than the serving cell (plus a hysteresis value).

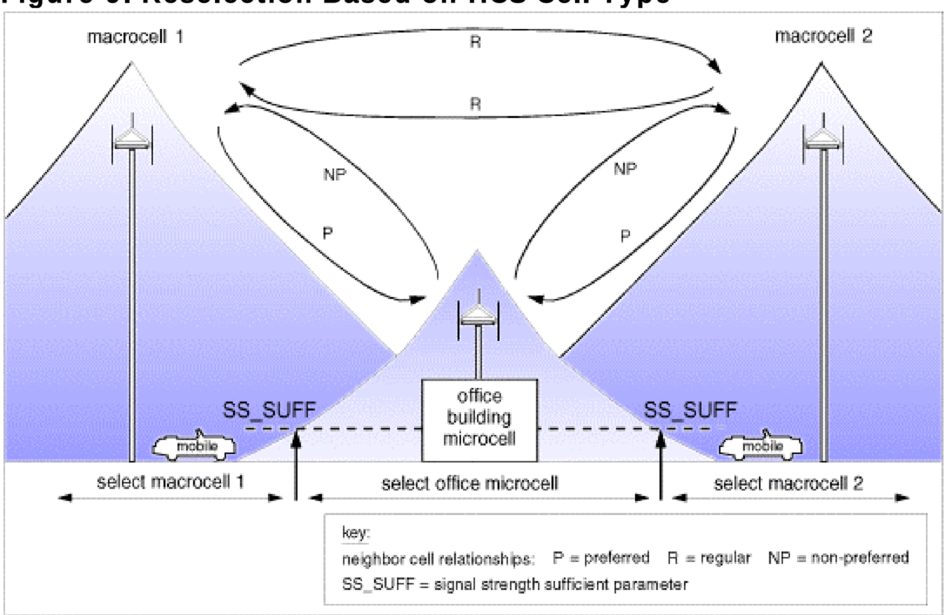
Operating Principle

HCSs enable the DCCH to identify and designate neighboring cells as preferred, regular, or non-preferred. A PCS phone uses that hierarchical information to reselect a particular neighbor cell over another based on the type of relationship defined between the cell it is using (serving cell) and the adjacent neighbor cell. Each neighbor cell's designation dictates which type of algorithm the phone uses when it considers the cell as a reselection candidate.

For example, when a low-power microcell is providing capacity in a dense-traffic area that is also served by a high-power macrocell, the HCS allows the phone to give preference to the weaker microcell. Without the multitier environment, the phones would have difficulty capturing microcells, and the cellular system would require highly specific parameter settings.

Figure 9 shows reselection based on HCS cell-type designation.

Figure 9. Reselection Based on HCS Cell Type



8. Public, Private, and Residential Systems

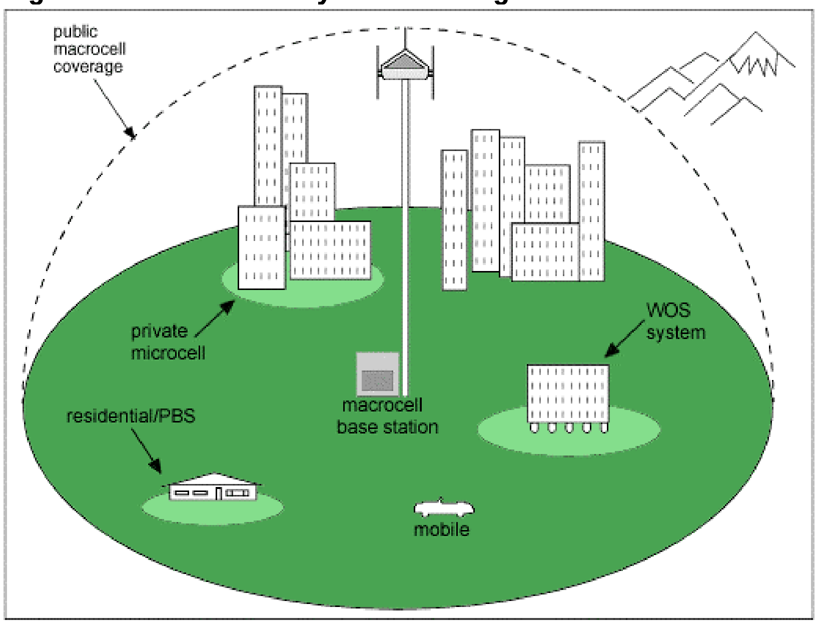
PCS phones can behave differently according to the type of system providing service to the user. For example, phones providing only basic service might not reselect or camp on private cells, thereby improving their time to service. Similarly, phones providing service on a residential system, such as a PBS, might perform different scanning routines in order to find their home system.

Operating Principle

PCS uses IS–136 identity structures to categorize each cell into three basic network types—public, private, or residential—and allows the phone to react to serving cells based on the broadcast identifiers of those network types. In other words, the phone can discriminate between, and access, different network systems and distinguish the types of services available on particular cells. Because a cell can have a mix of network types and subtypes, it can have a mix of services.

Figure 10 shows some network system configurations.

Figure 10. Network System Configurations



Network Types

Designations for the major network types and the subtypes include the following:

- **public**—The public designation refers to cells that provide the same basic cellular service to all customers.

- **private**—These cells provide special services to a predefined group of private or WOS customers only, and do not support public use of that cell. The private designation is used for in-building company systems with specific features.

- **semi-private**—A subtype, these cells provide basic service to all customers and also provide special services to a predefined group of private customers. An example would be a cell providing service to a WOS system as well as to public users.

- **residential**—These cells provide special services to a predefined group of residential customers only, and do not support public use of the cell. The PBS that allows a cellular phone to behave like a cordless home-phone is classed as a residential system.

- **semi-residential**—A subtype, these cells provide basic service to all customers and also provide special services to a predefined group of residential customers. This type is used in a neighborhood where the public macrocell is also providing residential cellular service.

- **autonomous**—These are cells that broadcast a DCCH in the same geographic area as other DCCH systems but are not listed as a neighbor on the neighbor list of the public system. Examples of autonomous systems include the PBS and private systems that are not coordinated with the public system. Phones must perform special frequency-scanning algorithms in order to find autonomous cells.

9. System Identities

A system-identity structure allows PCS phones to distinguish between public, private, semiprivate, and PBSs. This IS–136 feature facilitates the creation of private systems and allows control of phone behavior around a WOS, PBS, or residential service area. The IS–136 technology includes private-system identifiers for marking specific base stations as part of a private system, HCSs for defining cell preferences, and new registration features to complement private systems.

Operating Principle

- **private system identities (PSIDs)**—A PSID is assigned to a specific private system by the system operator to identify it to phones in the coverage area of the system. PSIDs are broadcast so that a phone can determine whether it has special services from a particular cell when reselecting a DCCH.

  PSIDs can be assigned on a sector-by-sector basis within a cell, which allows very small service areas to be defined. Alternatively, many cells, as well as systems, could broadcast the same PSID to create a geographically large virtual private system. Phones that recognize PSIDs notify the system and can activate location ID to inform users that they have entered the private system.

A single DCCH can broadcast up to 16 PSIDs, allowing the support of up to 16 different private systems on one DCCH. This feature is useful in a technology park or campus where it would not be economical to support a DCCH for each small business requiring WOS features.

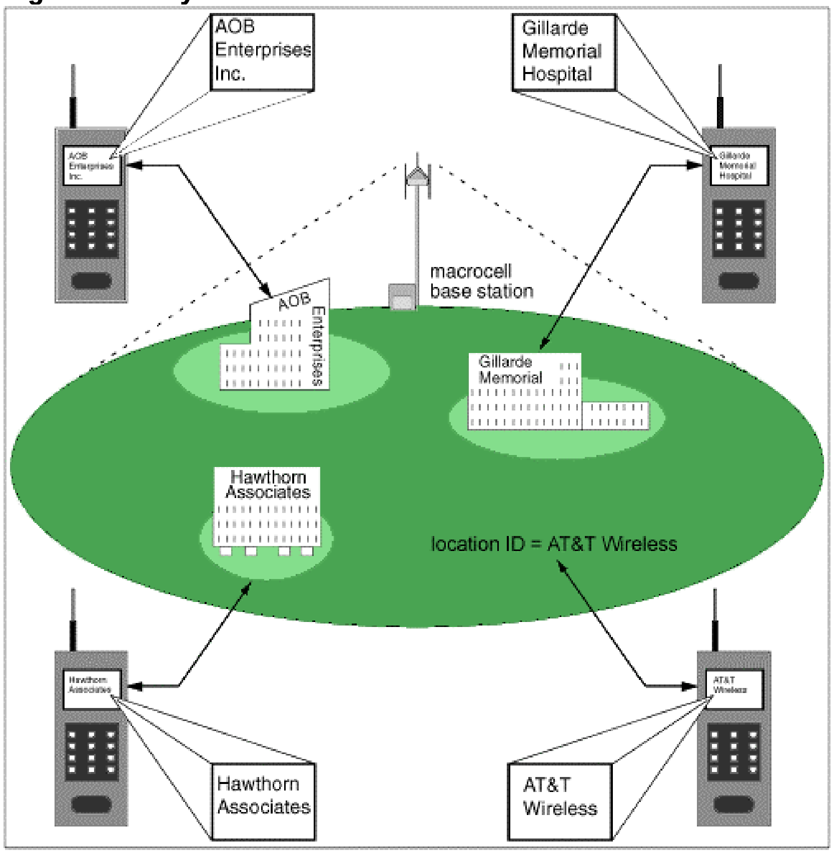
- **residential system identities (RSIDs)**—In a manner similar to a PSID, a RSID identifies a residential system within the public cellular and PCS coverage. RSIDs can be used to create residential-service areas or neighborhood residential systems by broadcasting an identifier that is recognized by phones as being at home and therefore receiving special services (for example, billing). A primary use of RSIDs is in the PBS, which allows a cellular or PCS phone to be used like a cordless phone in conjunction with a residential base station.

Location ID

All PCS phones display the name of the wireless carrier providing service. If a phone also has WOS coverage, the location ID feature can display a company name (as shown in *Figure 11*) or a system banner to inform subscribers that they have entered their private system. This can be particularly important when there is a billing or service difference that should be indicated to the subscriber. The identifying name or banner is removed from the display when the subscriber leaves the WOS coverage. A non-subscriber entering a WOS service area would continue to have only the wireless carrier name displayed.

Figure 11 shows some examples of location ID for private systems and the wireless carrier.

Figure 11. System Identities and Location ID



Self-Test

1. How many frequencies are in a radio channel?

    a. 1

    b. 2

    c. 3

    d. 4

2. How many layers are there to the PCS air interface?

    a. 1

    b. 2

    c. 3

    d. 4

3. What is the maximum possible number of characters in a PCS message?
    a. 64
    b. 256
    c. 1021
    d. 239
4. Which of the following is not an example of a PCS–enabled service?
    a. automatic callback
    b. MWI
    c. caller ID
    d. SMS
5. Which kind of cells typically provide WOS services?
    a. microcells
    b. macrocells
6. Which of the following network types does not provide service to the general public?
    a. residential
    b. public
    c. private
    d. autonomous
7. PCS phones do not scan constantly for incoming calls.
    a. true
    b. false
8. DCCH information is confined to the 21 ACCs.
    a. true
    b. false

9. The lower levels in the IS–136 platform are changed.

    a. true

    b. false

10. There is one logical channel carrying information from PCS phones to their system.

    a. true

    b. false

Correct Answers

1. How many frequencies are in a radio channel?

    a. 1

    b. 2

    c. 3

    d. 4

    See Topic 2.

2. How many layers are there to the PCS air interface?

    a. 1

    b. 2

    c. 3

    d. 4

    See Topic 3.

3. What is the maximum possible number of characters in a PCS message?

    a. 64

    b. 256

    c. 1021

d. 239

See Topic 6.

4. Which of the following is not an example of a PCS–enabled service?

    a. automatic callback

    b. MWI

    c. caller ID

    d. SMS

    See Topic 1.

5. Which kind of cells typically provide WOS services?

    a. microcells

    b. macrocells

    See Topic 7.

6. Which of the following network types does not provide service to the general public?

    a. residential

    b. public

    c. private

    d. autonomous

    See Topic 8.

7. PCS phones do not scan constantly for incoming calls.

    a. true

    b. false

    See Topic 7.

8. DCCH information is confined to the 21 ACCs.

    a. true

b. false

See Topic 2.

9. The lower levels in the IS–136 platform are changed.

    a. true

    b. false

    See Topic 3.

10. There is one logical channel carrying information from PCS phones to their system.

    a. true

    b. false

    See Topic 4.

Glossary

ACC
analog control channel

ARCH
access response channel

AVC
analog voice channel

BCCH
broadcast channel

CNI
calling number identification

DCCH
digital-control channel

DTC
digital-traffic channel

E–BCCH
extended broadcast channel

F–BCCH
fast broadcast channel

FDCCH
forward DCCH

HCS
hierarchical cell structure

MWI
message waiting indicator

OAA/P
over-the-air activation and programming

PBS
personal base station

PC
personal computer

PCH
paging channel

PCS
personal communications services

PSID
private system identity

RACH
random-access channel

RDCCH
reverse DCCH

RF
radio frequency

RSID
residential system identity

SCF
shared channel feedback

SMS
short message service

SMSCH
short message service channel

SPACH
SMS point-to-point messaging, paging, and access response channel

TIA
Telecommunications Industry Association

TDMA
time-division multiple access

WOS
wireless office services