

SUBSCRIBER HANDOFF BETWEEN MULTIPLE ACCESS COMMUNICATIONS SYSTEM

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Field of the Invention

The present invention is related in general to wireless communication systems, and more particularly to an improved method and system for performing a handoff between cellular communication systems having different multiple access schemes.

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Background of the Invention

In order to maximize the use and reuse of radio frequency spectrum, wireless communication systems use various schemes for allowing multiple users to simultaneously, or nearly simultaneously, access communication resources. For example, in cellular telephone systems, many cellular subscribers are allowed access to wireline communications resources (*i.e.*, the public switched telephone network (PSTN)) via various air interfaces that permit multiple subscriber access.

A multiple access scheme may be defined as a set of rules for sharing a communication resource, such as radio frequency spectrum, by allocating combinations of transmit or receive times, channel frequency, channel bandwidth, channel codes, transmit or receive locations, or the like. Examples of well known multiple access schemes include: AMPS (Advanced Mobile Phone System), NAMPS (Narrowband AMPS), TACS (Total Access Communications System), GSM (Global System for Mobile Communications), TDMA (Time Division Multiple Access), and CDMA (Code Division Multiple Access). Many of these multiple access schemes are well documented in industry standards promulgated by the Cellular Telecommunications Industry Association (CTIA), the Telecommunication Industry Association (TIA), and other standards

bodies. An example is the standard IS-95 for code division multiple access cellular communications systems.

As newer multiple access schemes are deployed, the coverage area of the new multiple access system is typically not as widespread as the older, more established communication systems that use a different multiple access scheme. Therefore, in order to provide subscribers using the new multiple access scheme a wider area of communications service, dual mode subscriber units have been developed so that subscribers may have service from the newer multiple access system, and when they roam outside the coverage of the newer multiple access system, the subscriber unit is able to communicate with an older or alternate multiple access system.

With reference now to FIG. 1, there is depicted a typical relationship between the coverage of a communications system with a first multiple access scheme and the coverage of a communications system using a second multiple access scheme. More specifically, the cellular coverage area 20 of FIG. 1 shows a cellular system using a code division multiple access (CDMA) scheme, illustrated with hexagonal cells 22, and, for clarity of illustration, an alternate multiple access (MA) scheme, illustrated with circularly shaped cells 24. The boundary between the area covered by CDMA cells 22 and an area covered by an alternate MA with alternate MA cells 24 is shown by border 26, shown with a heavy line.

As subscriber 28 moves between CDMA cells 22, a CDMA base station controller 30 supervises or manages handoffs between CDMA cells 22. Similarly, as subscriber 28 moves between alternate MA cells 24, alternate MA base station controller 32 supervises or manages handoffs between alternate MA cells 24. A handoff is a process in a cellular communications system by which a traffic channel is switched from communication with one cell to communication with another cell.

The problem solved by the present invention occurs when the communications system using a first MA wants to handoff a subscriber to a communications system using a second MA. This problem occurs in FIG. 1 when subscriber 28 moves from CDMA cell 22, across border 26 to an alternate MA cell 24. The problem may also occur without subscriber 28 crossing border 26, when, for example, the first MA communications system wants to handoff subscriber 28 to an alternate MA cell 24 having coverage within the area covered by the first MA communications system.

In the prior art, when, for example, the first MA is CDMA, a pilot beacon 34 is used to warn CDMA base station controller 30 that subscriber 28 is nearing the edge of CDMA coverage (*i.e.*, border 26). As used herein, a pilot beacon 34 is a transmitted signal that is defined in, or typically received by a component in, the first MA, the MA that is the source of the handoff. For example, when CDMA is the source MA, pilot beacon 34 is a pilot channel beacon, which makes alternate MA cells 24 outside and adjacent to border 26 look like another CDMA cell 22. This means that subscriber 28 reports the presence and strength of pilot beacon 34 to CDMA base station controller 30, according to the rules of CDMA IS-95, so that it can arrange a handoff with the alternate MA base station controller 32 through an inter-MA base station controller communication link 36. For a more detailed description, see United States Patent No. 5,594,718 to Weaver, Jr., et al., issued January 14, 1997.

Placing pilot beacons 34 in cells adjacent and outside border 26 has many problems. First, it is expensive. Each pilot beacon 34 requires a transmitter coupled to an antenna mounted on a suitable structure.

Second, it increases the complexity of the communication system. CDMA pilot beacons must be synchronized with the rest of the system and identified with a unique timing offset. Power levels must be properly set.

Third, additional antenna sites must be leased or purchased. Some of these site agreements may require negotiation with cellular system competitors for space on a competitor's tower.

5 Fourth, the pilot beacons may add to the noise floor of a system operated in the same radio frequency band by another licensee.

Fifth, the pilot beacon measured by the first or source MA communications system may not be a good indicator of communication quality of a radio frequency link using the second MA communications system. That is, the signal quality of a CDMA pilot beacon transmitted from a collocated AMPS cell and measured at a subscriber location may not accurately correspond to an AMPS signal quality at the same subscriber location; the AMPS signal may be experiencing a fade while the CDMA pilot beacon is not. This may be caused by differences in propagation between the CDMA pilot signal on one frequency and the AMPS signal on another frequency.

15 An alternative to using pilot beacons for handoffs between different MA systems is a blind handoff—one without any prior knowledge of traffic channel conditions in the second MA communications system. This alternative may easily result in a dropped call. And when more than one cell the second MA communications system may handle the traffic channel, there is no intelligent choice as to which is the better handoff candidate.

25 For the reasons discussed above, there is a need for an improved method and apparatus for performing a handoff between communications systems having different multiple access schemes.

Brief Description of the Drawings

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 depicts a sample coverage area provided by two communications systems using two different multiple access schemes wherein handoff between the two systems uses pilot beacons, according to the prior art;

FIG. 2 is a high-level schematic of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention;

FIG. 3 illustrates an alternate embodiment of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention;

FIG. 4 depicts a high-level schematic of a code division multiple access system for performing a handoff with an alternate MA communication system in accordance with the method and system of the present invention;

FIG. 5 is a more detailed block diagram of a first embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention;

FIG. 6 depicts a second embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention;

FIG. 7 is a high-level logic flow chart which illustrates the method of performing a handoff with an alternate MA communication system according to the present invention;

FIG. 8 is a more detailed flow chart which illustrates the process of subscriber unit initialization according to the present invention;

FIG. 9 is a more detailed flow chart which illustrates the process of measuring a signal characteristic in an alternate MA communication system in accordance with the present invention; and

FIG. 10 is a more detailed flow chart which illustrates the process of configuring a receiver to measure a signal characteristic in an alternate MA communication system in accordance with the present invention.

Detailed Description of the Invention

With reference now to figures, and in particular with reference to FIG. 2, there is depicted a high-level schematic of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention. As is shown, subscriber unit 50 generally comprises first multiple access transceiver 52 and second multiple access transceiver 54, both of which are coupled to antenna 56. First MA transceiver 52 is adapted to communicate with cells in a first communication system using a first multiple access scheme. Similarly, second MA transceiver 54 is adapted to communicate with cells in a second communication system using a second multiple access scheme. Appropriate duplexers (not shown) may be used to separate transmitted signals from received signals. The frequency of first MA transceiver 52 is controlled by local oscillator 58, and the frequency of second MA transceiver 54 is controlled by local oscillator 60. Both local oscillators 58 and 60 may be set to a selected frequency by a command or signal from control circuit 62.

Also shown in the embodiment of FIG. 2 is second MA measurement circuit 64, which has an input coupled to antenna 56 and a measurement output coupled to control circuit 62. Second MA measurement circuit 64 also receives control signals via a control line from control circuit 62.

Referring again to first MA transceiver 52, downlink traffic 66 is output from first MA transceiver 52, and may be coupled to control circuit 62 and clock 68. Downlink traffic 66 may contain control information, clock or synchronization information, and voice data or other data for processing by circuits in the subscriber unit that are not shown.

Uplink traffic 70 is an input signal for first MA transceiver 52. Uplink traffic 70 may contain voice or other subscriber data, and control information from control circuit 62.

Second MA transceiver 54 may include an output for downlink traffic 72 and an input for uplink traffic 74 in a similar manner. Both downlink traffic 66 and 72 and uplink traffic 70 and 74 are processed in portions of subscriber unit 50 that are not shown in a manner known in the art of cellular subscriber units to provide either voice or computer data communication services.

In operation, subscriber unit 50 communicates with a cell in a first multiple access communication system via transceiver 52. Subscriber unit 50 has been instructed to tune first MA transceiver 52 to a particular frequency, which is set or derived from local oscillator 58. Periodically, control circuit 62 may receive an instruction that starts the process to switch or handoff to a traffic channel in the second multiple access communication system. After such an instruction has been received, control circuit 62 causes second MA measurement circuit 64 to measure a signal characteristic of a signal from the second MA communication system. Such a signal characteristic is typically signal strength. The second MA signal characteristic is measured to determine whether or not a successful handoff may take place between the first MA communication system and the second MA communication system. The measurement of the second MA signal is typically taken at a predetermined time according to clock 68, preferably at a time that avoids interruption of downlink traffic 66 or uplink traffic 70. Second MA measurement circuit reports the signal of characteristic measurement to control circuit 62. Control circuit

62 then determines whether and how to report the second MA signal characteristic measurement to the first MA base station controller via uplink traffic 70 and first MA transceiver 52.

The measurement frequency of second MA measurement circuit 64 is controlled by the frequency of local oscillator 60, which may be set by control circuit 62.

Once the reports of the second MA signal measurements have been received by the base station controller in the first MA communication system, the base station controller may decide that a handoff to the second MA communication system is appropriate and will be successful. Alternatively, this handoff determination may be made by the subscriber unit, in which case the subscriber requests the first MA base station controller to schedule the handoff.

Subscriber handoff to the second MA communication system is initiated by a command received through antenna 56 and first MA transceiver 52. At the agreed upon time, control circuit 62 switches the downlink traffic and uplink traffic in subscriber unit 50 from first MA transceiver 52 to second MA transceiver 54, thus completing a handoff from the first MA communications system to the second MA communications system.

With reference now to FIG. 3, there is depicted an alternate embodiment of an apparatus for performing a handoff between different multiple access communication systems in accordance with the method and system of the present invention. In this embodiment, the measurement of the signal from the second multiple access communication system is performed by second MA transceiver 80. Such a measurement may be implemented with an RSSI (Receive Signal Strength Indicator) such as those included in many AMPS transceivers. To correctly take the second MA signal characteristic measurement, control circuit 62 may pass control information to second MA transceiver 80. Such control information may include gain settings, frequencies,

frequency ranges, the type of multiple access signal to be measured, time slot information, and the timing of the second MA signal measurement.

The embodiment of FIG. 3 also includes a single local oscillator 82. Thus, both transceivers 52 and 80 for the first and second MA communication systems share the same local oscillator 82, which is under
5 the control of control circuit 62. Local oscillator 82 should be capable of quickly switching between two frequencies and settling in a short time so that a second MA signal characteristic may be measured without unduly interrupting downlink traffic 66 or uplink traffic 70.

10 With reference now to FIG. 4, there is depicted a high-level schematic of a code division multiple access (CDMA) system for performing a handoff with an alternate communication system in accordance with the method and system of the present invention. As illustrated, subscriber unit 90 includes antenna 56 for receiving and
15 transmitting signals from cells in both a CDMA and an alternate MA communication system. In this example, an alternate MA communication system is a communication system using a multiple access scheme different from CDMA. CDMA receiver 92 includes a CDMA downlink traffic path that includes down-converter 94, gain
20 control 96, filter 98, analog-to-digital (A-to-D) converter 100, despreader 102, and CDMA demodulator 104. CDMA downlink traffic 106 is output by CDMA demodulator 104.

Down-converter 94 performs a frequency translation from the radio frequency signals at antenna 56 to a lower intermediate frequency
25 which is passed to gain control 96. Local oscillator 108 provides an input reference frequency for down-converter 44.

Gain control 96 may be implemented with a variable gain amplifier which operates under the control of signals from control circuit 110.

A-to-D converter 100 converts analog signals into a digital word
30 which has been sampled at discrete times.

Such a digital word is input into despreader 102, wherein during normal CDMA operation, the digital word is multiplied with a despreading code from despreading code source 112.

According to an important aspect of the present invention, despreader signal 114 is selected by despreader signal selector 116 under the control of control circuit 110. When despreading code source 112 is selected to provide despreader signal 114, the output of despreader 102 is directed to CDMA demodulator 104 which provides CDMA downlink traffic signal 106 for operation in a normal CDMA demodulation mode. In a measurement mode, despreader signal selector 116 selects despreader signal 114 from alternate signal source 118. Thus, when the signal from alternate signal source 118 is input into despreader 102, the output of despreader 102 is directed to signal characteristic measurement circuit 120. A signal characteristic value 122 produced by signal characteristic measurement circuit 120 is then input into control circuit 110. Two embodiments of signal characteristic measurement circuit 120 will be described below in relation to FIGs. 5 and 6.

Also providing inputs for control circuit 110 are reference levels 124, control signals 126, clock 128, and optionally measurement signal 130 from alternate MA transceiver 132.

CDMA transmitter 134 is coupled to antenna 56 for transmitting CDMA uplink traffic 136. CDMA transmitter 134 also operates under the control of signals from control circuit 110.

Alternate MA transceiver 132 is coupled to antenna 56 for receiving downlink traffic 138 and transmitting uplink traffic 140 according to the rules of the alternate MA scheme. Alternate MA transceiver 132 operates under the control of signals from control circuit 110. Such control signals may control the frequency of alternate MA transceiver 132, the type of MA used by alternate MA transceiver 132, the precise timing for switching to downlink traffic 138 and uplink traffic 140,

which are to be received and transmitted via alternate MA transceiver 132, and other similar controls.

In operation, control circuit 110 receives a command via CDMA downlink traffic 106 to initiate a handoff procedure to an alternate MA communication system. Before the handoff is made, however, a measurement of a signal from the MA communication system is made and reported to the CDMA base station controller. In the embodiment shown in FIG. 4, CDMA receiver 92 operates in two modes: a normal CDMA demodulation mode, and an alternate MA signal measurement mode.

In the normal CDMA demodulation mode, despreader signal selector 116 selects a signal from despreading code source 112 for despreader signal 114 that is input into despreader 102. In this mode, regular CDMA downlink traffic 106 is output by CDMA demodulator 104. Such CDMA downlink traffic 106 may include control signals 126 and timing signals or queues, which are input into control circuit 110 and clock 128, respectively.

In the alternate MA signal measurement mode, despreader signal selector 116 selects a signal from alternate signal source 118 for the despreader signal 114 which is input into despreader 102. The output of despreader 102 is then used by signal characteristic measurement circuit 120 to measure a signal characteristic of a signal from an alternate MA system. A signal characteristic value 122, the result of the measurement, is input into control circuit 110, and may be compared with a reference level recalled from or calculated by reference levels 124. In accordance with an agreed upon reporting criteria, control circuit 110 reports such a comparison to the CDMA base station controller 30 (see FIG. 1) via CDMA transmitter 134. When the data pertinent to the handoff decision has been collected, the decision to handoff is made either by the subscriber unit, the base station controller, or at some other location; the specific

place or functional unit that makes the decision is up to the system designer.

When directed to perform a handoff between communication systems, subscriber unit 90 will switch from using CDMA downlink traffic 106 and CDMA uplink traffic 136 to using alternate MA downlink traffic 138 and alternate MA uplink traffic 140.

With reference now to FIG. 5, there is depicted a more detailed block diagram of a first embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention. As illustrated, signal characteristic measurement circuit 120 includes narrowband filter 150, power measurement function 152, and integrator 154. Thus, the output of signal characteristic measurement circuit 120 may be a estimated power level integrated over a period of time. Such a power level value may be compared to a reference level in control circuit 110. If signal characteristic measurement circuit 120 is measuring a signal from a single AMPS communications system channel, narrowband filter 150 may be tuned to the bandwidth of an AMPS channel, which is 30 kHz.

With reference now to FIG. 6, there is depicted a second embodiment of a signal characteristic measurement circuit which may be used in implementing the method and system of the present invention. As illustrated, this second embodiment of signal characteristic measurement circuit 120 includes wideband filter 156 and frequency analysis circuit 158. In operation, wideband filter 156 may, for example, be set to receive a frequency range that covers several AMPS channels. Frequency analysis circuit 158 may be used to perform a Fourier transform on the filtered signal. Such a Fourier transform may reveal several AMPS frequencies from several AMPS base stations, any one which may be selected as the destination base station of a handoff from the CDMA system to the AMPS system.

Prior to measurements by signal characteristic measurement circuit 120 shown in either FIG. 5 or FIG. 6, it may be necessary to set an appropriate gain at gain control 96 (see FIG. 4). Depending upon which measurement circuit is used, and what multiple access system is to be measured, control circuit 110 may set gain control 96 in an appropriate manner so that a valid measurement may be made.

With reference now to FIG. 7, there is depicted a high-level logic flowchart which illustrates the method of performing a handoff with an alternate communications system in accordance with the present invention. As illustrated, the process begins at block 200 and thereafter passes to block 202 wherein the process initializes the subscriber unit. This initialization process involves transferring parameters and negotiating protocols between the base station controller and the subscriber unit. Such an initialization process is described in greater detail below with reference to FIG. 8.

Next, the subscriber unit measures a signal characteristic of a signal from an alternate multiple access communication system, as illustrated at block 204. Such a measurement may be accomplished with an alternate MA transceiver in the subscriber unit as illustrated in FIG. 3, or with an alternate MA measurement circuit in the subscriber unit as illustrated in the example of FIG. 2. Yet another way of measuring the alternate MA signal is to use the current MA receiver, as illustrated in FIG. 4, wherein a CDMA receiver may be reconfigured to measure a signal in an alternate MA, such as AMPS.

After measuring the alternate MA signal, the subscriber unit optionally measures a signal characteristic of a signal from the current MA communications system, as depicted at block 206. In some communications systems, this step may be optional because the signal characteristic of a signal from the current MA system may be irrelevant to the handoff decision. However, some systems may be designed to

compare the signal characteristic of the signal from the alternate MA with the signal characteristic of the signal from the current MA.

After taking the appropriate signal measurements, the subscriber unit reports these signal characteristic measurements to the base station controller, as illustrated at block 208. The criteria for reporting signal characteristic measurements may be negotiated during the initialization procedure in block 202. Some measurements may only be reported if they exceed a certain threshold value, wherein the absence of a signal characteristic report is interpreted as a measurement of a value below the threshold value.

Note that the step at block 208 may not be necessary if the system is designed to let the subscriber decide when and where to handoff, in which case the subscriber may ask to be handedoff rather than reporting signal measurement values.

After all signal characteristic measurements have been reported to the current MA base station controller, the process determines whether or not a handoff should be attempted to the alternate MA communication system, as depicted at block 210. If, for whatever reason, a handoff attempt should not be made, the process iteratively returns to block 204 to update the signal measurements. If the system determines that a handoff should be made from the current MA communications system to the alternate MA communications system, the process then determines whether or not the alternate MA system can accept the subscriber traffic, as illustrated at block 212.

If the alternate system cannot accept the subscriber traffic, the process iteratively returns to block 204, wherein the measurements are updated. If the alternate MA communications system can accept the subscriber traffic, the process coordinates a handoff with the alternate MA communication system, as depicted at block 214. This step may be implemented by communication between the current MA base station controller and the alternate MA base station controller via inter-MA base

station controller communications link 36 (see FIG. 1). Coordination of the handoff may include parameters such as a destination frequency of a channel in the alternate MA communications system and a specific time for the handoff to occur.

5 After coordinating the handoff, the process performs a subscriber handoff from the current MA communication system to the alternate MA communication system, as illustrated at block 216. As with handoffs between cells of any cellular communication system, the handoff between communication systems with different MAs should take place quickly so
10 that the subscriber traffic channel is not unduly interrupted.

 The process of performing a handoff from a communication system with a first MA to a communication system with a second MA is then terminated at block 218.

 With reference now to FIG. 8, there is depicted a more detailed
15 flowchart which illustrates the process of initializing a subscriber unit according to the present invention. As illustrated, the initialization procedure starts at block 300, and thereafter passes to block 302 wherein the process sends the alternate MA communication system type to the subscriber. This step may be implicit if the subscriber unit is only
20 designed to handoff to one other alternate communications system type. The alternate communication system type may, for example, specify an AMPS system, a TDMA system, a GSM system, or any other standardized multiple access system.

 After receiving the alternate MA communication system type, the
25 process sends a frequency list or frequency range which is used by the alternate MA communication system, as illustrated at block 304. The frequency list may include a list of frequencies of control channels used at various base stations in, for example, an AMPS system. Alternatively, a frequency range may be specified wherein the signal strength, or other
30 signal characteristic, of several frequencies within the range may be reported back to the base station controller.

Next, the subscriber unit receives the reporting criteria for reporting measurements of signals from the alternate MA communication system, as depicted at block 306. Such reporting criteria may include instructions not to report signal characteristics from the alternate MA that fall below a threshold value. Thus, the absence of a response to request for a report may be interpreted by the base station controller as a measurement of a value that falls below the agreed upon threshold. The reason for such reporting criteria may be to reduce reporting traffic between the subscriber unit and the base station controller.

Thereafter, the process negotiates the timing of alternate MA signal measurements with the current MA communications system, as illustrated at block 308. Such negotiation may result in measurements being taken at predetermined time intervals, or measurements taken only upon request.

The initialization process is then terminated, as indicated at block 310.

With reference now to FIG. 9, there is depicted a more detailed flowchart which illustrates the process of measuring a signal characteristic or a signal in an alternate MA communications system in accordance with the method of the present invention. As illustrated, the process begins at block 400, and thereafter passes to block 402 wherein the process determines whether or not it is time to measure a signal characteristic of a signal from an alternate MA communication system. If it is not time to take a measurement, the process iteratively loops until it is time to take a measurement. The time to take a measurement may be set at predetermined intervals or only as requested by a base station controller in the current MA communication system. The time to take alternate MA communication system measurements may be negotiated during the initialization procedure, as described with reference to FIG. 8.

If it is time to take a signal characteristic measurement of a signal from an alternate communication system, the process configures the subscriber unit for the alternate MA signal measurement, as depicted at block 404. In some embodiments of the present invention, this configuration process prepares signal characteristic circuit 120 to take the measurement, and may also set various filters and gain adjustments so that the measurement circuit may provide a valid measurement. This subscriber configuration process is described in greater detail with reference to FIG. 10 below.

Next, the process measures the signal characteristic of the signal from the alternate MA communication system, as illustrated at block 406. In a preferred embodiment, this signal characteristic is signal strength. According to the architecture of the subscriber unit, the signal measurement may be taken with a special configuration of the current MA demodulator, or with a dedicated receiver that receives alternate MA signals, or with the receiver portion of the alternate MA transceiver. These various subscriber architectures are described with reference to FIGs. 2-4.

After making the signal characteristic measurement, the process reconfigures the subscriber unit for normal operation in the current MA communication system, as depicted at block 408. If the circuit used to measure the signal characteristic is not completely independent from the current MA transceiver, the period of time between blocks 404 and 408 should be minimized so that subscriber traffic is not unduly interrupted.

After reconfiguring the subscriber unit for normal demodulation in the current MA communication system, the process determines whether or not the alternate MA signal measurement was valid, as illustrated at block 410. If the measurement was valid, the process ends, as depicted at "return" block 412. Alternatively, if the measurement was not good, the process adjusts the measurement configuration parameters, such as filter and gain settings, as depicted at block 414. Thereafter, the

process iteratively returns to block 402 to await another measurement time. For obvious reasons, the subscriber unit will probably be returned to normal operations while waiting for the next opportunity to take a measurement.

5 With reference now to FIG. 10, there is depicted a more detailed flowchart which illustrates the process of configuring a receiver to measure a signal characteristic in an alternate MA communication system in accordance with the method of the present invention. As illustrated, the process begins at block 500 and thereafter passes to block
10 502 wherein the process suspends code division multiple access talking and listening, or modulating and demodulating. Note that the process described in relation to FIG. 10 specifically relates to a CDMA receiver which is used to make signal characteristic measurements of a signal from an alternate MA communication system, such as the CDMA
15 receiver shown in FIG. 4.

Next, the process sets the local oscillator frequency to receive an alternate MA communication system frequency, as illustrated at block 504. This step may be used to set local oscillator 108 with a control signal from control circuit 110 in subscriber unit 90 illustrated in FIG. 4.

20 After setting the local oscillator, the process sets the signal gain and filters for receiving the signal from the alternate MA communication system, as depicted at block 506. Similarly, control circuit 110 may send signals to gain control 96 and filter 98 in preparation for measuring a signal from an alternate MA communication system.

25 Note that steps 504 and 506 may be referred to as configuring a tuner to receive a signal from an alternate MA system. Such a tuner is shown at reference numeral 142 in FIG. 4. Next, the process selects an alternate despreading signal for use in the CDMA despreader, as illustrated at block 508. With reference to FIG. 4, this step may be
30 accomplished by switching despreader signal selector 116 to the alternate signal source position so that despreader signal 114 comes from alternate

signal source 118. Alternate signal source 118 may be a series of zeros or ones, which produces a constant valued signal that suspends the despread operation in despreader 102.

After selecting the alternate despread signal, the process enables the alternate MA signal characteristic measurement circuitry, as depicted at block 510. This step may be accomplished by clearing registers or otherwise resetting signal characteristic measurement circuit 120. Thereafter, the configuration process terminates, as illustrated at block 512.

To configure a subscriber unit having an architecture such as that illustrated in FIG. 3, the configuration process may execute blocks 502, 504, 506, and then jump to block 510 to enable the measurement circuitry within second MA transceiver 80. In a subscriber unit having architecture depicted in FIG. 2, the measurement configuration process may execute step 506 and then skip to step 510 to take the measurement with second MA measurement circuit 64. Setting a local oscillator is not necessary because the measurement circuitry uses an independent local oscillator 60.

In summary, the invention described above permits a handoff from a first multiple access communication system to a second multiple access communication system, wherein a dual mode subscriber unit assists the handoff by measuring signals from the second multiple access system at the subscriber unit. A plurality of pilot beacons transmitting signals in the MA scheme of the first multiple access communication system are not required, thereby lowering the cost of infrastructure necessary to enable the inter-system handoff.

While some of the specific examples described above relate to handing-off a subscriber unit from a CDMA system to an AMPS system, the principles and basic architectures of the present invention may be used to perform a handoff from any MA communication system to any other MA communication system.

Various means of measuring alternate MA signal characteristics have been described, including: a subscriber system that uses an independent measurement circuit, a subscriber unit that shares a local oscillator circuit between transceivers for the different MA's, and a
5 subscriber unit that uses a reconfigured CDMA receiver to measure a signal characteristic of a signal from an alternate MA communication system. Such a CDMA receiver may be set so that the despreading operation is suspended and the alternate signal passing through the despreader may be analyzed by integrating power over a narrow band, or
10 by analyzing a wide band frequency spectrum.

In some embodiments of the present invention, alternate signal source 118 may be a specialized signal that will enhance the measurement of an alternate MA signal or signals that have known characteristics. For example, such a signal may contain multiple discrete frequencies that can
15 be used to detect the power of multiple alternative MA signals.

The foregoing description of a preferred embodiment of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Modifications or variations are possible in
20 light of the above teachings. The embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application, and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such
25 modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.



Claims

What is claimed is:

- 1 1. A method in a cellular telecommunications system for performing
2 a subscriber handoff from a first multiple access communications system
3 to a second multiple access communications system, said method
4 comprising the steps of:
5 from a subscriber unit in communication with said first multiple
6 access communications system, measuring a signal characteristic of
7 a signal from said second multiple access communications system
8 to produce a signal characteristic value;
9 in response to said signal characteristic value, configuring said
10 subscriber unit to communicate with said second multiple access
11 communications system; and
12 performing a subscriber handoff from said first multiple access
13 communications system to said second multiple access
14 communications system.
- 1 2. The method for performing a subscriber handoff according to claim
2 1 wherein said signal characteristic is signal strength.



1 3. The method for performing a subscriber handoff according to claim
2 1 wherein said first multiple access communications system is a code
3 division multiple access system and said subscriber unit includes a
4 despreader using a despreading signal, and wherein the step of measuring
5 a signal characteristic further includes:

6 selecting an alternate despreading signal for use in said despreader;

7 passing said signal from said second multiple access communications
8 system through said despreader; and

9 measuring a signal characteristic of a signal from said second multiple
10 access communications system to produce a signal characteristic
11 value.

1 4. The method for performing a subscriber handoff according to claim
2 3 wherein said alternate despreading signal includes a constant value
3 despreading signal.

1 5. The method for performing a subscriber handoff according to claim
2 3 wherein said alternate despreading signal includes a signal having
3 multiple preselected discrete frequencies for measuring power in
4 multiple signals in said second multiple access communications system
5 having different frequencies.



1 6. The method for performing a subscriber handoff according to claim
2 3 wherein said step of measuring a signal characteristic of a signal from
3 said second multiple access communications system to produce a signal
4 characteristic value further includes performing a frequency analysis of a
5 signal from said second multiple access communications system to
6 produce signal power values over a frequency range.

1 7. The method for performing a subscriber handoff according to claim
2 1 wherein said step of configuring said subscriber unit to communicate
3 with said second multiple access communications system in response to
4 said signal characteristic value further includes configuring said
5 subscriber unit to communicate with said second multiple access
6 communications system in response to said signal characteristic value
7 exceeding a predetermined threshold.

1 8. The method for performing a subscriber handoff according to claim
2 1 further including the steps of:

3 from said subscriber unit, measuring a signal characteristic of a signal
4 from said first multiple access communications system to produce
5 a first system signal characteristic value;

6 comparing said signal characteristic value with said first system signal
7 characteristic value; and

8 configuring said subscriber unit to communicate with said second
9 multiple access communications system in response to said signal
10 characteristic value exceeding said first system signal characteristic
11 value.



1 9. The method for performing a subscriber handoff according to claim
2 1 wherein said step of configuring said subscriber unit to communicate
3 with said second multiple access communications system in response to
4 said signal characteristic value further includes switching subscriber
5 uplink and downlink traffic from a first multiple access transceiver to a
6 second multiple access transceiver to communicate with said second
7 multiple access communications system in response to said signal
8 characteristic value.



1 10. A method in a code division multiple access subscriber unit for
2 measuring a signal characteristic of a signal from an alternate multiple
3 access communication system, said method comprising the steps of:

4 configuring a tuner to receive said signal from said alternate multiple
5 access communication system;

6 selecting an alternate despreading signal for use in a despreader in said
7 code division multiple access subscriber unit;

8 passing said signal from said alternate multiple access communication
9 system through said despreader; and

10 measuring said signal characteristic of said signal from said alternate
11 multiple access communication system.

1 11. The method in a code division multiple access subscriber unit
2 according to claim 10 wherein said step of configuring a tuner to receive
3 said signal from said alternate multiple access communication system
4 further includes setting a frequency, setting a gain, and setting a filter,
5 wherein each are set to receive said signal from said alternate multiple
6 access communication system.

1 12. The method in a code division multiple access subscriber unit
2 according to claim 10 wherein said alternate despreading signal is a
3 constant value signal.



- 1 13. The method in a code division multiple access subscriber unit
2 according to claim 10 wherein said step of measuring said signal
3 characteristic of said signal from said alternate multiple access
4 communication system further includes performing a frequency analysis
5 of said signal from said alternate multiple access communication system.



1 14. An apparatus for receiving a code division multiple access signal
2 and measuring a signal characteristic of a signal from an alternate
3 multiple access communications system comprising:

4 a despreader having a signal input, a despreading input, and a
5 despreader output;

6 a despreading code signal source;

7 an alternate despreading signal source;

8 a despreader signal selector having inputs coupled to said despreading
9 code signal source and said alternate despreading signal source, and
10 an output coupled to said despreading input;

11 a tuner having an output coupled to said signal input;

12 a signal characteristic measurement circuit coupled to said despreader
13 output; and

14 a control circuit coupled to said tuner and said despreader signal
15 selector for configuring said apparatus for receiving said code
16 division multiple access signal or for measuring a signal
17 characteristic of a signal from an alternate multiple access
18 communications system.

1 15. The apparatus according to claim 14 wherein said alternate
2 despreading signal source is a constant value signal source.



- 1 16. The apparatus according to claim 14 wherein said alternate
- 2 desreading signal source produces a signal having multiple preselected
- 3 discrete frequencies.