Title: POWER SCAN RSSI MEASUREMENT

Abstract: The disclosure provides for determining a received signal strength indicator (RSSI) for a frequency. In an aspect, a wireless device obtains samples of received energy on the frequency over at least a time-period equal in length to a subframe. The device determines that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot. The determining includes aligning the samples with the expected energy pattern. The RSSI is measured based on a subset of samples aligned with the first downlink time slot. The RSSI may be measured by selecting a maximum energy of samples aligned with the first downlink time slot and samples aligned with a second downlink time slot. A minimum RSSI may be set when a ratio of downlink time slot energy to gap period energy is below a threshold.
POWER SCAN RSSI MEASUREMENT

BACKGROUND

[0001] The present disclosure relates generally to communication systems, and more particularly, to power scanning in wireless networks.

[0002] Wireless communication networks are widely deployed to provide various communication services such as telephony, video, data, messaging, broadcasts, and so on. The networks may be multiple access networks capable of supporting communications for multiple users by sharing the available network resources. An example of such a network is a Universal Terrestrial Radio Access Network (UTRAN). UTRAN is the Radio Access Network (RAN) that is part of the Universal Mobile Telecommunications System (UTMS), a third generation (3G) mobile phone technology promulgated by the “3rd Generation Partnership Project” (3GPP). UMTS, which is the successor to Global System for Mobile Communications (GSM), currently uses various standards including Wideband Code Division Multiple Access (WCDMA), High Speed Downlink Packet Data (HSDPA), Time Division–Code Division Multiple Access (TD-CDMA), and Time Division–Synchronous Code Division Multiple Access (TD-SCDMA). By way of example, China is pursuing TD-SCDMA as the underlying air interface in the UTRAN architecture with the existing GSM infrastructures for the core network.

[0003] As the demand for mobile broadband access continues to increase, there exists a need for further improvements in UMTS technology. Preferably, these improvements should be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

[0004] Frequency scanning and acquisition provides an opportunity for improvement. When a wireless device is out of service or otherwise not connected to a network or is looking for a better network, the wireless device may attempt to find and connect to a suitable network by scanning for signals on a range of frequencies across one or more frequency bands and attempting to acquire a cell on a frequency. A received signal strength indicator (RSSI) is often used to measure the relative strength of the cell. In time division systems, known RSSI measurements may measure uplink signals that do not provide an accurate representation of a downlink signal strength.
SUMMARY

[0005] The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

[0006] The disclosure provides for determining a received signal strength indicator (RSSI) for a frequency. In an aspect, a wireless device obtains samples of received energy on the frequency over at least a time-period equal in length to a subframe. The device determines that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot. The determining includes aligning the samples with the expected energy pattern. The RSSI is measured based on a subset of samples aligned with the first downlink time slot. The RSSI may be measured by selecting a maximum energy of samples aligned with the first downlink time slot and samples aligned with a second downlink time slot. A minimum RSSI may be set when a ratio of downlink time slot energy to gap period energy is below a threshold.

[0007] In an aspect, the disclosure provides a method of determining a RSSI for a frequency. The method includes: obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe; determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

[0008] In an aspect of the disclosure, an apparatus for determining a RSSI for a frequency is provided. The apparatus includes: means for obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe; means for determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no
expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and means for measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

[0009] In another aspect, the disclosure provides a computer-readable medium storing computer executable code for determining a RSSI for a frequency. The computer-readable medium includes code for: obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe; determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

[0010] In an aspect, the disclosure provides an apparatus for determining a RSSI for a frequency. The apparatus includes at least one processor; and a memory coupled to the at least one processor. The at least one processor is configured to: obtain samples of received energy on the frequency over at least a time-period equal in length to a subframe; determine that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and measure the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a conceptual diagram illustrating a wireless device in communication with a radio network.

[0012] FIG. 2 is a flowchart conceptually illustrating an example of a method of determining an RSSI.

[0013] FIG. 3 is a flowchart conceptually illustrating an example of another method of determining an RSSI.

[0014] FIG. 4 is a conceptual diagram illustrating an example of a channel structure in a telecommunications system.
[0015] FIG. 5 is a conceptual diagram illustrating an example of an expected energy pattern.

[0016] FIG. 6 is a conceptual diagram illustrating an example of a hardware implementation for an apparatus employing a processing system.

[0017] FIG. 7 is a conceptual diagram illustrating an example of a telecommunications system.

[0018] FIG. 8 is a conceptual diagram illustrating an example of an access network.

[0019] FIG. 9 is a conceptual diagram illustrating an example of a NodeB in communication with a UE in a telecommunications system.

DETAILED DESCRIPTION

[0020] The detailed description set forth below, in connection with the appended drawings, is intended as a description of various configurations and is not intended to represent the sole configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0021] A wireless device, for example, a user equipment (UE), may perform a public land mobile network (PLMN) search in order to locate a network. A PLMN search generally includes at least two phases. First, the wireless device scans frequencies to determine which frequencies are being used by networks. The wireless device may determine a received signal strength indicator (RSSI) for each frequency. Second, the wireless device attempts to receive signals at the strongest frequencies and identify a network cell using the frequency. The wireless device may attempt to receive and decode a control channel to obtain system information blocks (SIBs).

[0022] In a time division synchronous code division multiple access (TD-SCDMA) system, the pilot signals transmitted by a cell may occur at specific time slots within a radio frame or sub-frame. In some working frequencies, circuit switched calls may use other time slots for uplink and downlink traffic. These frequencies may not include a primary common control physical channel (PCCPCH); however, when a
wireless device scans these frequencies, interference from the circuit switched call may generate a significant RSSI measurement that will appear as if the frequency is being used by a cell. The wireless device may attempt to acquire a cell using the frequency, but be unable to read SIBs because no PCCPCH is present. Such attempts to acquire a cell on a frequency that is not being used by a cell may consume significant time and delay the process of finding an appropriate cell.

[0023] The present disclosure provides for determining the RSSI of a frequency based on the pilot channel or control channel. By matching the energy of a received signal to an expected energy pattern, a wireless device may determine whether the received signal is likely to include the pilot and control channels of a cell. The wireless device may also identify the portions of the received signal corresponding to the pilot channel and/or control channel. The wireless device may then measure the RSSI for the frequency based on the portions corresponding to the pilot channel and/or control channel. Accordingly, the RSSI may accurately reflect the strength of a signal broadcast by a cell. The RSSI may be used for ranking frequencies and determining whether to acquire a cell on the frequency.

[0024] Referring to FIG. 1, in an aspect, a wireless communication system 100 includes a user equipment (UE) 110 having a modem component 120 configured to determine an RSSI for a frequency. In an aspect, the term “component” as used herein may be one of the parts that make up a system, may be hardware or software, and may be divided into other components. For example, modem component 120 may include a processor configured to scan a range of frequencies for a base station such as base stations 102, 104, or 106 utilizing frequencies 112 or 114 for communications. In an aspect, two or more base stations may use the same frequency, for example frequency 114, using different codes. A component may be a block or module. The frequencies 112 or 114 may carry a subframe 108, which may include both uplink and downlink traffic. The subframe 108 may include a PCCPCH 116 and a pilot 118 transmitted by one or more of base stations 102, 104, or 106. The PCCPCH 116 may carry one or more SIBs broadcast by a base station 102, 104, or 106. The Pilot 118 may carry an identification code broadcast by a base station 102, 104, or 106. The PCCPCH 116 and the pilot 118 may be separated by one or more guard periods (GP) or gaps when a base station does not transmit.
The modem component 120 may be configured to perform frequency scanning, acquisition, and/or camping. During frequency scanning, the modem component 120 may determine whether one or more frequencies are being used by one or more cells. During acquisition, the modem component 120 may identify one or more cells using a particular frequency. During camping, the modem component 120 may obtain information from a cell and register the UE 110 to the cell. The modem component 120 may include a receiving component 130, a gap detecting component 140, an RSSI component 150, and a transmitting component 160.

The receiving component 130 may receive wireless signals such as radio frequency signals transmitted by one or more base stations 102, 104, 106. In an aspect, the receiving component 130 may include a radio receiver and receive chain components and/or modules. The receiving component 130 may receive radio frequency (RF) analog signals and sample the signals to provide digital samples. For example, in a TD-SCDMA system, the receiving component 130 may operate at a chip rate of 1.28 million chips per second (Mcps). The receiving component 130 may obtain a sample for each chip position. In an aspect, the receiving component 130 may receive signals from multiple antennas. The receiving component 130 may obtain samples from each of the multiple antennas and then combine the samples to obtain a composite signal. The receiving component 130 may also combine the energy from multiple sequential chips for a measurement length, $A$. For example, the receiving component 130 may combine 24 chips for each chip position. In an aspect, during a frequency scan, the receiving component 130 may obtain at least one sub-frame of samples at a frequency. For example, in a TD-SCDMA system, the receiving component 130 may obtain samples for 5 milliseconds (ms) or 6400 chips. One sub-frame should include a pattern of special time slots including a downlink pilot time slot (DwPTS), guard period, and uplink pilot time slot (UpPTS) if the frequency is being used by a cell. In an aspect, the receiving component 130 may obtain an array $Q_k$ representing received samples. For example, the array $Q_k$ may be determined according to the following formula:

$$Q_k = \sum_{a}^{d-1} \sum_{n=0}^{A} | y_{a,n+k} |^2,$$

(1)
In formula (1), \(a\) may be a number of antennas and \(y_{a,k}\) may be the raw sample obtained from the \(a^{\text{th}}\) antenna at the \(k^{\text{th}}\) chip position. \(A\) may be a configurable measurement length.

The gap detecting component 140 may be configured to analyze the samples to determine whether the samples match an expected energy pattern. An expected energy pattern may include any pattern of energy that may be predicted based on characteristics of a radio access technology (RAT). For example, in a radio access technology using time division, an expected energy pattern may include a pattern of high and low energy based on a structure of time slots within a radio frame or subframe. The gap detecting component 140 may include hardware, firmware, and/or a processor executing software configured to determine whether the samples match an expected energy pattern. For example, in a TD-SCDMA system, the frame structure including downlink time slots and special time slots may create a high-low-high-low pattern in the received energy. The gap detecting component 140 may align the samples with the expected energy pattern, for example, by identifying chip positions within the samples that correlate with the expected pattern. In an aspect, the gap detecting component 140 may attempt to match the pattern by determining a ratio of high energy to low energy at various candidate chip positions based on the expected energy pattern. The gap detecting component 140 may include a ratio determining component 142 and a ratio evaluating component 144.

The ratio determining component 142 may be configured to determine a gap ratio for each candidate chip position. The candidate chip position may be a position within the expected pattern such as, for example, the start of the special time slots. In an aspect, the ratio determining component 142 may determine a ratio \(M_k\) for each candidate chip position. The ratio \(M_k\) may be determined according to the following formula:

\[
(2) \quad M_k = \frac{\min\left\{Q_{k-D_0}, Q_{k+D_1}\right\}}{\max\left\{Q_k, Q_{k+D_2}\right\}}
\]

In formula (2), \(k\) may be the candidate chip position. \(D_0\) may be a number of chips from a position within TS0 when the PCCPCH 116 is transmitted to the candidate chip position (for example, 56 chips). \(D_1\) may be configured as at least the length of a guard period plus a measurement length. \(D_1\) may be a number of chips from the
candidate chip position to a location within the pilot 118 (for example, 56 chips). D2 may be a number of chips from the candidate chip position to a location within a gap (for example, 112 chips).

[0029] The ratio evaluating component 144 may be configured to compare a maximum gap ratio to a threshold. The ratio evaluating component 144 may be further configured to determine a location of the gap based on the maximum gap ratio. For example, the gap detecting component 140 may indicate a chip position that is most likely the start of the special time slots. In an aspect, the start of the special time slots may be indicated by \( \hat{k}_{\text{GAP}} \) determined according to the following formula:

\[
(3) \quad \hat{k}_{\text{GAP}} = \arg \max_{k \in [0,56399]} M_k
\]

In the formula (3) \( \hat{k}_{\text{GAP}} \) may be chip position of the maximum value of \( M_k \) for 6400 chip positions. \( M_{\hat{k}_{\text{GAP}}} \) may indicate the maximum value of \( M_k \). The ratio evaluating component 144 may compare the maximum gap ratio for the samples to a threshold to determine whether the samples include a gap. For example, the ratio evaluating component 144 may compare \( M_{\hat{k}_{\text{GAP}}} \) to a threshold. In an aspect, a threshold for a TD-SCDMA system may be approximately 2-4 dB. The threshold may be configured based on a desired system to acquire. The configured threshold may be adjusted based on radio environment properties such as noise and interference and/or a desired acceptance rate. For example, the threshold may be lowered if there is a large amount of noise or if very few frequencies satisfy the gap detection threshold.

[0030] The RSSI component 150 may be configured to determine an RSSI based on whether the plurality of samples matches the expected energy pattern. The RSSI component 150 may include hardware, firmware, and/or a processor executing software configured to determine an RSSI based on whether the plurality of samples matches the expected gap pattern. In an aspect, if the samples do not match the expected energy pattern or no gap has been detected, the RSSI component 150 may set the RSSI for the frequency to a minimum value. For example, the RSSI component 150 may set an RSSI value to -128 dBm for the frequency. The RSSI component 150 may use any other means to exclude the frequency from further analysis or processing. In an aspect, if the gap detecting component 140 detects a gap, the RSSI component 150 may determine the RSSI based on the location of the gap.
For example, the RSSI component 150 may measure the RSSI based on samples located in either the PCCPCH 116 or the pilot 118. The RSSI component 150 may take a measurement from the same chip positions used to detect the high energy locations of the gap pattern. The RSSI measurement may use the maximum of the high energy locations. In an aspect, the RSSI may be determined according to the following formula:

\[ \text{RSSI} = \max(\hat{Q}_{k_{GAF}-D_0}, \hat{Q}_{k_{GAF}+D1}) \]

In formula (4), the values D0 and D1 may be the same values as formula (2). The determined RSSI value may be used as the RSSI for the frequency.

[0031] The transmitting component 160 may be configured to transmit data. The transmitting component 160 may include a transmitter. The transmitting component 160 may transmit information during uplink time slots. For example, the transmitting component 160 may transmit pilot signals to a selected base station during a special uplink pilot time slot. The transmitting component 160 may be used to transmit any other information in the uplink direction as needed during regular uplink time slots. In an aspect, the transmitting component 160 and the receiving component 130 may be integrated into a single component or module which may be referred to as a transceiver.

[0032] FIG. 2 is a flowchart illustrating a method 200 of determining an RSSI. Referring to FIG. 1, in an operational aspect, a UE 110 may perform various aspects of a method 200 for determining an RSSI. While, for purposes of simplicity of explanation, the method is shown and described as a series of acts, it is to be understood and appreciated that the method (and further methods related thereto) is/are not limited by the order of acts, as some acts may, in accordance with one or more aspects, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, it is to be appreciated that a method could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a method in accordance with one or more features described herein.

[0033] In block 202, the method 200 may include obtaining samples of received energy on a frequency over at least a time-period equal in length to a subframe. The receiving component 130 may obtain samples of received energy on a frequency over
at least the time-period equal in length to a subframe. In an aspect, the number of samples may correspond to the length of a subframe. For example, in a 1.28 Mcps TD-SCMDA system, samples at 6400 chip positions may correspond to a 5 ms subframe. It should be apparent that, during an RSSI scan, the samples are unlikely to be synchronized with the start of the subframe because the UE 110 has not yet been synchronized with the network. By obtaining samples over at least a time period equal in length to a subframe (or a multiple thereof), the receiving component 130 may process the received samples cyclically. For example, if the samples are stored in an array Q of length 6400, Q[0] may follow Q[6399]. Further, when describing the order of samples, the samples may be considered cyclically. For example, Q[0] may be considered as being between Q[6399] and Q[1]. Accordingly, the samples may exhibit the energy pattern of a complete sub-frame even if the samples are taken across two or more subframes.

[0034]  In block 204, the method 200 may include determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern. The gap detecting component 140 may determine that the samples match an expected energy pattern of the subframe. The expected energy pattern of the subframe may be based on RAT characteristics. The gap time period may be a portion of the subframe when a base station is not expected to transmit, for example, a guard period. Accordingly, the gap time period may have no expected energy. A person skilled in the art should recognize that during a gap time period, noise and/or interference may be received. Energy from noise and/or interference may not be included in the expected energy pattern. Determining that the samples match the expected gap pattern may include aligning the samples with the expected energy pattern. The gap detecting component 140 may align the samples with the expected energy pattern by correlating characteristics of the samples and the expected energy pattern. For example, the gap detecting component 140 may consider samples spaced a configurable number of chips (for example, 56 chips) apart in order to correlate with time periods of the expected energy pattern. In an aspect, the gap detecting component 140 may determine a gap ratio of high energy samples to low energy samples for each
candidate chip position. High energy samples may be samples having a received energy greater than a threshold. For example, the receiving component 130 may obtain high energy samples when a base station is transmitting a signal during a downlink time period. Low energy samples may be samples having a received energy lower than a threshold. For example, the receiving component 130 may obtain low energy samples during a guard period when a base station is not transmitting. The gap detecting component 140 may determine a candidate chip position having the maximum gap ratio among the candidate chip positions as a most likely location of a gap. The maximum gap ratio may be the greatest value for the gap ratio of the candidate chip positions. The gap detecting component 140 may compare the maximum gap ratio to a threshold to determine whether the samples match the expected gap pattern.

[0035] In block 206, the method 200 may include measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern. The RSSI component 150 may measure the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern. For example, the RSSI may be the energy received during a measurement window aligned with either a downlink time slot or a downlink pilot time slot of the expected energy pattern. In an aspect, measuring the RSSI based on a subset of samples aligned with the first downlink time slot may include setting a minimum RSSI when a ratio of energy of the subset of samples aligned with the first downlink time slot to energy of a subset of samples aligned with the gap time period is below a threshold. In an aspect, the RSSI component 150 may determine a minimum RSSI value, -180 dBm, for example, if the samples do not match the expected energy pattern. In an aspect, if the samples matches the expected energy pattern, the RSSI component 150 may measure an RSSI value at a high energy chip position near the gap. For example, the RSSI component 150 may measure the RSSI within the expected time slot for a PCCPCH 116 or a pilot 118 based on the location of the gap.

[0036] FIG. 3 is a flowchart illustrating another method 300 of determining an RSSI for a frequency. Referring to FIG. 1, in an operational aspect, a UE 110 may perform various aspects of a method 300 for determining an RSSI. While, for purposes of simplicity of explanation, the method is shown and described as a series of acts, it is
to be understood and appreciated that the method (and further methods related thereto) is/are not limited by the order of acts, as some acts may, in accordance with one or more aspects, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, it is to be appreciated that a method could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a method in accordance with one or more features described herein.

[0037] In block 302, the method 300 may include obtaining samples. The receiving component 130 may obtain samples. The receiving component 130 may generate samples for the length of at least one sub-frame. For example, in a 1.28 Mcps system, the receiving component 130 may receive an analog signal for 5 ms and obtain samples at 6400 chip positions. In an aspect, the receiving component 130 may obtain raw samples on multiple antennas. The raw samples may be unprocessed samples from the multiple antennas. The receiving component 130 may buffer the obtained samples.

[0038] In block 304, the method 300 may optionally include combining the obtained samples. The receiving component 130 may combine the obtained samples. The obtained samples for each antenna having the same chip position may be added. The receiving component 130 may also combine samples over a measurement length, A. For example, the measurement length A may be 24 chips in order to obtain a measurement of received energy over time.

[0039] In block 306, the method 300 may include determining a gap ratio for each candidate chip position. The ratio determining component 142 may determine a gap ratio for each candidate chip position. Every chip position within the received sub-frame may be tested as a candidate chip position. The gap ratio may provide an indication of how well the candidate chip position matches the expected energy pattern. The gap ratio may be a ratio between a minimum measurement for expected high energy chip positions and a maximum measurement for expected low energy chip positions. In particular, in a TD-SCDMA system, high energy positions may be expected during the PCCPCH in TS0 and during the pilot signal in the downlink pilot time slot. Low energy positions may be expected during guard periods or gaps.
[0040] In block 308, the method 300 may include selecting a candidate chip position having a maximum gap ratio. The ratio evaluating component 144 may select the candidate chip position having the maximum gap ratio. The gap detecting component 140 may compare the gap ratios for each of the candidate chip positions and select the candidate chip position having the greatest gap ratio.

[0041] In block 310, the method 300 may include determining whether the maximum gap ratio exceeds a threshold. The ratio evaluating component 144 may determine whether the maximum gap ratio exceeds the threshold. If the maximum gap ratio does not exceed the threshold, the method 300 may proceed to block 312. If the maximum gap ratio exceeds the threshold, the method 300 may proceed to block 314.

[0042] In block 312, the method 300 may include setting the RSSI for a frequency to a minimum value. The RSSI component 150 may set the RSSI for the frequency to the minimum value. The RSSI component 150 may set RSSI value by, for example, marking or storing in a table or otherwise associating the minimum value with the frequency. In an aspect, the minimum value may be configured as -128 dBm. Setting the RSSI to a minimum value may ensure that the frequency is not further considered for selection. The RSSI component 150 may otherwise exclude the frequency, for example, by setting a flag indicating the frequency is unavailable or excluding the frequency from a list of available frequencies.

[0043] In block 314, the method 300 may include setting the RSSI for a frequency to a measured value at a high energy portion of the gap pattern based on the selected candidate chip position. The RSSI component 150 may set the RSSI for the frequency to the measured value at a high energy portion of the gap pattern based on the selected candidate chip position. The RSSI component 150 may measure the high energy portion based on an expected chip length from the selected candidate chip position. In an aspect, the PCCPCH 116 may be expected before the selected candidate chip position and the pilot 118 may be expected after the selected candidate chip position.

[0044] In block 318, the method 300 may optionally include acquiring a cell on the frequency. The modem component 120 may acquire a cell on the frequency. The modem component 120 may receive additional samples on the frequency and attempt to decode the samples. Acquiring a cell may confirm that the cell is available for camping or establishing a connection.
FIG. 4 shows the channel structure 400 for a TD-SCDMA carrier. The carrier has a TD-SCDMA frame 402 that is 10 ms in length. The TD-SCDMA frame 402 is made up of two 5 ms subframes 404, and each subframe 404 is made up of seven time slots TS0 through TS6. The first time slot is TS0 and the last time slot is TS6. The first time slot, TS0, is for downlink (DL) only. TS0 may be a dedicated time slot and may be used exclusively for DL signaling. For example, TS0 may be used to carry the PCCPCH. The second time slot, TS1, is for uplink (UL) only. TS1 may be a dedicated time slot and may be used exclusively for UL transmissions. The remaining time slots TS2 through TS6 may be utilized for UL or DL, which can provide for flexibility in assigning the corresponding time slots. Between TS0 and TS1, there are three special timeslots, which include a DL pilot time slot (DwPTS) 406, a guard period (GP) 408, and a UL pilot time slot (UpPTS) 410 (also known as the UL pilot channel (UpPCH)). Each time slot TS0-TS6 includes two separate data portions 412 separated by a midamble 414 and followed by a guard period (GP) 416. The midamble 414 may be used for channel estimation and the GP 416 may be used to avoid inter-burst interference.

The special time slots 406, 408, 410, may have a further defined structure. DwPTS 406 may include an initial guard period 418 that is 32 chips in length followed by a SYNC_DL code 420 that is 64 chips in length. The DwPTS 406 may be considered a downlink time slot. The portion of DwPTS carrying SYNC_DL code 420 may be considered a downlink time slot. The guard period 408 may be 96 chips in length. The UpPTS 410 may be 160 chips in length. The UpPTS 410 may include a SYNC_UL 422 that is 128 chips in length followed by a guard period 424 that is 32 bits in length.

FIG. 5 illustrates a diagram showing an expected energy pattern of a portion 500 of a TD-SCDMA subframe. The portion may include an end part of the TS0 time slot and the special time slots 406, 408, 410. The end part of the TS0 time slot may include the data portion 412 followed by a guard period 416 that is 32 chips in length. The expected energy 502 during the data portion 412 may be expected to be high because the data portion 412 may carry at least the PCCPCH. The expected energy 502 during the GP 416 may be expected to be low. Likewise, the expected energy 502 during the GP 418 may be expected to be low. The expected energy 502 during the
SYNC_DL 420 may be expected to be high because the SYNC_DL 420 is transmitted from the base station. The expected energy 502 during the GP 408 may be expected to be low. The expected energy 502 during the SYNC_UL 422 may be expected to be high due to SYNC_UL transmitted by other UEs, but may be variable or low if no other UEs are present or no UEs have uplink transmissions.

[0048] The timing of the selected candidate chip position $k$ is illustrated at the start of the GP 418 at the start of the special time slots 406, 408, 410. The parameters for the measurements for pattern matching may be configurable. In an example configuration, each measurement of $Q$ may have a measurement length $A$ of 24 chips in length. $Q_k$ may measure 24 chips within GP 418. If $D0$ is 56 chips, $Q_{k-D0}$ may measure the last 24 chips of TS0 data 412. If $D1$ is 56 chips, $Q_{k-D1}$ may measure the 24 chips within SYNC_DL. If $D2$ is 112 chips, $Q_{k-D2}$ may measure 24 chips within GP 408. Each of the measurements may occur near the middle of a time period having an expected energy level, which may minimize inter-period interference. The expected ratio of energy at $k-D0$ or $k+D1$ to energy at $k$ or $k+D2$ may be relatively high. In an aspect, the RSSI may be measured at either $k-D0$ or $k+D1$. Further, it should be appreciated that the RSSI may be measured on a portion of the subframe 404 including downlink transmissions without decoding the received data.

[0049] FIG. 6 is a conceptual diagram illustrating an example of a hardware implementation for an apparatus 600 employing a processing system 614. The apparatus 600 may correspond to the UE 110 (FIG. 1) and include a modem component 120 for measuring RSSI. In this example, the processing system 614 may be implemented with a bus architecture, represented generally by the bus 602. The bus 602 may include any number of interconnections (for example, buses and bridges) depending on the specific application of the processing system 614 and the overall design constraints. The bus 602 links together or interconnects modules, components, or various circuits including one or more processors, represented generally by the processor 604, and computer-readable media, represented generally by the computer-readable medium 606. The bus 602 also may link or interconnect modem component 120 to processor 604, and computer-readable medium 606. The bus 602 may also link various other circuits such as timing sources, peripherals, voltage regulators, and power management circuits, which are well known in the art, and therefore, will not
be described any further. A bus interface 608 provides an interface between the bus 602 and a transceiver 610. The transceiver 610 provides a means for communicating with various other apparatus over a transmission medium that may include for example the receiving component 130 and/or the transmitting component 160. Depending upon the nature of the apparatus, a user interface 612 (e.g., keypad, display, speaker, microphone, joystick) may also be provided.

[0050] The processor 604 is responsible for managing the bus 602 and general processing, including the execution of software stored on the computer-readable medium 606. The software, when executed by the processor 604, causes the processing system 614 to perform the various functions described infra for any particular apparatus. The computer-readable medium 606 may also be used for storing data that is manipulated by the processor 604 when executing software.

[0051] In an aspect, the modem component 120 may be implemented by software executing on processor 604 and operating in conjunction with the computer-readable medium 606 and the bus 602.

[0052] FIG. 7 is a conceptual diagram illustrating an example of a telecommunications system. Various concepts presented throughout this disclosure may be utilized across a broad array of telecommunication systems, network architectures and communication standards. One non-limiting example will now be presented with reference to a UMTS system employing a TD-SCDMA standard. In this example, the UMTS system includes a radio access network (RAN) 702 (e.g., UTRAN) that provides various wireless services including telephony, video, data, messaging, broadcasts, and/or other services. The RAN 702 may be divided into a number of Radio Network Subsystems (RNS), each controlled by a Radio Network Controller (RNC). Only one RNC 706 is shown for illustrative purposes, however, the RAN 702 may include any number of RNCs. The RNC 706 is an apparatus responsible for, among other things, assigning, reconfiguring and releasing radio resources within the RNS. The RNC 706 may be interconnected to other RNCs in the RAN 702 through an interface comprising a direct physical connection or a virtual network using any suitable transport network.

[0053] The geographic region covered by the RNS may be divided into a number of cells, with a radio transceiver apparatus serving each cell. The radio transceiver
apparatus is commonly referred to as a NodeB in UMTS applications, but may also be referred to by those skilled in the art as a base station, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), or some other suitable terminology. Two NodeBs 708 are shown for illustrative purposes, however, the RNS may include any number of wireless NodeBs 708. The NodeBs 708 provide wireless access points to a core network 704 for any number of mobile apparatuses. Examples of a mobile apparatuses include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, or any other similar functioning device. The mobile apparatus is commonly referred to as user equipment (UE) in UMTS applications, but may also be referred to by those skilled in the art as a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology. For illustrative purposes, three UEs 710 are shown in communication with the NodeBs 708.

[0054] The core network 704 is shown as a GSM core network. However, as those skilled in the art will recognize, the various concepts presented throughout this disclosure may be implemented in a RAN, or other suitable access network, to provide UEs with access to other core networks.

[0055] In this example, the core network 704 supports circuit-switched services with a Mobile Switching Center (MSC) 712 and a Gateway MSC (GMSC) 714. One or more RNCs may be connected to the MSC 712. The MSC 712 is an apparatus that controls call setup, call routing, and UE mobility functions. The MSC 712 also includes a Visitor Location Register (VLR) (not shown) that contains subscriber related information for the duration that a UE is in the coverage area of the MSC 712. The GMSC 714 provides a gateway for the UE to a Public Switched Telephone Network (PSTN) 716. The GMSC 714 includes a Home Location Register (HLR) (not shown) which contains subscriber data, such as the details of the services to
which a user has subscribed. Associated with an HLR is an Authentication Center (AuC) that contains subscriber specific authentication data. The GMSC 714 is responsible for querying the HLR when a call is received for a UE to determine its location and for forwarding the call to the MSC serving that location.

[0056] The core network 704 also supports packet-data services with a Serving GPRS Support Node (SGSN) 718 and a Gateway GPRS Support Node (GGSN) 720. GPRS, which stands for General Packet Radio Service, is designed to provide packet-data services at higher speeds than those available with standard GSM circuit-switched data services. The GGSN 720 provides a connection for the RAN 702 to a packet-based network 722. The packet-based network 722 may be the Internet, a private data network, or some other suitable packet-based network. The primary function of the GGSN 720 is to provide the UEs 710 with network connectivity. Data packets are transferred between the GGSN 720 and the UEs 710 through the SGSN 718, which performs primarily the same functions in the packet-based domain as the MSC 712 performs in the circuit-switched domain.

[0057] The UMTS air interface is a Direct-Sequence Code Division Multiple Access (DS-CDMA) system. DS-CDMA means that user data is spread over a much wider bandwidth through multiplication by a sequence of pseudorandom bits called chips. The TD-SCDMA standard calls for a Time Division Duplex (TDD) system. TDD systems use the same carrier for both the uplink (UL) and downlink (DL) between a NodeB 708 and a UE 710. The duplexing is based on time and not frequency, as is done typically with Frequency Division Duplex (FDD).

[0058] Referring to Fig. 8, an access network 800 in a UTRAN architecture is illustrated. The access network 800 may provide wireless communication access for UEs 830, 832, 834, 836, 838, 840, which may each be an example of the UE 110 in FIG. 1. The multiple access wireless communication system includes multiple cellular regions (cells), including cells 802, 804, and 806, each of which may include one or more sectors. The multiple sectors can be formed by groups of antennas with each antenna responsible for communication with UEs in a portion of the cell. For example, in cell 802, antenna groups 812, 814, and 816 may each correspond to a different sector. In cell 804, antenna groups 818, 820, and 822 each correspond to a different sector. In cell 806, antenna groups 824, 826, and 828 each correspond to a
different sector. The cells 802, 804 and 806 may include several wireless
communication devices, e.g., User Equipment or UEs, which may be in
communication with one or more sectors of each cell 802, 804 or 806. For example,
UEs 830 and 832 may be in communication with Node B 842, UEs 834 and 836 may
be in communication with Node B 844, and UEs 838 and 840 can be in
communication with Node B 846. Here, each Node B 842, 844, 846 is configured to
provide an access point to a core network 704 (see FIG. 7) for all the UEs 830, 832,
834, 836, 838, 840 in the respective cells 802, 804, and 806.

[0059] As the UE 834 moves from the illustrated location in cell 804 into cell 806, a
serving cell change (SCC) or handover may occur in which communication with the
UE 834 transitions from the cell 804, which may be referred to as the source cell, to
cell 806, which may be referred to as the target cell. Management of the handover
procedure may take place at the UE 834, at the Node Bs corresponding to the
respective cells, at a radio network controller 706 (see FIG. 7), or at another suitable
node in the wireless network. For example, during a call with the source cell 804, or
at any other time, the UE 834 may monitor various parameters of the source cell 804
as well as various parameters of neighboring cells such as cells 806 and 802. Further,
depending on the quality of these parameters, the UE 834 may maintain
communication with one or more of the neighboring cells. During this time, the UE
834 may maintain an Active Set, that is, a list of cells that the UE 834 is
simultaneously connected to (i.e., the UTRA cells that are currently assigning a
downlink dedicated physical channel DPCH or fractional downlink dedicated physical
channel F-DPCH to the UE 834 may constitute the Active Set).

[0060] FIG. 9 is a block diagram of a NodeB 910 in communication with a UE 950 in
a RAN. In the DL, a transmit processor 920 may receive data from a data source 912
and control signals from a controller/processor 940. The transmit processor 920
provides various signal processing functions for the data and control signals, as well
as reference signals (e.g., pilot signals). By way of example, the transmit processor
920 may provide cyclic redundancy check (CRC) codes for error detection, coding
and interleaving to facilitate forward error correction (FEC), mapping to signal
constellations based on various modulation schemes (e.g., binary phase-shift keying
(BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-
quadrature amplitude modulation (M-QAM)), spreading with Orthogonal Variable Spreading Factors (OVSF), and multiplying with scrambling codes to produce a series of symbols. Channel estimates from a channel processor 944 may be used by a controller/processor 940 to determine the coding, modulation, spreading, and/or scrambling schemes for the transmit processor 920. The channel estimates may be derived from a reference signal transmitted by the UE 950 or feedback contained in the midamble from the UE 950. The symbols generated by the transmit processor 920 may be provided to a transmit frame processor 930 to create a channel structure by multiplexing the symbols with a midamble from the controller/processor 940 to create a series of frames. The frames may then be provided to a transmitter 932, which provides various signal conditioning functions including amplification, filtering, and modulating the frames onto a carrier for DL transmission over the wireless medium through smart antennas 934. The smart antennas 934 may be implemented with beam steering bidirectional adaptive antenna arrays.

At the UE 950, a receiver 954 receives the DL transmission through an antenna 952 and processes the transmission to recover the information modulated onto the carrier. The information recovered by the receiver 954 is provided to a receive frame processor 960. The receive frame processor 960 parses each frame, and provides the midamble to a channel processor 994 and the data, control, and reference signals to a receive processor 970. The receive processor 970 performs the inverse processing done by the transmit processor 920 in the NodeB 910. More specifically, the receive processor 970 descrambles and despreads the symbols, and then determines the most likely signal constellation points transmitted by the NodeB 910 based on the modulation scheme. These soft decisions may be based on channel estimates computed by the channel processor 994. The soft decisions are then decoded and deinterleaved to recover the data, control and reference signals. The CRCs are then checked to determine whether the frames were successfully decoded. The data carried by the successfully decoded frames may be provided to a data sink 972. The data sink 972 represents applications running in the UE 950 and various user interfaces (e.g., display). Control signals carried by successfully decoded frames may be provided to a controller/processor 990. The controller/processor 990 may also use an acknowledgement (ACK) and/or negative acknowledgement (NACK) protocol
to support retransmission requests for frames that were unsuccessfully decoded by the receive processor 970.

[0062] In the UL, data from a data source 978 and control signals from the controller/processor 990 are provided to a transmit processor 980. The data source 978 may represent applications running in the UE 950 and various user interfaces (e.g., keyboard). Similar to the functionality described in connection with the DL transmission by the NodeB 910, the transmit processor 980 provides various signal processing functions including CRC codes, coding and interleaving to facilitate FEC, mapping to signal constellations, spreading with OVSFs, and scrambling to produce a series of symbols. Channel estimates derived by the channel processor 994 from a reference signal transmitted by the NodeB 910 or feedback contained in the midamble transmitted by the NodeB 910 may be used to select the appropriate coding, modulation, spreading and/or scrambling schemes. The symbols produced by the transmit processor 980 may be provided to a transmit frame processor 982 to create a channel structure by multiplexing the symbols with a midamble from the controller/processor 990 to create a series of frames. The frames may then be provided to a transmitter 956, which provides various signal conditioning functions including amplification, filtering, and modulating the frames onto a carrier for UL transmission over the wireless medium through the antenna 952.

[0063] The UL transmission is processed at the NodeB 910 in a manner similar to that described in connection with the receiver function at the UE 950. A receiver 935 receives the UL transmission through the antenna 934 and processes the transmission to recover the information modulated onto the carrier. The information recovered by the receiver 935 is provided to a receive frame processor 936. The receive frame processor 936 parses each frame, and provides the midamble to the channel processor 944 and the data, control, and reference signals to a receive processor 938. The receive processor 938 performs the inverse processing done by the transmit processor 920 in the NodeB 910. The data carried by the successfully decoded frames may be provided to a data sink 939. Control signals carried by successfully decoded frames may be provided to the controller/processor 940. The controller/processor 940 may also use a acknowledgement (ACK) and/or negative acknowledgement (NACK)
protocol to support retransmission requests for frames that were unsuccessfully decoded by the receive processor 938.

[0064] The controller/processors 940 and 990 may be used to direct the operation at the NodeB 910 and the UE 950, respectively. By way of example, the controller/processors 940 and 990 may provide various functions including timing, peripheral interfaces, voltage regulation, power management, and other control functions. Memories 942 and 992 may store data and software for the NodeB 910 and the UE 950, respectively. A scheduler/processor 946 at the NodeB 910 may be used to allocate resources to the UEs and schedule DL and/or UL transmissions for the UEs.

[0065] Several aspects of a telecommunications system have been presented with reference to a TD-SCDMA system. As those skilled in the art will readily appreciate, various aspects described throughout this disclosure may be extended to other telecommunication systems, network architectures and communication standards. By way of example, various aspects may be extended to other UMTS systems such as WCDMA, HSPA and TD-CDMA. Various aspects may also be extended to systems employing Long Term Evolution (LTE), CDMA2000, Evolution-Data Optimized (EV-DO), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Ultra-Wideband (UWB), Bluetooth, and/or other suitable systems. The actual telecommunication standard, network architecture, and/or communication standard employed will depend on the specific application and the overall design constraints imposed on the system.

[0066] Several processors have been described in connection with various apparatuses and methods. These processors may be implemented using electronic hardware, computer software, or any combination thereof. Whether such processors are implemented as hardware or software will depend upon the particular application and overall design constraints imposed on the system. By way of example, a processor, any portion of a processor, or any combination of processors presented in this disclosure may be implemented with a microprocessor, microcontroller, digital signal processor (DSP), a field programmable gate array (FPGA), a programmable logic device (PLD), a state machine, gated logic, discrete hardware circuits, and other suitable processing component configured to perform the various functions described throughout this disclosure. The functionality of a processor, any portion of a
processor, or any combination of processors presented in this disclosure may be implemented with software being executed by a microprocessor, microcontroller, DSP, or other suitable platform. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. The software may reside on a computer-readable medium. A computer-readable medium may include, by way of example, memory such as a magnetic storage device (e.g., hard disk, floppy disk, magnetic strip), an optical disk (e.g., compact disk (CD), digital versatile disk (DVD)), a smart card, a flash memory device (e.g., card, stick, key drive), random access memory (RAM), read only memory (ROM), programmable ROM (PROM), erasable PROM (EPROM), electrically erasable PROM (EEPROM), a register, or a removable disk. Although memory is shown separate from the processors in the various embodiments presented throughout this disclosure, the memory may be internal to the processors (e.g., cache or register). A computer-readable medium may also include a carrier wave, a transmission line, or any other suitable medium for storing or transmitting software. Computer-readable medium may be embodied in a computer-program product. By way of example, a computer-program product may include a computer-readable medium in packaging materials. Those skilled in the art will recognize how best to implement the described functionality presented throughout this disclosure depending on the particular application and the overall design constraints imposed on the overall system.

[0067] It is understood that the specific order or hierarchy of steps in the methods disclosed is an illustration of exemplary processes. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the methods may be rearranged. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented unless specifically recited therein.

[0068] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects
will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language of the claims, wherein reference to an element in the singular is not intended to mean “one and only one” unless specifically so stated, but rather “one or more.” Unless specifically stated otherwise, the term “some” refers to one or more. A phrase referring to “at least one of” a list of items refers to any combination of those items, including single members. As an example, “at least one of: a, b, or c” is intended to cover: a; b; c; a and b; a and c; b and c; and a, b and c. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 U.S.C. §112, sixth paragraph, unless the element is expressly recited using the phrase “means for” or, in the case of a method claim, the element is recited using the phrase “step for.”
CLAIMS

1. A method of determining a received signal strength indicator (RSSI) for a frequency, the method comprising:

   obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe;

   determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and

   measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

2. The method of claim 1, wherein the expected energy pattern further includes a second downlink time slot separated from the first downlink time slot by the gap time period.

3. The method of claim 1, wherein measuring the RSSI comprises selecting a maximum energy of samples aligned with the first downlink time slot and samples aligned with the second downlink time slot.

4. The method of claim 1, wherein measuring the RSSI comprises setting a minimum RSSI when a ratio of energy of the subset of samples aligned with the first downlink time slot to energy of a subset of samples aligned with the gap time period is below a threshold.

5. The method of claim 1, wherein the expected energy pattern is a TD-SCDMA expected energy pattern including: a downlink time slot; the gap time period including at least one guard period; and a downlink pilot time slot.
6. The method of claim 5, wherein measuring the RSSI comprises selecting a maximum energy of samples aligned with the downlink time slot and the downlink pilot time slot as the RSSI.

7. The method of claim 1, further comprising attempting to acquire a cell using the frequency when the RSSI exceeds a threshold.

8. The method of claim 1, wherein the samples include 6400 samples obtained at consecutive chip positions.

9. The method of claim 1, wherein determining that the samples match an expected gap pattern comprises:
   determining a gap ratio for each candidate chip position of the samples.
   selecting a maximum gap ratio of the determined gap ratios of the candidate chip positions; and
   determining whether the maximum gap ratio exceeds a threshold gap ratio.

10. The method of claim 9, wherein determining a gap ratio for a candidate chip position comprises:
    determining a minimum energy of a first chip position located before the candidate chip position and a second chip position located after the candidate chip position,
    determining a maximum energy of the candidate chip position and a chip position located after the second chip position; and
    determining a ratio of the minimum energy to the maximum energy.

11. The method of claim 1, further comprising combining a first subset of samples received on a first antenna with a second subset of samples received on a second antenna to determine a total received energy for samples at each chip position.
12. An apparatus for determining a received signal strength indicator (RSSI) for a frequency, comprising:
   means for obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe;
   means for determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and
   means for measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.

13. The apparatus of claim 12, wherein the expected energy pattern further includes a second downlink time slot separated from the first downlink time slot by the gap time period.

14. The apparatus of claim 13, wherein the means for measuring the RSSI are configured to select a maximum energy of samples aligned with the first downlink time slot and samples aligned with the second downlink time slot.

15. The apparatus of claim 12, wherein the means for measuring the RSSI are configured to set a minimum RSSI when a ratio of energy of the subset of samples aligned with the first downlink time slot to energy of a subset of samples aligned with the gap time period is below a threshold.

16. The apparatus of claim 17, wherein the expected energy pattern is a TD-SCDMA expected energy pattern including: a downlink time slot; the gap time period including at least one guard period; and a downlink pilot time slot.

17. The apparatus of claim 12, wherein the means for measuring the RSSI are configured to select a maximum energy of samples aligned with the downlink time slot and the downlink pilot time slot as the RSSI.
18. The apparatus of claim 12, wherein the samples include 6400 samples obtained at consecutive chip positions.

19. The apparatus of claim 12, the means for determining that the samples match an expected gap pattern comprises:
   means for determining a gap ratio for each candidate chip position of the samples.
   means for selecting a maximum gap ratio of the determined gap ratios of the candidate chip positions; and
   means for determining whether the maximum gap ratio exceeds a threshold gap ratio.

20. The apparatus of claim 19, wherein the means for determining a gap ratio for a candidate chip position are configured to:
   determine a minimum energy of a first chip position located before the candidate chip position and a second chip position located after the candidate chip position,
   determine a maximum energy of the candidate chip position and a chip position located after the second chip position; and
   determine a ratio of the minimum energy to the maximum energy.

21. A computer-readable medium storing computer executable code for determining a received signal strength indicator (RSSI) for a frequency, the computer-readable medium comprising code for:
   obtaining samples of received energy on the frequency over at least a time-period equal in length to a subframe;
   determining that the samples match an expected energy pattern of the subframe, the expected energy pattern including a gap time period having no expected energy and a first downlink time slot, wherein the determining includes aligning the samples with the expected energy pattern; and
   measuring the RSSI based on a subset of samples aligned with the first downlink time slot of the expected energy pattern.
22. The computer-readable medium of claim 21, wherein the expected energy pattern further includes a second downlink time slot separated from the first downlink time slot by the gap time period.

23. The computer-readable medium of claim 21, wherein measuring the RSSI comprises selecting a maximum energy of samples aligned with the first downlink time slot and samples aligned with the second downlink time slot.

24. The computer-readable medium of claim 21, wherein measuring the RSSI comprises setting a minimum RSSI when a ratio of energy of the subset of samples aligned with the first downlink time slot to energy of a subset of samples aligned with the gap time period is below a threshold.

25. The computer-readable medium of claim 21, wherein the expected energy pattern is a TD-SCDMA expected energy pattern including: a downlink time slot; the gap time period including at least one guard period; and a downlink pilot time slot.

26. The computer-readable medium of claim 21, wherein measuring the RSSI comprises selecting a maximum energy of samples aligned with the downlink time slot and the downlink pilot time slot as the RSSI.

27. The computer-readable medium of claim 26, wherein determining that the samples match an expected gap pattern comprises:
   determining a gap ratio for each candidate chip position of the samples.
   selecting a maximum gap ratio of the determined gap ratios of the candidate chip positions; and
   determining whether the maximum gap ratio exceeds a threshold gap ratio.

28. The computer-readable medium of claim 27, wherein determining a gap ratio for a candidate chip position comprises:
determining a minimum energy of a first chip position located before the
candidate chip position and a second chip position located after the candidate chip
position,
determining a maximum energy of the candidate chip position and a chip
position located after the second chip position; and
determining a ratio of the minimum energy to the maximum energy.

29. An apparatus for determining a received signal strength indicator (RSSI) for a
frequency, comprising:

at least one processor; and

a memory coupled to the at least one processor,

wherein the at least one processor is configured to:

obtain samples of received energy on the frequency over at least a time-period
equal in length to a subframe;

determine that the samples match an expected energy pattern of the subframe,
the expected energy pattern including a gap time period having no expected energy
and a first downlink time slot, wherein the determining includes aligning the samples
with the expected energy pattern; and

measure the RSSI based on a subset of samples aligned with the first downlink
time slot of the expected energy pattern.

30. The apparatus of claim 29, further comprising a receiver configured to
generate the samples of received energy on the frequency.
FIG. 2

200

OBTAIN SAMPLES OF RECEIVED ENERGY ON A FREQUENCY OVER AT LEAST A TIME-PERIOD EQUAL IN LENGTH TO A SUBFRAME

202

DETERMINE THAT THE SAMPLES MATCH AN EXPECTED ENERGY PATTERN OF THE SUBFRAME, THE EXPECTED ENERGY PATTERN INCLUDING A GAP TIME PERIOD HAVING NO EXPECTED ENERGY AND A FIRST DOWNLINK TIME SLOT

204

MEASURE THE RSSI BASED ON A SUBSET OF SAMPLES AlIGNED WITH THE FIRST DOWNLINK TIME SLOT OF THE EXPECTED ENERGY PATTERN

206
300

302

OBTAINT SAMPLES

304

COMBINE SAMPLES

306

DETERMINE GAP RATIO FOR EACH CHIP POSITION

308

SELECT CANDIDATE CHIP POSITION HAVING MAXIMUM GAP RATIO

310

MAXIMUM GAP RATIO \( \geq \) THRESHOLD

312

RSSI = MINIMUM VALUE (-128 dBm)

314

RSSI = MAXIMUM OF PCCPCH AND PILOT ENERGY

316

ACQUIRE CELL

FIG. 3
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   H04W 24/00(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
   H04W,H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
   WPI, EPODOC, CNPAT, CNKI: rssi, strength, energy, +frame, samp+, measr+, downlink, uplink, time, indicat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>A</td>
<td>EP 2154787 B1 (RESEARCH IN MOTION LIMITED) 08 June 2011 (2011-06-08) the whole document</td>
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
   "A" document defining the general state of the art which is not considered to be of particular relevance
   "E" earlier application or patent but published on or after the international filing date
   "L" document which, while not giving all of the information required for an evaluation of the application, contains a claim or other special reason (as specified)
   "G" document referring to an oral disclosure, use, exhibition or other means
   "P" document published prior to the international filing date but later than the priority date claimed
   "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
   "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
   "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
   "&" document member of the same patent family

Date of the actual completion of the international search

18 March 2015

Date of mailing of the international search report

17 April 2015

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA(ISA/CN)
6,Xintucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China

Authorized officer

ZHAO,Xin

Facsimile No. (86-10)62019451

Telephone No. (86-10)82245935

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