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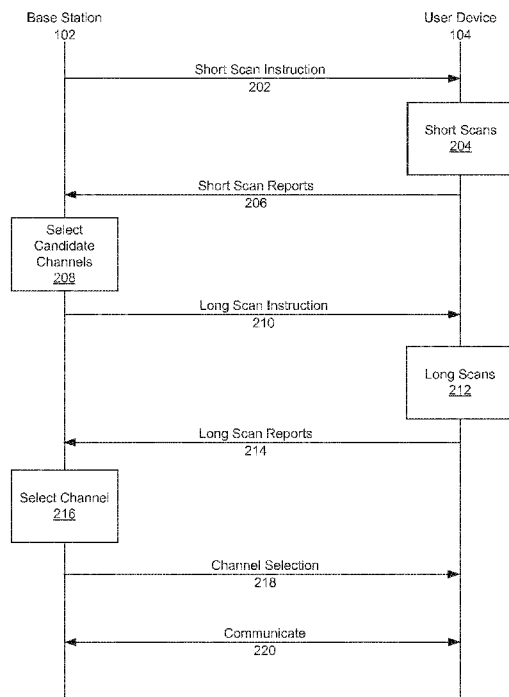


FIG. 2A

(57) Abstract: According to an example embodiment, a method may include sending, by a base station to a user device, an instruction to perform a short scan on each of a plurality of channels, receiving, from the user device, signal strength measurement reports for each of the plurality of channels, sending, to the user device, an instruction to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, receiving, from the user device, channel occupancy measurement reports for each of the candidate channels, and selecting one of the candidate channels based on the channel occupancy measurement reports.

DESCRIPTION

TITLE

5 LONG SCANS ON CANDIDATE CHANNELS WHICH ARE A SUBSET OF CHANNELS
ON WHICH SHORT SCANS WERE PERFORMED

TECHNICAL FIELD

[0001] This description relates to wireless networking.

BACKGROUND

10 **[0002]** A communication system may be a facility that enables communication
between two or more nodes or devices, such as fixed or mobile communication devices.
Signals can be carried on wired or wireless carriers.

[0003] An example of a cellular communication system is an architecture that is
being standardized by the 3rd Generation Partnership Project (3GPP). A recent
15 development in this field is often referred to as the long-term evolution (LTE) of the
Universal Mobile Telecommunications System (UMTS) radio-access technology. E-UTRA
(evolved UMTS Terrestrial Radio Access) is the air interface of 3GPP's Long Term
Evolution (LTE) upgrade path for mobile networks. In LTE, base stations, which may also
be referred to as enhanced Node Bs (eNBs), provide wireless access within a coverage
20 area or cell. In LTE, mobile devices or mobile stations may also referred to as user
equipments (UE). LTE has included a number of improvements or developments.

SUMMARY

[0004] According to an example embodiment, a method may include sending, by a
25 base station to a user device, an instruction to perform a short scan on each of a plurality
of channels, receiving, from the user device, signal strength measurement reports for
each of the plurality of channels, sending, to the user device, an instruction to perform
long scans on each of a plurality of candidate channels, the plurality of candidate channels
being a subset of the plurality of channels, receiving, from the user device, channel
30 occupancy measurement reports for each of the candidate channels, and selecting one of
the candidate channels based on the channel occupancy measurement reports.

[0005] According to an example embodiment, a non-transitory computer-readable
storage medium may comprise instructions stored thereon. When executed by at least
one processor, the instructions may be configured to cause a computing system to send,
35 to a user device, an instruction to perform a short scan on each of a plurality of channels,

receive, from the user device, signal strength measurement reports for each of the plurality of channels, send, to the user device, an instruction to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, receive, from the user device, channel occupancy measurement reports for each of the candidate channels, and select one of the candidate channels based on the channel occupancy measurement reports.

[0006] According to an example embodiment, an apparatus may comprise at least one processor and at least one memory device comprising instructions stored thereon. When executed by the at least one processor, the instructions may be configured to cause a computing system to send, to a user device, an instruction to perform a short scan on each of a plurality of channels, receive, from the user device, signal strength measurement reports for each of the plurality of channels, send, to the user device, an instruction to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, receive, from the user device, channel occupancy measurement reports for each of the candidate channels, and select one of the candidate channels based on the channel occupancy measurement reports..

[0007] According to an example embodiment, an apparatus may comprise means for sending, to a user device, an instruction to perform a short scan on each of a plurality of channels, means for receiving, from the user device, signal strength measurement reports for each of the plurality of channels, means for sending, to the user device, an instruction to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, means for receiving, from the user device, channel occupancy measurement reports for each of the candidate channels, and means for selecting one of the candidate channels based on the channel occupancy measurement reports.

[0008] According to another example embodiment, a method may include receiving, by a user device from a base station, an instruction to perform short scans on each of a plurality of channels, performing short scans on each of the plurality of channels, sending, to the base station, signal strength measurement reports for each of the plurality of channels based on the performed short scans, receiving, from the base station, an instruction to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, performing long scans on each candidate channel, sending, to the base station, channel occupancy measurement reports for each of the candidate channels based on each of the long scans, and receiving, from the base station, a selection of one of the candidate channels.

[0009] According to an example embodiment, a non-transitory computer-readable storage medium may comprise instructions stored thereon. When executed by at least one processor, the instructions may be configured to cause a computing system to receive, from a base station, an instruction to perform short scans on each of a plurality of channels, perform short scans on each of the plurality of channels, send, to the base station, signal strength measurement reports for each of the plurality of channels based on the performed short scans, receive, from the base station, an instruction to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, perform long scans on each candidate channel, send, to the base station, channel occupancy measurement reports for each of the candidate channels based on each of the long scans, and receive, from the base station, a selection of one of the candidate channels.

[0010] According to an example embodiment, an apparatus may comprise at least one processor and at least one memory device comprising instructions stored thereon. When executed by the at least one processor, the instructions may be configured to cause a computing system to receive, from a base station, an instruction to perform short scans on each of a plurality of channels, perform short scans on each of the plurality of channels, send, to the base station, signal strength measurement reports for each of the plurality of channels based on the performed short scans, receive, from the base station, an instruction to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, perform long scans on each candidate channel, send, to the base station, channel occupancy measurement reports for each of the candidate channels based on each of the long scans, and receive, from the base station, a selection of one of the candidate channels.

[0011] According to an example embodiment, an apparatus may comprise means for receiving, by a user device from a base station, an instruction to perform short scans on each of a plurality of channels, means for performing short scans on each of the plurality of channels, means for sending, to the base station, signal strength measurement reports for each of the plurality of channels based on the performed short scans, means for receiving, from the base station, an instruction to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels, means for performing long scans on each candidate channel, means for sending, to the base station, channel occupancy measurement reports for each of the candidate channels based on each of the long scans, and means for receiving, from the base station, a selection of one of the candidate channels.

[0012] The details of one or more implementations are set forth in the accompa-

nying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1A is a diagram showing a wireless network according to an example embodiment.

[0014] FIG. 1B is a diagram showing the wireless network in an example in which a user device has moved.

[0015] FIG. 2A is a timing diagram showing messages exchanged between, and processes performed by, a base station and the user device included in the wireless network according to an example embodiment.

[0016] FIG. 2B is a timing diagram showing messages exchanged between, and processes performed by, the base station and the user device included in the wireless network according to another example embodiment.

[0017] FIG. 3 is a diagram showing a short scan report message according to an example embodiment.

[0018] FIG. 4 is a diagram showing a long scan report message according to an example embodiment.

[0019] FIG. 5 is a flowchart showing a method performed by the base station according to an example embodiment.

[0020] FIG. 6 is a flowchart showing a method performed by the user device according to an example embodiment.

[0021] FIG. 7 is a block diagram of a wireless station (e.g., base station or user device or other wireless node) according to an example embodiment.

[0022] Like reference numbers refer to like elements.

DETAILED DESCRIPTION

[0023] In a wireless infrastructure network, such as a Long-Term Evolution (LTE) network or an LTE-Advanced network, base stations may communicate with user devices via allocated or licensed bands. The allocated or licensed bands may have limited bandwidths, such as 20 MHz, which may not be sufficient to provide a desired data rate.

[0024] Unlicensed frequency spectra, such as spectra around 2.4 GHz and/or 5.0 GHz, may be available for communication. However, other devices, such as IEEE 802.11 access points and devices communicating with the access points, may generate and send interfering signals within the unlicensed spectra.

[0025] Base stations and/or user devices may scan the unlicensed spectra to determine interference metrics, based upon which the base stations and/or user devices may determine whether to communicate via a portion of the unlicensed spectra. However, performing a full scan of a channel may take significant time, such as hundreds of milliseconds per 20 MHz channel. With a large number of possible channels, such as between fifteen and thirty channels with between 300 MHz and 600 MHz available, performing a full scan on each possible channel may be impractical due to the time required perform a full scan on each channel.

[0026] To select a channel for communication, the base station may instruct a user device to perform short scans, of a few milliseconds each and/or less than ten milliseconds each, on all of the possible channels. The user device may perform the scans on all of the possible channels, determine total received signal strength, and report the scans to the base station. Based on the reports, the base station may select a few, such as between two and five, candidate channels, and instruct the user device to perform long scans on each of the candidate channels. The user device may perform the long scans of the candidate channels to generate a fuller picture of the interference at each candidate channel, and may determine, for example, peak power, channel occupancy, and average received signal strength. The user device may report these measurements to the base station, and the base station may select one of the candidate channels based on these reported measurements. The base station and user device may then communicate via the selected channel within the unlicensed spectrum, in addition to the original channel in the licensed spectrum.

[0027] FIG. 1A is a diagram showing a wireless network 100 according to an example embodiment. The network 100 may include a wireless network, such as an LTE network, a cellular network, or any other infrastructure network served by a single base station. The network 100 may be part of a larger network served by multiple base stations not shown in FIG. 1. The network 100 may be served by base station 102. The base station 102, which may also be referred to as an enhanced Node B (eNB), may serve multiple user devices 104. While one user device 104 is shown in FIG. 1A, multiple user devices in the network 100 may be served by the base station 102.

[0028] A user device (user terminal, user equipment (UE)) may refer to a portable computing device that includes wireless mobile communication devices operating with or without a subscriber identification module (SIM), including, but not limited to, the following types of devices: a mobile station, a mobile phone, a cell phone, a smartphone, a personal digital assistant (PDA), a handset, a device using a wireless modem (alarm or measurement device, etc.), a laptop and/or touch screen computer, a tablet, a phablet, a

game console, a notebook, and a multimedia device, as examples. It should be appreciated that a user device may also be a nearly exclusive uplink only device, of which an example is a camera or video camera loading images or video clips to a network.

[0029] The base station 102 and user device 104 may communicate via a primary cell (PCell) with an allocated frequency band and/or licensed frequency band. The allocated frequency band may have bandwidth of any size, such as 20 MHz. Other frequency bands may be available in an unlicensed spectrum, such as spectra around 2.4 GHz or 5 GHz. However other devices such as access points 106A, 106B, and/or devices (not shown in FIG. 1A) in communication with the access points 106A, 106B, may also be transmitting and receiving signals via the unlicensed spectrum. These signals may interfere with potential communication between the base station 102 and user device 104 via channels in the unlicensed spectrum. It may be helpful for the base station 102 to select a frequency band or channel with minimal interference to communicate with the user device 104. The base station 102 may request the user device 104 to perform measurements to acquire information about channels within the unlicensed spectrum.

[0030] The base station 102 may request and/or instruct the user device 104 to perform short scans of a large number of channels within the unlicensed spectrum. The user device 104 may perform the short scans in response to receiving the request and/or instruction. The user device 104 may send short scan reports, which include information about the channels based on the measurements during the short scans, to the base station 102. The base station 102 may select candidate channels from the scanned channels based on the short scan reports. The number of channels upon which the short scans were performed may be at least ten times the number of candidate channels. The base station 102 may request and/or instruct the user device 104 to perform long scans on the selected candidate channels. The user device 104 may perform the long scans on the candidate channels. The user device 104 may perform each of the long scans for a duration that is at least ten times as long as a duration of each of the long scans. The channels on which the short scans and long scans are performed may have frequencies within 500 MHz of 5 GHz, according to an example embodiment. The user device 104 may send long scan reports, which may include information about the candidate channels based on the measurements during the long scans, to the base station 102. The base station 102 may select a channel from the candidate channels for communication with the user device, in addition to the original channel via which the messages were exchanged, based on the long scan reports.

[0031] FIG. 2A is a timing diagram showing messages exchanged between, and processes performed by, the base station 102 and the user device 104 according to an

example embodiment. The messages and processes shown and described with respect to FIG. 2A may be part of a process for selecting and/or communicating via a channel within an unlicensed frequency band.

[0032] The base station 102 may send the user device 104 a short scan instruction 202. The short scan instruction 202 may instruct the user device 104 to perform short scans on the unlicensed spectrum. The frequency (such as 2.4 GHz or 5.0 GHz) and/or channels of the unlicensed spectrum upon which the user device 104 should perform the short scans may be included in the short scan instruction 202, or may be previously agreed upon or included in program code as part of a protocol for communicating via an unlicensed frequency band.

[0033] The short scans may be relatively short scans of a relatively large number of channels (in comparison to the long scans described below), such as less than 10 ms scans of between fifteen and thirty channels. The channels upon which the scans are performed may have a same or smaller bandwidth as the channels via which the messages shown in FIG. 2A are sent, and via which the base station 102 and user device 104 have communicated such as the LTE or LTE-Advanced protocol, and may be, for example, 20 MHz or less than 20 MHz.

[0034] In response to receiving the short scan instruction 202, the user device 104 may perform short scans (204). The user device 104 may perform short scans (204) on channels included in and/or identified by the short scan instruction 202, or may perform short scans on channels previously agreed upon or included in program code as part of a protocol for communicating via an unlicensed frequency band. The short scans may be performed serially, and/or by the user device 104 scanning one channel at a time. The short scans (204) may each be performed for a shorter time duration, such as one-tenth or less than a duration of long scans (212) described below. The short scans (204) may, for example, be performed for a time duration of less than ten milliseconds (10 ms), such as between two milliseconds (2 ms) and five milliseconds (5 ms).

[0035] During each of the short scans, the user device 104 may perform measurements for each channel. The user device 104 may measure, for example, a total received power and/or a peak power of received signals within the channel during the duration of the short scan. The user device 104 may compile the measurements performed during the short scans. The user device 104 may send the base station 102 short scan reports 206 of the compiled measurements based on the short scans.

[0036] FIG. 3 is a diagram showing a short scan report message 300 according to an example embodiment. The short scan report message 300 may include the short scan

reports 206 set by the user device 104 to the base station 102. The short scan report message 300 may include a header field 302 and channel report fields 304, 306, 308 for each channel. While not shown in FIG. 3, a short scan report message may also include a trailer, which may include error correction information. The header field 302 may include
5 addressing information such as a source field identifying the user device 104 and a destination field identifying the base station 102.

[0037] Each channel report field, such as the channel 0 report field 304, may be associated with a channel and may include a report of channel information for the associated channel measured by the user device 104 for the associated channel during
10 the short scan. The channel report field 304 may include identifying information such as a channel ID field 310 identifying the scanned channel for which measured information is included. In an example embodiment, the channel report field 304 may not include a channel ID field 310, and the measured information may be interpreted based on a predetermined order for the channels. The channel report field 304 may include one or
15 more fields reporting measured information based on the respective scan for the associated channel, such as received power 312. The received power 312 may include a value indicating the total amount of power received from wireless signals during the short scan, for example, or a peak power received from wireless signals during the short scan.

[0038] Returning to FIG. 2A, the base station 102 may, in response to receiving
20 the short scan reports 206, select candidate channels (208). The base station 102 may select candidate channels as a subset of the channels upon which the user device 104 performed short scans. The base station 102 may select candidate channels based on the power values 312, and/or other measurement(s) included in the short scan reports 206. The base station 102 may select a predetermined number of candidate channels which
25 have lowest received signal power values, may select a contiguous group of channels with power values below a threshold as candidate channels, or may select the candidate channels by any other method that selects candidate channels based on the power values or other measurements included in the short scan reports 206.

[0039] After selecting the candidate channels (208), the base station 102 may
30 send a long scan instruction 210 to the user device 104. The long scan instruction 210 may instruct the user device 104 to perform long scans on each of the selected candidate channels. The long scan instruction 210 may also include and/or identify the selected candidate channels.

[0040] The user device 104 may, in response to receiving the long scan instruction
35 210, perform long scans (212) on each of the identified candidate channels. The long scans may be performed serially, and/or by the user device 104 scanning one candidate

channel at a time. Each of the long scans may be performed for longer durations than the durations of each of the short scans, such as at least ten times as long as the durations of the short scans. The long scans 212 may, for example, be at least 100 ms long for each of the candidate channels, and/or may be between 200 ms and 600 ms. In an example
5 embodiment, during the long scans, the user device 104 may measure, for each candidate channel, a peak power value, the channel occupancy, and/or average received signal strength indication (RSSI), as non-limiting examples. After performing the long scans (212), the user device 104 may send long scan reports 214 to the base station. The long scan reports 214 may include reports for each candidate channel based on the
10 measurements performed by the user device 104.

[0041] FIG. 4 is a diagram showing a long scan report message 400 according to an example embodiment. The long scan report message 400 may include a header field 402 and candidate channel report fields 404, 406. While not shown in FIG. 4, the long scan report message 400 may also include a trailer, which may include error correction
15 information. The header field 402 may include addressing information, such as a source address of the user device 104 and a destination address of the base station 102.

[0042] Each candidate channel field 404, 406 may be associated with one of the candidate channels, and may include information such as a channel ID field 408 identifying the scanned channel and information based on the measurements. In an
20 example embodiment, the candidate channel fields may not include a channel ID field 408 identifying the candidate channel, and the candidate channel fields 404, 406 may be ordered according to a mutually understood scheme, such as a same order that the channels were included in the long scan instruction 210.

[0043] The candidate channel fields 404, 406 may include fields reporting the
25 measurements performed during the long scans. For example, the candidate channel fields 404 may include a peak power field 410 indicating the measured peak power for the candidate channel, a channel occupancy field 412 indicating the fractional percentage of time that the user device 104 measured interference and/or signals above a threshold power level, and/or an average RSSI field 414 indicating the average RSSI received
30 during the long scan as non-limiting examples. The peak power field 410 may indicate, for example, a highest measured power for the candidate channel during the long scan period. The channel occupancy field 412 may indicate how frequently the user device 104 detected transmissions by the access point(s) 106A, 106B transmitted signals, or how often during the long scan period the received signal strength exceeded a threshold,
35 expressed as a number of incidents or scaled over the long scan period. The average RSSI field 414 may indicate, for example, an average received signal strength over the

long scan period expressed as a total received power or scaled over the long scan period. More or fewer fields may be included, reporting measurements performed by the user device during the long scan of the candidate channel associated with the candidate channel field 404, 406.

5 **[0044]** Returning to FIG. 2A, the base station 102 may select a channel (216) for communication based on the long scan reports 214 the base station 102 received from the user device 104. The base station 102 may select the channel (216) based, for example, on the channel occupancy metric or any combination of the values included in the long scan reports 214. The base station 102 may select the channel (216) based, for example,
10 on the channel occupancy metric indicating that the access point(s) 106A, 106B is transmitting no more frequently than a threshold frequency, such as no more than once every hundred milliseconds, twice every hundred milliseconds, three times every hundred milliseconds, four times every hundred milliseconds, or five times every hundred milliseconds, as non-limiting examples.

15 **[0045]** After performing the channel selection, the base station 102 may send the channel selection 218 to the user the device 104. The channel selection 218 may identify the selected channel for communication. After the base station 102 has sent the channel selection 218 to the user device 104, the base station 102 and user device 104 may communicate (220) via the selected channel. The base station 102 and user device 104
20 may communicate via the selected channel as an SCell in addition to the original PCell.

[0046] FIG. 1B shows the user device 104 moving within the network 100. The base station 102 may determine that the user device 104 has moved. Movement of the user device within the network 100 may result in different interference patterns, which may cause the selected channel to be less optimal and/or may cause other channels to be
25 more optimal for communication between the base station 102 and the user device 104. The base station 102 may, in response to determining that the user device 104 has moved, consider selecting a new channel for communication as an SCell. In response to the user device 104 moving, the base station 102 may send a short scan instruction 202 or a scan instruction 252 to the user device 104, prompting any or all of the messages and
30 processes for selecting a communication channel shown and described with respect to FIG. 2A or FIG. 2B.

[0047] The base station 102 may also begin the messages and processes for selecting a communication channel based on events other than the user device 104 moving within the network 100. The base station 102 may also begin the messages and
35 processes for selecting a communication channel periodically, such as based on expiration of a timer or reaching a specified time value, or based on detecting a threshold

level of interference or a threshold number of unsuccessful messages within the previously-selected channel.

[0048] FIG. 2B is a timing diagram showing messages exchanged between, and processes performed by, the base station 102 and the user device 104 included in the wireless network 100 according to another example embodiment. In this example, the base station 102 may send the user device 104 a scan instruction 252, and the base station 102 and user device 104 need not communicate regarding candidate channels because the user device 104 will select the candidate channels. According to an example embodiment, while the user device 104 is selecting the candidate channels, between the scan instruction 252 and the user device 104 sending the base station 102 the measurement reports based on the long scans, the base station 102 and user device 104 may still communicate via the original channel and/or PCell.

[0049] The scan instruction 252 may identify channels on which to perform short scans and from which the new channel should be selected, or the channels on which short scans should be performed may have been previously understood and/or programmed into the base station 102 and user device 104. In response to receiving the scan instruction 252, the user device 104 may perform short scans (204) as described above with respect to FIG. 2A. The user device 104 may select candidate channels (258) based on the measurements performed during the short scans using similar criteria as the base station 102 selecting candidate channels (208) in the example described with respect to FIG. 2A.

[0050] The user device 104 may perform long scans (212) on the selected candidate channels as described above with respect to FIG. 2A. The user device 104 may then select channels for which to report measurement results (260) based on the measurements performed during the long scans using similar criteria as the base station 102 selecting the channel (216) in the example described with respect to FIG. 2A. The user device 104 may send a measurement report message 260 to the base station 102 for the candidate channels selected based on the short scans (204), for which the long scans (212) were performed, indicating the quality of the each of the candidate channels for which the long scans (212) were performed. The measurement report message 260 may include similar information to the long scan reports 214 described above with respect to FIG. 2A. The base station 102 may then select the new channel for communication (216) based on the information included in the measurement report 260 in a similar manner to the selecting (216) described above with respect to FIG. 2A, and send the channel selection 218 identifying the selected new channel in a similar manner as described above with respect to FIG. 2A. The user device 104 and base station 102 may then communicate

(220) via the new channel as described above.

[0051] FIG. 5 is a flowchart showing a method 500 performed by the base station 102 according to an example embodiment. According to this example, the method 500 may include the base station 102 sending, to the user device 104, an instruction (202) to perform a short scan on each of a plurality of channels (502). The method 500 may also include receiving, from the user device 104, signal strength measurement reports (206) for each of the plurality of channels (504). The method 500 may also include sending, to the user device 104, an instruction 210 to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels (506). The method 500 may also include receiving, from the user device 104, channel occupancy measurement reports 214 for each of the candidate channels (508). The method 500 may also include selecting one of the candidate channels (216) based on the channel occupancy measurement reports (510).

[0052] In an example embodiment, a number of the plurality of channels is at least five times a number of the plurality of candidate channels.

[0053] In an example embodiment, the method 500 may further include selecting the plurality of candidate channels (208) from the plurality of channels based on the received signal strength measurement reports.

[0054] In an example embodiment, the method 500 may further include selecting the plurality of candidate channels (208) based on the received signal strength measurement reports indicating that the candidate channels have received signal strength values below a threshold signal strength.

[0055] In an example embodiment, the method 500 may further include receiving, from the user device 104, peak power level reports 214 for each candidate channel. The selecting (510) may include selecting one of the candidate channels based on the channel occupancy measurement reports and the peak power level reports.

[0056] In an example embodiment, the method 500 may further include receiving, from the user device 104, average received signal strength reports 214 for each candidate channel within the subset. The selecting (510) may include selecting one of the candidate channels based on the channel occupancy measurement reports and the average received signal strength reports.

[0057] In an example embodiment, the method 500 may further include receiving, from the user device 104, peak power level reports 214 for each candidate channel, and receiving, from the user device 104, average received signal strength reports 214 for each candidate channel. The selecting (510) may include selecting one of the candidate

channels within the subset based on the channel occupancy measurement reports, the peak power level reports, and the average received signal strength reports.

[0058] In an example embodiment, the method 500 may further include communicating 220 with the user device 104 via the selected one of the candidate channels.

[0059] In an example embodiment, the instruction to perform short scans 202, the signal strength measurement reports 206, the instruction to perform long scans 210, and the channel occupancy measurement reports 214 may be sent or received via a Primary Cell (PCell). The method 500 may further include communicating 220 with the user device via a Secondary Cell (SCell), the SCell including the selected one of the candidate channels.

[0060] In an example embodiment, the instruction to perform short scans 202 may be sent to the user device 104 in response to the user device 104 changing location.

[0061] In an example embodiment, the short scans (204) and the long scans (212) may be performed on channels and candidate channels with bandwidths of 20 MHz and frequencies within 500 MHz of 5 GHz.

[0062] FIG. 6 is a flowchart showing a method 600 performed by the user device 104 according to an example embodiment. According to this example, the method 600 may include the user device 104 receiving, from the base station 102, an instruction 202 to perform short scans on each of a plurality of channels (602). The method 600 may further include performing short scans (204) on each of the plurality of channels (604). The method 600 may further include sending, to the base station 104, signal strength measurement reports 206 for each of the plurality of channels based on the performed short scans (606). The method 600 may further include receiving, from the base station 102, an instruction 210 to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels (608). The method 600 may further include performing long scans (212) on each candidate channel (610). The method 600 may further include sending, to the base station 104, channel occupancy measurement reports 214 for each of the candidate channels based on each of the long scans (612). The method 600 may further include receiving, from the base station 104, a selection of one of the candidate channels (614).

[0063] In an example embodiment, a duration of each of the long scans is at least ten times a duration of each of the short scans.

[0064] In an example embodiment, a duration of each of the short scans is less than ten milliseconds (10 ms).

[0065] In an example embodiment, a duration of each of the long scans is greater than one hundred milliseconds (100 ms).

[0066] In an example embodiment, the performing short scans (204) (604) includes scanning one of the channels at a time and the performing long scans (212) (610) includes scanning one of the candidate channels at a time.

[0067] FIG. 7 is a block diagram of a wireless station (e.g., base station or user device) 700 according to an example embodiment. The wireless station 700 may include, for example, two RF (radio frequency) or wireless transceivers 702A, 702B, where each wireless transceiver includes a transmitter to transmit signals and a receiver to receive signals. The wireless station 700 also includes a processor or control unit/entity (controller) 704 to execute instructions or software and control transmission and receptions of signals, and a memory 706 to store data and/or instructions.

[0068] Processor 704 may also make decisions or determinations, generate frames, packets or messages for transmission, decode received frames or messages for further processing, and other tasks or functions described herein. Processor 704, which may be a baseband processor, for example, may generate messages, packets, frames or other signals for transmission via wireless transceiver 702 (702A or 702B). Processor 704 may control transmission of signals or messages over a wireless network, and may control the reception of signals or messages, etc., via a wireless network (e.g., after being down-converted by wireless transceiver 702, for example). Processor 704 may be programmable and capable of executing software or other instructions stored in memory or on other computer media to perform the various tasks and functions described above, such as one or more of the tasks or methods described above. Processor 704 may be (or may include), for example, hardware, programmable logic, a programmable processor that executes software or firmware, and/or any combination of these. Using other terminology, processor 704 and transceiver 702 together may be considered as a wireless transmitter/receiver system, for example.

[0069] In addition, referring to FIG. 7, a controller (or processor) 708 may execute software and instructions, and may provide overall control for the station 700, and may provide control for other systems not shown in FIG. 7, such as controlling input/output devices (e.g., display, keypad), and/or may execute software for one or more applications that may be provided on wireless station 700, such as, for example, an email program, audio/video applications, a word processor, a Voice over IP application, or other application or software.

[0070] In addition, a storage medium may be provided that includes stored

instructions, which when executed by a controller or processor may result in the processor 704, or other controller or processor, performing one or more of the functions or tasks described above.

[0071] According to another example implementation, RF or wireless transceiver(s) 702A/702B may receive signals or data and/or transmit or send signals or data. Processor 704 (and possibly transceivers 702A/702B) may control the RF or wireless transceiver 702A or 702B to receive, send, broadcast or transmit signals or data.

[0072] An example of an apparatus may include means (704, 702A/702B) for controlling sending, by a first node in a wireless network without the first node being authenticated to a core network, a message to a second node, the message including data to be forwarded to the core network, means (704, 702A/702B) for offloading authentication of the first node with the core network from the first node to the second node, and means (704, 702A/702B) for terminating controlling the sending the message by the first node without the first node performing authentication with the core network.

[0073] An example of an apparatus may include means (704, 702A/702B) for controlling receiving, by a second node from a first node in a wireless network, a request to offload authentication of the first node with the core network to the second node, means (704, 702A/702B) for controlling receiving, by the second node from the first node, data to be forwarded to the core network, means for performing, by the second node based on the request, an authentication with the core network on behalf of the first node while the first node is not connected with the second node, and means (704, 702A/702B) for controlling forwarding the received data from the second node to the core network while the first node is not connected with the second node.

[0074] Another example of an apparatus may include means (704, 702A/702B) for controlling receiving, by a first node from each of a plurality of second nodes in a wireless network, data to be forwarded to a core network, the plurality of second nodes associated with a user or a system, means (704) for aggregating the data received from each of the plurality of second nodes into a set of data, means for (704, 702A/702B) authenticating the user or the system to the core network, and means (704, 702A/702B) for controlling forwarding the aggregated set of data from the first node to the core network.

[0075] Implementations of the various techniques described herein may be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. Implementations may implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device, for execution by, or to control the operation of, data

processing apparatus, e.g., a programmable processor, a computer, or multiple computers. A computer program, such as the computer program(s) described above, can be written in any form of programming language, including compiled or interpreted languages, and can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

[0076] Method steps may be performed by one or more programmable processors executing a computer program to perform functions by operating on input data and generating output. Method steps also may be performed by, and an apparatus may be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit).

[0077] Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. Elements of a computer may include at least one processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer also may include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in special purpose logic circuitry.

[0078] To provide for interaction with a user, implementations may be implemented on a computer having a display device, e.g., a cathode ray tube (CRT) or liquid crystal display (LCD) monitor, for displaying information to the user and a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input.

[0079] Implementations may be implemented in a computing system that

includes a back-end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front-end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation, or any combination of such back-end, middleware, or front-end components. Components may be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network (LAN) and a wide area network (WAN), e.g., the Internet.

[0080] While certain features of the described implementations have been illustrated as described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the embodiments of the invention.

WHAT IS CLAIMED IS:

1. A method comprising:

5 sending, by a base station to a user device, an instruction to perform a short scan on each of a plurality of channels;

receiving, from the user device, signal strength measurement reports for each of the plurality of channels;

10 sending, to the user device, an instruction to perform long scans on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels;

receiving, from the user device, channel occupancy measurement reports for each of the candidate channels; and

15 selecting one of the candidate channels based on the channel occupancy measurement reports.

2. The method of claim 1, wherein a number of the plurality of channels is at least five times a number of the plurality of candidate channels.

20 3. The method of either of claims 1 or 2, further comprising selecting the plurality of candidate channels from the plurality of channels based on the received signal strength measurement reports.

25 4. The method of either of claims 1 or 2, further comprising selecting the plurality of candidate channels based on the received signal strength measurement reports indicating that the candidate channels have received signal strength values below a threshold signal strength.

30 5. The method of any of claims 1 through 4, further comprising:
receiving, from the user device, peak power level reports for each candidate channel,
wherein the selecting includes selecting one of the candidate channels based on the channel occupancy measurement reports and the peak power level reports.

6. The method of any of claims 1 through 5, further comprising:

receiving, from the user device, average received signal strength reports for each candidate channel within the subset,

wherein the selecting includes selecting one of the candidate channels based on the channel occupancy measurement reports and the average received signal strength reports.

7. The method of any of claims 1 through 4, further comprising:
receiving, from the user device, peak power level reports for each candidate channel, and
receiving, from the user device, average received signal strength reports for each candidate channel,

wherein the selecting includes selecting one of the candidate channels within the subset based on the channel occupancy measurement reports, the peak power level reports, and the average received signal strength reports.

8. The method of any of claims 1 through 7, further comprising
communicating with the user device via the selected one of the candidate channels.

9. The method of any of claims 1 through 8, wherein:
the instruction to perform short scans, the signal strength measurement reports, the instruction to perform long scans, and the channel occupancy measurement reports are sent or received via a Primary Cell (PCell); and

the method further includes communicating with the user device via a Secondary Cell (SCell), the SCell including the selected one of the candidate channels.

10. The method of any of claims 1 through 9, wherein the instruction to perform short scans is sent to the user device in response to the user device changing location.

11. The method of any of claims 1 through 10, wherein the short scans and the long scans are performed on channels and candidate channels with bandwidths of 20 MHz and frequencies within 500 MHz of 5 GHz.

12. A method comprising:
receiving, by a user device from a base station, an instruction to perform short scans on each of a plurality of channels;

performing short scans on each of the plurality of channels;

sending, to the base station, signal strength measurement reports for each of the plurality of channels based on the performed short scans;

receiving, from the base station, an instruction to perform a long scan on each of a plurality of candidate channels, the plurality of candidate channels being a subset of the plurality of channels;

performing long scans on each candidate channel;

sending, to the base station, channel occupancy measurement reports for each of the candidate channels based on each of the long scans; and

receiving, from the base station, a selection of one of the candidate channels.

13. The method of claim 12, wherein a duration of each of the long scans is at least ten times a duration of each of the short scans.

14. The method of either of claims 12 and 13, wherein a duration of each of the short scans is less than ten milliseconds (10 ms).

15. The method of any of claims 12 through 14, wherein a duration of each of the long scans is greater than one hundred milliseconds (100 ms).

16. The method of any of claims 12 through 15, wherein the performing short scans includes scanning one of the channels at a time and the performing long scans includes scanning one of the candidate channels at a time.

17. A non-transitory computer-readable storage medium comprising instructions stored thereon that, when executed by at least one processor, are configured to cause a computing system to perform any of the methods of claims 1 through 16.

18. An apparatus comprising:
at least one processor; and

at least one memory device comprising instructions stored thereon that, when executed by the at least one processor, are configured to cause the apparatus to perform any of the methods of claims 1 through 16.

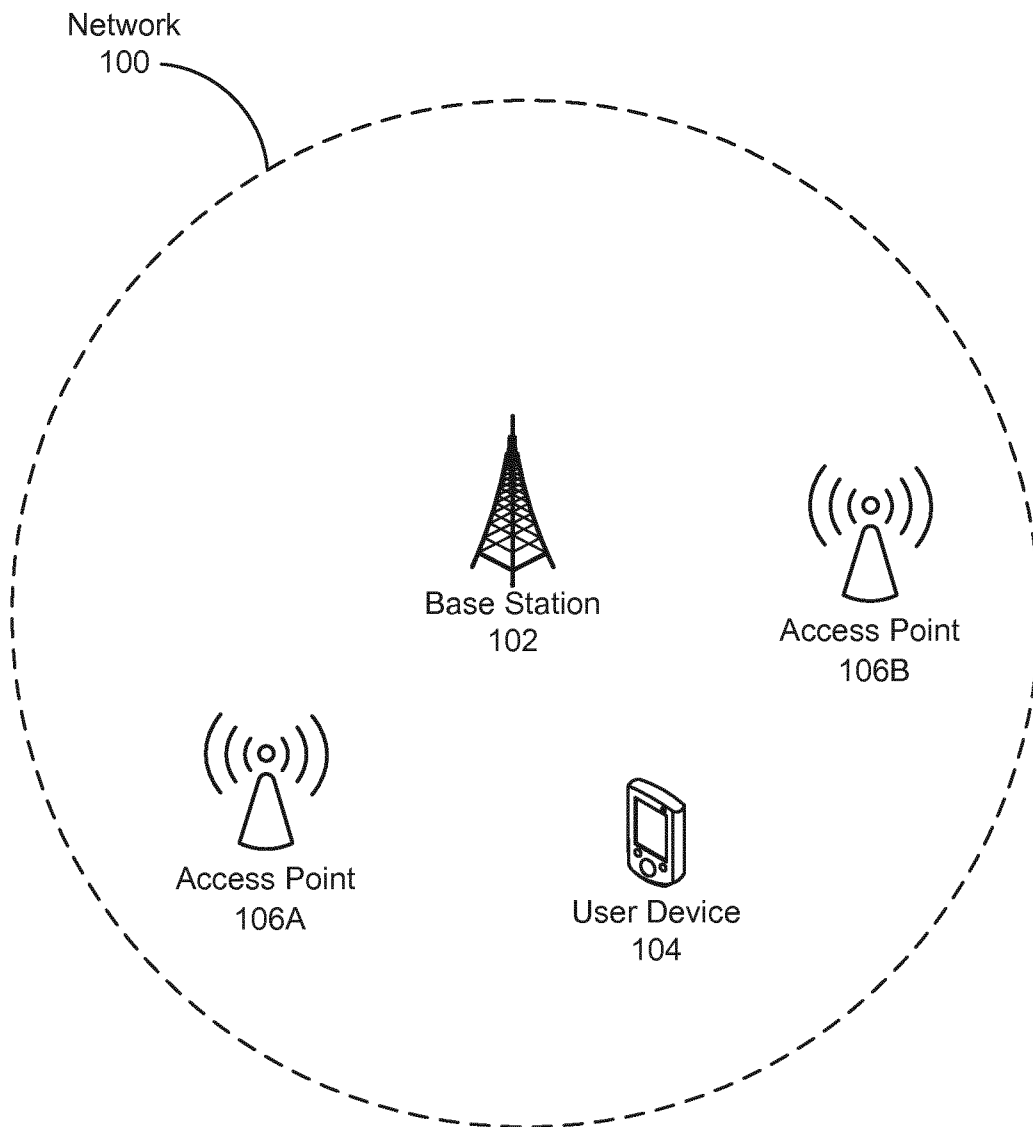


FIG. 1A

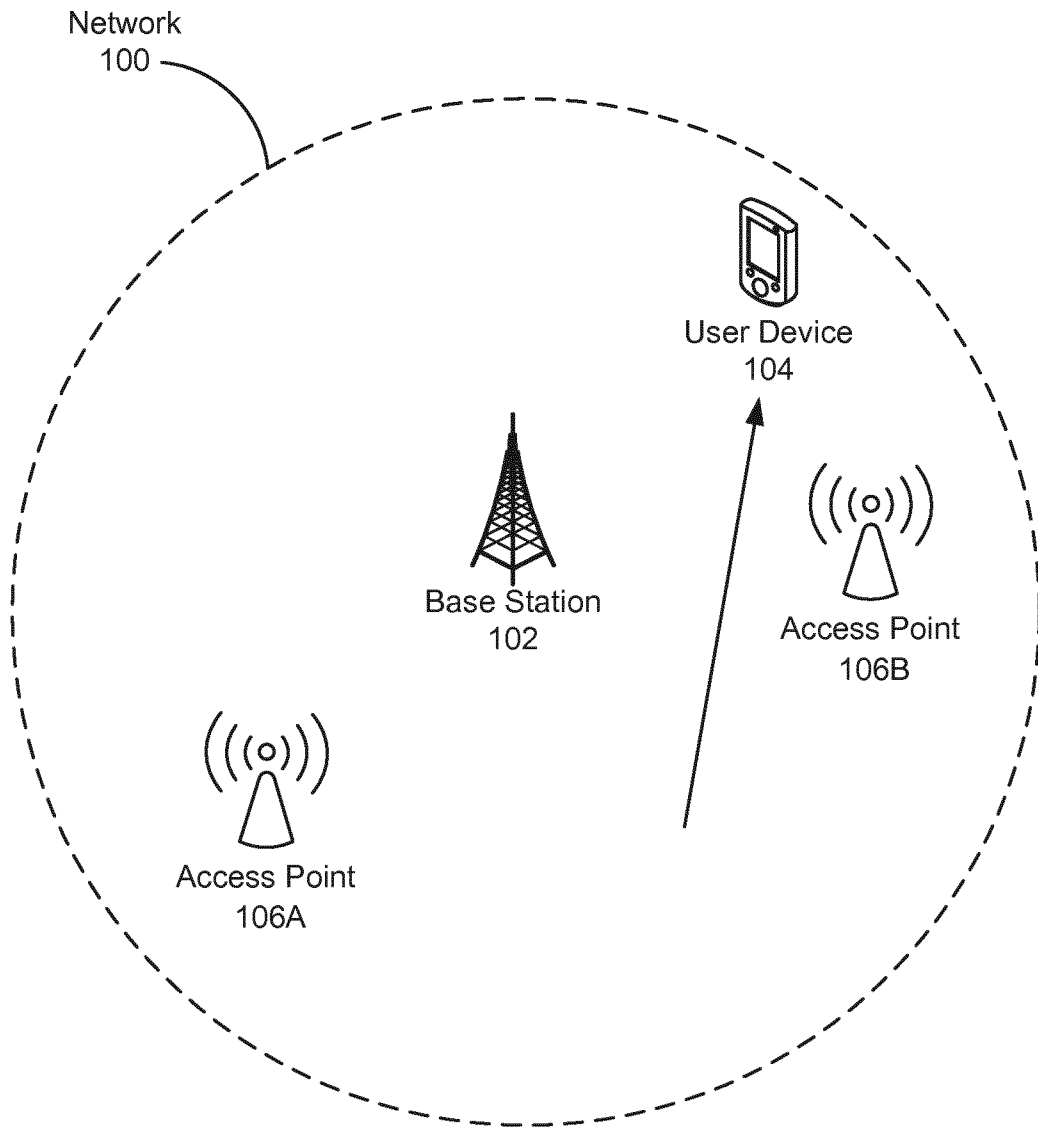


FIG. 1B

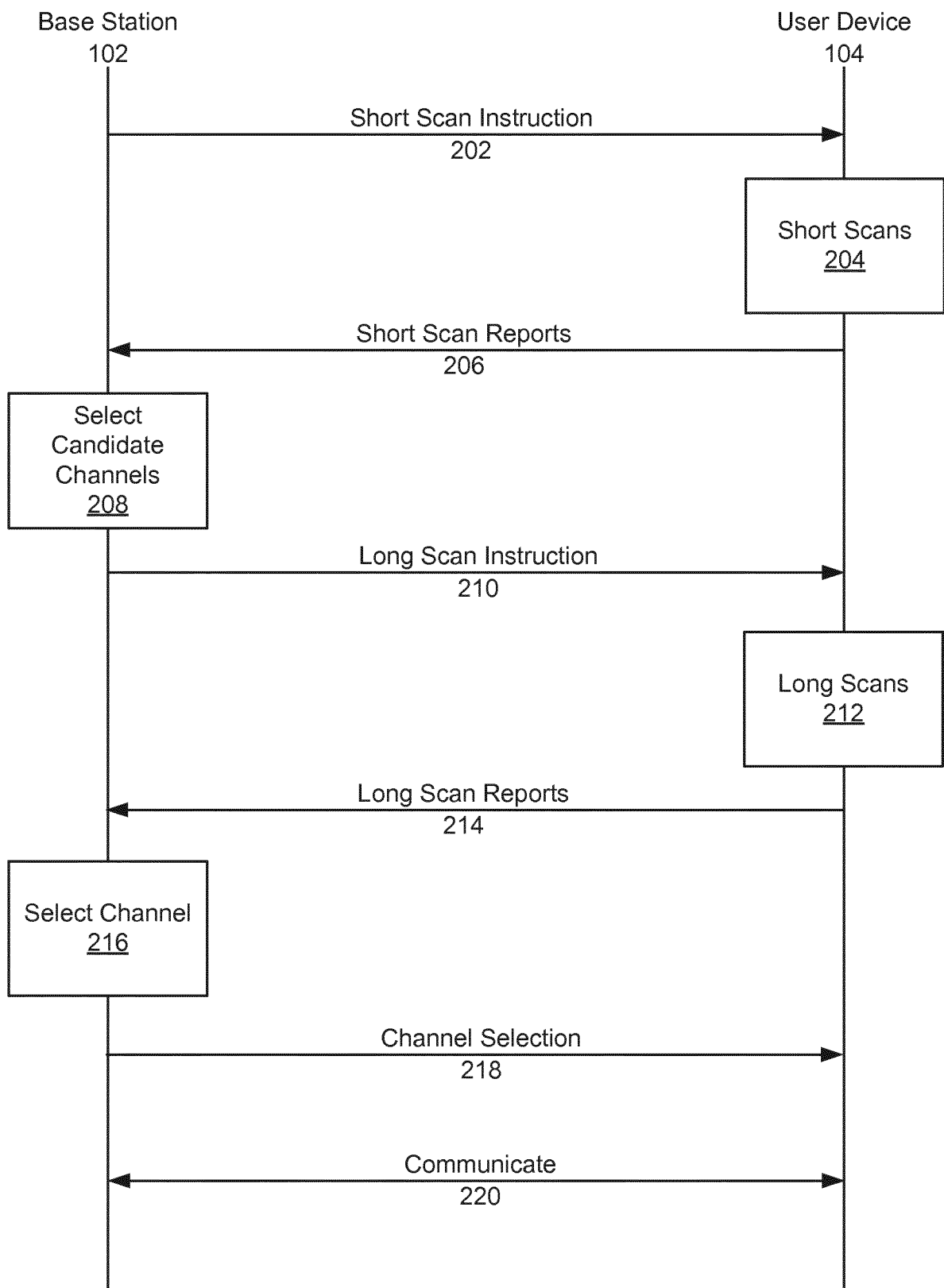


FIG. 2A

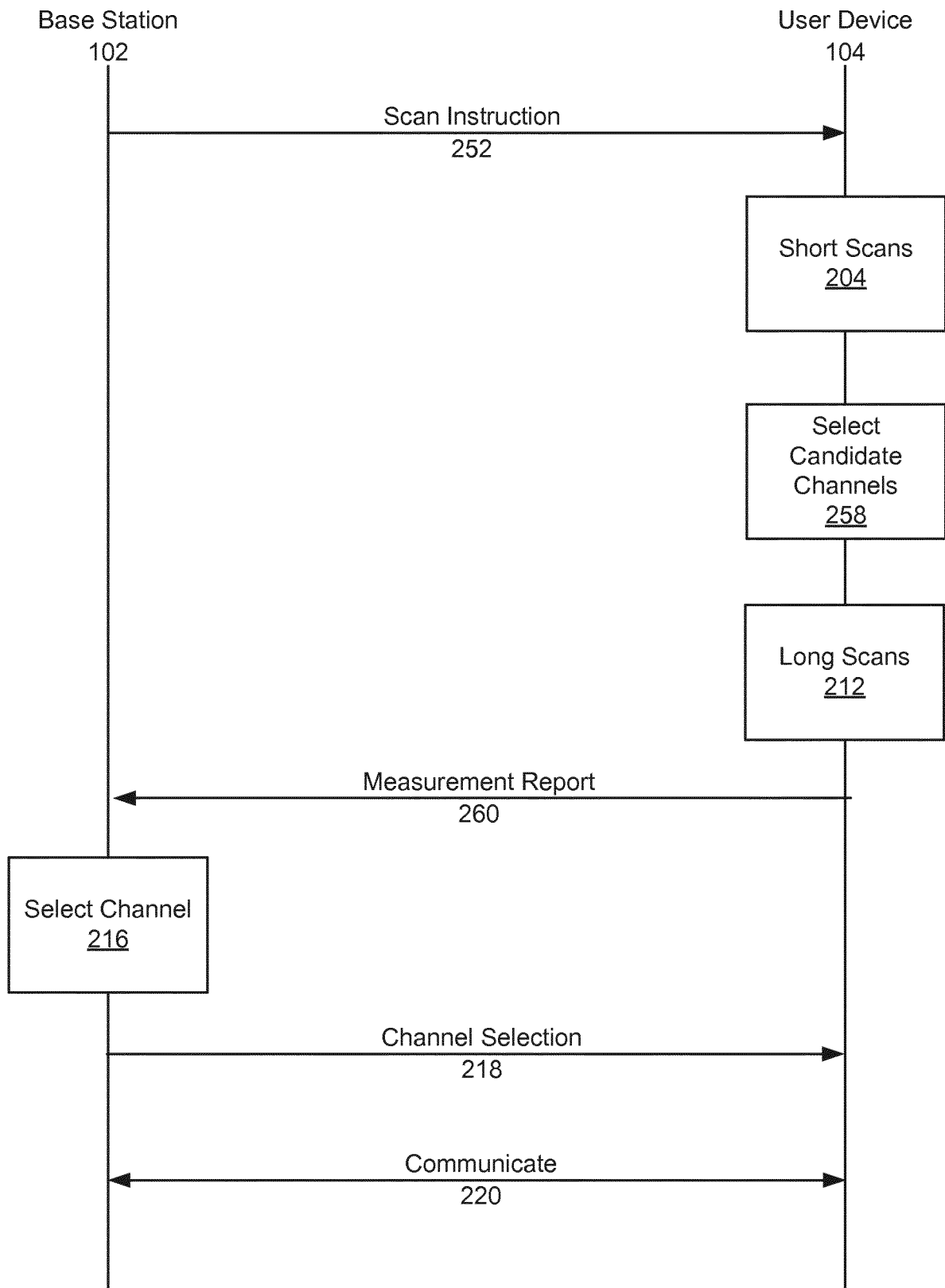


FIG. 2B

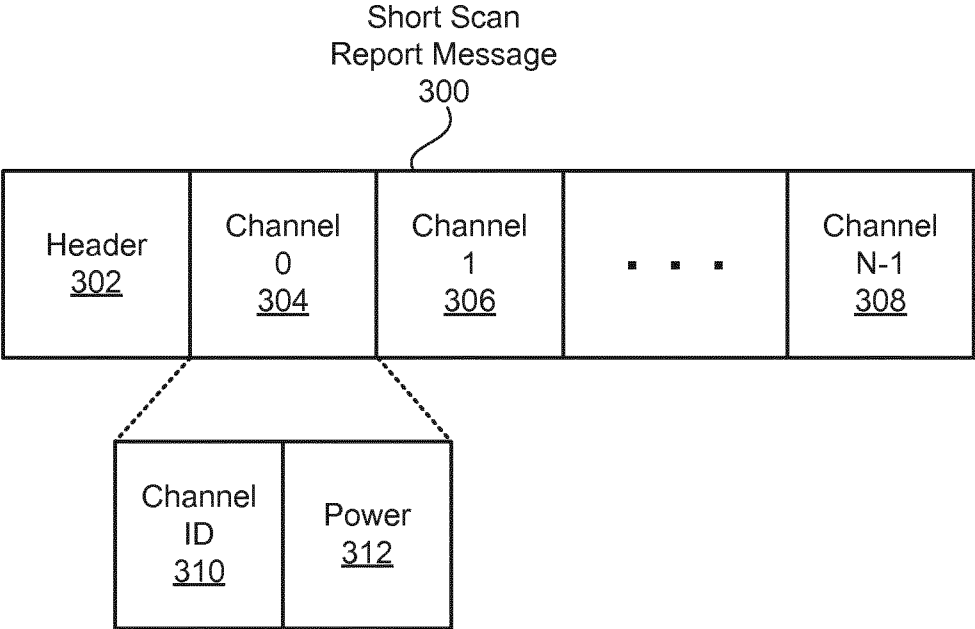


FIG. 3

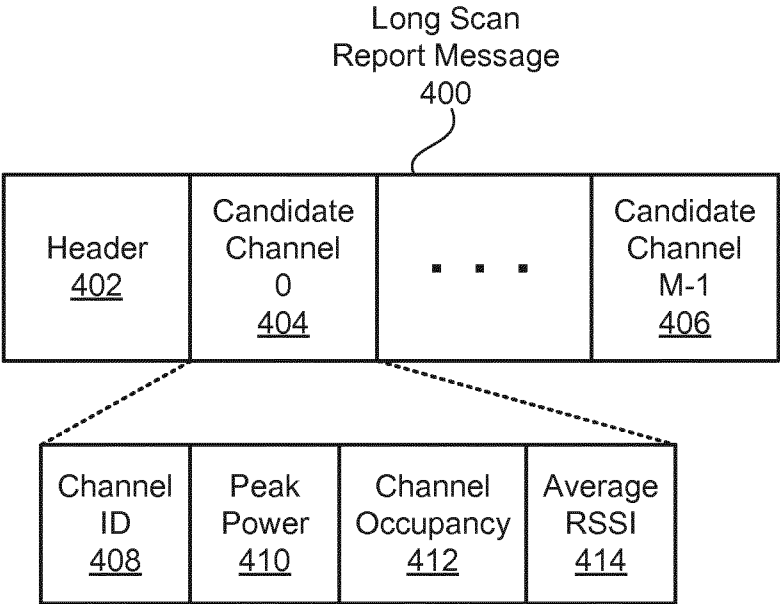
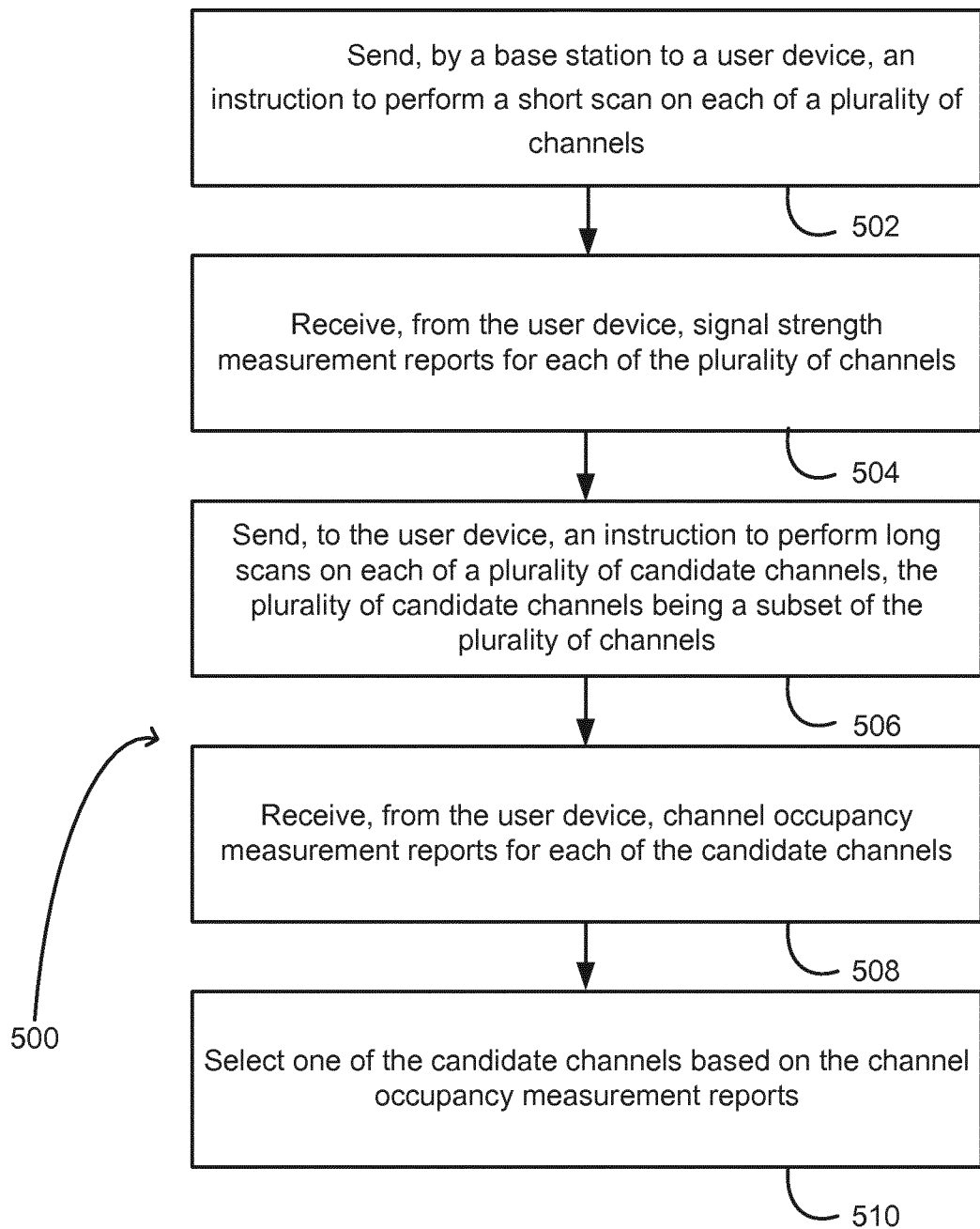
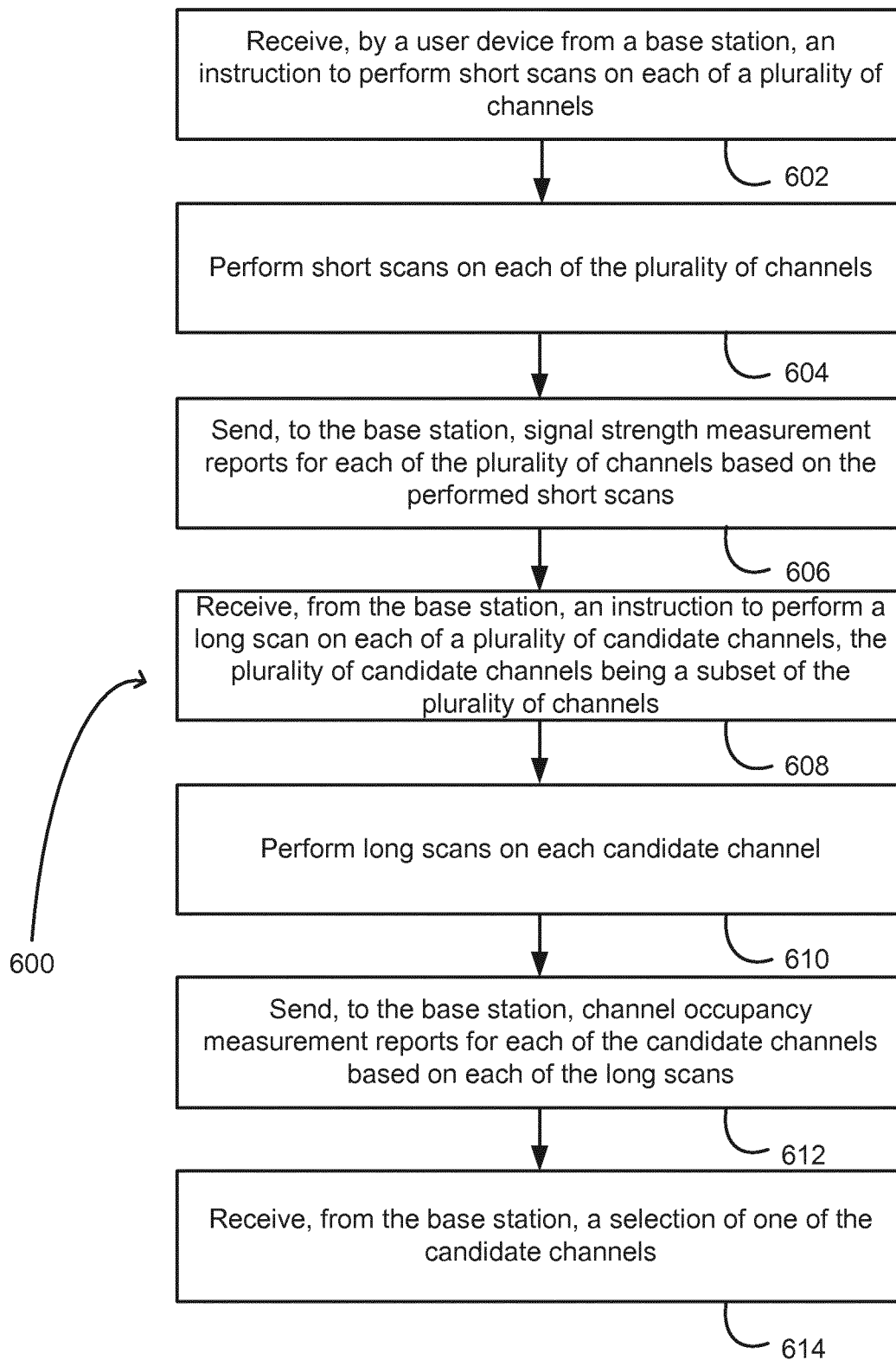


FIG. 4

**FIG. 5**

**FIG. 6**

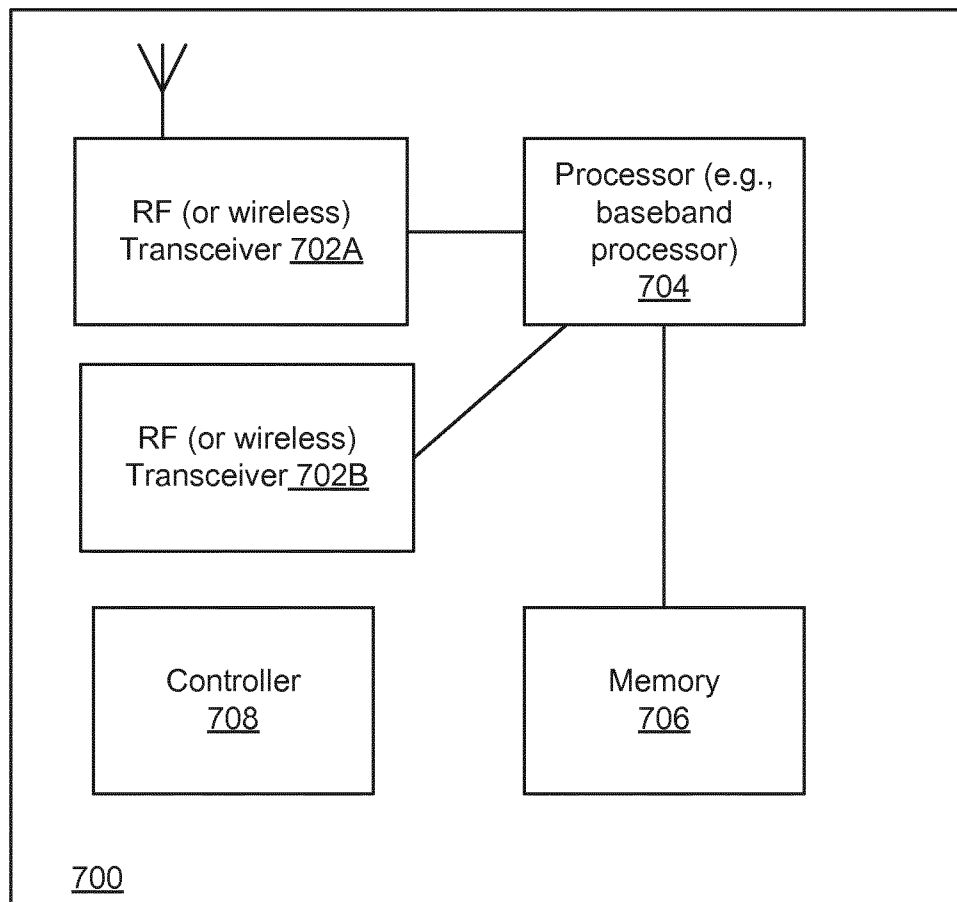


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/063645

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W16/14

ADD. H04W24/10 H04W72/08

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 H04B

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)

EPO-Internal, WPI Data

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Y	WO 2012/068731 A1 (NOKIA CORP [FI]; LI ZHENHONG [CN]; WANG HAIMING [CN]; GAO CHUNYAN [CN]) 31 May 2012 (2012-05-31) paragraph [0008] - paragraph [0012] paragraphs [0024], [0025] paragraph [0031] - paragraph [0046] figure 7 ----- -/-	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

24 February 2015

Date of mailing of the international search report

04/03/2015

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/063645

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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