



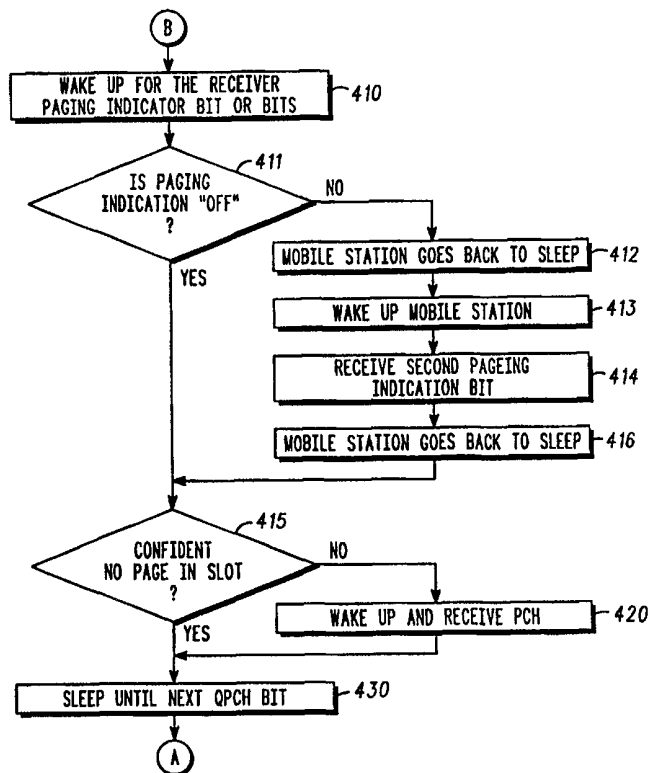
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(54) Title: METHOD FOR DETERMINING WHETHER TO WAKE UP A MOBILE STATION

(57) Abstract

The present invention provides a method for determining whether to wake up a mobile station (410). The mobile station includes first configuration parameters relating to a base station. The method includes the steps of receiving a configuration change indicator at the mobile station. The configuration change indicator (QPCH) is indicative that the first configuration parameters relating to the base station are different than second configuration parameters that currently relate to the base station. The method further includes waking up the mobile station to receive the second configuration parameters.



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**METHOD FOR DETERMINING WHETHER
TO WAKE UP A MOBILE STATION**

5 Field of the Invention

The present invention relates generally to communication systems, and more particularly, to a method for determining whether to wake up a mobile station.

10

Background of the Invention

15 In order to ensure that stored configuration parameter values are always up-to-date after idle handoffs, current cdma2000 procedures require that a mobile station always wake up for the regular Paging Channel (PCH) following an idle handoff, as described in section 2.6.2.1.4.2 of TR45.5.2.3.SIG/98.12.01.02. Experience with current CDMA systems shows that idle handoffs are typically frequent in areas with multiple pilots. Since the Quick Paging Channel (QPCH) is bypassed following an idle handoff, there is no standby time improvement due to the QPCH for the first paging channel slot following an idle handoff.

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In order to ensure that stored configuration parameter values are up-to-date for mobile stations monitoring the QPCH paging indicator bits, the base station, after updating the overhead configuration information, sets all QPCH paging indicator bits to "ON" for an amount of time which is a function of the maximum slot cycle index. For example, in current systems, the base station sets all QPCH paging indicator bits to "ON" for 1.28 seconds if the maximum

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slot cycle index is set to 0. This is described in TR45.5.2.3.SIG/98.11.17.07, TR45.5.2.3.SIG/98.11.17.08, and TR45.5.2.3.SIG/98.11.18.06.

5 However, if a mobile station were monitoring another base station when the configuration information for a base station changed and then the mobile station were to perform an idle handoff to the base station, monitoring the QPCH paging indicator bits would not cause the mobile station to update its stored
10 configuration parameter values.

Thus, a need exists for an improved method for ensuring up-to-date stored configuration parameter values after idle handoffs.

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Brief Description of the Drawings

FIG. 1 depicts a quick paging channel in accordance with a preferred embodiment of the present
20 invention;

FIG. 2 depicts bit positions of a mobile station's quick paging channel paging indicator bits in accordance with the prior art;

FIG. 3 depicts a quick paging channel including a
25 configuration change indicator every 10 ms in accordance with a preferred embodiment of the present invention;

FIG. 4 depicts a flowchart for determining whether to wake up a mobile station in accordance with a
30 preferred embodiment of the present invention;

FIG. 5 depicts a quick paging channel timeline in accordance with a preferred embodiment of the present invention;

FIG. 6 depicts a hash function modifier table in
35 accordance with a preferred embodiment of the present

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invention; and

FIG. 7 depicts a table showing the transmit power level associated with a QPCH power level field in accordance with a preferred embodiment of the present invention.

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Detailed Description of a Preferred Embodiment

10 The present invention provides a method for determining whether to wake up a mobile station. The mobile station includes first configuration parameters relating to a base station. The method comprises the steps of receiving a configuration change indicator at
15 the mobile station. The configuration change indicator is indicative that the first configuration parameters relating to the base station are different than second configuration parameters that currently relate to the base station. The method further comprises waking up
20 the mobile station to receive the second configuration parameters.

According to the standard TIA/EIA-95-B's paging channel monitoring procedures, a mobile station
25 preferably determines whether its configuration parameter values are up-to-date by checking the CONFIG_MSG_SEQ field in the *General Page Message*. It should be understood that the term "page" can refer to a paging message, such as a general page message, or
30 any other message directed to the mobile station. Alternately, the mobile station determines whether its configuration parameter values are up-to-date by checking in another message when it wakes up for its paging channel slot. If the CONFIG_MSG_SEQ does not
35 match the mobile station's stored value, the mobile

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station stays awake for a longer amount of time to receive new configuration parameter values.

The Paging Channel is preferably divided into 80 ms slots called Paging Channel slots. Paging and control messages for a mobile station operating in the non-slotted mode can be received in any of the Paging Channel slots; therefore, the non-slotted mode of operation requires the mobile station to monitor all slots. A mobile station operating in the non-slotted mode shall monitor the Paging Channel at all times.

During operation in the slotted mode, the mobile station preferably ensures that its stored configuration parameter values are current as shown below. The mobile station will preferably not operate in the slotted mode if its configuration parameters are not current.

The overhead messages on the Paging Channel are preferably:

- *System Parameters Message*
- *Access Parameters Message*
- *Neighbor List Message*
- *CDMA Channel List Message*
- *Extended System Parameters Message*
- *Global Service Redirection Message*
- *Extended Neighbor List Message*
- *General Neighbor List Message*

The *Response to Overhead Information Operation* is preferably performed whenever the mobile station receives an overhead message. The mobile station updates internally stored information from the received message's data fields. Configuration parameters and access parameters are received in the configuration messages and the *Access Parameters Message*. The configuration messages are preferably:

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- *System Parameters Message*
- *Neighbor List Message*
- *CDMA Channel List Message*
- *Extended System Parameters Message*
- 5 • *Global Service Redirection Message*
- *Extended Neighbor List Message*
- *General Neighbor List Message*

Associated with the set of configuration messages
10 sent on each Paging Channel is a configuration message
sequence number (CONFIG_MSG_SEQ). When the contents of
one or more of the configuration messages change, the
configuration message sequence number is preferably
incremented. For each of the configuration messages
15 received, the mobile station stores the configuration
message sequence number contained in the configuration
message (SYS_PAR_MSG_SEQ_S, NGHBR_LIST_MSG_SEQ_S,
EXT_NGHBR_LST_MSG_SEQ_S, GEN_NGHBR_LST_MSG_SEQ_S,
CHAN_LIST_MSG_SEQ_S, EXT_SYS_PAR_MSG_SEQ_S, or
20 GLOB_SERV_REDIR_MSG_SEQ_S). The mobile station also
stores the most recently received configuration message
sequence number (CONFIG_MSG_SEQ_S) contained in any
message. The mobile station examines the stored values
of the configuration message sequence numbers to
25 determine whether the configuration parameters stored
by the mobile station are current.

The configuration message sequence number is also
included in the *General Page Message*. This allows the
mobile station to determine whether the stored
30 configuration parameters are current without waiting
for a configuration message. *Access Parameters
Messages* are independently sequence-numbered by the
ACC_MSG_SEQ field. The mobile station preferably
stores the most recently received *Access Parameters
35 Message* sequence number (ACC_MSG_SEQ_S).

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The mobile station preferably stores the configuration parameters from Paging Channels it has recently monitored. When a mobile station starts monitoring a Paging Channel that it has recently monitored, the mobile station can determine whether the stored parameters are current by examining the CONFIG_MSG_SEQ_S in a configuration message or a *General Page Message*. The mobile station uses a special value, NULL, to be stored in place of sequence numbers for messages that have not been received or are marked as not current. The special value NULL shall be unequal to any valid message sequence number. The mobile station considers the stored configuration parameters to be current only if all of the following conditions are true:

- All stored configuration message sequence numbers (SYS_PAR_MSG_SEQ_S, NGHBR_LIST_MSG_SEQ_S, EXT_NGHBR_LIST_MSG_SEQ_S, CHAN_LIST_MSG_SEQ_S, EXT_SYS_PAR_MSG_SEQ_S, GEN_NGHBR_LIST_MSG_SEQ_S and GLOB_SERV_REDIR_MSG_SEQ_S) are equal to CONFIG_MSG_SEQ_S; and
- CONFIG_MSG_SEQ_S is not equal to NULL; and
- No more than 600 ~~T_{31m}~~ seconds (~~see Annex D~~) have elapsed since the mobile station last received a valid message on the Paging Channel for which the parameters were stored.

If the configuration parameters are not current, the mobile station preferably processes the stored parameters upon receipt of the configuration messages.

Whenever a *System Parameters Message* is received on the Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_r, is preferably compared to that stored in SYS_PAR_MSG_SEQ_S. If the comparison results in a match, the mobile station

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preferably ignores the message. If the comparison results in a mismatch, then the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameters:

- Configuration message sequence number
(CONFIG_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
SYS_PAR_MSG_SEQ_S = CONFIG_MSG_SEQ_R)

Whenever an *Access Parameters Message* is received on the Paging Channel, the sequence number, ACC_MSG_SEQ_R, is compared to ACC_MSG_SEQ_S. If the comparison results in a match, the mobile station preferably ignores the message. If the comparison results in a mismatch, the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameter:

- *Access Parameters Message* sequence number
(ACC_MSG_SEQ_S = ACC_MSG_SEQ_R)

Whenever a valid *Neighbor List Message* is received on the current Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_R, is preferably compared to that stored in NGHBR_LST_MSG_SEQ_S. If the comparison results in a match, the mobile station ignores the message. If the comparison results in a mismatch, the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameter:

- Configuration message sequence number
(CONFIG_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
NGHBR_LST_MSG_SEQ_S = CONFIG_MSG_SEQ_R)

Whenever a *CDMA Channel List Message* is received

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on the Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_r, is preferably compared to that stored in CHAN_LST_MSG_SEQ_s. If the comparison results in a match, the mobile station preferably ignores the message. If the comparison results in a mismatch, the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameter:

- Configuration message sequence number
(CONFIG_MSG_SEQ_s = CONFIG_MSG_SEQ_r,
CHAN_LST_MSG_SEQ_s = CONFIG_MSG_SEQ_r)

Whenever an *Extended System Parameters Message* is received on the Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_r, is compared to that stored in EXT_SYS_PAR_MSG_SEQ_s. If the comparison results in a match, the mobile station preferably ignores the message. If the comparison results in a mismatch, the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameters:

- Configuration message sequence number
(CONFIG_MSG_SEQ_s = CONFIG_MSG_SEQ_r,
EXT_SYS_PAR_MSG_SEQ_s = CONFIG_MSG_SEQ_r)

Whenever a *Global Service Redirection Message* is received on the Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_r, is preferably compared to that stored in GLOB_SERV_REDIR_MSG_SEQ_s. If the comparison results in a match, the mobile station preferably ignores the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameter:

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- Configuration message sequence number
(CONFIG_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
GLOB_SERV_REDIR_MSG_SEQ_S = CONFIG_MSG_SEQ_R)

5 Whenever a valid *Extended Neighbor List Message* is received on the current Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_R, is preferably compared to that stored in EXT_NGHBR_LST_MSG_SEQ_S. If the comparison results in a
10 match, the mobile station preferably ignores the message. If the comparison results in a mismatch, the mobile station processes the remaining fields in the message. If the comparison results in a mismatch, the mobile station preferably stores the following
15 parameters:

- Configuration message sequence number
(CONFIG_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
EXT_NGHBR_LST_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
NGHBR_LST_MSG_SEQ_S = CONFIG_MSG_SEQ_R)

20

 Whenever a valid *General Neighbor List Message* is received on the current Paging Channel, the configuration message sequence number, CONFIG_MSG_SEQ_R is preferably compared to that stored in
25 GEN_NGHBR_LST_MSG_SEQ_S. If the comparison results in a mismatch, the mobile station processes the remaining field in the message. If the comparison results in a mismatch, the mobile station preferably stores the following parameters:

- Configuration message sequence number
(CONFIG_MSG_SEQ_S = CONFIG_MSG_SEQ_R,
30 GEN_NGHBR_LST_MSG_SEQ_S = CONFIG_MSG_SEQ_R).

 Whenever the mobile station receives a *General Page Message*, the mobile station preferably compares
35

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the configuration message sequence number, CONFIG_MSG_SEQ_r, to CONFIG_MSG_SEQ_s. If the comparison results in a mismatch, the mobile station sets CONFIG_MSG_SEQ_s to CONFIG_MSG_SEQ_r.

5

TR45.5 has adopted a Quick Paging Channel (QPCH) approach to increase mobile station battery life in the next version of TIA/EIA-95-B. This next version is commonly known as cdma2000. The QPCH as well as the
10 paging channel (PCH) in the cdma2000 standard are channels broadcast on a common frequency spectrum of a CDMA communications system. A pilot channel is also broadcast. As is well-known, the channels may be associated with Walsh codes or other unique spreading
15 codes. The QPCH reduces the amount of time a mobile station is awake. As used herein, a mobile station is awake when it is consuming power from a power source to demodulate a channel using a radio frequency receiver and demodulation hardware. As used herein, the term
20 "wake up" is used to mean activation of, and application of a power source to, hardware necessary for demodulating a paging signal. Similarly the terms "sleep" and "go to sleep" refer to the deactivation of the hardware for the purpose of conserving a power
25 source in the mobile station.

No error correction coding or interleaving is used for the paging indicator bits. Consequently, the time awake to receive the bit is small compared to the time awake to receive the regular paging channel slot. A
30 paging indicator bit indicates to the mobile station whether it is to wake up for its paging channel slot to receive a page. On-off keying is used by the base station to transmit the QPCH bits. For example, for one value the base station transmits a spread spectrum
35 signal at a given power level during the bit time

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period using a particular spreading code and for the other value the base station does not transmit any power during the bit time period using the particular spreading code.

5 When the mobile station receives a QPCH bit, there are preferably three possibilities: "ON", "OFF", or "not certain". "ON" means that the base station clearly transmitted the bit. "OFF" means that the base station clearly did not transmit the bit. "Not
10 certain" means that the mobile station is not certain whether or not the base station transmitted the bit. If the mobile station determines that the received power for the QPCH bit time period and spreading code is sufficiently strong, then it can be certain that the
15 base station transmitted the bit. If the mobile station determines that the pilot power for the QPCH bit time period is sufficiently strong and that there is little received power for the QPCH bit time period and spreading code, then it can be certain that the
20 base station did not transmit the bit. If the mobile station determines that the pilot power for the QPCH bit time period is not sufficiently strong, the mobile station cannot be certain whether or not the base station transmitted the bit.

25

The present invention can be better understood with reference to FIGs. 1-7. FIG. 1 depicts a quick paging channel 100 in accordance with a preferred embodiment of the present invention. Quick Paging
30 Channel 100 is preferably divided into 80 ms slots 101 called Quick Paging Channel slots. Associated with a mobile station's "regular" 80 ms paging channel (PCH) slot 101 is a Quick Paging Channel (QPCH) slot 103. The beginning of a QPCH slot 103 preferably occurs 100
35 ms earlier in time than the beginning of the associated

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PCH slot 101. Each QPCH slot 103 is preferably divided into four 20 ms frames 105-108. In a QPCH slot 103, a mobile station's first paging indicator bit will preferably be in one of the first two 20 ms frames 105 or 106 of the QPCH slot 103. A mobile station's second
5 paging indicator bit will preferably occur in the frame two frames after the frame containing the mobile station's first paging indicator bit.

10 FIG. 2 shows an example of the bit positions of a mobile station's QPCH paging indicator bits 201 in accordance with the prior art. It should be noted that the positions of a mobile station's QPCH paging indicator bits 201 within a QPCH slot 203 vary as a
15 function of the system time.

In order to ensure that stored configuration parameter values are up-to-date for mobile stations monitoring the QPCH paging indicator bits 201, it has been proposed that the base station, after updating the
20 overhead configuration information, sets all QPCH paging indicator bits 201 to "ON" for an amount of time which is a function of the maximum slot cycle index. In the preferred embodiment, the amount of time is 1.28 seconds if the maximum slot cycle index is set to 0.
25 In alternate embodiments of the present invention, the amount of time could be 2.56 or 3.84 seconds if the maximum slot cycle index is set to 0, or 2.56, 5.12, or 7.68 seconds if the maximum slot cycle index is set to 1.

30 When a mobile station is in idle mode and is monitoring a paging channel or quick paging channel, it measures the strengths of pilot signals of neighboring base stations. When a mobile station determines that a neighboring pilot signal is sufficiently stronger than
35 the pilot signal associated with the base station whose

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5 paging channel or quick paging channel is being monitored, it performs a handoff to the neighboring base station to monitor the paging channel and quick paging channel of the neighboring base station. This type of handoff is called an idle handoff.

According to TIA/EIA-95-B and the proposed cdma2000 standard, mobile stations have a 10 minute timer for remembering stored configuration parameter values when performing idle handoffs from cell to cell. For example, if a mobile station receives configuration parameter values from cell A, performs an idle handoff to cell B, then 5 minutes later performs an idle handoff back to cell A, the mobile station retrieves its stored configuration parameter values. The mobile station need not waste its battery or other power source receiving the configuration parameter values again if a sequence number, such as the CONFIG_MSG_SEQ in a configuration message or *General Page Message*, still matches the stored value for the cell. According to TIA/EIA-95-B, a mobile station updates its configuration parameter values by receiving the paging channel over which configuration parameter messages are sent for a period of time until all configuration parameters are up-to-date. Cdma2000 mobile stations may also update configuration parameters by receiving a paging channel. Another possibility is to update configuration parameters by receiving a special broadcast channel (BCCH), over which configuration parameter messages are sent for a period of time, until all configuration parameters are up-to-date. The BCCH is a channel similar to the PCH and is spread in a similar manner and is typically broadcast in the same frequency spectrum.

Because the base station, when updating its configuration parameter values, preferably sets all

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QPCH paging indicator bits to "ON" for a short time compared to 10 minutes, when a mobile station performs an idle handoff back to a cell for which it has stored overhead information, it would have to wake up for a paging channel slot in order to insure that its overhead information is up-to-date. This time ranges from 20 ms to 160 ms. Waking up for such a relatively long time defeats the purpose of the QPCH. Idle handoffs can be quite frequent in the soft handoff region between cells, and are wasteful of the battery or other power source. On the other hand, if the mobile station were to begin monitoring the quick paging bits immediately after idle handoff without checking for a configuration change, the result could be a lost mobile station, i.e. a mobile station which does not respond when paged. For example, if the channel configuration changed, the mobile station could be monitoring the wrong channel. Also, if the power level of the QPCH were lowered, the mobile station might not respond when paged. Quickly updating the mobile when the overhead information changes is critical.

Preferably the mobile station would be able to determine immediately after the idle handoff if configuration information has changed without waking up for a paging channel slot.

In the preferred embodiment of the present invention as depicted in FIG. 3, every 10 ms one QPCH bit 301 is reserved as a Configuration Change indicator bit 303. In the alternate embodiment of the present invention, a QPCH bit is reserved as a Configuration Change indicator bit every 5 ms. In a further alternate embodiment, a QPCH bit is reserved as a Configuration Change indicator bit every 20 ms. When

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the base station changes the configuration parameter values, it preferably sets all Configuration Change indicator bits 303, also transmitted using On-Off Keying as with paging indicator QPCH bits, to "ON" preferably for 10 minutes after changing the configuration information. It should be noted that this is in addition to setting all paging indicator bits for the maximum slot cycle.

When a mobile station performs an idle handoff, it receives at least one configuration change indicator bit 303 for the new base station if the ten minute timer for the new base station has not expired. In an alternate embodiment, the mobile station can receive and combine multiple configuration change quick bits. This is helpful in RF conditions where the signal from the base station is weak and the mobile station could not otherwise be confident that the configuration is not being changed.

In addition, the mobile station receives one or two paging indicator bits 305. If the mobile station is confident that there is no page and is confident that there was no configuration change, it will go to sleep until the next quick paging slot. It should be noted that Configuration Change indicator bit 303 is only monitored by the mobile after an idle handoff; once the mobile is confident that there is no change in configuration, it does not have to receive a configuration change bit 303 in a subsequent quick paging slot. This is an important feature of the invention because power is consumed monitoring the configuration change quick bit only for the first quick paging slot after an idle handoff. If the mobile station determines that the configuration has changed after receiving a configuration change quick bit, it will wake up for its regular paging slot and stay awake

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until it the configuration parameter values are up-to-date. Consequently, the present invention provides a greatly enhanced battery life by waking up the mobile station only when necessary to receive up-to-date
5 configuration parameters.

If a broadcast channel (BCCH) is used and the mobile station determines that the configuration has changed after receiving configuration change indicator bit 303, the mobile station wakes up and receives the
10 BCCH until the configuration parameter values are up-to-date. If the mobile station does not support simultaneous demodulation of a BCCH and a PCH, the mobile station wakes up and receives its PCH slot first if required based upon the paging indicator bits, then
15 receives the BCCH. This method can also prevent the mobile station from missing a page. Preferably, a mobile station supports simultaneous demodulation of a BCCH and a PCH; in this case the mobile would receive the BCCH and simultaneously receive the PCH if required
20 based upon the paging indicator bits. Simultaneous demodulation of the PCH and BCCH can be used to conserve the battery or other power source by minimizing the amount of time the radio receiver and associated hardware are on and consuming power.

If the valid configuration parameters timer for the new base station has expired when the mobile determines that it needs to perform an idle handoff to the new base station, the mobile station should conserve the battery or other power source by not
30 waking up to receive either the paging indicator bits or the configuration change indicator bits. This applies when there is no BCCH and only a PCH. If a BCCH is configured in this case, the mobile station preferably wakes up for the BCCH without waking up for
35 the configuration change indicators. Alternately, the

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mobile station may receive the paging indicator bits to determine whether to wake up for the PCH.

FIG. 4 depicts a flowchart 400 of the mobile station procedure. The mobile station scans (401) the neighbor pilots by waking up and measuring the pilot strengths of the neighboring pilots. The mobile station determines (405) if a neighboring pilot is sufficiently stronger than the currently monitored pilot. If the result of step 405 is negative, the mobile station proceeds to step 410; otherwise the mobile station proceeds to step 425. The mobile station wakes up and receives (410) the first paging indicator bit. If the mobile station determines (411) that the first paging indicator bit is "OFF", the mobile station proceeds to step 415. If the first paging indicator bit is not "OFF", the mobile station goes (412) back to sleep, then wakes up (413) again and receives (414) the second paging indicator bit, then goes (416) back to sleep and proceeds to decision step 415.

The mobile station then determines (415) if it is confident that there is no page in the following PCH slot. If the mobile determines that either of the paging indicator bits was "OFF", then the result of decision step 415 is positive and the mobile station proceeds to step 430. If neither paging indicator bit was "OFF", the result is negative and the mobile station wakes up (420) and receives the PCH until it either receives a page directed to it or until it determines that there are no pages for it in the PCH slot. The mobile station then proceeds to step 430. The mobile station sleeps (430) until the next QPCH bit it must receive; when the mobile station wakes up for the next QPCH bit this may be several ms earlier than

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the QPCH bit to allow enough time for neighbor searching. After step 430 the mobile station proceeds back to step 401.

5 If the neighbor pilot is sufficiently stronger than the current pilot as determined at step 405, the mobile station performs (425) the idle handoff to the new pilot. The mobile station then determines (435) whether its configuration parameter value timer has expired for the new base station. If the result of
10 this step is positive, the mobile station wakes up (440) and receives the updated configuration parameters. This is preferably accomplished without receiving the configuration change indicator, because to receive the configuration change indicator would
15 consume power from the battery or other power source when the mobile station has no choice but to wake up to receive the configuration parameters. After receiving the updated configuration parameters the mobile station then goes to sleep until the next QPCH bit as in step
20 430. The mobile station then proceeds back to step 401.

If the configuration timeout has not expired as determined at step 435, the mobile station receives (445) configuration change indicator bits and paging
25 indicator bits on the QPCH as necessary. Reception of paging indicator bits is performed in a similar manner as in steps 410, 411, 412, 413, 414, and 415. If there is no BCCH and the mobile station does not determine that that one of the paging indicator bits is off, it
30 can avoid being awake for the configuration change indicator bit since it must in this case wake up for the PCH slot anyway. Typically, however, the mobile station would receive at least one paging indicator bit and at least one configuration change indicator bit.
35 Preferably the mobile station receives the first paging

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indicator and, after receiving it, stays awake until the next scheduled configuration change indicator bit, receives it, and then goes back to sleep. If the mobile station does not determine that the first paging indicator is set to "OFF", the mobile station then wakes up in time to receive the second paging indicator. If the mobile station receives the second paging indicator, determines that it is set to "OFF", but did not determine that the first received configuration change indicator bit was set to "OFF", the mobile station stays awake to receive a second configuration change indicator bit. This is preferably the next scheduled configuration change indicator bit.

If the mobile station determines (446) that the second configuration change indicator bit is set to "OFF", it preferably goes (447) to sleep and then proceeds to step 450. If the mobile station determines (446) that the second configuration change indicator bit is not set to "OFF", the mobile station determines (448) whether the configuration change bits are "OFF" by combining the results of the first two configuration change indicator bits. If, after combining the two configuration change indicator bits the mobile station is confident there has not been a configuration change, it preferably goes to sleep and proceeds to step 450. If the mobile station determines (448) that the configuration change indicator bits are not "OFF", the mobile station preferably remains awake (449) for yet another configuration change bit, reevaluates, and so on. Alternately, or it may go back to sleep even though it is not confident that there has been a configuration change. If the mobile station receives a configuration change indicator bit at any time and determines that it is "ON", it need not stay awake for the sake of receiving another configuration change

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indicator bit. After receiving configuration change indicator bits and paging indicator bits as needed, the mobile station proceeds to decision step 450.

5 The mobile station then determines (450) if it is confident that there is no page in the slot and if it is confident that there has not been a configuration change. If the result of step 450 is positive, the mobile station sleeps (460) until the next QPCH bit as in step 430 and then proceeds back to step 401. If the
10 mobile station is not confident that there is no page and no configuration change, the mobile station wakes up (455) and makes sure that it has up-to-date configuration parameter values if it is not confident that there has not been a configuration change. The
15 mobile station also must stay awake for its paging channel slot until it either receives a page directed to it or until it determines that there are no pages for it in the PCH slot. After the mobile is sure that its configuration parameter values are up-to-date and
20 there are no pages for it, it sleeps until the next QPCH bit as in step 430 then proceeds to step 401.

When the base station updates its configuration parameter value information, it preferably sets all
25 QPCH paging indicator bits to "ON" for an amount of time which is a function of the maximum slot cycle index. If the change in configuration parameter values includes a change in the power level of the QPCH, the power level of the paging indicator bits for this time
30 period is set to the old QPCH power level. This is particularly important in order to ensure that mobile stations monitoring the QPCH paging indicators wake up to receive the new parameters when the power of the QPCH is being reduced. If the reduced power level were
35 used immediately, the mobile stations could become

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"lost" because they are unaware of the configuration change. After this time period, the new power level of the paging indicator bits may be used.

Similarly, when the base station updates its
5 configuration parameter value information, it sets all Configuration Change indicator bits to "ON" for a predetermined amount of time, preferably for ten minutes after changing the configuration information. If the change in configuration parameter values
10 includes a change in the power level of the QPCH, the power level of the configuration change indicator bits for this time period is set to the old QPCH power level. This is particularly important in order to ensure that mobile stations monitoring the QPCH
15 configuration change indicators after an idle handoff wake up to receive the new parameters when the power of the QPCH is being reduced. If the reduced power level were used immediately, the mobile stations might become "lost" because they are unaware of the configuration
20 change. After this time period, the new power level of the configuration change indicator bits is preferably used.

The following operators define mathematical
25 operations:

\times indicates multiplication.

$\lfloor x \rfloor$ indicates the largest integer less than or equal to x : $\lfloor 1.1 \rfloor = 1, \lfloor 1.0 \rfloor = 1$.

$\lceil x \rceil$ indicates the smallest integer greater or equal
30 to x : $\lceil 1.1 \rceil = 2, \lceil 2.0 \rceil = 2$.

$|x|$ indicates the absolute value of x : $|-17| = 17, |17| = 17$.

\oplus indicates exclusive OR (modulo-2 addition).

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$\min(x, y)$ indicates the minimum of x and y .

$\max(x, y)$ indicates the maximum of x and y .

$x \bmod y$ indicates the remainder after dividing x by y : $x \bmod y = x - (y \times \lfloor x/y \rfloor)$.

5

If the mobile station supports the Quick Paging Channel operation, the mobile station monitors the Paging Channel in certain slots assigned to it, as described below. Otherwise, the mobile station
10 monitors the Paging Channel in each of its assigned slots. For its assigned slots, the mobile station will begin monitoring the Paging Channel in time to receive the first bit of the slot. If the mobile station is not configured to receive broadcast addresses, the
15 mobile station will continue to monitor the Paging Channel until predetermined conditions are satisfied.

The Quick Paging Channel is preferably divided into 80 ms slots called Quick Paging Channel slots.
20 The Quick Paging Channel protocol provides for scheduling the transmission of paging indicators for a mobile station in Quick Paging Channel slots assigned to the mobile station. The Quick Paging Channel protocol also preferably provides for scheduling the
25 transmission of configuration change indicators for mobile stations in Quick Paging Channel slots.

FIG. 5 depicts a quick paging channel timeline in accordance with a preferred embodiment of the present
30 invention. If the mobile station is operating in the slotted mode and it supports the Quick Paging Channel, the mobile station monitors paging indicators on the Quick Paging Channel as follows. Quick Paging Channel slots 501 are offset from Paging Channel slots 503 by
35 20 ms. The Quick Paging Channel slot 501 immediately

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preceding the mobile station's assigned Paging Channel slot 503 is the mobile station's assigned Quick Paging Channel slot 505. In the preferred embodiment of the present invention, two paging indicators are assigned to a mobile station in its assigned Quick Paging Channel slot 505.

In the following example, t^* is the start time of the mobile station's assigned Paging Channel slot 503. Paging indicators are preferably assigned as follows. The first paging indicator for the mobile station is preferably assigned between $(t^*-100\text{ ms})$ and $(t^*-80\text{ ms})$, marked as 511, and the second paging indicator is assigned between $(t^*-60\text{ ms})$ and $(t^*-40\text{ ms})$, marked as 513. Alternately, the first paging indicator for the mobile station is assigned between $(t^*-80\text{ ms})$ and $(t^*-60\text{ ms})$, marked as 512, and the second paging indicator is assigned between $(t^*-40\text{ ms})$ and $(t^*-20\text{ ms})$, marked as 514.

If the mobile station is operating in the slotted mode and it supports the Quick Paging Channel, the mobile station preferably, when performing an idle handoff to a base station whose paging channel has recently been monitored, monitors one or more configuration change indicators. Configuration change indicators are preferably scheduled every 10 ms on the Quick Paging Channel.

A mobile station operating in the slotted mode preferably monitors the paging indicators in the mobile station's assigned Quick Paging Channel slot 505 if the mobile station supports the Quick Paging Channel and the mobile station is not monitoring the Paging Channel. Otherwise the mobile station monitors the assigned paging channel slot 503 associated with the

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Quick Paging Channel slot 505.

The mobile station's assigned Quick Paging Channel slots 505 are preferably those slots in which:

$$\lfloor (t-5)/4 \rfloor - \text{PGSLOT} \bmod (16 \times T) = 0.$$

5 where t is the System Time in frames, PGSLOT is preferably selected in the range 0 to 2047, and T is the slot cycle length, preferably in units of 1.28 seconds such that:

$$T = 2^i,$$

10 and i is the slot cycle index.

To determine the position of the mobile station's two assigned paging indicators relative to the beginning of the mobile station's assigned Quick Paging Channel slot 501, the mobile station preferably uses the hash function specified above.

15 The mobile station preferably determines the bit position of its first assigned paging indicator with respect to the first QPCH bit in the QPCH slot 501 according to the following formula:

$$20 \quad 1 + \lfloor (R_1) / (N/4) \rfloor + R_1$$

where N is the value from FIG. 6 used to determine R_1 .

The mobile station preferably determines the bit position of its second assigned paging indicator with respect to the first QPCH bit in QPCH slot 501 according to the following formula:

$$25 \quad 1 + \lfloor (R_2) / (N/4) \rfloor + R_2$$

where N is the value from FIG. 6 used to determine R_2 .

30 The preferred method of the present invention occurs as follows. The mobile station receives its first assigned paging indicator. If the mobile station does not detect that the first assigned paging indicator is "OFF", the mobile station receives the second paging indicator. If the mobile station does

35

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not detect that the second assigned paging indicator is "OFF", the mobile station preferably receives its assigned Paging Channel slot immediately following its assigned Quick Paging Channel slot.

5 Before performing an idle handoff to a base station whose paging channel was recently monitored, a mobile station operating in the slotted mode preferably monitors one or more configuration change indicators on the assigned Quick Paging Channel for the new base
10 station if the mobile station supports the Quick Paging Channel, the new base station supports Quick Paging Channel, the mobile station is not monitoring the Paging Channel, and no more than 600 seconds have elapsed since the mobile station last received a valid
15 message on the new Paging Channel.

 The mobile station preferably determines the bit positions of its configuration change indicator bits with respect to the first QPCH bit in a QPCH slot according to the following formula:

20

$$((N/4) + 1) \times P$$

 where N is the value from FIG. 6 used to determine R₁ and R₂, and where P preferably ranges from 0 to 7.

25

 If the mobile station monitors a configuration change indicator and determines that it is set to "OFF", the mobile station preferably avoids entering the non-slotted mode after an idle handoff.

30

 While performing an idle handoff, if the mobile station supports the Quick Paging Channel operation and the mobile station determines that the QPCH configuration change indicator for the new QPCH is set to "OFF" and if no more than 600 seconds have elapsed since the mobile station last received a valid message
35 on the new Paging Channel, the mobile station preferably does not begin operating in the non-slotted

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mode after the idle handoff. Otherwise the mobile station will operate in the non-slotted mode until the mobile station has received at least one valid configuration message, or *General Page Message*, on the new Paging Channel. Following the reception of this message the mobile station may resume slotted mode operation.

After performing an idle handoff, the mobile station preferably discards all unprocessed messages received on the old Paging Channel.

If the mobile station enters the non-slotted mode, the mobile station sets CONFIG_MSG_SEQ_S to NULL; otherwise, the mobile station sets CONFIG_MSG_SEQ_S to the stored information for the new Paging Channel. If the mobile station has not stored configuration parameters for the new Paging Channel, or if the stored information is not current, the mobile station sets SYS_PAR_MSG_SEQ_S, NGHBR_LST_MSG_SEQ_S, EXT_NGHBR_LST_MSG_SEQ_S, GEN_NGHBR_LST_MSG_SEQ_S, CHAN_LST_MSG_SEQ_S, EXT_SYS_PAR_MSG_SEQ_S, and GLOB_SERV_REDIR_MSG_SEQ_S to NULL.

Certain procedures require a uniform distribution of mobile stations among N resources. The following function returns an integer, using as arguments the mobile station's IMSI or ESN, the number of resources N, and a modifier DECORR. The modifier serves to decorrelate the values obtained for the various applications from the same mobile station.

If the hashing function is to be used for determining the Access Channel PN Randomization, HASH_KEY shall be equal to the mobile station ESN. Otherwise, HASH_KEY is preferably equal to the 32 least significant bits of $IMSI_O_S1 + 2^{24} \times IMSI_O_S2$.

Define:

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- Word L to be bits 0-15 of HASH_KEY
- Word H to be bits 16-31 of HASH_KEY

where bit 0 is the least significant bit of HASH_KEY.
The hash value is computed as follows:

$$5 \quad R = \lfloor N \times ((40503 \times (L \oplus H \oplus \text{DECORR})) \bmod 2^{16}) / 2^{16} \rfloor$$

For determining mobile station's assigned paging indication bit positions, the hash value is computed as follows:

$$R_1 = \lfloor N \times ((40503 \times (L \oplus H \oplus \text{DECORR}_1)) \bmod 2^{16}) / 2^{16} \rfloor,$$

10 and

$$R_2 = \lfloor (N/2) \times ((40503 \times (L \oplus H \oplus \text{DECORR}_2)) \bmod 2^{16}) / 2^{16} \rfloor + N + \lfloor (2 \times R_1) / N \rfloor \times (N/2).$$

The mobile station preferably chooses the range N
15 and the modifiers DECORR, DECORR₁, and DECORR₂ according to the application as shown in FIG. 6. In the table, HASH_KEY [0...11] denotes the 12 least significant bits of HASH_KEY.

20 The base station may support a Quick Paging Channel. When a Quick Paging Channel is supported, the base station transmits paging indicators to the mobile station in the assigned positions in the assigned Quick Paging Channel slot. The base station sets the paging
25 indicators to "ON" if the mobile station is to receive the Paging Channel in the Paging Channel slot following its assigned Quick Paging Channel slot.

If the base station operates with a Quick Paging Channel, after any configuration parameter value is
30 updated, the base station preferably sets all paging indicators to "ON" for each Quick Paging Channel slot for a time interval of T units of 1.28 seconds, where:

$$T = N \times 2^{\text{MAX_SLOT_CYCLE_INDEX}}$$

and N is an integer greater than or equal to 1.

35

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If the base station operates with a Quick Paging Channel, after any configuration parameter value is updated, the base station preferably sets all configuration change indicators to "ON" for each Quick Paging Channel slot for a time interval of 600 seconds. At all other times, the base station sets all configuration change indicators to "OFF".

To determine the mobile station's assigned Quick Paging Channel, the base station preferably uses the hash function specified in FIG. 6 with the following inputs. IMSI_S based on the IMSI with which the mobile station registered and the number of Quick Paging Channels which the base station transmits on the mobile station's assigned CDMA Channel.

In the preferred embodiment, the mobile station's assigned Quick Paging Channel slots are those slots for which

$$\lfloor (t-5)/4 \rfloor - \text{PGSLOT} \bmod (16 \times T) = 0,$$

where t is the System Time in frames, PGSLOT is selected preferably in the range 0 to 2047 by using hash function specified in FIG. 6, and T is the slot cycle length, preferably in units of 1.28 seconds such that

$$T = 2^i,$$

and i is the slot cycle index.

To determine the mobile station's assigned paging indicators, the base station preferably uses the same formula as used by the mobile station. To determine the position of the configuration change indicators, the base station preferably uses the same formula as used by the mobile station.

If the base station sets QPCH_SUPPORTED to '1',

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the base station shall set this field to the Quick Paging Channel transmit power level relative to that of the Pilot Channel as specified in FIG. 7.

5 While this invention has been described in terms of certain examples thereof, it is not intended that it be limited to the above description, but rather only to the extent set forth in the claims that follow.

10 I claim:

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Claims

1. A method for determining whether to wake up a mobile station, the mobile station including first configuration parameters relating to a base station,
5 the method comprising the steps of:

receiving a configuration change indicator at the mobile station, the configuration change indicator indicative that the first configuration parameters
10 relating to the base station are different than second configuration parameters relating to the base station;
and

waking up the mobile station to receive the second configuration parameters.

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2. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein the first configuration parameters were received on a first channel, and wherein the step of waking up the mobile station to receive the second configuration parameters comprises waking up the mobile station on a second channel distinct from the first channel.
3. A method for determining whether to wake up a mobile station in accordance with claim 1, further comprising the step of receiving, at the mobile station, the second configuration parameters.
4. A method for determining whether to wake up a mobile station in accordance with claim 1, further comprising the step of determining, at the mobile station, whether configuration parameter values at the mobile station are up-to-date by checking another message when the mobile station wakes up for its paging channel slot.
5. A method for determining whether to wake up a mobile station in accordance with claim 1, further comprising the step of staying awake, if a configuration sequence number does not match the mobile station's stored value, for a longer amount of time to receive new configuration parameter values.

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6. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein the mobile station receives the configuration parameter values again if a sequence number matches the stored value for the base station.

7. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein configuration parameters are updated by receiving a special broadcast channel (BCCH), over which configuration parameter messages are sent, for a period of time until all configuration parameters are up-to-date.

15

8. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein the mobile station receives and combines multiple configuration change quick bits.

20

9. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein, if the mobile station determines that the configuration has changed after receiving a configuration change quick bit, the mobile station wakes up for its regular paging slot and stays awake until the configuration parameter values are up-to-date.

25

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10. A method for determining whether to wake up a mobile station in accordance with claim 1, wherein, if a broadcast channel (BCCH) is used and the mobile station determines that the configuration has changed
5 after receiving the configuration change indicator bit, the mobile station wakes up and receives the BCCH until the configuration parameter values are up-to-date.

10

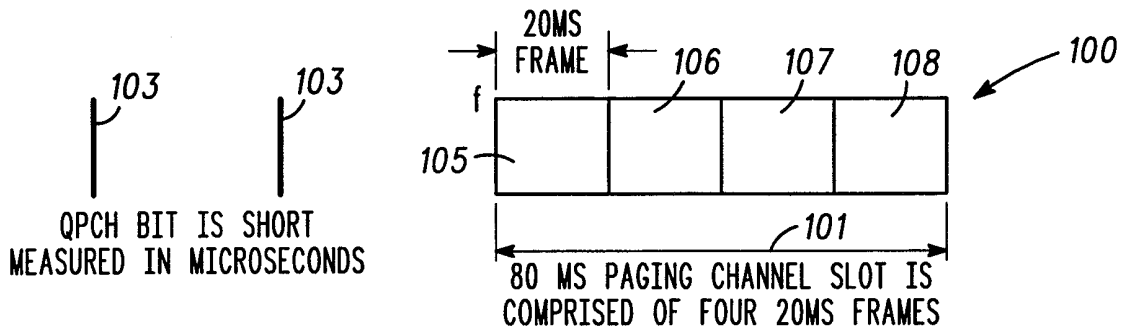
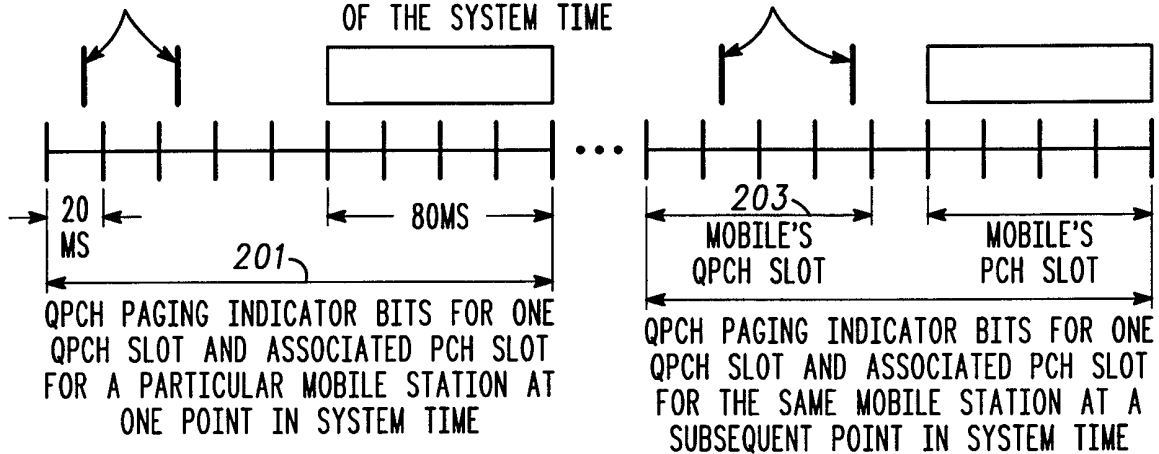


FIG. 1

THE POSITION OF A PARTICULAR MOBILE STATION'S QPCH PAGING INDICATOR BITS WITHIN A QPCH SLOT VARIES AS A FUNCTION OF THE SYSTEM TIME



-PRIOR ART-

FIG. 2

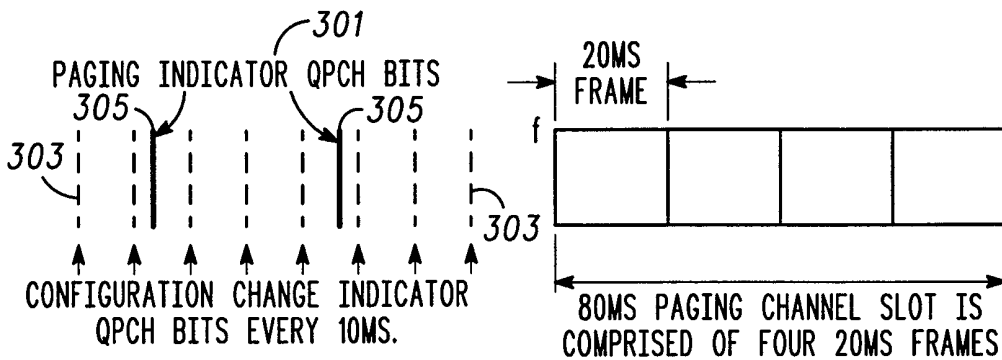
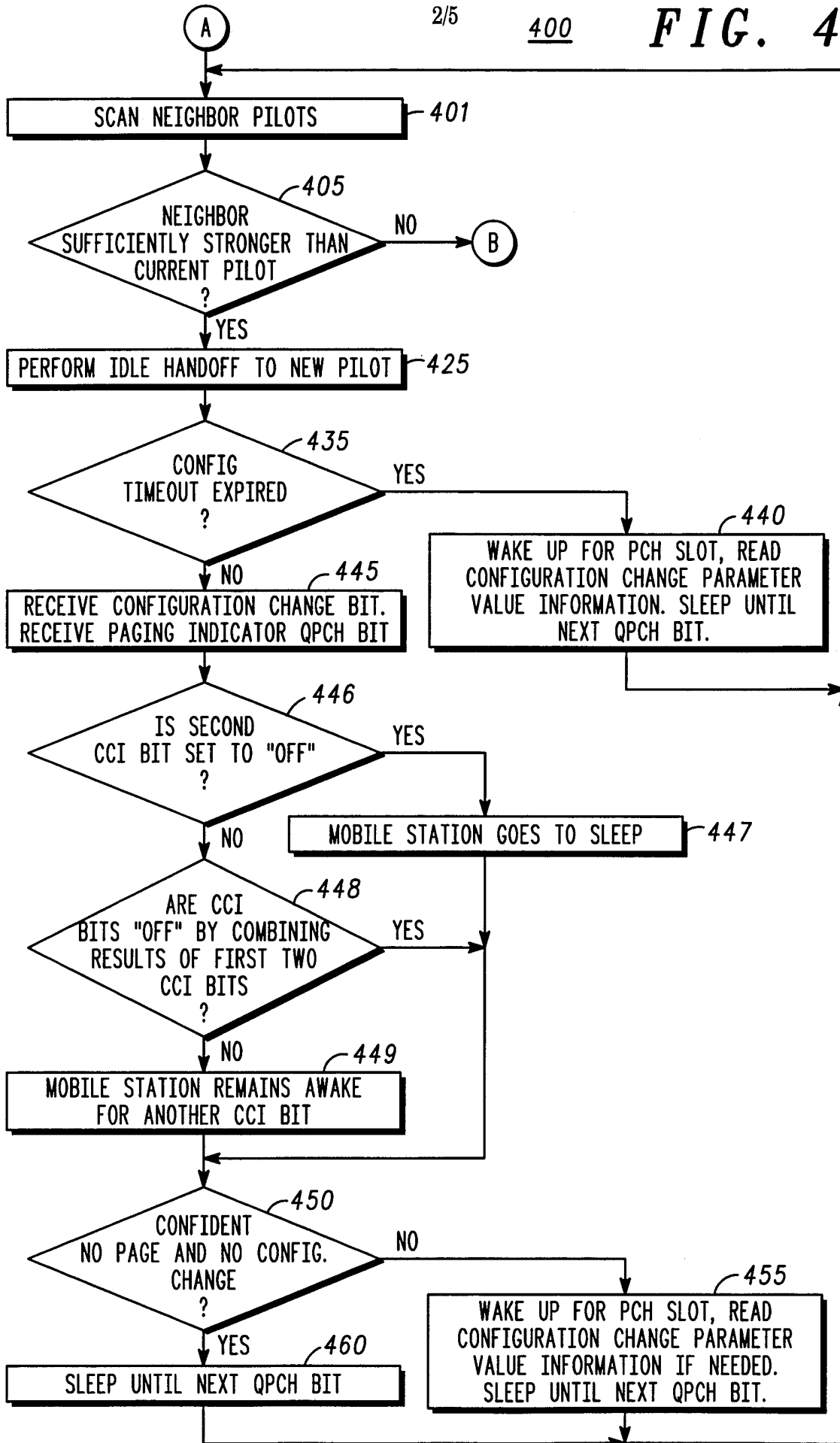
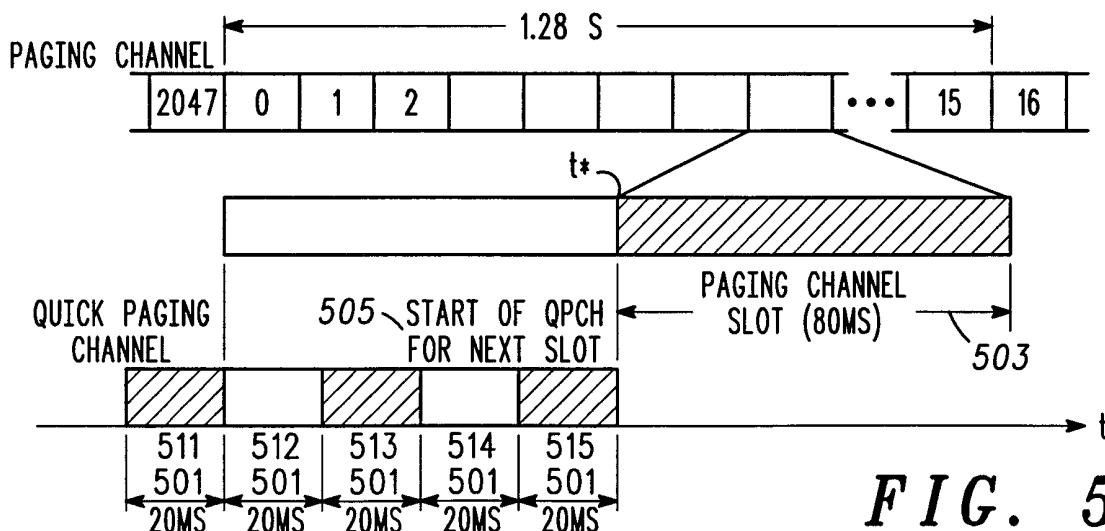
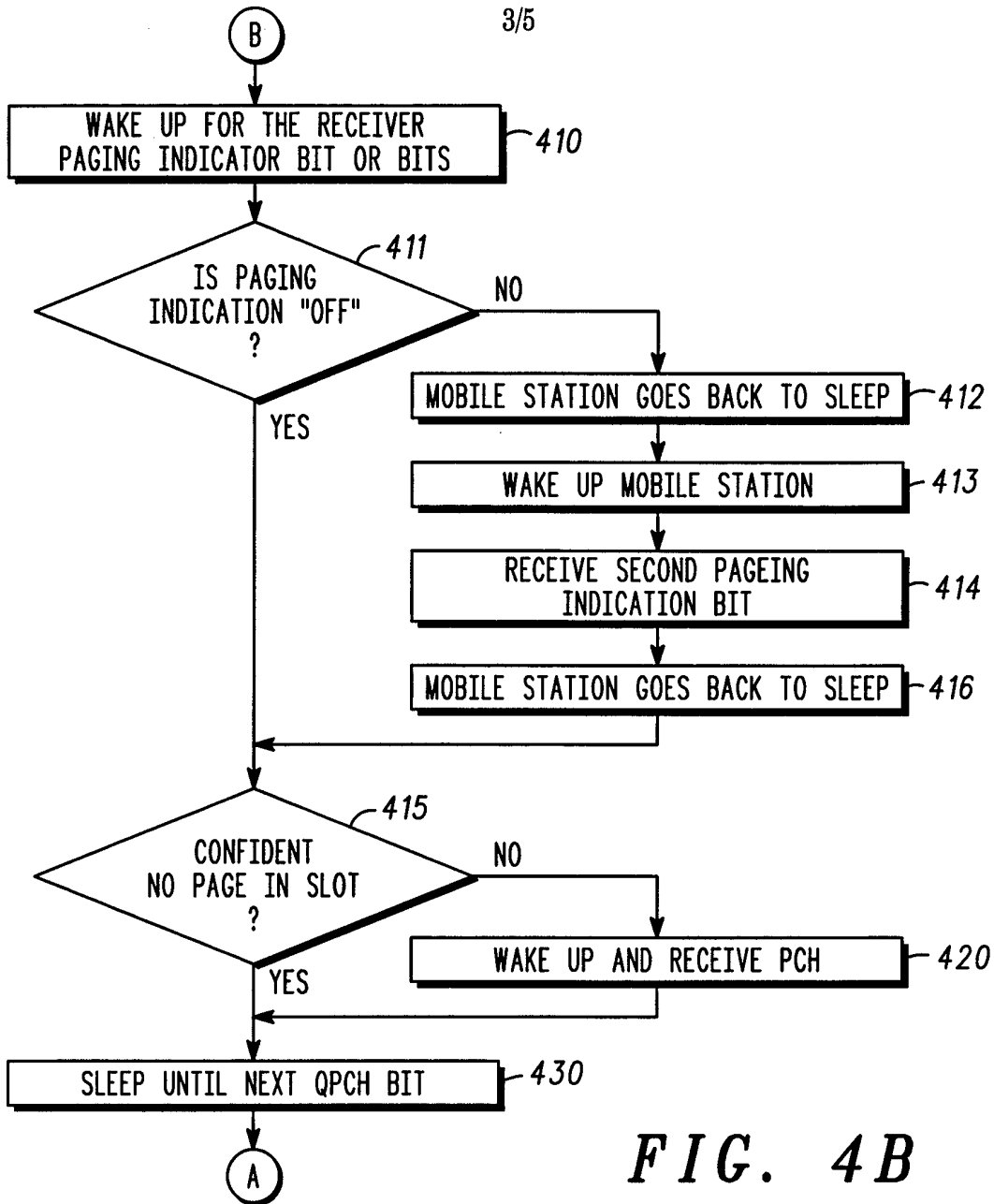


FIG. 3





APPLICATION	N	DECORR	RETURN VALUE
CDMA CHANNEL NUMBER	NUMBER OF CHANNELS IN LAST CDMA CHANNEL LIST MESSAGE (UP TO 10)	0	R+1
PAGING CHANNEL NUMBER	PAGE_CHAN _s FROM SYSTEM PARAMETERS MESSAGE (UP TO 7)	2xHASH_KEY[0...11]	R+1
QUICK PAGING CHANNEL NUMBER	NUM_QPCH _s FROM EXTENDED SYSTEM PARAMETERS MESSAGE (UP TO 7)	2xHASH_KEY[0...11]	R+1
PAGING SLOT NUMBER	2048	6xHASH_KEY[0...11]	R
ACCESS CHANNEL PN RANDOMIZATION	2*PROBE_PN_RAN _s WHERE PROBE_PN_RAN _s IS FROM ACCESS PARAMETERS MESSAGE (UP TO 512)	14xHASH_KEY[0...11]	R
PAGING INDICATOR POSITION	380 (FOR 9600 BPS), OR 188 (FOR 4800 BPS)	$ECORR_1 = \left[\frac{t}{64} \right] \text{ MOD } 2^{16}$ $DECORR_2 = \left[\frac{t}{64+1} \right] \text{ MOD } 2^{16}$ WHERE t IS THE SYSTEM TIME IN FRAMES	R ₁ AND R ₂

FIG. 6

QPCH_POWER_LEVEL FIELD (BINARY)	TRANSMIT POWER LEVEL
000	3dB BELOW THE PILOT CHANNEL TRANSMIT POWER
001	2dB BELOW THE PILOT CHANNEL TRANSMIT POWER
010	1dB BELOW THE PILOT CHANNEL TRANSMIT POWER
011	SAME AS THE PILOT CHANNEL TRANSMIT POWER
100	1dB ABOVE THE PILOT CHANNEL TRANSMIT POWER
101	2dB ABOVE THE PILOT CHANNEL TRANSMIT POWER
110-111	RESERVED

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/26681

A. CLASSIFICATION OF SUBJECT MATTER IPC(6) :H04B 1/16 US CL :455/343 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) U.S. : 455/343, 38.3, 422, 436, 574, 575, 13.4. Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched none Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) East search terms: base station configurations, wake up, battery saving		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,761,622 A (PRIEST) 02 JUNE 1998, SEE ABSTRACT.	1-10
A	US 5,745,860 A (KALLIN) 28 APRIL 1998, SEE FIGS. 1-7.	1-10
A	US 5,752,202 A (OBRIGHT) 12 MAY 1998, SEE FIGS. 1-6.	1-10
A	US 5,539,921 A (TAYLOE) 23 JULY 1996, SEE FIG. 5.	1-10
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:	"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	
"A" document defining the general state of the art which is not considered to be of particular relevance	"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	
"E" earlier document published on or after the international filing date	"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	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"G" document member of the same patent family	
"O" 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		
Date of the actual completion of the international search 11 FEBRUARY 2000	Date of mailing of the international search report 14 MAR 2000	
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer D. TO <i>[Signature]</i> Telephone No. (703) 305-4827	