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(54) Title: CONFIGURING TRANSMISSION POWER OF A TRANSMISSION BY A WIRELESS COMMUNICATION DEVICE

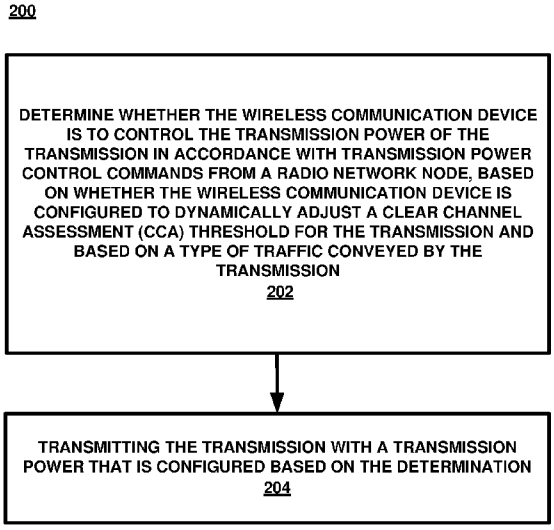

FIG. 2

(57) Abstract: Methods and devices for configuring a transmission power of a transmission by a wireless communication device (102) are provided. For instance, an example method (200) is described that includes determining (202) whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from a radio network node (106). In an aspect, the determination is based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104). The example method may also include transmitting (204) the transmission (104) with a transmission power (114) that is configured based on such a determination.

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CONFIGURING TRANSMISSION POWER OF A TRANSMISSION BY A WIRELESS COMMUNICATION DEVICE

RELATED APPLICATION

This application claims priority to U.S. Provisional Patent Application Serial Number 62/337,324 filed May 15, 2016, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

The application relates to methods and devices for configuring a transmission power of a transmission by a wireless communication device.

BACKGROUND

In current wireless communication standards for WiFi communication promulgated by Institute of Electrical and Electronics Engineers (IEEE), Carrier Sensing Multiple Access with Collision Avoidance (CSMA/CA) is utilized to ensure the available wireless resources of a Wireless Local Area Network (WLAN) are made available to mobile stations (STAs) utilizing the WLAN in an efficient and uniform manner. According to CSMA/CA, every STA that wishes to send data over the available resources first tunes to a common communication channel before transmitting on the channel to determine if any other devices are currently utilizing the channel for uplink transmission. During this channel sensing process, an STA concludes that the channel is being utilized by a different STA when it detects a transmission having received signal strength level greater than a Clear Channel Assessment (CCA) threshold (CCAT) level.

Presently, a common CCAT is defined for each Access Point (AP) in a WLAN, which is utilized by each STA when performing CSMA/CA on the common communication channel associated with an AP. In certain scenarios (*e.g.*, where a relatively small number of STAs are within the communication footprint of an AP), the common CCAT may be set at a level that is overly conservative (low) and therefore limits the performance of the system. Accordingly, dynamic sensitivity control (DSC) techniques have been proposed for improving system performance by dynamically adjusting the CCAT to a more aggressive value than is allowed in static CCAT implementations.

Complexities arise, however, when DSC techniques are employed on top of other techniques to control transmission power, such as the use of transmission power control (TPC) commands from the network.

SUMMARY

One or more embodiments herein recognize that, when higher CCAT values are implemented by STAs using an AP during DSC, transmissions by other STAs using neighboring

APs may be subjected to interference from the STAs using DSC. In such cases, the transmission power of these STAs may be limited by an AP via transmission power control (TPC) commands, which correspondingly reduces the probability that a DSC-implementing STA will introduce interference into neighboring transmissions. Though implementing TPC over DSC reduces the risk of introducing interference into neighboring transmissions, this benefit comes at the cost of decreased overall system performance, particularly when TPC commands mandate transmission power levels when such a reduction is unnecessary to avoid interfering with ongoing neighbor STA transmissions. Furthermore, when this unnecessary transmission power reduction is implemented along with DSC in STAs transmitting high-priority (*e.g.*, delay sensitive) transmissions, these important transmissions have an increased probability of being incorrectly received and decoded by APs.

One or more example embodiments herein include methods and wireless communication devices, as well as computer programs and carriers for configuring a transmission power of a transmission by the wireless communication device. In an aspect, the example embodiments include determining whether the wireless communication device is to control the transmission power of the transmission in accordance with transmission power control commands from a radio network node. Such a determination may be based on whether the wireless communication device is configured to dynamically adjust a CCA threshold for the transmission and based on a type of traffic conveyed by the transmission. Additionally, the example embodiments include transmitting the transmission with a transmission power that is configured based on the determination.

In addition, one or more example embodiments herein include methods and radio network nodes, as well as corresponding computer programs and carriers for configuring a transmission power of a transmission by a wireless communication device configured to dynamically adjust a CCA threshold for the transmission. The example embodiments may include receiving, from the wireless communication device, a request message that requests permission to transmit the transmission without applying transmission power control commands transmitted by the radio network node to the wireless communication device. Furthermore, the example embodiments include determining, in response to receiving the request message, whether the wireless communication device is permitted to transmit the transmission without applying transmission power control commands. Some embodiments further include transmitting a response message to the wireless communication device, the response message indicating whether the wireless communication device is permitted to transmit the transmission without applying the transmission power control commands.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates a wireless communication system for implementing transmission power control, the system including a wireless communication device and a radio network node in one or more example embodiments.

Figure 2 illustrates a flowchart of an exemplary method implemented by a wireless communication device.

Figure 3 illustrates a flowchart of an exemplary method implemented by a radio network node.

Figure 4 illustrates details of an example wireless communication device according to one or more embodiments.

Figure 5 illustrates details of an example radio network node according to one or more embodiments.

Figure 6 illustrates a flowchart of an example method executed by a wireless communication device in one or more embodiments.

Figure 7 illustrates a flowchart of an example method executed by a radio network node according to one or more embodiments.

Figure 8 illustrates a flowchart of an example method executed by a radio network node according to one or more embodiments.

DETAILED DESCRIPTION

A wireless communication device according to embodiments presented herein may determine whether to implement TPC commands received from a radio network node on an uplink transmission. In an aspect, the wireless communication device may determine not to control the transmission power for the transmission in accordance with the TPC commands based on a type of traffic conveyed by the transmission, for instance, where the wireless communication device implements DSC for channel access for the transmission. In some embodiments, the wireless communication device may transmit a request to the radio network node for permission to avoid implementing the TPC commands and may receive a corresponding response indicating whether the radio network node may perform the transmission without implementing the TPC commands.

Figure 1 illustrates a wireless communication system 100 for implementing TPC for one or more transmissions by a wireless communication device 102 to a radio network node. In some examples, the wireless communication system 100 may be a WLAN system implementing communication procedures defined by the IEEE 802.11 (WiFi) family of standards, though the techniques presented herein are not meant to be limited to implementation in wireless communication systems utilizing any particular wireless communication protocols. Accordingly, the wireless communication device 102 may be an STA and the radio network node 106 (may also be referred to simply as “radio network node”) may be an AP.

In some examples, the TPC techniques implemented in the wireless communication system 100 may be utilized where a transmission 104 from the wireless communication device 102 to the radio network node 106 has a particular traffic type, such as a high-priority traffic type. For purposes of the present disclosure, traffic having this high-priority traffic type may include, but is not limited to, delay-sensitive transmissions such as voice traffic, video traffic, or other traffic types characterized as having particular Quality of Service mandates. In an aspect, such high-priority traffic may be characterized as having a particular associated Enhanced Distributed Channel Access QoS access category (*e.g.*, AC_VO, AC_VI, AC_BE, AC_BK). Furthermore, these TPC techniques may be implemented for wireless communication devices 102 utilizing dynamic CCA thresholds during common communication channel access procedures (*e.g.*, STAs implementing DSC) when preparing to perform transmission(s) of high-priority traffic to a radio network node 106 (*e.g.*, AP). In addition, these TPC techniques may be utilized when TPC commands are issued by the radio network node 106 to wireless communication devices utilizing DSC for channel access to perform transmission(s) for the high-priority traffic.

Accordingly, in an aspect of the wireless communication system 110, a wireless communication device 102 may determine that a CCA threshold 110 for a particular radio network node 106 is to be dynamically adjusted (*i.e.*, that DSC is utilized for the radio network node 106). Likewise, the wireless communication system 110 may determine that a traffic type 112 for a particular transmission 104 is of a particular type (e.g., high-priority). Based on making these determinations (or a subset thereof, in some optional examples), the wireless communication device may determine whether to control the transmission power 114 of the transmission 104 in accordance with one or more TPC commands 108 from radio network node 106. In some embodiments, the wireless communication device 102 makes this determination responsive to (i.e., after) receiving the one or more TPC commands 108 according to which the wireless communication device 102 is commanded to control its transmission power 114 by the radio network node 106. In other embodiments, though, the wireless communication device 102 makes this determination in advance of (i.e., before) receiving such TPC command(s) 108, e.g., in anticipation of receiving them in the future.

In some examples, the wireless communication device 102 may determine whether to control the transmission power 114 itself, for example, based on one or more policy rules or other received or preconfigured settings.

Though not explicitly illustrated in Figure 1, wireless communication device 102 may alternatively transmit a request (explicitly or implicitly) for permission to perform transmission 104 without implementing the received TPC command(s) 108. Responsive to receiving the request, the radio network node 106 may generate a response message indicating whether the wireless communication node is permitted to transmit transmission 104 without implementing the TPC command(s) 108 and may transmit the response message to the wireless

communication device. In some examples, the wireless communication device 102 may determine whether to implement the TPC command(s) 108 for the transmission 104 based at least in part on whether permission to do so is included in the response message. In a further aspect, once the wireless communication device 102 makes the determination whether to implement the TPC command(s) 108 for the transmission 104, the wireless communication device 102 may transmit the transmission 104 with a transmission power 114 that is configured based on the determination.

Figure 2 illustrates an example method 200 for configuring a transmission power of a transmission implemented by a wireless communication device (*e.g.* of Figure 1). In some embodiments, method 200 may include, at block 202, determining whether the wireless communication device is to control the transmission power of the transmission in accordance with transmission power control commands from a radio network node. This determination at block 202 may be based on whether the wireless communication device is configured to dynamically adjust a CCA threshold for the transmission (*i.e.*, perform DSC). Additionally, the determination at block 202 may be based on a type of traffic conveyed by the transmission. For instance, in some examples, TPC may not be applied by the device for a transmission where the type of traffic conveyed by that transmission is deemed high-priority (e.g., higher than a threshold level of priority).

In addition, method 200 may include, at block 202, transmitting the transmission with a transmission power that is configured based on the determination of block 202. Though not explicitly described in reference to Figure 2, method 200 may include one or more aspects described below in reference to method 600 of Figure 6. As such, though described in reference to separate figures in the present disclosure, methods 200 and 600 may include one or more features of methods 600 and 200, respectively, in certain example embodiments.

Figure 3 illustrates a method 300 performed by a radio network node (*e.g.*, of FIG 1) for configuring a transmission power of a transmission of high-priority traffic by a wireless communication device configured to dynamically adjust a CCA threshold for the transmission. In some embodiments, method 300 may include, at block 302, receiving, from the wireless communication device, a request message that requests permission to transmit the transmission without applying transmission power control commands transmitted by the radio network node to the wireless communication device. In some examples, this request message may be explicit in that it is communicated in a transmission having a format that is unique to such explicit request messages. Such explicit request messages may be transmitted by the wireless communication device 102 at a power level mandated by TPC commands sent by the radio network node 106. In the implicit request message feature, instead of transmitting a request message of a particular format and at a power commanded by one or more TPC commands, the implicit request message may instead be a transmission (*e.g.* an initial

transmission or a first transmission after a particular waiting period has elapsed) of user data by the wireless communication device 102 and without applying the TPC commands.

In a further feature, method 300 may include, at block 304, determining, in response to receiving the request message, whether the wireless communication device is permitted to transmit the transmission without applying transmission power control commands. In some examples, the determination at block 304 may be based on one or more of a traffic load associated with the radio network node, a wireless communication device load associated with the radio network node, information contained in one or more measurement reports received from one or more wireless communication devices, information indicative of a type of traffic conveyed by the transmission, a frequency of link failure associated with the radio network node; and a rate of retransmissions associated with the radio network node or one or more wireless communication devices in communication with the radio network node.

In addition, method 300 may include, at block 306, transmitting a response message to the wireless communication device, the response message indicating whether the wireless communication device is permitted to transmit the transmission without applying the transmission power control commands. Furthermore, though not explicitly described in reference to Figure 3, method 300 may include one or more aspects described below in reference to method 700 of Figure 7. As such, though described in reference to separate figures in the present disclosure, methods 300 and 700 may include one or more features of methods 700 and 300, respectively, in certain example embodiments.

Figure 4 illustrates additional details of a wireless communication device 102 according to one or more embodiments. For purposes of the present disclosure, the wireless communication device 102 may be referred to simply as “the device.” The wireless communication device 102 is configured, e.g., via functional means or units, to implement the processing of method 200 in Figure 2 and/or the method 600 of Figure 6, below.

The device 102, in some embodiments, includes a determining unit 402 or means for determining whether the wireless communication device is to control the transmission power of the transmission in accordance with transmission power control commands from a radio network node, for instance, based on whether the wireless communication device is configured to dynamically adjust a CCA threshold for the transmission and based on a type of traffic conveyed by the transmission. The device 102 in this case further includes a transmitting unit 404 or means for transmitting the transmission with a transmission power that is configured based on the determination by determining unit 402 or means for determining.

In at least some embodiments, the device 102 may include one or more processing circuits 406 configured to implement the above processing, such as by implementing functional means or units. In one embodiment, for example, the processing circuit(s) 406 implement functional means or units as respective circuits. The circuits in this regard may comprise circuits dedicated to performing certain functional processing and/or one or more microprocessors in

conjunction with memory 408. Such functional processing may include any processing described in reference to method 200 or method 600 herein, or any other functionality of device 102 contained in the present disclosure. In embodiments that employ memory 408, which may comprise one or several types of memory such as read-only memory (ROM), random-access memory, cache memory, flash memory devices, optical storage devices, etc., the memory 408 stores program code that, when executed by the one or more for carrying out one or more microprocessors, carries out the techniques described herein.

In one or more embodiments, the device 102 also comprises one or more communication interfaces 410. The one or more communication interfaces 410 include various components (not shown) for sending and receiving data and control signals. More particularly, the communication interface(s) 410 include one or more transmitters that are each configured to use known signal processing techniques, typically according to one or more standards, and is configured to condition a signal for transmission (e.g., over the air via one or more antennas 412). Similarly, the communication interface(s) 410 include one or more receivers that are each configured to convert signals received (e.g., via the antenna(s) 412) into digital samples for processing by the one or more processing circuits. In an aspect, the communication interface(s) 410 and/or antenna(s) 412 may be implemented in, or may be otherwise associated with, transmitting unit 404.

Figure 5 illustrates additional details of the radio network node 106 according to one or more embodiments. The radio network node 106 is configured, e.g., via functional means or units, to implement the processing of method 300 in Figure 3. The radio network node 106, in some embodiments, includes a receiving unit 502 or means for receiving, from the wireless communication device, a request message that requests permission to transmit the transmission without applying transmission power control commands transmitted by the radio network node to the wireless communication device. The radio network node 106 in this case further includes a determining unit 503 or means for determining, in response to receiving the request message, whether the wireless communication device is permitted to transmit the transmission without applying transmission power control commands. In addition, radio network node 106 in this case further includes a transmitting unit 504 or means for transmitting a response message to the wireless communication device, the response message indicating whether the wireless communication device is permitted to transmit the transmission without applying the transmission power control commands.

In at least some embodiments, the radio network node 106 comprises one or more processing circuits 506 configured to implement the above processing, such as by implementing functional means or units. In one embodiment, for example, the processing circuit(s) 506 implement functional means or units as respective circuits. The circuits in this regard may comprise circuits dedicated to performing certain functional processing and/or one or more microprocessors in conjunction with memory 508. Such functional processing may include any

processing described in reference to method 300 or method 700 herein, or any other functionality of radio network node 106 contained in the present disclosure. In embodiments that employ memory 508, which may comprise one or several types of memory such as read-only memory (ROM), random-access memory, cache memory, flash memory devices, optical storage devices, etc., the memory 508 stores program code that, when executed by the one or more for carrying out one or more microprocessors, carries out the techniques described herein.

In one or more embodiments, the radio network node 106 also comprises one or more communication interfaces. The one or more communication interfaces include various components (not shown) for sending and receiving data and control signals. More particularly, the interface(s) include a transmitter that is configured to use known signal processing techniques, typically according to one or more standards, and is configured to condition a signal for transmission (e.g., over the air via one or more antennas). Similarly, the interface(s) include a receiver that is configured to convert signals received (e.g., via the antenna(s)) into digital samples for processing by the one or more processing circuits 506. In an aspect, the communication interface(s) 510 and/or antenna(s) 512 may be implemented in, or may be otherwise associated with, receiving unit 502 and/or transmitting unit 504.

Figure 6 illustrates an example method 600 for configuring a transmission power of a transmission implemented by a wireless communication device (*e.g.* of Figure 1). As described above, aspects of method 600 may be combined with aspects of method 200. In an aspect, method 600 includes, at block 602 determining that a traffic type of the transmission is high-priority and/or that a dynamic CCA threshold (or DSC) is utilized for opportunistic wireless communication device 102 access to a common communication channel (*e.g.*, a shared uplink channel). Upon making one or both of the determinations at block 602, method 600 may proceed to block 604, where the wireless communication device 102 may transmit a request to a radio network node 106 to request permission to perform transmission without implementing TPC commands from the radio network node 106. In some examples, the request may be a request message of a particular format and structure that is identifiable by the ratio network node 106 and may be transmitted at block 604 in accordance with TPC commands from the radio network node.

In other examples, the request may be the transmission, and may be transmitted without implementing TPC commands from the radio network node 106. In other words, rather than taking any specific form or structure, the request may simply be an uplink transmission of user data (or other data types) at a transmission power other than that specified by one or more TPC commands from the radio network node.

Next, at block 606, the wireless communication device 102 may receive a response message from the radio network node 106 indicating whether the wireless communication device 102 is permitted by the radio network node 106 to perform transmission without implementing the TPC commands. At block 608, the wireless communication device may

determine that the response message indicated that transmission is permitted without performing TPC and may therefore proceed to block 610 to transmit the transmission without applying the TPC commands. In an alternative aspect, at block 608 the wireless communication device may determine that it is not permitted to transmit the transmission without applying the TPC commands. In such a scenario, the method 600 may proceed to block 612, where the wireless communication device 102 may transmit the transmission(s) in accordance with the TPC commands. Furthermore, once the transmission is performed at either of blocks 610 or 612, the method 600 may proceed to block 602 where the wireless communication device 102 may wait until a further transmission is needed and again proceed with the method.

Furthermore, though not explicitly described in reference to Figure 6, method 600 may include one or more aspects described above in reference to method 200 of Figure 2. For instance, blocks 602, 604, 606, and 608 may be sub-steps of block 202 of method 200 and blocks 610 and 612 may be sub-steps of block 204 of Figure 2. As such, though described in reference to separate figures in the present disclosure, methods 600 and 200 may include one or more features of methods 200 and 600, respectively, in certain example embodiments.

Figure 7 illustrates a method 700 performed by a radio network node (*e.g.*, of FIG 1) for configuring a transmission power of a transmission of high-priority traffic by a wireless communication device configured to dynamically adjust a CCA threshold for the transmission. In some embodiments, method 700 may include, at block 702, receiving a request message from the wireless communication device 102 requesting permission to perform transmission without applying one or more TPC commands. The request may be a request message of a particular format and structure that is identifiable by the ratio network node 106 and having a received signal strength that is in an expected range for a request message transmitted in accordance with TPC commands from the radio network node. In other words, the radio network node 106 may identify the request message based on determining one or more of whether the request message conforms to a defined request frame structure, whether the received signal strength of the request message is similar to an expected received signal strength associated with the wireless communication device, and whether the request message comprises information indicative of the type of traffic conveyed by the transmission. For instance, the request message may be identified where the expected received signal strength corresponds to a received signal strength expected where the wireless communication device transmits in accordance with the transmission power control commands.

In other examples, the request may be the transmission, and may be transmitted by the wireless communication device 102 without implementing TPC commands from the radio network node 106. In other words, rather than taking any specific form or structure, the request may simply be an uplink transmission of user data (or other data types) at a transmission power other than that specified by one or more TPC commands from the radio network node. Though this form of request message may not have an identifiable structure because it can be a

transmission of user data (or other data types) it may be identified based on its received signal strength at the radio network node 106.

In other words, the radio network node 106 may identify the request message based on determining that the received signal strength of the request message is greater than an expected received signal strength associated with the wireless communication device. Alternatively, the radio network node 106 may identify the request message based on determining that the received signal strength of the request message is greater than the expected received signal strength by at least a threshold amount.

Moving to block 704, the radio network node 106 may proceed to block 704 where the radio network node 106 determines whether the wireless communication device is permitted to transmit the transmission without applying TPC commands. In some examples, the determination at block 704 may be based on one or more of a traffic load associated with the radio network node, a wireless communication device load associated with the radio network node, information contained in one or more measurement reports received from one or more wireless communication devices, information indicative of a type of traffic conveyed by the transmission, a frequency of link failure associated with the radio network node; and a rate of retransmissions associated with the radio network node or one or more wireless communication devices in communication with the radio network node.

Where transmission without applying the TPC commands is determined to be permitted, the method 700 may proceed to block 706, where the radio network node 106 may transmit an acknowledgement message to the wireless communication device 102, which indicates that such transmission is permitted. Alternatively, where such transmission without applying the TPC commands is determined to be not permitted at block 704, the method 700 may proceed to block 710 whereby the radio network node 106 transmits a rejection message to the wireless communication device 102 in response to the request. After either transmission at blocks 706 and/or 710, the method 700 may proceed back to block 702 and may proceed with the method 600 again when another transmission is needed (and optionally after a period of waiting for a transmission to be queued for transmission).

Furthermore, though not explicitly described in reference to Figure 7, method 700 may include one or more aspects described above in reference to method 300 of Figure 3. As such, though described in reference to separate figures in the present disclosure, methods 700 and 300 may include one or more features of methods 300 and 700, respectively, in certain example embodiments.

Figure 8 illustrates another example method 800 performed by a radio network node 106 (*e.g.*, of FIG 1) for configuring a transmission power of a transmission by a wireless communication device 102. In an aspect, method 800 may include, at block 802, determining whether the wireless communication device 102 is to control the transmission power of the transmission in accordance with transmission power control commands, such as those sent

from the radio network node. In addition, this determination by the radio network node 106 can be based on whether the wireless communication device 102 is configured to dynamically adjust a CCA threshold for the transmission 104 and/or can be based on a traffic type conveyed by the transmission 104. In some instances, the radio network node 106 may determine whether the wireless communication device 102 is configured to dynamically adjust a CCA threshold for the transmission 104 and/or can be based on a traffic type conveyed by the transmission 104 based on messaging sent from the wireless communication device 102, from another network node, from a core network node, and/or from memory. In addition, method 800 may include, at block 804, controlling the wireless communication device 102 to configure the transmission with a transmission power, and this controlling aspect may be based on the determination from block 802. And again, though not explicitly described in reference to Figure 8, method 700 may include one or more aspects described above, such as, but not limited to, those described in reference to method 300 of Figure 3 and/or method 700 of Figure 7.

Those skilled in the art will also appreciate that embodiments herein further include corresponding computer programs. A computer program comprises instructions which, when executed on at least one processor of the radio network node or the wireless communication device, cause node or device to carry out any of the respective processing described above. Embodiments further include a carrier containing such a computer program. This carrier may comprise one of an electronic signal, optical signal, radio signal, or computer readable storage medium. A computer program in this regard may comprise one or more code modules corresponding to the means or units described above.

In some embodiments, a radio network node (e.g. the radio network node 106 of Figure 1, for instance) can correspond to any type of radio network node or any radio network node, which communicates with a wireless communication device (*e.g.* a mobile station (STA) or user equipment (UE)) and/or with another radio network node. Examples of radio network nodes are a Wifi AP, or, in the context of implementations in cellular or wide area network systems, a base station, Node B, MeNB, SeNB, network controller, radio network controller (RNC), base station controller (BSC), relay, donor node controlling relay, base transceiver station (BTS), access point (AP), transmission points, transmission nodes, RRU, RRH, nodes in distributed antenna system (DAS), core radio network node (e.g. MSC, MME etc.), O&M, OSS, SON, positioning node (e.g. E-SMLC), MDT etc.

In some embodiments the wireless communication device 102 may be a mobile station STA configured to communicate according to WiFi communication standards defined in the IEEE 802.11 family of specifications. In alternative implementations, the wireless communication device may be a user equipment as understood and defined as a mobile communication terminal utilized in cellular or other wide area networks. Generally, the non-limiting term UE is used and it refers to any type of wireless device communicating with a radio network node and/or with another UE in a cellular or mobile communication system. In some

examples, the wireless communication devices referred to and/or described herein (e.g. the wireless communication device 102 of Figure 1) may be a UE. However it should be noted that the UE does not necessarily have a "user" in the sense of an individual person owning and/or operating the device.

Those skilled in the art will also appreciate that embodiments herein further include corresponding computer programs.

A computer program comprises instructions which, when executed on at least one processor of a node, cause the node to carry out any of the respective processing described above. A computer program in this regard may comprise one or more code modules corresponding to the means or units described above.

Embodiments further include a carrier containing such a computer program. This carrier may comprise one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

In this regard, embodiments herein also include a computer program product stored on a non-transitory computer readable (storage or recording) medium and comprising instructions that, when executed by a processor of a node, cause the node to perform as described above.

Embodiments further include a computer program product comprising program code portions for performing the steps of any of the embodiments herein when the computer program product is executed by a computing device. This computer program product may be stored on a computer readable recording medium.

The present invention may, of course, be carried out in other ways than those specifically set forth herein without departing from essential characteristics of the invention. The present embodiments are to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

CLAIMS

What is claimed is:

1. A method (200) for configuring a transmission power (114) of a transmission (104) by a wireless communication device (102), comprising:

determining (202) whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from a radio network node (106), based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104); and

transmitting (204) the transmission (104) with a transmission power (114) that is configured based on the determination.

2. The method of claim 1, wherein determining (202) whether the wireless communication device (102) is to control the transmission power (114) in accordance with the transmission power control commands (108) comprises determining that the wireless communication device (102) is not to control the transmission power (114) in accordance with the transmission power control commands (108), responsive to determining that the wireless communication device (102) is configured to dynamically adjust the CCA threshold for the transmission (104) and that the traffic type (112) conveyed by the transmission (104) is high-priority; and

wherein transmitting (204) the transmission (104) to the radio network node (106) comprises transmitting (610) the transmission (104) to the radio node without applying the transmission power control commands (108) to the transmission (104) based on the determination that the wireless communication device (102) is not to control the transmission power (114) of the transmission (104).

3. The method of any of claims 1 or 2, further comprising:

receiving (606) an acknowledgement message from the radio network node (106) responsive to the transmission (104); and

transmitting (610) one or more subsequent transmissions without applying the transmission power control commands (108) to the one or more subsequent transmissions based on receiving the acknowledgement message.

4. The method of any of claims 1 or 2, further comprising:

receiving (606) a rejection message from the radio network node (106) responsive to the transmission (104); and

transmitting (612) one or more subsequent transmissions in accordance with the transmission power control commands (108). based on receiving the rejection message.

5. The method of claim 1, wherein determining whether the wireless communication device (102) is to control the transmission power (114) in accordance with the transmission power control commands (108) comprises:

based on whether the wireless communication device (102) is configured to dynamically adjust the CCA threshold for the transmission (104) and based on the traffic type (112) conveyed by the transmission (104), generating a request message requesting permission to control the transmission power (114) of the transmission (104) without regard to transmission power control commands (108) from the radio network node (106); and

transmitting the request message to the radio network node (106).

6. The method of claim 5, further comprising:

receiving (606) an acknowledgement message from the radio network node (106) responsive to the request message; and

transmitting (610) the transmission (104) without applying the transmission power control commands (108) based on receiving the acknowledgement message.

7. The method of claim 5, further comprising:

receiving (606) a rejection message from the radio network node (106) responsive to the request message; and

transmitting (612) the transmission (104) in accordance with the transmission power control commands (108) based on receiving the rejection message.

8. The method of any of claims 5-7, wherein the request message comprises information indicative of the traffic type (112) conveyed by the transmission (104).

9. The method of claim 1, wherein determining whether the wireless communication device (102) is to control the transmission power (114) in accordance with the transmission power control commands (108) is based on one or more transmission power (114) policy rules stored in memory of the wireless communication device (102).

10. The method of claim 9, wherein the one or more transmission power (114) policy rules are received from the radio network node (106) or preconfigured by a user, a device manufacturer, or network operator.

11. A method (300) performed by a radio network node (106) for configuring a transmission power (114) of a transmission (104) by a wireless communication device (102) configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104), comprising:

receiving (302), from the wireless communication device (102), a request message that requests permission to transmit the transmission (104) without applying transmission power control commands (108) transmitted by the radio network node (106) to the wireless communication device (102);

determining (304), in response to receiving the request message, whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying transmission power control commands (108); and

transmitting (306) a response message to the wireless communication device (102), the response message indicating whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying the transmission power control commands (108).

12. The method of claim 11, further comprising identifying the request message based on determining that the received signal strength of the request message is greater than an expected received signal strength associated with the wireless communication device (102).

13. The method of either of claims 11 or 12, further comprising identifying the request message based on determining that the received signal strength of the request message is greater than the expected received signal strength by at least a threshold amount.

14. The method of either of claims 11 or 12, further comprising identifying the request message based on determining one or more of whether the request message conforms to a defined request frame structure, whether the received signal strength of the request message is similar to an expected received signal strength associated with the wireless communication device (102), and whether the request message comprises information indicative of the traffic type (112) conveyed by the transmission (104).

15. The method of claim 14, wherein the expected received signal strength corresponds to a received signal strength expected where the wireless communication device (102) transmits in accordance with the transmission power control commands (108).

16. The method of any of claims 11-15, wherein determining whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying

transmission power control commands (108) is based on one or more of a traffic load associated with the radio network node (106), a wireless communication device (102) load associated with the radio network node (106), information contained in one or more measurement reports received from one or more wireless communication devices (102), information indicative of a traffic type (112) conveyed by the transmission (104), a frequency of link failure associated with the radio network node (106); and a rate of retransmissions associated with the radio network node (106) or one or more wireless communication devices (102) in communication with the radio network node (106).

17. The method of any of claims 11-16, wherein the request message is the transmission (104).

18. The method of any of claims 11-17, wherein the transmission (104) comprises traffic having a high-priority traffic type.

19. The method of any of claims 8, 14, or 16, wherein the information indicative of the traffic type (112) conveyed by the transmission (104) comprises Quality of Service (QoS) information associated with the transmission (104).

20. The method of claim 19, wherein the QoS information comprises at least one Enhanced Distributed Channel Access QoS access category.

21. The method of any of claims 1-20, wherein the wireless communication device (102) is a mobile station and the radio network node (106) is an access point operating in a Wireless Local Area Network.

22. A method (800) performed by a radio network node (106) for configuring a transmission power (114) of a transmission (104) by a wireless communication device (102), comprising:

determining (802) whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from the radio network node (106), based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104); and

controlling (804) the wireless communication device (102) to configure the transmission (104) with a transmission power (114) based on the determination.

23. A wireless communication device (102) for configuring a transmission power (114) of a transmission (104) by the wireless communication device (102), comprising:

a processor (406) and a memory (408), the memory (408) containing instructions executable by the processor (406) whereby the wireless communication device (102) is configured to:

determine whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from a radio network node (106), based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104); and

transmit the transmission (104) with a transmission power (114) that is configured based on the determination.

24. The wireless communication device (102) of claim 23, wherein the wireless communication device (102) is configured to perform the method of any of claims 1-10 and 19.

25. A radio network node (106) for configuring a transmission power (114) of a transmission (104) of high-priority traffic by a wireless communication device (102) configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104), comprising:

a processor (506) and a memory (508), the memory (508) containing instructions executable by the processor (506) whereby the radio network node (106) is configured to:

receive, from the wireless communication device (102), a request message that requests permission to transmit the transmission (104) without applying transmission power control commands (108) transmitted by the radio network node (106) to the wireless communication device (102);

determine, in response to receiving the request message, whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying transmission power control commands (108); and

transmit a response message to the wireless communication device (102), the response message indicating whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying the transmission power control commands (108).

26. The radio network node (106) of claim 23, wherein the radio network node (106) is configured to perform the method of any of claims 11-21.

27. A wireless communication device (102) for configuring a transmission power (114) of a transmission (104) by the wireless communication device (102), comprising:

a first module (402) configured to determine whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from a radio network node (106), based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104); and

a second module (404) configured to transmit the transmission (104) with a transmission power (114) that is configured based on the determination.

28. The wireless communication device (102) of claim 27, wherein the wireless communication device (102) comprises modules to perform the method of any of claims 1-10 and 19.

29. A radio network node (106) for configuring a transmission power (114) of a transmission (104) of high-priority traffic by a wireless communication device (102) configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104), comprising:

a first module (502) configured to receive, from the wireless communication device (102), a request message that requests permission to transmit the transmission (104) without applying transmission power control commands (108) transmitted by the radio network node (106) to the wireless communication device (102);

a second module (504) configured to determine, in response to receiving the request message, whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying transmission power control commands (108); and

a third module (506) configured to transmit a response message to the wireless communication device (102), the response message indicating whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying the transmission power control commands (108).

30. The radio network node (106) of claim 29, wherein the radio network node (106) is configured to perform the method of any of claims 11-21.

31. A wireless communication device (102) for configuring a transmission power (114) of a transmission (104) by the wireless communication device (102), the wireless communication device (102) configured to:

determine whether the wireless communication device (102) is to control the transmission power (114) of the transmission (104) in accordance with transmission power control commands (108) from a radio network node (106), based on whether the wireless communication device (102) is configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104) and based on a traffic type (112) conveyed by the transmission (104); and

transmit the transmission (104) with a transmission power (114) that is configured based on the determination.

32. The wireless communication device (102) of claim 31, wherein the wireless communication device (102) is configured to perform the method of any of claims 1-10 and 19.

33. A radio network node (106) for configuring a transmission power (114) of a transmission (104) of high-priority traffic by a wireless communication device (102) configured to dynamically adjust a clear channel assessment (CCA) threshold for the transmission (104), the radio network node (106) configured to:

receive, from the wireless communication device (102), a request message that requests permission to transmit the transmission (104) without applying transmission power control commands (108) transmitted by the radio network node (106) to the wireless communication device (102);

determine, in response to receiving the request message, whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying transmission power control commands (108); and

transmit a response message to the wireless communication device (102), the response message indicating whether the wireless communication device (102) is permitted to transmit the transmission (104) without applying the transmission power control commands (108).

34. The radio network node (106) of claim 33, wherein the radio network node (106) is configured to perform the method of any of claims 11-21.

35. A computer program comprising instructions which, when executed by at least one processor of a wireless communication device (102), causes the wireless communication device (102) to carry out the method of any of claims 1-10 and 19.

36. A carrier containing the computer program of claim 35, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

37. A computer program comprising instructions which, when executed by at least one processor of a radio network node (106), causes the radio network node (106) to carry out the method of any of claims 11-21.

38. A carrier containing the computer program of claim 37, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

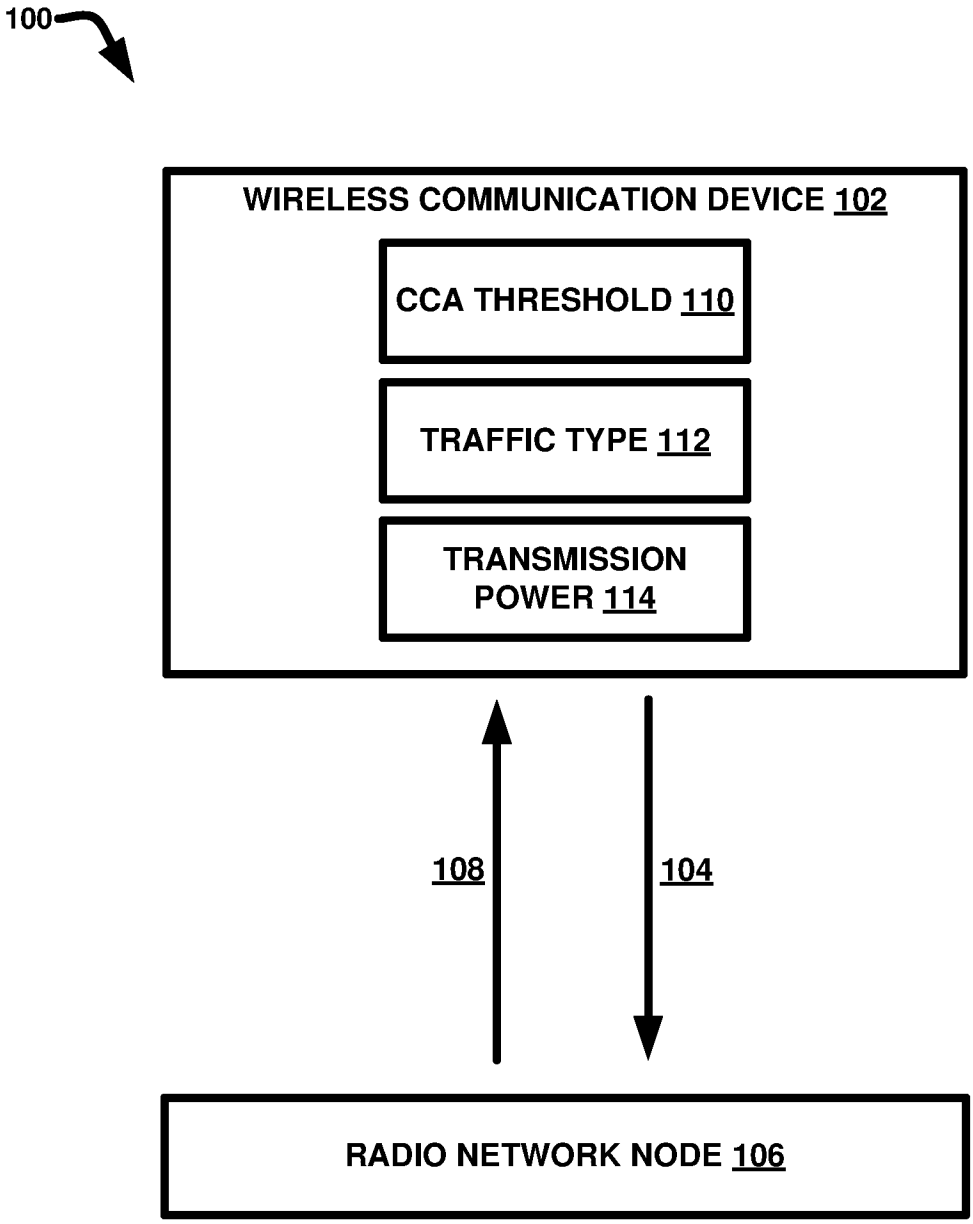
100
WIRELESS COMMUNICATION DEVICE 102
CCA THRESHOLD 110
TRAFFIC TYPE 112
TRANSMISSION POWER 114
108
104
RADIO NETWORK NODE 106

FIG. 1

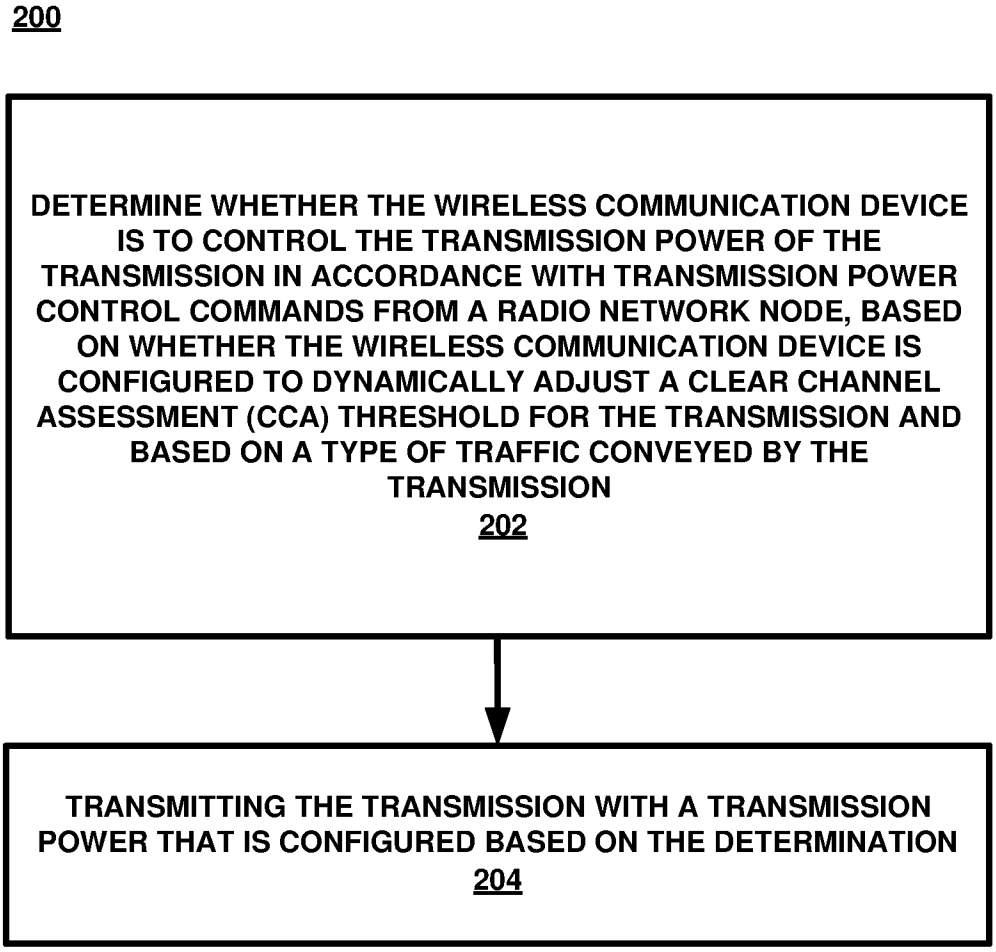
200
DETERMINE WHETHER THE WIRELESS COMMUNICATION DEVICE IS TO CONTROL THE TRANSMISSION POWER OF THE TRANSMISSION IN ACCORDANCE WITH TRANSMISSION POWER CONTROL COMMANDS FROM A RADIO NETWORK NODE, BASED ON WHETHER THE WIRELESS COMMUNICATION DEVICE IS CONFIGURED TO DYNAMICALLY ADJUST A CLEAR CHANNEL ASSESSMENT (CCA) THRESHOLD FOR THE TRANSMISSION AND BASED ON A TYPE OF TRAFFIC CONVEYED BY THE TRANSMISSION
202
TRANSMITTING THE TRANSMISSION WITH A TRANSMISSION POWER THAT IS CONFIGURED BASED ON THE DETERMINATION
204

FIG. 2

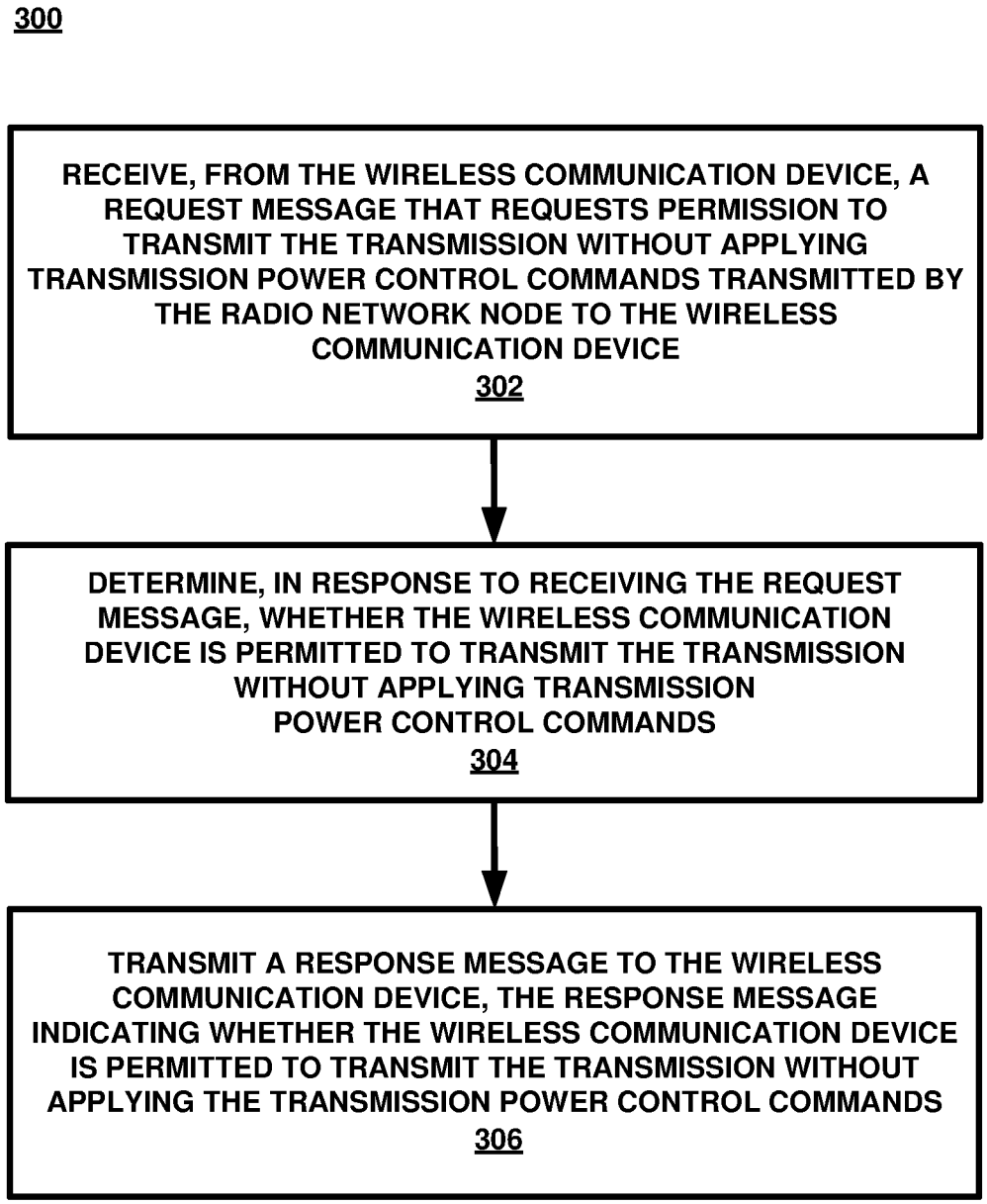
300
RECEIVE, FROM THE WIRELESS COMMUNICATION DEVICE, A REQUEST MESSAGE THAT REQUESTS PERMISSION TO TRANSMIT THE TRANSMISSION WITHOUT APPLYING TRANSMISSION POWER CONTROL COMMANDS TRANSMITTED BY THE RADIO NETWORK NODE TO THE WIRELESS COMMUNICATION DEVICE
302
DETERMINE, IN RESPONSE TO RECEIVING THE REQUEST MESSAGE, WHETHER THE WIRELESS COMMUNICATION DEVICE IS PERMITTED TO TRANSMIT THE TRANSMISSION WITHOUT APPLYING TRANSMISSION POWER CONTROL COMMANDS
304
TRANSMIT A RESPONSE MESSAGE TO THE WIRELESS COMMUNICATION DEVICE, THE RESPONSE MESSAGE INDICATING WHETHER THE WIRELESS COMMUNICATION DEVICE IS PERMITTED TO TRANSMIT THE TRANSMISSION WITHOUT APPLYING THE TRANSMISSION POWER CONTROL COMMANDS
306

FIG. 3

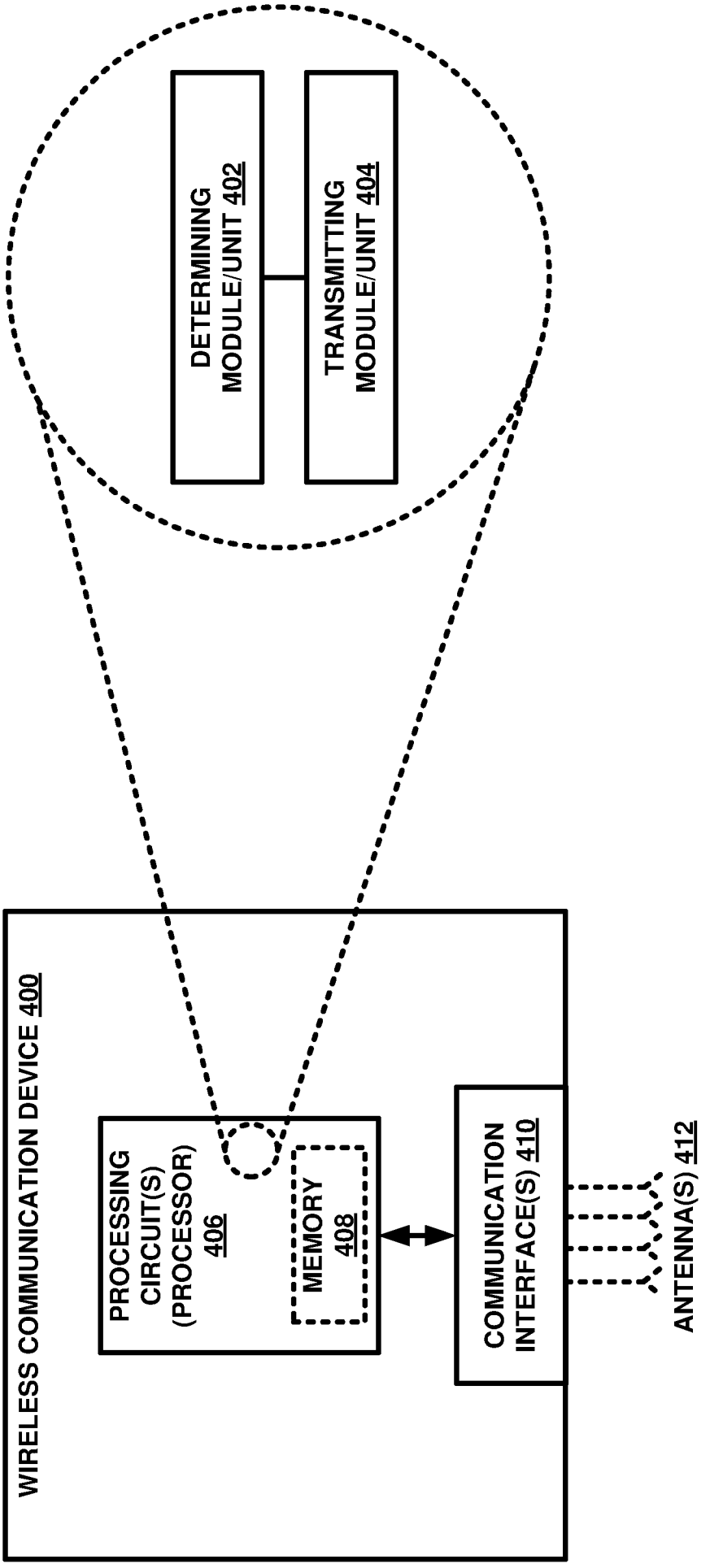
DETERMINING MODULE/UNIT 402
TRANSMITTING MODULE/UNIT 404
WIRELESS COMMUNICATION DEVICE 400
PROCESSING CIRCUIT(S) (PROCESSOR) 406
MEMORY 408
COMMUNICATION INTERFACE(S) 410
ANTENNA(S) 412

FIG. 4

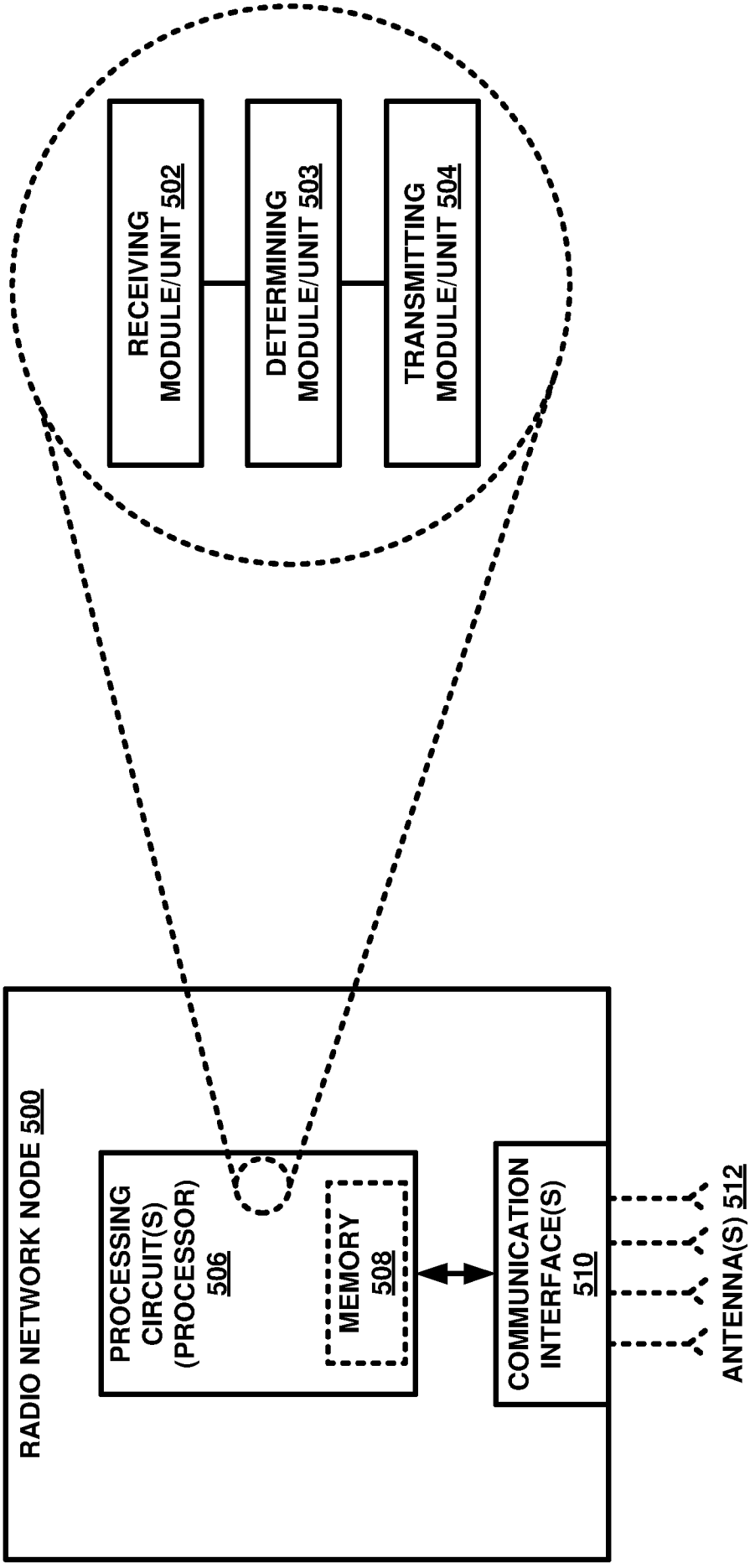
RECEIVING MODULE/UNIT 502
DETERMINING MODULE/UNIT 503
TRANSMITTING MODULE/UNIT 504
RADIO NETWORK NODE 500
PROCESSING CIRCUIT(S) (PROCESSOR) 506
MEMORY 508
COMMUNICATION INTERFACE(S) 510
ANTENNA(S) 512

FIG. 5

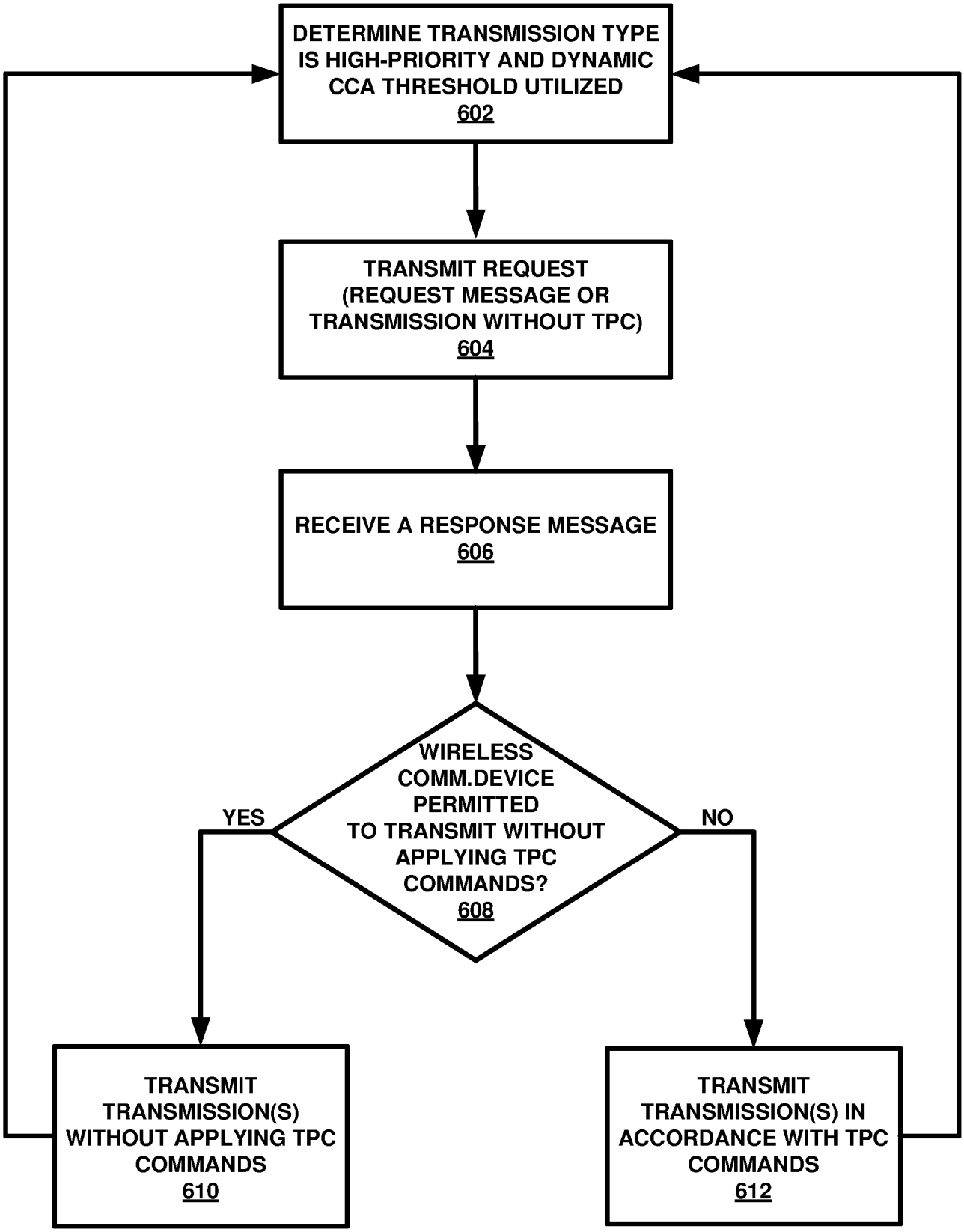
DETERMINE TRANSMISSION TYPE IS HIGH-PRIORITY AND DYNAMIC CCA THRESHOLD UTILIZED
602
TRANSMIT REQUEST (REQUEST MESSAGE OR TRANSMISSION WITHOUT TPC)
604
RECEIVE A RESPONSE MESSAGE
606
WIRELESS COMM.DEVICE PERMITTED TO TRANSMIT WITHOUT APPLYING TPC COMMANDS?
608
YES
NO
TRANSMIT TRANSMISSION(S) WITHOUT APPLYING TPC COMMANDS
610
TRANSMIT TRANSMISSION(S) IN ACCORDANCE WITH TPC COMMANDS
612

FIG. 6

700

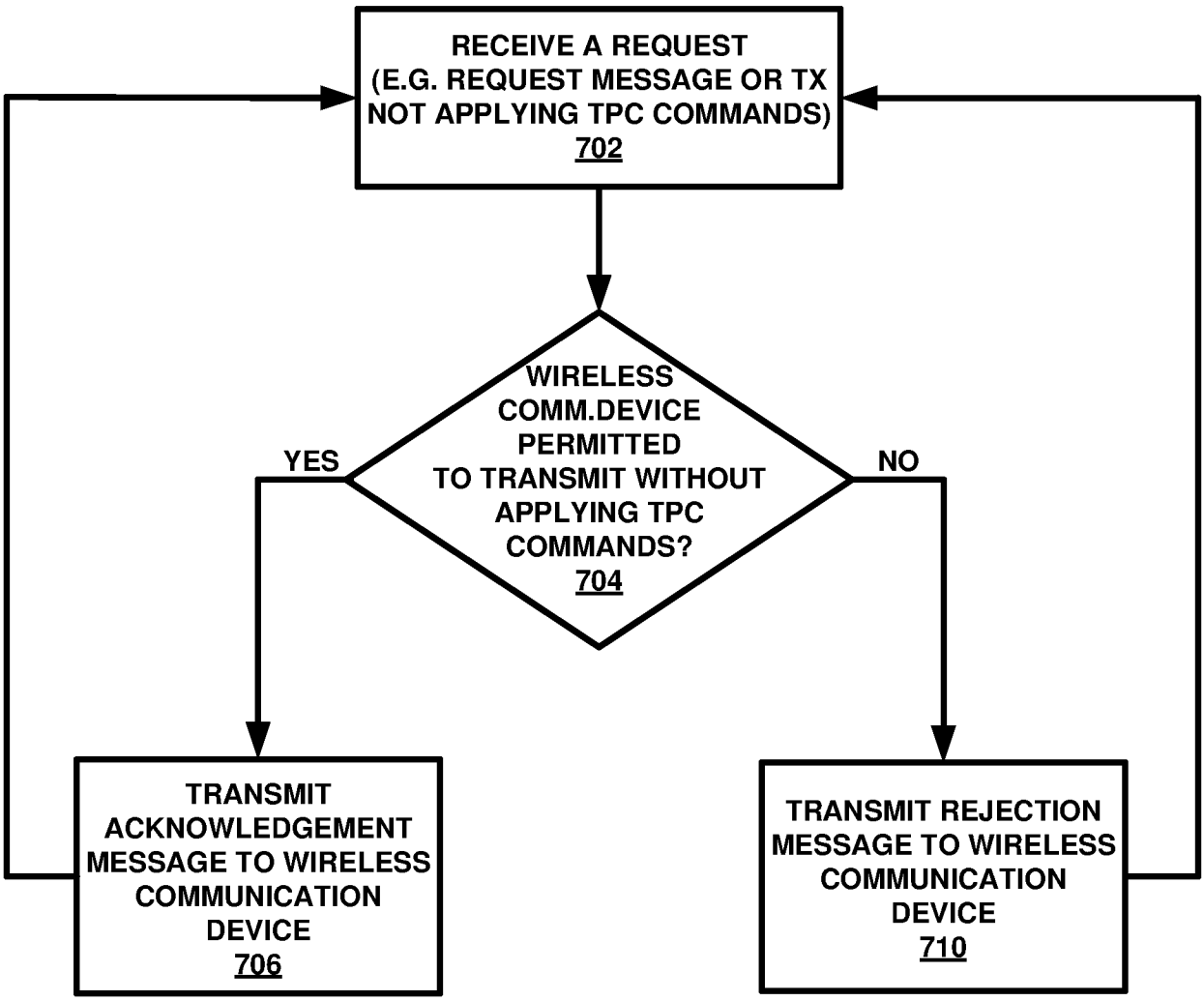
RECEIVE A REQUEST
(E.G. REQUEST MESSAGE OR TX
NOT APPLYING TPC COMMANDS)
702
WIRELESS
COMM.DEVICE
PERMITTED
TO TRANSMIT WITHOUT
APPLYING TPC
COMMANDS?
704
YES
NO
TRANSMIT
ACKNOWLEDGEMENT
MESSAGE TO WIRELESS
COMMUNICATION
DEVICE
706
TRANSMIT REJECTION
MESSAGE TO WIRELESS
COMMUNICATION
DEVICE
710

FIG. 7

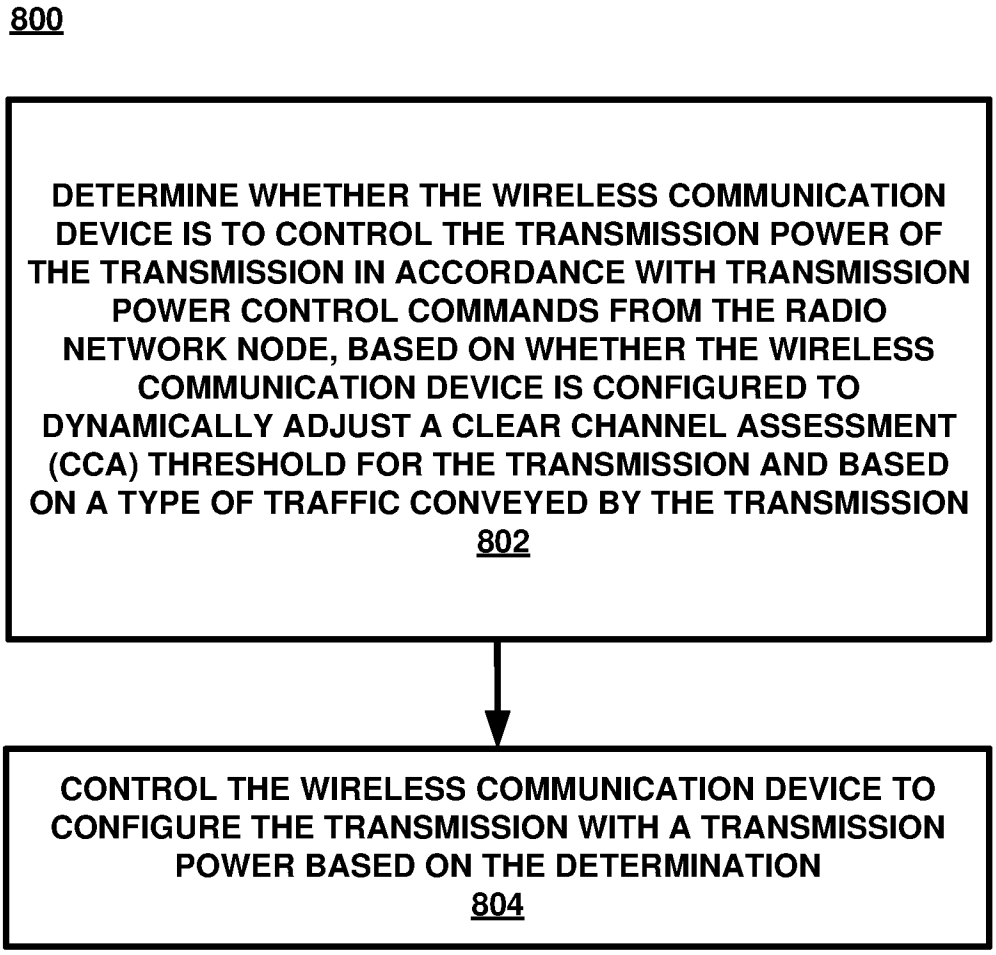
800
DETERMINE WHETHER THE WIRELESS COMMUNICATION DEVICE IS TO CONTROL THE TRANSMISSION POWER OF THE TRANSMISSION IN ACCORDANCE WITH TRANSMISSION POWER CONTROL COMMANDS FROM THE RADIO NETWORK NODE, BASED ON WHETHER THE WIRELESS COMMUNICATION DEVICE IS CONFIGURED TO DYNAMICALLY ADJUST A CLEAR CHANNEL ASSESSMENT (CCA) THRESHOLD FOR THE TRANSMISSION AND BASED ON A TYPE OF TRAFFIC CONVEYED BY THE TRANSMISSION
802
CONTROL THE WIRELESS COMMUNICATION DEVICE TO CONFIGURE THE TRANSMISSION WITH A TRANSMISSION POWER BASED ON THE DETERMINATION
804

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/050485

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: H04W

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20150373652 A1 (DABEER ONKAR JAYANT ET AL), 24 December 2015 (2015-12-24); abstract; paragraphs [0009], [0093], [0094]; claims 1-3 --	1-38
A	CCA threshold and transmission power for LAA, R1-154139, 3GPP TSG-RAN WG1 #82, [online], [retrieved on 2017-08-07]. Retrieved from 3GPP database <URL: http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_82/Docs/R1-154139.zip>; page 2 --	1-38
A	US 20160088571 A1 (CHOI YONGHAE ET AL), 24 March 2016 (2016-03-24); abstract; paragraphs [0025], [0071] --	1-38

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which 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)

"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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09-08-2017	10-08-2017

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Sanja Sain Telephone No. + 46 8 782 28 00

International application No.
PCT/SE2017/050485

Continuation of: second sheet

International Patent Classification (IPC)

H04W 52/28 (2009.01)
H04W 52/22 (2009.01)
H04W 74/08 (2009.01)

US	20150373652	A1	24/12/2015	CN	106465288	A	22/02/2017
				EP	3162131	A1	03/05/2017
				KR	20170020359	A	22/02/2017
				WO	2015200133	A1	30/12/2015
US	20160088571	A1	24/03/2016	WO	2016048072	A1	31/03/2016