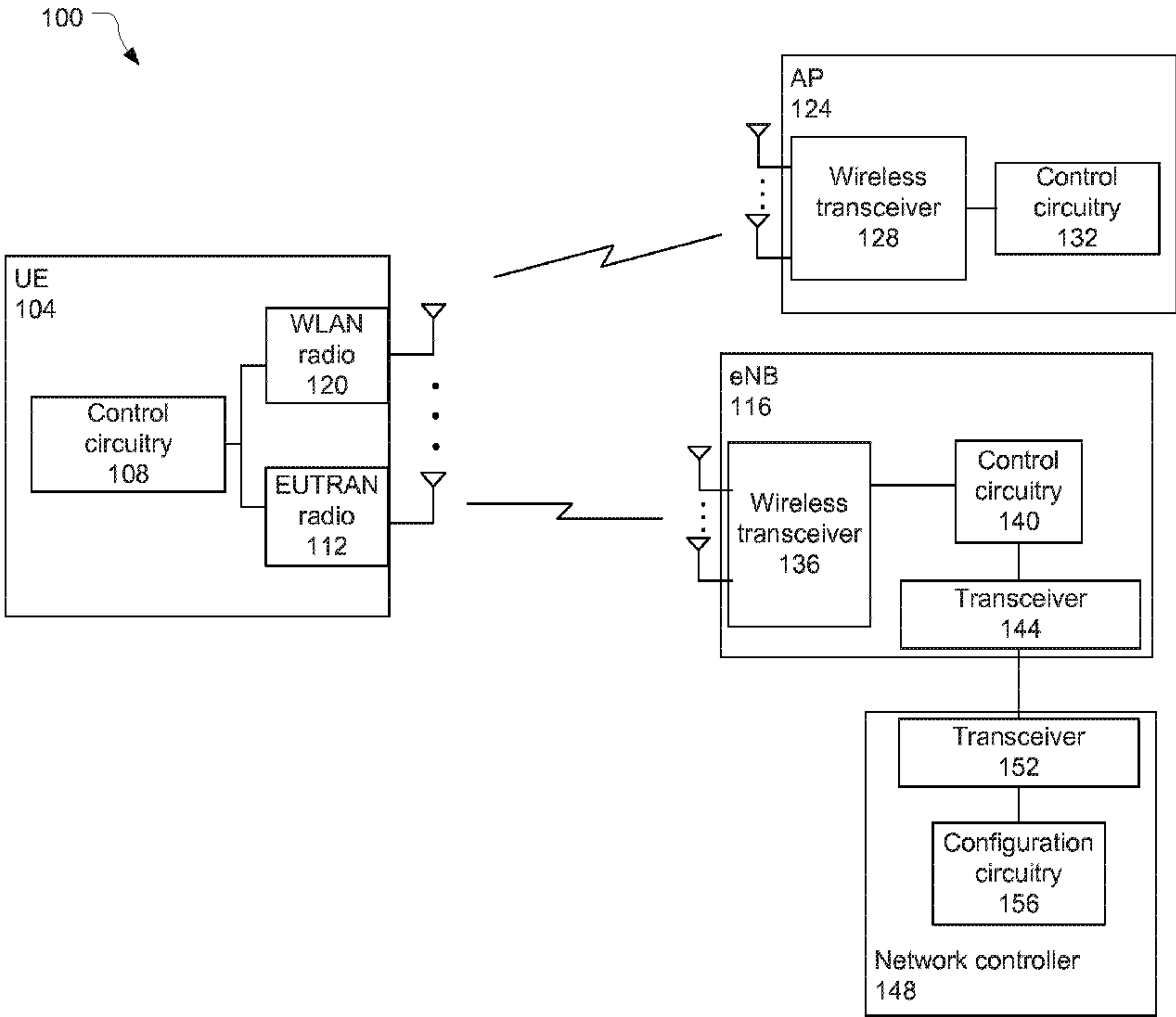




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(54) Titre : SYSTEMES, DISPOSITIFS ET PROCEDES POUR INTERFUNCTIONNEMENT ENTRE LTE ET WLAN
(54) Title: SYSTEMS, DEVICES, AND METHODS FOR LONG TERM EVOLUTION AND WIRELESS LOCAL AREA
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(57) **Abrégé/Abstract:**
Embodiments of the present disclosure describe systems, devices, and methods for long-term evolution and wireless local area interworking. Various embodiments may include utilizing access network selection and traffic steering rules based on radio access network assistance parameters. Other embodiments may be described or claimed.

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(54) **Title:** SYSTEMS, DEVICES, AND METHODS FOR LONG TERM EVOLUTION AND WIRELESS LOCAL AREA INTERWORKING

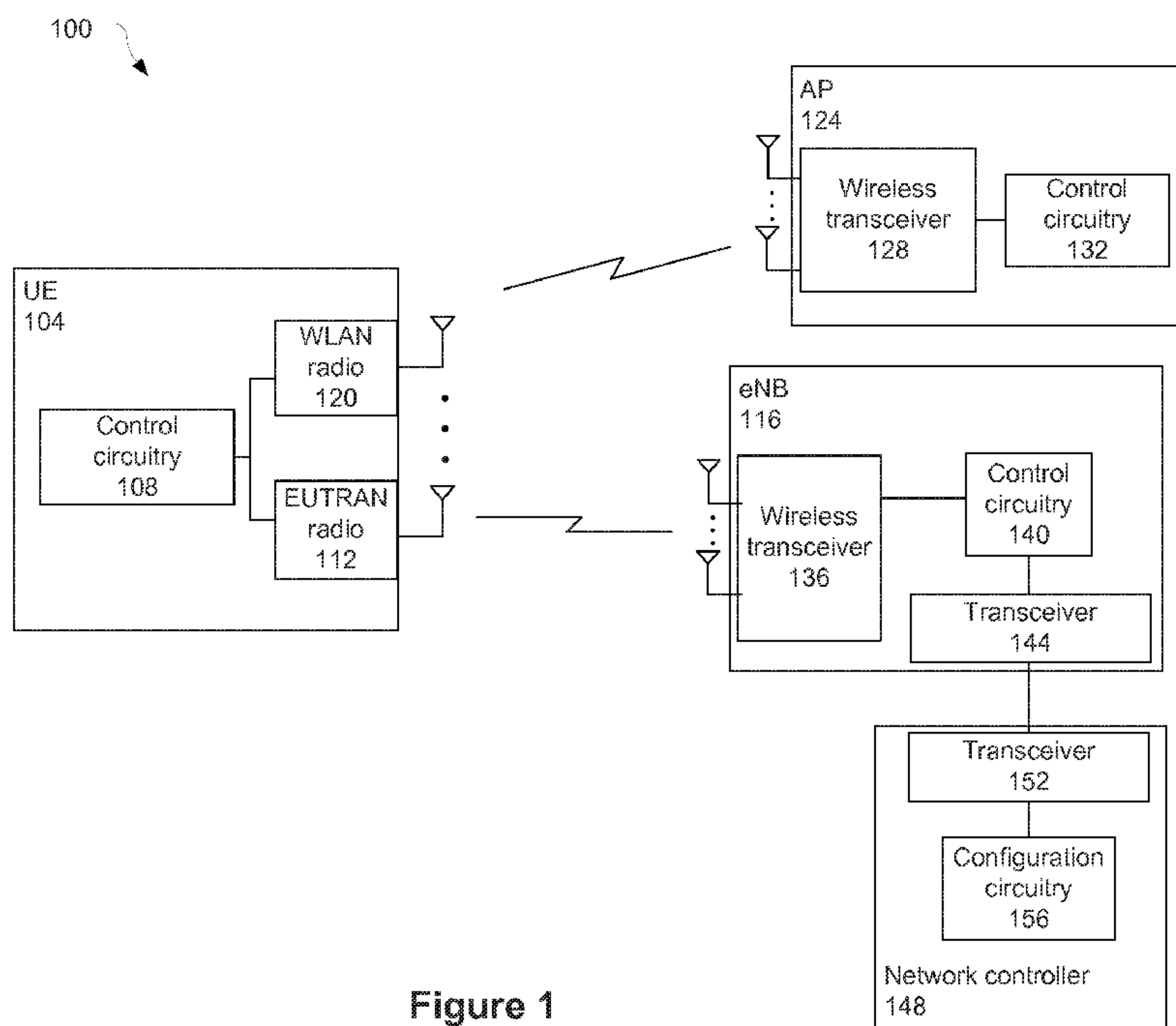


Figure 1

(57) **Abstract:** Embodiments of the present disclosure describe systems, devices, and methods for long-term evolution and wireless local area interworking. Various embodiments may include utilizing access network selection and traffic steering rules based on radio access network assistance parameters. Other embodiments may be described or claimed.

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SYSTEMS, DEVICES, AND METHODS FOR LONG TERM EVOLUTION AND WIRELESS LOCAL AREA INTERWORKING

Cross-Reference To Related Application

This application claims the benefit of U.S. Patent Application No. 14/583,027
 5 filed December 24, 2014, entitled “SYSTEMS, DEVICES, AND METHODS FOR
 LONG TERM EVOLUTION AND WIRELESS LOCAL AREA INTERWORKING”,
 which claims the benefit of U.S. Provisional Application No. 61/990,694 filed May 8,
 2014, entitled “Stage-2 and Stage-3 Details of LTE/WLAN Radio Interworking”, and
 U.S. Provisional Application No. 62/029,936 filed July 28, 2014, entitled “Amendment to
 10 WLAN/3GPP Interworking RAN Rules”.

Field

Embodiments of the present disclosure generally relate to the field of wireless
 communication, and more particularly, to systems, devices, and methods for long-term
 evolution and wireless local area interworking.

15 Background

Typically, cellular networks need to be able to handoff or offload user equipment
 (UEs) to wireless local area networks (WLANs). UEs may also need to know how to
 direct traffic across multiple networks including both radio access network (RANs) and
 WLANs. An example of a cellular network may include a 3G or 4G network such as
 20 those defined by third generation partnership project (3GPP) specifications. An example
 of a WLAN may include a Wi-Fi network such as those described by the Institute of
 Electrical and Electronics Engineers (IEEE) 802.11 specifications.

Summary of the Invention

Accordingly, it is an object of this invention to at least partially overcome some of
 25 the disadvantages of the prior art.

Accordingly, in one aspects of the present invention, there is provided a user
 equipment (UE) comprising: a first radio to communicate via an evolved universal
 terrestrial radio access network (EUTRAN); a second radio to communicate via a wireless
 local area network (WLAN); and control circuitry coupled with the first and second
 30 radios, the control circuitry to receive, in a broadcast system information block or a radio
 resource control (RRC) connection reconfiguration message dedicated to the UE, radio
 access network (RAN) assistance parameters for access network selection and traffic
 steering between the EUTRAN and the WLAN, wherein the RAN assistance parameters

include a WLAN identifier that corresponds to the WLAN, a reference signal received power (RSRP) threshold value, and a reference signal received quality (RSRQ) threshold value; transmit traffic over the EUTRAN via the first radio; determine that a measured cell receive level value of the EUTRAN is less than the RSRP threshold or a measured
 5 cell quality value of the EUTRAN is less than the RSRQ threshold; and steer traffic to the WLAN via the second radio based on said determination that the measured RSRP of the EUTRAN is less than the RSRP threshold or the measured RSRQ of the EUTRAN is less than the RSRQ threshold.

In a further aspect of the present invention, there is provided a user equipment
 10 (UE) comprising: a first radio to communicate via an evolved universal terrestrial radio access network (EUTRAN); a second radio to communicate via a wireless local area network (WLAN); and control circuitry coupled with the first and second radios, the control circuitry to receive, in a broadcast system information block or a radio resource control (RRC) connection reconfiguration message dedicated to the UE, radio access
 15 network (RAN) assistance parameters for access network selection and traffic steering between the EUTRAN and the WLAN, wherein the RAN assistance parameters include a WLAN channel utilization threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, a WLAN beacon received signal strength indicator (RSSI) threshold, and a WLAN beacon received signal strength indicator (RSSI)
 20 threshold; transmit traffic over the WLAN via the second radio; determine a WLAN channel utilization is greater than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or a beacon RSSI is less than the WLAN beacon RSSI threshold; and steer traffic to the
 25 EUTRAN via the first radio based on said determination that the WLAN channel utilization is greater than the WLAN channel utilization threshold, the WLAN downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or the beacon RSSI is less than the WLAN beacon RSSI threshold.

30 In a further aspect of the present invention, there is provided an enhanced node B (eNB) circuitry comprising: control circuitry to determine a set of RAN assistance parameters for each of a plurality of public land mobile networks (PLMNs) served by the eNB, wherein individual sets of the RAN assistance parameters include first evolved

universal terrestrial radio access network (EUTRAN) thresholds for steering traffic from an EUTRAN to a wireless local area network (WLAN), second EUTRAN thresholds for steering traffic from a WLAN to an EUTRAN, first WLAN thresholds for steering traffic from an EUTRAN to a WLAN, and second WLAN thresholds for steering traffic from a WLAN to an EUTRAN; and to generate dedicated or broadcast signaling messages that include the RAN assistance parameters for each of the plurality of PLMNs; and a wireless transceiver to transmit the dedicated or broadcast signaling messages to one or more user equipments (UEs) in the EUTRAN cell.

In yet a further aspect of the present invention, there is provided one or more non-transitory computer-readable media having instructions that, when executed, cause a user equipment (UE) to: process a system information message or a radio resource control (RRC) message to determine radio access network (RAN) assistance parameters; determine conditions of first and second access networks; determine that the conditions of the first and second access networks satisfy access network selection and traffic steering (ANSTS) rules for a predetermined period of time based on the RAN assistance parameters; and steer traffic from the first access network to the second access network based on said determination that the conditions of the first and second access networks satisfy the ANSTS for the predetermined period of time.

In yet a further aspect of the present invention, there is provided one or more computer-readable media having instructions that, when executed, cause a user equipment ("UE") to: determine, based on a radio resource control ("RRC") connection reconfiguration message or a system information block message, radio access network ("RAN") assistance parameters for access network selection and traffic steering between an evolved universal terrestrial radio access network ("EUTRAN") and a wireless local area network ("WLAN"), wherein the RAN assistance parameters include: a WLAN beacon received signal strength indicator ("RSSI") threshold; and an EUTRAN reference signal received power ("RSRP") threshold or an EUTRAN reference signal received quality ("RSRQ") threshold; determine an EUTRAN RSRP or an EUTRAN RSRQ; determine, based on a beacon in the WLAN, a WLAN RSSI; determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI being greater than the WLAN beacon RSSI threshold; steer traffic from a first radio

of the UE that communicates via the EUTRAN to a second radio of the UE that communicates via the WLAN based on said determination that the plurality of steering conditions are met for the predetermined time interval.

In yet a further aspect of the present invention, there is provided an apparatus
5 comprising: a wireless local area network (“WLAN”) radio to receive a beacon from a WLAN; a cellular radio to receive a radio resource control (“RRC”) connection reconfiguration message or a system information block (“SIB”) message from an evolved universal terrestrial radio access network (“EUTRAN”); and control circuitry coupled with the WLAN radio and the cellular radio, the control circuitry to: determine, based on
10 the RRC connection reconfiguration message or the SIB message, radio access network (“RAN”) assistance parameters for access network selection and traffic steering between the EUTRAN and the WLAN, wherein the RAN assistance parameters include: a WLAN beacon received signal strength indicator (“RSSI”) threshold; and an EUTRAN reference signal received power (“RSRP”) threshold or an EUTRAN reference signal received
15 quality (“RSRQ”) threshold; determine an EUTRAN RSRP or an EUTRAN RSRQ; determine, based on the beacon, a WLAN RSSI; determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI
20 being greater than the WLAN beacon RSSI threshold; and steer traffic from the cellular radio to the WLAN radio based on said determination that the plurality of steering conditions are met for the predetermined time interval.

In yet a further aspect of the present invention, there is provided an apparatus of a user equipment (“UE”), the apparatus comprising: access stratum circuitry to: determine,
25 based on a radio resource control (“RRC”) connection reconfiguration message or a system information block message, radio access network (“RAN”) assistance parameters for access network selection and traffic steering between an evolved universal terrestrial radio access network (“EUTRAN”) and a wireless local area network (“WLAN”), wherein the RAN assistance parameters include: a WLAN beacon received signal
30 strength indicator (“RSSI”) threshold; and an EUTRAN reference signal received power (“RSRP”) threshold or an EUTRAN reference signal received quality (“RSRQ”) threshold; determine an EUTRAN RSRP or an EUTRAN RSRQ; determine, based on a beacon in the WLAN, a WLAN RSSI; determine a plurality of steering conditions are met

for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI being greater than the WLAN beacon RSSI threshold; and non-access stratum circuitry to: receive an indication from the access stratum circuitry that the plurality of steering conditions are met for the predetermined time interval and steer traffic from a first radio of the UE that communicates via the EUTRAN to a second radio of the UE that communicates via the WLAN based on said indication.

In yet a further aspect of the present invention, there is provided one or more computer-readable media having instructions that, when executed, cause a user equipment ("UE") to: determine, based on a radio resource control ("RRC") connection reconfiguration message or a system information block message, radio access network ("RAN") assistance parameters for access network selection and traffic steering between an evolved universal terrestrial radio access network ("EUTRAN") and a wireless local area network ("WLAN"), wherein the RAN assistance parameters include: a WLAN beacon received signal strength indicator ("RSSI") threshold; and an EUTRAN reference signal received power ("RSRP") threshold or an EUTRAN reference signal received quality ("RSRQ") threshold; determine an EUTRAN RSRP or an EUTRAN RSRQ; determine, based on a beacon in the WLAN, a WLAN RSSI; determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being greater than the EUTRAN RSRP threshold and the EUTRAN RSRQ being greater than the EUTRAN RSRQ threshold; and the WLAN RSSI being less than the WLAN beacon RSSI threshold; steer traffic from a first radio of the UE that communicates via the WLAN to a second radio of the UE that communicates via the EUTRAN based on said determination that the plurality of steering conditions are met for the predetermined time interval.

Further aspects of the invention will become apparent upon reading the following detailed description and drawings, which illustrate the invention and preferred embodiments of the invention.

Brief Description of the Drawings

Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference

numerals designate like structural elements. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

Figure 1 schematically illustrates a wireless communication environment in accordance with various embodiments.

5 Figure 2 is flowchart of an access network selection and traffic steering operation of a user equipment in accordance with some embodiments.

Figure 3 is a flowchart of a configuration operation of a network node in accordance with some embodiments.

Figure 4 is a block diagram of an example computing device that may be used to practice various embodiments described herein.

Detailed Description

In the following detailed description, reference is made to the accompanying
5 drawings, which form a part hereof wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure.

Various operations may be described as multiple discrete actions or operations in
10 turn, in a manner that is most helpful in understanding the claimed subject matter. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order than the described embodiment. Various additional operations may be
15 performed or described operations may be omitted in additional embodiments.

For the purposes of the present disclosure, the term "or" is used as an inclusive term to mean at least one of the components coupled with the term. For example, the phrase "A or B" means (A), (B), or (A and B); and the phrase "A, B, or C" means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B, and C).

20 The description may use the phrases "in an embodiment," or "in embodiments," which may each refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous.

As used herein, the term "circuitry" may refer to, be part of, or include
25 an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, or other suitable hardware components that provide the described functionality.

Figure 1 schematically illustrates a wireless communication environment 100
30 in accordance with various embodiments. The environment 100 may include a user equipment (UE) 104 that is capable of communicating over at least two wireless communication networks. The UE 104 may include control circuitry 108 coupled with an evolved universal terrestrial radio access network (EUTRAN) radio 112 that is capable of

wireless communication with one or more nodes of a EUTRAN, for example, evolved node B (eNB) 116. The control circuitry 108 may be further coupled with a WLAN radio 120 that is capable of wireless communication with one or more nodes of a WLAN, for example, access point 124.

5 The AP 124 may include wireless transceiver 128 coupled with control circuitry 132. The control circuitry 132 may control operation and communication of the AP 124. In some embodiments the control circuitry 132 may control communications over the wireless transceiver 128 and one or more additional transceivers, which may be wired or wireless. In some embodiments the control circuitry 132 may be embodied in an access
10 controller that is disposed separately from an access point.

 The eNB 116 may also include a wireless transceiver 136 and control circuitry 140. The control circuitry 140 may control operation and communication of the eNB 116. The eNB 116 may be part of a 3rd Generation Partnership Project (3GPP) long-term evolution (LTE) network (or an LTE-Advanced (LTE-A) network) and may include
15 transceiver 144 to communicate with one or more nodes of the LTE/LTE-A network, for example, network controller 148. The eNB 116 may include one or more additional transceivers, which may be wired or wireless.

 The network controller 148 may include a transceiver 152 to communicate with the transceiver 144 of the eNB 116. The network controller 148 may further include
20 configuration circuitry 156. In some embodiments, the configuration circuitry 156 may provide radio access network (RAN) assistance parameters to UEs present in a serving cell of the eNB 116, for example, UE 104. The RAN assistance parameters may be provided to the UEs through dedicated or broadcast signaling. The RAN assistance parameters may be used by the UEs, in conjunction with rules with which the UEs are provisioned, to make
25 access network selection and traffic steering decisions as will be described in further detail herein.

 The network controller 148 may be part of the EUTRAN along with the eNB 116, another EUTRAN, or an Evolved Packet Core (EPC) that is coupled with the EUTRAN of the eNB 116. As used herein, an EUTRAN of the eNB 116 may refer to a serving cell
30 provided by the eNB 116.

 The EPC may include an access network discovery and selection function (ANDSF) to assist UEs to discover non-3GPP access networks that can be used for data communication in addition to 3GPP access networks and provide the UE with rules

policing the connection to these networks. The EPC may also provide a communication interface between various RANs and other networks.

While the configuration circuitry 156 is shown in the network controller 148, in other embodiments some or all of the configuration circuitry 156 may be disposed in the eNB 116.

Various embodiments include RAN-assisted UE-based bidirectional traffic steering between EUTRAN and WLAN. For example, a UE 104 may use information provided by components of the EUTRAN, for example, eNB 116, to determine when to steer traffic from the EUTRAN to the WLAN and vice versa. In some embodiments, the UE 104 may steer traffic differently based on whether the UE is in an RRC idle or an RRC connected mode.

The RAN assistance parameters may include EUTRAN signal strength and quality thresholds, WLAN utilization thresholds, WLAN backhaul data rate thresholds, WLAN identifiers (used in access network selection and traffic steering (ANSTS) rules) and offload preference indicator (OPI) (used in ANDSF policies). The UE 104 may use the RAN assistance parameters in the evaluation of ANSTS rules, described herein, to perform traffic steering decisions between EUTRAN and WLAN.

After receiving the RAN assistance parameters, the UE 104 may keep and apply the parameters or discard or ignore the parameters based on various situations and whether the parameters were received through dedicated or broadcast signaling. For example, if the UE 104 is in RRC_CONNECTED, the control circuitry 108 may apply the RAN assistance parameters obtained via dedicated signaling. Otherwise, the UE 104 may apply the RAN assistance parameters obtained via broadcast signaling. If the UE 104 is in RRC_IDLE, it may keep and apply the RAN assistance parameters obtained via dedicated signaling until a cell reselection or handover occurs or a timer has expired since the UE 104 entered RRC_IDLE. After a cell reselection or handover occurs or the timer expires, the UE 104 may apply RAN assistance parameters obtained via broadcast signaling.

In some embodiments, a user of the UE 104 may set preferences with respect to the network with which communication should be conducted. These user-preference settings may take precedent over ANSTS rules.

A user equipment in RRC_CONNECTED or RRC_IDLE that supports traffic steering, shall use the ANSTS unless the UE is provisioned with ANDSF policies by the ANDSF of the EPC. If the UE 104 is provisioned with ANDSF policies, the UE 104 may

forward received RAN assistance parameters to upper layers of the UE 104. If the UE 104 is not provisioned with ANDSF policies (or it does not have an active ANDSF policy), it may use received RAN assistance parameters in ANSTS defined in RAN.

When the UE 104 applies ANSTS rules, using received RAN assistance parameters, it may perform traffic steering between the EUTRAN and WLAN with access point name (APN) granularity. For example, when the UE 104 moves the traffic of an evolved packet system (EPS) bearer belonging to an APN between EUTRAN and WLAN it may move the traffic of all the EPS bearers that belong to that APN. The information about which APNs are offloadable to WLAN may be provided by NAS.

In some situations, a EUTRAN may be shared among a number of public land mobile networks (PLMNs). In these situations, each PLMN sharing the EUTRAN may be associated with its own set of RAN assistance parameters. In some embodiments, the eNB 116 may receive or otherwise determine a set of RAN assistance parameters for each PLMN that the eNB 116 serves. The eNB 116 may then deliver these sets of RAN assistance parameters to the UEs in the EUTRAN through broadcast or dedicated signaling.

RAN assistance parameters may be provided to the UE 104 in one or more system information blocks (SIBs) or in an RRC connection reconfiguration message. If any of the RAN assistance parameters are provided in dedicated signaling, for example, in an RRC connection reconfiguration message, the UE 104 may ignore RAN assistance parameters provided in system information, for example, SIBs. In some embodiments, the control circuitry 108 may determine that RAN assistance parameters received via system information are valid only if the UE 104 is camped on a suitable cell.

In some embodiments, the RAN assistance parameters may include identifiers of target WLANs, for example the WLAN associated with the AP 124, to which traffic may be steered. The WLAN identifiers may include service set identifiers (SSIDs), basic service set identifiers (BSSIDs), and/or homogeneous extended service set identifiers (HHIDs). ANSTS rules may be applicable to the target WLANs. In some embodiments, these ANSTS rules may only be applicable if the UE 104 is capable of traffic steering between EUTRAN and WLAN and the UE 104 is not provisioned with active ANDSF policies as described above.

In some respects, the ANSTS rules and the ANDSF policies may be considered two alternative mechanisms that provide similar functionality. Some operators may use

ANDSF, while others use ANSTS. Generally speaking, ANDSF may be more comprehensive and, therefore, expensive. Operators that do not need full functionality of ANDSF may prefer to use cheaper ANSTS instead.

Generally, a single operator may only use one mechanism. However, in certain cases, conflicts may happen. For example, when a UE from operator A that uses ANDSF is roaming in a network of operator B that uses ANSTS. In such instances, the mechanism that takes precedent may be explicitly defined.

A first set of the ANSTS rules may describe situations in which traffic may be steered from an EUTRAN to a WLAN. These situations may be based on operational states in the EUTRAN and the WLAN as compared to various thresholds provided in the RAN assistance parameters. In some embodiments, if predefined conditions are met, then an access stratum in the control circuitry 108 may indicate to upper layers of the control circuitry 108, for example, a non-access stratum, when and for which WLAN identifiers (out of a list of WLAN identifiers provided in the RAN access parameters) certain conditions for steering traffic from an EUTRAN to a WLAN are satisfied for a predetermined time interval. The predetermined time interval may be based on a timer value, $T_{steeringWLAN}$, which may be a parameter of the RAN assistance parameters.

The conditions for steering traffic to a WLAN may include EUTRAN serving cell conditions and target WLAN conditions. The EUTRAN serving cell conditions may include: $Q_{rxlevmeas} < ThreshServingOffloadWLAN, LowP$; or $Q_{qualmeas} < ThreshServingOffloadWLAN, LowQ$, where $Q_{rxlevmeas}$ may be a measured reference signal received power (RSRP) (in dBm) of the EUTRAN cell, $ThreshServingOffloadWLAN, LowP$ may be an RSRP threshold (in dBm) used by the UE 104 for traffic steering to WLAN, $Q_{qualmeas}$ may be a measured reference signal received quality (RSRQ) (in dB) in the EUTRAN cell, and $ThreshServingOffloadWLAN, LowQ$ may be an RSRQ threshold (in dB) used by the UE 104 for traffic steering to WLAN. Thus, the control circuitry 108 may determine that the EUTRAN serving cell conditions are satisfied if a measured cell receive level value of the EUTRAN is less than the corresponding RSRP threshold or a measured cell quality value of the EUTRAN is less than the corresponding RSRQ threshold.

The target WLAN conditions may include: $ChannelUtilizationWLAN < ThreshChUtilWLAN, Low$; $BackhaulRateDIWLAN > ThreshBackhRateDIWLAN, High$; $BackhaulRateUIWLAN > ThreshBackhRateUIWLAN, High$; and $BeaconRSSI >$

ThreshRSSIWLAN, High, where ChannelUtilizationWLAN may be a WLAN channel utilization value from basic service set (BSS) load information element (IE) obtained from IEEE 802.11 (Beacon or Probe Response) signaling for an indicated WLAN identifier, ThreshChUtilWLAN, Low may be a WLAN channel utilization (BSS load) threshold used by the UE 104 for traffic steering to WLAN, BackhaulRateDlWLAN may be a backhaul available downlink bandwidth that may be calculated as $\text{Downlink Speed} * (1 - \text{Downlink Load} / 255)$, where the Downlink Speed and Downlink Load parameters may be drawn from wide area network (WAN) Metrics element obtained via access network query protocol (ANQP) signaling from Wi-Fi Alliance (WFA) hotspot (HS) 2.0 (based on IEEE 802.11u and WFA extensions), ThreshBackhRateDlWLAN, High may be a backhaul available downlink bandwidth threshold used by the UE 104 for traffic steering to WLAN, BackhaulRateUlWLAN may be a backhaul available uplink bandwidth that may be calculated as $\text{Uplink Speed} * (1 - \text{Uplink Load} / 255)$, where the Uplink Speed and Uplink Load parameters may be drawn from the WAN metrics element obtained via ANQP signaling from WFA HS2.0, ThreshBackhRateUlWLAN, High may be a backhaul available uplink bandwidth threshold used by the UE 104 for traffic steering to WLAN, BeaconRSSI may be an RSSI as measured by the UE 104 on the WLAN Beacon, and ThreshRSSIWLAN, High may be a Beacon RSSI threshold used by the UE 104 for traffic steering to WLAN. Thus, the control circuitry 108 may determine that the WLAN conditions are satisfied if a WLAN channel utilization is less than the corresponding WLAN channel utilization threshold, a WLAN downlink backhaul rate is greater than a corresponding WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is greater than a corresponding WLAN uplink backhaul rate threshold, and a beacon RSSI is greater than a corresponding WLAN beacon RSSI threshold.

In some embodiments, the UE 104 may receive only a subset of thresholds discussed herein. In such embodiments, the UE 104 may exclude the evaluation of a measurement for which a corresponding threshold has not been provided.

In an embodiment in which more than one target WLAN meets the conditions above, it may be up to the UE 104 to choose one of the available target WLANs. In some embodiments, each of the target WLANs may have an associated priority by which the UE 104 selects the WLAN with which to associate. The associated priority may be transmitted with the WLAN identifiers in the RAN assistance parameters.

A second set of the ANSTS rules may describe situations in which traffic may be steered from a WLAN to an EUTRAN cell. Similar to the above discussion, these situations may be based on operational states in the WLAN and EUTRAN cell as compared to various thresholds provided in the RAN assistance parameters. In some
 5 embodiments, if predefined conditions are met, then an access stratum in the control circuitry 108 may indicate to upper layers of the control circuitry 108, for example, a non-access stratum, when certain conditions for steering traffic from a WLAN to an EUTRAN cell are satisfied for a predetermined time interval, $T_{steeringWLAN}$.

The WLAN conditions for steering traffic to a target EUTRAN cell from the
 10 WLAN may include: $ChannelUtilizationWLAN > ThreshChUtilWLAN, High$; $BackhaulRateDIWLAN < ThreshBackhRateDIWLAN, Low$; $BackhaulRateUIWLAN < ThreshBackhRateUIWLAN, Low$; or $BeaconRSSI < ThreshRSSIWLAN, Low$, where $ThreshChUtilWLAN, High$ may be a WLAN channel utilization (BSS load) threshold used by the UE 104 for traffic steering to EUTRAN, $ThreshBackhRateDIWLAN, Low$ may be
 15 a backhaul available downlink bandwidth threshold used by the UE 104 for traffic steering to EUTRAN, $ThreshBackhRateUIWLAN, Low$ may be a backhaul available uplink bandwidth threshold used by the UE 104 for traffic steering to EUTRAN, and $ThreshRSSIWLAN, Low$ may be a Beacon RSSI threshold used by the UE 104 for traffic steering to EUTRAN. Thus, the control circuitry 108 may determine the WLAN
 20 conditions for steering traffic to the target EUTRAN cell are satisfied if a WLAN channel utilization is greater than a corresponding WLAN channel utilization threshold, a WLAN downlink backhaul rate is less than a corresponding WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is less than a corresponding WLAN uplink backhaul rate threshold, or a beacon RSSI is less than a corresponding WLAN beacon
 25 RSSI threshold.

The EUTRAN conditions for steering traffic to a target EUTRAN cell from a WLAN may include: $Qrxlevmeas > ThreshServingOffloadWLAN, HighP$; and $Qqualmeas > ThreshServingOffloadWLAN, HighQ$, where $ThreshServingOffloadWLAN, HighP$ may be an RSRP threshold (in dBm) used by the UE 104 for traffic steering to EUTRAN and
 30 $ThreshServingOffloadWLAN, HighQ$ may be an RSRQ threshold (in dB) used by the UE 104 for traffic steering to EUTRAN. Thus, the control circuitry 108 may determine the EUTRAN conditions for steering traffic to the target EUTRAN cell are satisfied if a measured cell receive level value of the EUTRAN is greater than a corresponding RSRP

threshold and a measured cell quality value of the EUTRAN is greater than a corresponding RSRQ threshold.

As can be seen in the above, and in Table 1 below, the RAN assistance parameters may include first EUTRAN/WLAN thresholds for steering traffic from an EUTRAN to the WLAN and second EUTRAN/WLAN thresholds for steering traffic from a WLAN to an EUTRAN. The different thresholds may be separated by a sufficient degree to prevent ping-ponging between EUTRAN and WLAN. Thus, the high and low thresholds may define an acceptable operating range in which traffic steering may not be employed.

In some embodiments, if upper layers of the control circuitry 108 receive an indication provided by an access stratum of the control circuitry 108 that contradicts with user preferences or if the UE 104 has an active ANDSF policy, the upper layers may ignore the indication and may not engage in traffic steering.

As discussed above, in some embodiments, the RAN assistance parameters be transmitted in a SystemInformation message. The SystemInformation message may be used to convey one or more system information blocks (SIBs). The included SIBs may be transmitted with the same periodicity. The SystemInformation message may be transmitted from the EUTRAN to the UE 104 over a broadcast control channel (BCCH) logical channel and may have a transparent mode (TM) radio link control (RLC) - service access point (SAP).

In some embodiments, the SystemInformation message may have an abstract syntax notation (ASN) as follows.

--ASN1START

```

SystemInformation ::=
    criticalExtensions
    systemInformation-r8
    criticalExtensionsFuture
    }
    }
    SystemInformation-r8-IEs ::=
    sib-TypeAndInfo
    sib2
    SystemInformationBlockType2,
    SEQUENCE {
    CHOICE {
    SystemInformation-r8-IEs,
    SEQUENCE {}
    }
    SEQUENCE (SIZE
    (1..maxSIB)) OF CHOICE {
    sib2
    SystemInformationBlockType2,
  
```


sib3
SystemInformationBlockType3,
sib4
SystemInformationBlockType4,
5 sib5
SystemInformationBlockType5,
sib6
SystemInformationBlockType6,
sib7
10 SystemInformationBlockType7,
sib8
SystemInformationBlockType8,
sib9
SystemInformationBlockType9,
15 sib10
SystemInformationBlockType10,
sib11
SystemInformationBlockType11,
...
20 sib12-v920
SystemInformationBlockType12-r9
sib13-v920
SystemInformationBlockType13-r9
sib14-v1130
25 SystemInformationBlockType14-r11
sib15-v1130
SystemInformationBlockType15-r11
sib16-v1130
SystemInformationBlockType16-r11
30 sib17-v12xy
SystemInformationBlockType17-r12
sib18-v12xy
SystemInformationBlockType18-r12

```

    },
    nonCriticalExtension                               SystemInformation-v8a0-IEs
              OPTIONAL                                -- Need OP
  }
5
SystemInformation-v8a0-IEs ::= SEQUENCE {
    lateNonCriticalExtension                           OCTET STRING
              OPTIONAL,                                -- Need OP
    nonCriticalExtension                               SEQUENCE {
10              OPTIONAL                                -- Need OP
    }
-- ASN1STOP

```

The above ASN of the *SystemInformation* message system includes information for system information block types 17 and 18, which may include the RAN assistance parameters in some embodiments. In one example, the various thresholds of the RAN assistance parameters may be included in SystemInformationBlockType17 and the list of target WLAN identifiers may be included in SystemInformationBlockType18.

SystemInformationBlockType17 information element may have an ANS format as indicated below in accordance with some embodiments.

```

20 -- ASN1START
SystemInformationBlockType17-r12 ::= SEQUENCE {
    wlanOffloadParam-r12                               CHOICE {
        wlanOffload-Common-r12                        WlanOffload-Param-r12,
        wlanOffload-PerPLMN-List-r12                   SEQUENCE (SIZE (1..maxPLMN-r11)) OF
25          WlanOffload-ParamPerPLMN-r12
    }
              OPTIONAL,
    ...,
    lateNonCriticalExtension                           OCTET STRING      OPTIONAL
  }
30 WlanOffload-ParamPcrPLMN-r12 ::= SEQUENCE {
    ran-Param-r12                                       WlanOffload-Param-r12      OPTIONAL
  }
WlanOffload-Param-r12 ::= SEQUENCE {

```

	thresholdRSRP-Low-r12	RSRP-Range
	OPTIONAL,	
	thresholdRSRP-High-r12	RSRP-Range
	OPTIONAL,	
5	thresholdRSRQ-Low-r12	RSRQ-Range
	OPTIONAL,	
	thresholdRSRQ-High-r12	RSRQ-Range
	OPTIONAL,	
	thresholdRSSI-Low-r12	RSSI-Range
10	OPTIONAL,	
	thresholdRSSI-High-r12	RSSI-Range
	OPTIONAL,	
	thresholdChannelUtilization-Low-r12	INTEGER (1...255)
	OPTIONAL,	
15	thresholdChannelUtilization-High-r12	INTEGER (1...255)
	OPTIONAL,	
	thresholdBackhaulDLBandwidth-Low-r12	INTEGER (1... 4194304)
	OPTIONAL,	
	thresholdBackhaulDLBandwidth-High-r12	INTEGER (1... 4194304)
20	OPTIONAL,	
	thresholdBackhaulULBandwidth-Low-r12	INTEGER (1... 4194304)
	OPTIONAL,	
	thresholdBackhaulULBandwidth-High-r12	INTEGER (1... 4194304)
	OPTIONAL,	
25	offloadPreferenceIndicator-r12	BIT STRING (SIZE (2))
	OPTIONAL,	
	t-SteeringWLAN-r12	T-Reselection
	OPTIONAL,	
	...	
30	}	
	-- ASN1STOP	

The field descriptions of the *SystemInformationBlockType17* are described in Table 1.

<i>SystemInformationBlockType17</i> field descriptions	
<i>wlanOffloadParam</i>	The RAN assistance parameters for traffic steering between E-UTRAN and WLAN.
<i>wlanOffload-Common</i>	The RAN assistance parameters for traffic steering between E-UTRAN and WLAN applicable for all PLMN(s).
<i>wlanOffload-PerPMN-List</i>	The RAN assistance parameters for traffic steering between E-UTRAN and WLAN per PLMN, listed in the same order as the PLMN(s) occur in <i>plmn-IdentityList</i> in <i>SystemInformationBlockType1</i> .
<i>thresholdRSRP-Low</i>	Indicates the RSRP threshold (in dBm) used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{ServingOffloadWLAN, LowP}}$ used in ANSTS rules described herein.
<i>thresholdRSRP-High</i>	Indicates the RSRP threshold (in dBm) used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{ServingOffloadWLAN, HighP}}$ used in ANSTS rules described herein.
<i>thresholdRSRQ-Low</i>	Indicates the RSRQ threshold (in dB) used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{ServingOffloadWLAN, LowQ}}$ used in ANSTS rules described herein.
<i>thresholdRSRQ-High</i>	Indicates the RSRQ threshold (in dB) used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{ServingOffloadWLAN, HighQ}}$ used in ANSTS rules described herein.
<i>thresholdRSSI-Low</i>	Indicates the Beacon RSSI threshold used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{RSSIWLAN, Low}}$ used in ANSTS rules described herein.
<i>thresholdRSSI-High</i>	Indicates the Beacon RSSI threshold used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{RSSIWLAN, High}}$ used in ANSTS rules described herein.
<i>thresholdChannelUtilization-Low</i>	Indicates the WLAN channel utilization (BSS load) threshold used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{ChUtilWLAN, Low}}$ used in ANSTS rules described herein.
<i>thresholdChannelUtilization-High</i>	Indicates the WLAN channel utilization (BSS load) threshold used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{ChUtilWLAN, High}}$ used in ANSTS rules described herein.
<i>thresholdBackhaulDLBandwidth-Low</i>	Indicates the backhaul available downlink bandwidth threshold used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{BackhRateDLWLAN, Low}}$ used in ANSTS rules described herein. Value in kilobits/second.
<i>thresholdBackhaulDLBandwidth-High</i>	Indicates the backhaul available downlink bandwidth threshold used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{BackhRateDLWLAN, High}}$ used in ANSTS rules described herein. Value in kilobits/second.
<i>thresholdBackhaulULBandwidth-Low</i>	Indicates the backhaul available uplink bandwidth threshold used by the UE for traffic steering to E-UTRAN. Parameter: $\text{Thresh}_{\text{BackhRateULWLAN, Low}}$ used in ANSTS rules described herein. Value in kilobits/second.

<i>thresholdBackhaulULBandwidth-High</i>
Indicates the backhaul available uplink bandwidth threshold used by the UE for traffic steering to WLAN. Parameter: $\text{Thresh}_{\text{BackhRateUL,WLAN, High}}$ used in ANSTS rules described herein. Value in kilobits/second.
<i>offloadPreferenceIndicator</i>
Indicates the Offload preference indicator.
<i>t-SteeringWLAN</i>
Indicates the timer value during which the rules should be fulfilled before starting traffic steering between E-UTRAN and WLAN. Parameter: $\text{Tsteering}_{\text{WLAN}}$ used in ANSTS rules described herein.

Table 1

In some embodiments, if the UE 104 has been provisioned with ANDSF policies as defined in 3GPP TS 24.312 v12.4.0 (March 17, 2014), then upon receiving the RAN assistance parameters in the SystemInformationBlockType17, the lower layers of the UE

5 104 may provide the RAN assistance parameters for access network selection and traffic steering between EUTRAN and WLAN to the upper layers of the UE 104.

SystemInformationBlockType18 information element may have an ANS format as indicated below in accordance with some embodiments.

-- ASN1START

```

10 SystemInformationBlockType18-r12 ::= SEQUENCE {
        wlanIdentifiersListPerPLMN-r12
        WlanIdentifiersListPerPLMN-r12 OPTIONAL,
        ...,
        lateNonCriticalExtension OCTET STRING
15 OPTIONAL
    }
WlanIdentifiersListPerPLMN-r12 ::= SEQUENCE (SIZE (1..maxPLMN-r11)) OF
WlanIdentifiersList-r12
WlanIdentifiersList-r12 ::= SEQUENCE (SIZE (1..maxWLANId-r12)) OF
20 WlanIdentifier-r12
WlanIdentifier-r12 ::= OCTET STRING (SIZE (FFS))
-- ASN1STOP

```

The wlanIdentifiersListPerPLMN may be a list of WLAN identifiers for WLAN access network selection per PLMN, listed in the same order that the PLMNs occur in

25 plmn-IdentityList in *SystemInformationBlockType1*. The list of WLAN identifiers may

indicate which WLANs the UE 104 may connect to if it is not provisioned with ANDSF policies.

In some embodiments changes to SIB types in addition to the SIBTypes that actually carry the RAN assistance parameters may be instituted to account for the RAN assistance parameters. For example, a *SystemInformationBlockType1* Message may be
 5 updated to include an ASN as follows.

-- ASN1START

```

SystemInformationBlockType1 ::=          SEQUENCE {
    cellAccessRelatedInfo          SEQUENCE {
10      plmn-IdentityList          PLMN-IdentityList,
      trackingAreaCode            TrackingAreaCode,
      cellIdentity                CellIdentity,
      cellBarred                  ENUMERATED {barred, notBarred},
      intraFreqReselection        ENUMERATED {allowed,
15      notAllowed},
      csg-Indication              BOOLEAN,
      csg-Identity                CSG-Identity  OPTIONAL -- Need
    OR
      },
20      cellSelectionInfo          SEQUENCE {
      q-RxLevMin                  Q-RxLevMin,
      q-RxLevMinOffset            INTEGER (1..8)  OPTIONAL
    - Need OP
      },
25      p-Max                      P-Max          OPTIONAL,      -- Need
    OP
      freqBandIndicator            FreqBandIndicator,
      schedulingInfoList           SchedulingInfoList,
      tdd-Config                   TDD-Config      OPTIONAL, -- Cond
30      TDD
      si-WindowLength             ENUMERATED {
      ms1, ms2, ms5, ms10, ms15, ms20,
      ms40},
  
```



```

        systemInfoValucTag      INTEGER (0..31),
        nonCriticalExtension     SystemInformationBlockType1-v890-IEs
                                OPTIONAL -- Need OP
    }
5  SystemInformationBlockType1-v890-IEs ::= SEQUENCE {
        lateNonCriticalExtension  OCTET STRING (CONTAINING
            SystemInformationBlockType1-v8h0-IEs)          OPTIONAL, -
            - Need OP
        nonCriticalExtension     SystemInformationBlockType1-v920-IEs  OPTIONAL -
10  - Need OP
    }
    -- Late non critical extensions
    SystemInformationBlockType1-v8h0-IEs ::= SEQUENCE {
        multiBandInfoList        MultiBandInfoList          OPTIONAL, -- Need
15  OR
        nonCriticalExtension     SystemInformationBlockType1-v9e0-IEs
            OPTIONAL -- Need OP
    }
    SystemInformationBlockType1-v9e0-IEs ::= SEQUENCE {
20  freqBandIndicator-v9e0       FreqBandIndicator-v9e0  OPTIONAL, -- Cond FBI-
        max
        multiBandInfoList-v9e0   MultiBandInfoList-v9e0  OPTIONAL, -- Cond
        mFBI-max
        nonCriticalExtension      SEQUENCE {}              OPTIONAL -- Need
25  OP
    }
    -- Regular non critical extensions
    SystemInformationBlockType1-v920-IEs ::= SEQUENCE {
        ims-EmergencySupport-r9   ENUMERATED {true}        OPTIONAL, -- Need
30  OR
        cellSelectionInfo-v920    CellSelectionInfo-v920   OPTIONAL, -- Cond
        RSRQ

```

```

        nonCriticalExtension      SystemInformationBlockType1-v1130-IEs
        OPTIONAL -- Need OP
    }
    SystemInformationBlockType1-v1130-IEs ::= SEQUENCE {
5      tdd-Config-v1130      TDD-Config-v1130  OPTIONAL, -- Cond TDD-OR
      cellSelectionInfo-v1130      CellSelectionInfo-v1130  OPTIONAL, -- Cond WB-
      RSRQ
      nonCriticalExtension      SEQUENCE {          OPTIONAL -- Need
      OP
10  }
    PLMN-IdentityList ::= SEQUENCE (SIZE (1..maxPLMN-r11)) OF PLMN-
    IdentityInfo
    PLMN-IdentityInfo ::= SEQUENCE {
        plmn-Identity          PLMN-Identity,
15      cellReservedForOperatorUse ENUMERATED {reserved, notReserved}
    }
    SchedulingInfoList ::= SEQUENCE (SIZE (1..maxSI-Message)) OF SchedulingInfo
    SchedulingInfo ::= SEQUENCE {
        si-Periodicity          ENUMERATED {
20      rf8, rf16, rf32, rf64, rf128, rf256, rf512},
        sib-MappingInfo          SIB-MappingInfo
    }
    SIB-MappingInfo ::= SEQUENCE (SIZE (0..maxSIB-1)) OF SIB-Type
    SIB-Type ::= ENUMERATED {
25      sibType3, sibType4, sibType5, sibType6,
      sibType7, sibType8, sibType9, sibType10,
      sibType11, sibType12-v920, sibType13-v920,
      sibType14-v1130, sibType15-v1130,
      sibType16-v1130, sibType17-v12xy, sibType18-v12xy, ...}
30  CellSelectionInfo-v920 ::= SEQUENCE {
        q-QualMin-r9          Q-QualMin-r9,
        q-QualMinOffset-r9    INTEGER (1..8)    OPTIONAL -- Need
        OP

```

```

}
CellSelectionInfo-v1130 ::=          SEQUENCE {
    q-QualMinWB-r11                    Q-QualMin-r9
}

```

5 -- ASN1STOP

As can be seen, SIB-Type may include SIB-type 17 and 18, which may carry the RAN assistance parameters as described above.

The field descriptions of SystemInformationBlockType1 may be in accordance with 3GPP TS 36.331 v.12.1.0 (March 19, 2014) .

10 In some embodiments, the system information containing the RAN access parameters may be referred to as “required” system information of which the UE 104, if in RRC_CONNECTED, should ensure having a valid version.

In some embodiments, the RAN access parameters may be provided in dedicated signaling such as an RRCConnectionReconfiguration message. The

15 RRCConnectionReconfiguration message may be the command to modify an RRC connection. It may convey information for measurement configuration, mobility control, radio resource configuration (including radio bearers, MAC Main configuration and physical channel configuration) including any associated dedicated NAS information security configuration. The *RRCConnectionReconfiguration* message may be transmitted
 20 to the UE 104 on signal radio bearer 1 (SRB1) in the downlink control channel (DCCH) and may have an acknowledged mode (AM) RLC-SAP. In some embodiments, the *RRCConnectionReconfiguration* message may have an ASN as shown below.

--ASN1START

```

RRCConnectionReconfiguration ::= SEQUENCE {
25   rrc-TransactionIdentifier          RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1
    CHOICE {
        rrcConnectionReconfiguration-r8
30   RRCConnectionReconfiguration-r8-IEs,
        spare7 NULL
        spare6 NULL, spare5 NULL, spare4 NULL,
        spare3 NULL, spare2 NULL, spare1 NULL
    }
}

```



```

        },
        criticalExtensionsFuture          SEQUENCE {}
    }
}
5  RRConnectionReconfiguration-r8-IEs ::= SEQUENCE {
    measConfig          MeasConfig          OPTIONAL, --Need
ON
    mobilityControlInfo      MobilityControlInfo      OPTIONAL, --Cond
HO
10  dedicatedInfoNASList      SEQUENCE (SIZE(1...maxDRB)) OF
    DedicatedInfoNAS          OPTIONAL, --Cond nonHO
    radioResourceConfigDedicated      RadioResrouceConfigDedicated
    OPTIONAL, --
Cond HO-toEUTRA
15  securityConfigHO          SecurityConfigHO
    OPTIONAL, -- Cond HO
    nonCriticalExtension      RRConnectionReconfiguration-
v890-IEs      OPTIONAL -- Need OP
}
20
RRConnectionReconfiguration-v890-IEs ::= SEQUENCE {
    lateNonCriticalExtension      OCTET STRING
    OPTIONAL, -- Need OP
    nonCriticalExtension      RRConnectionReconfiguration-
25  v920-IEs      OPTIONAL      -- Need OP
}
RRConnectionReconfiguration-v920-IEs ::= SEQUENCE {
    otherConfig-r9          otherConfig-r9
    OPTIONAL, -- Need ON
30  fullConfig-r9
    OPTIONAL, -- Cond HO-Reestab
    nonCriticalExtension
    RRConnectionReconfiguration

```

```

v1020-IEs          OPTIONAL          -- Need OP
}
RRCConnectionReconfiguration-v1020-IEs ::= SEQUENCE {
    sCellToReleaseList-r10          SCellToReleaseList-r10
5    OPTIONAL,          -- Need ON
    sCellToAddModList-r10          SCellToAddModList-r10
    OPTIONAL,          -- Need ON
    nonCriticalExtension
    RRCConnectionReconfiguration-
10  V1130-IEs  OPTIONAL  -- Need OP
}
RRCConnectionReconfiguration-v1130-IEs ::= SEQUENCE {
    systeminformationBlockType1Dedicated-r11  OCTET STRING
(CONTAINING SystemInformationBlockType1)
15    OPTIONAL, -- Need ON
    nonCriticalExtension
    RRCConnectionReconfiguration-
v12xy-IEs          OPTIONAL  -- Need
OP
20  }

RRCConnectionReconfiguration-v12xy-IEs ::= SEQUENCE {
    wlanOffloadParamDedicated-r12
    wlanOffloadParamDedicated-12          OPTIONAL,
25    nonCriticalExtension          SEQUENCE {}
    OPTIONAL  -- Need OP
}
SCellToAddModList-r10 ::= SEQUENCE (SIZE(1..maxSCell-r10)) OF
SCellToAddMod-r10
30  SCellToAddMod-r10 ::= SEQUENCE {
    sCellIndex-r10          SCellIndex-r10,
    cellIdentification-r10  SEQUENCE {
        physCellId-r10          PhysCellId,

```

```

        dl-CarrierFreq-r10                                ARFCN-ValueEUTRA
    }

        OPTIONAL, -- Cond SCellAdd
        radioResourceConfigCommonSCell-r10    RadioResourceConfigCommonSCell-
5   r10    OPTIONAL, -- Cond SCellAdd
        radioResourceConfigDedicatedSCell-r10
        RadioResourceConfigDedicatedSCell-r10    OPTIONAL, -- Cond SCellAdd2
        ...,
        [[    dl-CarrierFreq-v1090                ARFCN-ValueEUTRA-v9e0
10   OPTIONAL -- Cond EARFCN-max
        ]]
    }
    SCellToReleaseList-r10 ::=                SEQUENCE (SIZE (1..maxSCell-r10)) OF
    SCellIndex-r10
15   SecurityConfigHO ::=                SEQUENCE {
        handoverType                                CHOICE {
            intraLTE                                SEQUENCE {
                securityAlgorithmConfig
                SecurityAlgorithmConfig    OPTIONAL, -- Cond fullConfig
20             keyChangeIndicator                BOOLEAN,
                nextHopChainingCount
                NextHopChainingCount
            },
            interRAT                                SEQUENCE {
25             securityAlgorithmConfig
                SecurityAlgorithmConfig,
                nas-SecurityParamToEUTRA    OCTET STRING
                (SIZE(6))
            }
30     },
        ...
    }
-- ASN1STOP

```

The field descriptions of the *RRCConnectionReconfiguration* message are described in Table 2a and the conditional terms are described in Table 2b.

<i>RRCConnectionReconfiguration</i> field descriptions	
<i>dedicatedInfoNASList</i>	This field is used to transfer UE specific NAS layer information between the network and the UE. The RRC layer is transparent for each PDU in the list.
<i>fullConfig</i>	Indicates the full configuration option is applicable for the RRC Connection Reconfiguration message.
<i>keyChangeIndicator</i>	true is used only in an intra-cell handover when a K_{eNB} key is derived from a K_{ASME} key taken into use through the latest successful NAS SMC procedure, as described in 3GPP TS 33.401 v.12.10.0 (December 20, 2013) for K_{eNB} re-keying. false is used in an intra-LTE handover when the new K_{eNB} key is obtained from the current K_{eNB} key or from the NH as described in TS 33.401.
<i>nas-securityParamToEUTRA</i>	This field is used to transfer UE specific NAS layer information between the network and the UE. The RRC layer is transparent for this field, although it affects activation of AS- security after inter-RAT handover to E-UTRA. The content is defined in TS 24.301, v12.4.0 (March 17, 2014)
<i>nextHopChainingCount</i>	Parameter NCC: See TS 33.401.

Table 2a

Conditional presence	Explanation
<i>EARFCN-max</i>	The field is mandatory present if <i>dl-CarrierFreq-r10</i> is included and set to <i>maxEARFCN</i> . Otherwise the field is not present.
<i>fullConfig</i>	This field is mandatory present for handover within E-UTRA when the <i>fullConfig</i> is included; otherwise it is optionally present, Need OP.
<i>HO</i>	The field is mandatory present in case of handover within E-UTRA or to E-UTRA; otherwise the field is not present.
<i>HO-Reestab</i>	This field is optionally present, need ON, in case of handover within E-UTRA or upon the first reconfiguration after RRC connection re-establishment; otherwise the field is not present.
<i>IIO-toEUTRA</i>	The field is mandatory present in case of handover to E-UTRA or for reconfigurations when <i>fullConfig</i> is included; otherwise the field is optionally present, need ON.
<i>nonHO</i>	The field is not present in case of handover within E-UTRA or to E-UTRA; otherwise it is optional present, need ON.
<i>SCellAdd</i>	The field is mandatory present upon SCell addition; otherwise it is not present.
<i>SCellAdd2</i>	The field is mandatory present upon SCell addition; otherwise it is optionally present, need ON.

Table 2b

The *WlanOffloadParamDedicated* information element of the *RRCConnectionReconfiguration* message may contain information relevant for traffic steering between EUTRAN and WLAN. The *WlanOffloadParamDedicated* may have an ANS format as indicated below in accordance with some embodiments.

10 -- ASN1START

WlanOffloadParamDedicated-r12 ::=SEQUENCE {

 wlanOffload-Param-r12 WlanOffload-Param-r12

 OPTIONAL, -- Need ON

 wlanIdentifiersList-r12 WlanIdentifiersList-r12

15 OPTIONAL, -- Need ON

 t3350 ENUMERATED {

FFS}

OPTIONAL, -- Need OR

...

}

5 -- ASN1STOP

t350 may be a validity time for RAN assistance parameters. The UE 104 may start a validity timer, T350, upon the UE 104 entering RRC_IDLE with the validity time t350 received for RAN assistance parameters. If the UE 104 engages in cell reselection or handover, it may stop the validity timer. If the validity timer expires, the UE 104 may
10 discard the RAN assistance parameters provided by dedicated signaling.

Figure 2 is a flowchart depicting a traffic steering operation 200 of a user equipment, for example, UE 104, in accordance with some embodiments. In some embodiments, the UE 104 may include circuitry to perform the traffic-steering operation 200. For example, the UE 104 may include one or more non-transitory computer-readable
15 media having instructions that, when executed, cause the UE to perform the traffic-steering operation 200. Dedicated circuitry may additionally/alternatively be used to perform one or more aspects of the traffic-steering operation 200.

The traffic steering operation 200 may include, at 204, the UE 104 determining RAN assistance parameters. In some embodiments, the UE 104 may determine the RAN
20 assistance parameters by processing messages received from the configuration circuitry 156, which may be in the network controller 148 or the eNB 116. In embodiments in which the configuration circuitry 156 is located in the network controller 148, the RAN assistance parameters may be provided to the UE 104 through the eNB 116. The RAN assistance parameters may be provided to the UE 104 from the eNB 116 through dedicated
25 or broadcast signaling.

The traffic steering operation may include, at 208, the UE 104 determining whether conditions of the access networks (ANs), for example, the EUTRAN and the WLAN, satisfy ANSTS rules for a predetermined period of time. The determination at 208 may be based on the RAN assistance parameters received at 204. The UE 104 may set a
30 timer with a value, for example, TSteeringWLAN, and may monitor the conditions until expiration of the timer.

The conditions of the ANs may be determined by direct measurement, from reports from nodes of the ANs, for example, AP 124 or eNB 116, or a combination of the two.

If, at 208, the UE determines the ANs satisfy the predetermined conditions for the predetermined period of time, the UE may steer traffic to the appropriate access network at 212. In some embodiments, the access stratum of the control circuitry 108 may monitor the conditions and notify a non-access stratum of the control circuitry 108 of the satisfaction of the conditions. At such time, the non-access stratum may initiate transfer of traffic, for example, all EPS bearers of a particular APN, to the targeted access node.

Figure 3 is a flowchart depicting a configuration operation 300 of network node, for example, eNB 116 or network controller 148, in accordance with some embodiments. In some embodiments, the network node may include circuitry to perform the configuration operation 300. For example, the network node may include one or more non-transitory computer-readable media having instructions that, when executed, cause the network node to perform the configuration operation 300. Dedicated circuitry may additionally/alternatively be used to perform one or more aspects of the configuration operation 300. In some embodiments, some of the aspects of the configuration operation 300 may be performed by a first network node, for example, network controller 148, while other aspects of the configuration operation 300 may be performed by a second network node, for example, eNB 116.

The configuration operation 300 may include, at 304, the network node determining RAN access parameters. In some embodiments, the network node may be preconfigured with at least some of the RAN access parameters (WLAN identifiers) or receive them in reports from other nodes. In some embodiments, the network node may calculate at least some of the RAN access parameters. For example, the network node may calculate various thresholds based on its load.

The configuration operation 300 may include, at 308, transmitting system information (SI) messages that include the RAN access parameters. The SI messages may include SystemInformationBlockType1 SystemInformationBlockType17, or SystemInformationBlockType18 messages as discussed above. In some embodiments, the SI messages may be transmitted (periodically, event-driven, or otherwise) as broadcast signaling.

The configuration operation 300 may include, at 312, the network node determining whether dedicated signaling is needed. Dedicated signaling may be used if the network node determines specific or updated RAN access parameters should be provided to a particular UE.

If, at 312, it is determined that dedicated signaling is not needed, the configuration operation 300 may loop back to the transmission of the SI messages.

If, at 312, it is determined that dedicated signaling is needed, the configuration operation 300 may advance to 316 with the network node transmitting an RRC message
5 that includes any specific or updated RAN access parameters to the UE.

Following 316, the configuration operation 300 may loop back to the transmission of the SI messages at 308.

The UE 104, eNB 116, or network controller 148 as described herein may be implemented into a system using any suitable hardware, firmware, or software configured
10 as desired. Figure 4 illustrates, for one embodiment, an example system 400 comprising radio frequency (RF) circuitry 404, baseband circuitry 408, application circuitry 412, memory/storage 416, display 420, camera 424, sensor 428, input/output (I/O) interface 432, or network interface 436 coupled with each other as shown.

The application circuitry 412 may include circuitry such as, but not limited to, one
15 or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with memory/storage 416 and configured to execute instructions stored in the memory/storage 416 to enable various applications or operating systems running on the system 400.

20 The baseband circuitry 408 may include circuitry such as, but not limited to, one or more single-core or multi-core processors such as, for example, a baseband processor. The baseband circuitry 408 may handle various radio control functions that enable communication with one or more radio access networks via the RF circuitry 404. The radio control functions may include, but are not limited to, signal modulation, encoding,
25 decoding, radio frequency shifting, etc. In some embodiments, the baseband circuitry 408 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 408 may support communication with an EUTRAN or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), or a wireless personal area network (WPAN). Embodiments in
30 which the baseband circuitry 408 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

In various embodiments, baseband circuitry 408 may include circuitry to operate with signals that are not strictly considered as being in a baseband frequency. For

example, in some embodiments, baseband circuitry 408 may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

In some embodiments, the control circuitry 108 or 140, or the configuration
5 circuitry 156 may be embodied in the application circuitry 412 or the baseband circuitry 408.

RF circuitry 404 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 404 may include switches, filters, amplifiers, etc., to
10 facilitate the communication with the wireless network.

In various embodiments, RF circuitry 404 may include circuitry to operate with signals that are not strictly considered as being in a radio frequency. For example, in some embodiments, RF circuitry 404 may include circuitry to operate with signals having an intermediate frequency, which is between a baseband frequency and a radio frequency.

15 In some embodiments, the EUTRAN radio 112, the WLAN radio 120, or the wireless transceiver 136 may be embodied in the RF circuitry 404.

In some embodiments, some or all of the constituent components of the baseband circuitry 408, the application circuitry 412, or the memory/storage 416 may be implemented together on a system on a chip (SOC).

20 Memory/storage 416 may be used to load and store data or instructions, for example, for system 400. Memory/storage 416 for one embodiment may include any combination of suitable volatile memory (e.g., dynamic random access memory (DRAM)) or non-volatile memory (e.g., Flash memory).

In various embodiments, the I/O interface 432 may include one or more user
25 interfaces designed to enable user interaction with the system 400 or peripheral component interfaces designed to enable peripheral component interaction with the system 400. User interfaces may include, but are not limited to, a physical keyboard or keypad, a touchpad, a speaker, a microphone, etc. Peripheral component interfaces may include, but are not limited to, a non-volatile memory port, a universal serial bus (USB) port, an audio
30 jack, and a power supply interface.

In various embodiments, sensor 428 may include one or more sensing devices to determine environmental conditions or location information related to the system 400. In some embodiments, the sensors may include, but are not limited to, a gyro sensor, an

accelerometer, a proximity sensor, an ambient light sensor, and a positioning unit. The positioning unit may also be part of, or interact with, the baseband circuitry 408 or RF circuitry 404 to communicate with components of a positioning network, e.g., a global positioning system (GPS) satellite.

5 In various embodiments, the display 420 may include a display (e.g., a liquid crystal display, a touch screen display, etc.).

 In various embodiments, the network interface 436 may include circuitry to communicate over one or more wired networks. The transceiver 144 or 152 may be embodied in the network interface 436.

10 In various embodiments, the system 400 may be a mobile computing device such as, but not limited to, a laptop computing device, a tablet computing device, a netbook, an ultrabook, a smartphone, etc.; or a network node, e.g., an eNB or network controller. In various embodiments, system 400 may have more or fewer components, or different architectures.

15 The following paragraphs describe examples of various embodiments.

 Example 1 includes a user equipment (UE) comprising: a first radio to communicate via an evolved universal terrestrial radio access network (EUTRAN); a second radio to communicate via a wireless local area network (WLAN); and control circuitry coupled with the first and second radios, the control circuitry to receive, in a
20 broadcast system information block or a radio resource control (RRC) connection reconfiguration message dedicated to the UE, radio access network (RAN) assistance parameters for access network selection and traffic steering between the EUTRAN and the WLAN; and steer traffic through the first radio or the second radio based on the RAN assistance parameters.

25 Example 2 includes the UE of example 1, wherein the RAN assistance parameters are first RAN assistance parameters in the RRC connection reconfiguration message, and the control circuitry is further to: receive second RAN assistance parameters in the system information block; discard the second RAN assistance parameters; and
 save the first RAN assistance parameters.

30 Example 3 includes the UE of any of examples 1-2, wherein the control circuitry is to receive the RAN assistance parameters in an information element in the RRC connection reconfiguration message.

Example 4 includes the UE of example 3, wherein the RAN assistance parameters include a timer value and the control circuitry is to: set a timer with the timer value; start the timer upon entering an RRC idle mode; and discard the RAN assistance parameters received in RRC connection reconfiguration message upon expiration of the timer.

5 Example 5 includes the UE of any of examples 1-4, wherein the RAN assistance parameters include a WLAN identifier that corresponds to the WLAN, a reference signal received power (RSRP) threshold value, and a reference signal received quality (RSRQ) threshold value, and the control circuitry is further to: transmit traffic over the EUTRAN via the first radio; determine that a measured cell receive level value of the EUTRAN is
10 less than the RSRP threshold or a measured cell quality value of the EUTRAN is less than the RSRQ threshold; and steer traffic to the WLAN via the second radio based on said determination that the measured RSRP of the EUTRAN is less than the RSRP threshold or the measured RSRQ of the EUTRAN is less than the RSRQ threshold.

 Example 6 includes the UE of example 5, wherein the RAN assistance parameters
15 further include a WLAN channel utilization threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, and a WLAN beacon received signal strength indicator (RSSI) threshold, and the control circuitry is further to: determine that a WLAN channel utilization is less than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, a
20 WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and a beacon RSSI is greater than the WLAN beacon RSSI threshold; and steer traffic to the WLAN via the second radio based further on said determination that the WLAN channel utilization is less than the WLAN channel utilization threshold, the WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, the
25 WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and the beacon RSSI is greater than the WLAN beacon RSSI threshold.

 Example 7 includes the UE of any of examples 1-6, wherein the RAN assistance parameters include a WLAN channel utilization threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, a WLAN beacon received signal
30 strength indicator (RSSI) threshold, and a WLAN beacon received signal strength indicator (RSSI) threshold; and the controller is further to: transmit traffic over the WLAN via the second radio; determine a WLAN channel utilization is greater than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is less than the WLAN

downlink backhaul rate threshold, a WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or a beacon RSSI is less than the WLAN beacon RSSI threshold; and steer traffic to the EUTRAN via the first radio based on said determination that the WLAN channel utilization is greater than the WLAN channel utilization threshold,
 5 the WLAN downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or the beacon RSSI is less than the WLAN beacon RSSI threshold.

Example 8 includes the UE of example 7, wherein the RAN assistance parameters further include a reference signal received power (RSRP) threshold value and a reference
 10 signal received quality (RSRQ) threshold value, and the control circuitry is further to: determine a measured cell receive level value of the EUTRAN is greater than the RSRP threshold and a measured cell quality value of the EUTRAN is greater than the RSRQ threshold; and steer traffic to the EUTRAN via the first radio based on said determination that the measured cell receive level value corresponding to the EUTRAN is greater than
 15 the RSRP threshold and the measured cell quality value corresponding to the EUTRAN is greater than the RSRQ threshold.

Example 9 includes the UE of any of examples 1-8, further comprising: multi-mode baseband circuitry coupled with the first and second radios.

Example 10 includes enhanced node B (eNB) circuitry comprising: control
 20 circuitry to determine a set of RAN assistance parameters for each of a plurality of public land mobile networks (PLMNs) served by the eNB, wherein individual sets of the RAN assistance parameters include first evolved universal terrestrial radio access network (EUTRAN) thresholds for steering traffic from an EUTRAN to a wireless local area network (WLAN), second EUTRAN thresholds for steering traffic from a WLAN to an
 25 EUTRAN, first WLAN thresholds for steering traffic from an EUTRAN to a WLAN, and second WLAN thresholds for steering traffic from a WLAN to an EUTRAN; and to generate dedicated or broadcast signaling messages that include the RAN assistance parameters for each of the plurality of PLMNs; and a wireless transceiver to transmit the dedicated or broadcast signaling messages to one or more user equipments (UEs) in the
 30 EUTRAN cell.

In some embodiments, the eNB circuitry of example 10 may further include a transceiver to receive a first RAN assistance parameter of the set of RAN assistance

parameters from a network node, wherein the first RAN assistance parameter is a WLAN identifier.

Example 11 includes the eNB circuitry of example 10, wherein the control circuitry is to generate system information blocks that include the RAN assistance parameters and the wireless transceiver is to transmit the system information blocks.

Example 12 includes the eNB circuitry of example 10, wherein the control circuitry is to generate a radio resource control (RRC) connection reconfiguration message that includes the RAN assistance parameters, and the wireless transceiver is to transmit the RRC connection reconfiguration messages.

Example 13 includes the eNB circuitry of any of examples 10-12, wherein the first EUTRAN thresholds include a first reference signal received power (RSRP) threshold or a first reference signal received quality (RSRQ) threshold, and the second EUTRAN thresholds include a second RSRQ threshold or a second RSRQ threshold.

Example 14 includes the eNB circuitry of any of examples 10-13, wherein the first WLAN thresholds include a first channel utilization threshold, a first WLAN downlink backhaul rate threshold, a first WLAN uplink backhaul rate, or a first WLAN beacon received signal strength indicator (RSSI) and the second WLAN thresholds include a second channel utilization threshold, a second WLAN downlink backhaul rate threshold, a second WLAN uplink backhaul rate, or a second WLAN beacon received signal strength indicator (RSSI).

Example 15 includes one or more non-transitory computer-readable media having instructions that, when executed, cause a user equipment (UE) to: process a system information message or a radio resource control (RRC) message to determine radio access network (RAN) assistance parameters; determine conditions of first and second access networks; determine that the conditions of the first and second access networks satisfy access network selection and traffic steering (ANSTS) rules for a predetermined period of time based on the RAN assistance parameters; and steer traffic from the first access network to the second access network based on said determination that the conditions of the first and second access networks satisfy the ANSTS for the predetermined period of time.

Example 16 includes the one or more non-transitory computer-readable media of example 15, wherein the RAN assistance parameters include first evolved universal terrestrial radio access network (EUTRAN) thresholds for steering traffic from an

EUTRAN to a wireless local area network (WLAN), second EUTRAN thresholds for steering traffic from a WLAN to an EUTRAN, first WLAN thresholds for steering traffic from an EUTRAN to a WLAN, and second WLAN thresholds for steering traffic from a WLAN to an EUTRAN.

5 Example 17 includes the one or more non-transitory computer-readable media of any of examples 15-16, wherein the first access network is an evolved universal terrestrial radio access network (EUTRAN), the second access network is a wireless local area network (WLAN), the RAN assistance parameters include a WLAN identifier that corresponds to the WLAN, a reference signal received power (RSRP) threshold value, and
 10 a reference signal received quality (RSRQ) threshold value, and the instructions, when executed, further cause the UE to: determine that a measured cell receive level value of the EUTRAN is less than the RSRP threshold or a measured cell quality value of the EUTRAN is less than the RSRQ threshold; and steer traffic to the WLAN based on said determination that the measured RSRP of the EUTRAN is less than the RSRP threshold or
 15 the measured RSRQ of the EUTRAN is less than the RSRQ threshold.

 Example 18 includes the one or more non-transitory computer-readable media of example 17, wherein the RAN assistance parameters further include a WLAN channel utilization threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, and a WLAN beacon received signal strength indicator (RSSI)
 20 threshold, and the instructions, when executed, further cause the UE to: determine that a WLAN channel utilization is less than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and a beacon RSSI is greater than the WLAN beacon RSSI threshold; and steer traffic to the
 25 WLAN based further on said determination that the WLAN channel utilization is less than the WLAN channel utilization threshold, the WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and the beacon RSSI is greater than the WLAN beacon RSSI threshold.

30 Example 19 includes the one or more non-transitory computer-readable media of any of examples 15-18, wherein the first access network is a wireless local area network (WLAN), the second access network is an evolved universal terrestrial radio access network (EUTRAN), the RAN assistance parameters include a WLAN channel utilization

threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, a WLAN beacon received signal strength indicator (RSSI) threshold, and a WLAN beacon received signal strength indicator (RSSI) threshold; and the instructions, when executed, further cause the UE to: determine a WLAN channel utilization is greater
 5 than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or a beacon RSSI is less than the WLAN beacon RSSI threshold; and steer traffic to the EUTRAN based on said determination that the WLAN channel utilization is greater than the WLAN channel utilization threshold, the
 10 WLAN downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or the beacon RSSI is less than the WLAN beacon RSSI threshold.

Example 20 includes the one or more non-transitory computer-readable media of example 19, wherein the RAN assistance parameters further include a reference signal
 15 received power (RSRP) threshold value and a reference signal received quality (RSRQ) threshold value, and the instructions, when executed, further cause the UE to: determine a measured cell receive level value of the EUTRAN is greater than the RSRP threshold and a measured cell quality value of the EUTRAN is greater than the RSRQ threshold; and steer traffic to the EUTRAN based on said determination that the measured cell receive
 20 level value corresponding to the EUTRAN is greater than the RSRP threshold and the measured cell quality value corresponding to the EUTRAN is greater than the RSRQ threshold.

Example 21 includes a user equipment (UE) comprising: means for processing a system information message or a radio resource control (RRC) message to determine radio
 25 access network (RAN) assistance parameters; means for determining conditions of first and second access networks; means for determining that the conditions of the first and second access networks satisfy access network selection and traffic steering (ANSTS) rules for a predetermined period of time based on the RAN assistance parameters; and means for steering traffic from the first access network to the second access network based
 30 on said determination that the conditions of the first and second access networks satisfy the ANSTS for the predetermined period of time.

Example 22 includes the UE of example 21, wherein the RAN assistance parameters include first evolved universal terrestrial radio access network (EUTRAN)

thresholds for steering traffic from an EUTRAN to a wireless local area network (WLAN), second EUTRAN thresholds for steering traffic from a WLAN to an EUTRAN, first WLAN thresholds for steering traffic from an EUTRAN to a WLAN, and second WLAN thresholds for steering traffic from a WLAN to an EUTRAN.

5 Example 23 includes the UE of any of examples 21-22, wherein the first access network is an evolved universal terrestrial radio access network (EUTRAN), the second access network is a wireless local area network (WLAN), the RAN assistance parameters include a WLAN identifier that corresponds to the WLAN, a reference signal received power (RSRP) threshold value, and a reference signal received quality (RSRQ) threshold
10 value, and the UE further comprises: means for determining that a measured cell receive level value of the EUTRAN is less than the RSRP threshold or a measured cell quality value of the EUTRAN is less than the RSRQ threshold; and means for steering traffic to the WLAN based on said determination that the measured RSRP of the EUTRAN is less than the RSRP threshold or the measured RSRQ of the EUTRAN is less than the RSRQ
15 threshold.

 Example 24 includes the UE of example 23, wherein the RAN assistance parameters further include a WLAN channel utilization threshold, a WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate threshold, and a WLAN beacon received signal strength indicator (RSSI) threshold, and the UE further comprises: means
20 for determining that a WLAN channel utilization is less than the WLAN channel utilization threshold, a WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and a beacon RSSI is greater than the WLAN beacon RSSI threshold; and means for steering traffic to the WLAN based further on said
25 determination that the WLAN channel utilization is less than the WLAN channel utilization threshold, the WLAN downlink backhaul rate is greater than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is greater than the WLAN uplink backhaul rate threshold, and the beacon RSSI is greater than the WLAN beacon RSSI threshold.

30 Example 25 includes the UE of any of examples 21-24, wherein the first access network is a wireless local area network (WLAN), the second access network is an evolved universal terrestrial radio access network (EUTRAN), the RAN assistance parameters include a WLAN channel utilization threshold, a WLAN downlink backhaul

rate threshold, a WLAN uplink backhaul rate threshold, a WLAN beacon received signal strength indicator (RSSI) threshold, and a WLAN beacon received signal strength indicator (RSSI) threshold; and the UE further comprises: means for determining a WLAN channel utilization is greater than the WLAN channel utilization threshold, a WLAN
5 downlink backhaul rate is less than the WLAN downlink backhaul rate threshold, a WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or a beacon RSSI is less than the WLAN beacon RSSI threshold; and means for steering traffic to the EUTRAN based on said determination that the WLAN channel utilization is greater than the WLAN channel utilization threshold, the WLAN downlink backhaul rate is less
10 than the WLAN downlink backhaul rate threshold, the WLAN uplink backhaul rate is less than the WLAN uplink backhaul rate threshold, or the beacon RSSI is less than the WLAN beacon RSSI threshold.

Example 26 includes the UE of example 25, wherein the RAN assistance parameters further include a reference signal received power (RSRP) threshold value and a
15 reference signal received quality (RSRQ) threshold value, and the UE further comprises: means for determining a measured cell receive level value of the EUTRAN is greater than the RSRP threshold and a measured cell quality value of the EUTRAN is greater than the RSRQ threshold; and means for steering traffic to the EUTRAN based on said determination that the measured cell receive level value corresponding to the EUTRAN is
20 greater than the RSRP threshold and the measured cell quality value corresponding to the EUTRAN is greater than the RSRQ threshold.

Example 27 includes a method of operating an enhanced node B (eNB) comprising: receiving a set of RAN assistance parameters for each of a plurality of public land mobile networks (PLMNs) served by the eNB, wherein individual sets of the RAN
25 assistance parameters include first evolved universal terrestrial radio access network (EUTRAN) thresholds for steering traffic from an EUTRAN to a wireless local area network (WLAN), second EUTRAN thresholds for steering traffic from a WLAN to an EUTRAN, first WLAN thresholds for steering traffic from an EUTRAN to a WLAN, and second WLAN thresholds for steering traffic from a WLAN to an EUTRAN; generating
30 dedicated or broadcast signaling messages that include the RAN assistance parameters for each of the plurality of PLMNs; and transmitting the dedicated or broadcast signaling messages to one or more user equipments (UEs) in the EUTRAN cell.

Example 28 includes the method of example 27, wherein said generating comprises generating system information blocks that include the RAN assistance parameters and said transmitting comprises transmitting the system information blocks.

Example 29 includes the method of example 27, wherein said generating
5 comprises generating a radio resource control (RRC) connection reconfiguration message that includes the RAN assistance parameters, and the wireless transceiver is to transmit the RRC connection reconfiguration messages.

Example 30 includes the method of any of examples 27-29, wherein the first
10 EUTRAN thresholds include a first reference signal received power (RSRP) threshold or a first reference signal received quality (RSRQ) threshold, and the second EUTRAN thresholds include a second RSRQ threshold or a second RSRQ threshold.

Example 31 includes the method of any of examples 27-30, wherein the first
15 WLAN thresholds include a first channel utilization threshold, a first WLAN downlink backhaul rate threshold, a first WLAN uplink backhaul rate, or a first WLAN beacon received signal strength indicator (RSSI) and the second WLAN thresholds include a second channel utilization threshold, a second WLAN downlink backhaul rate threshold, a second WLAN uplink backhaul rate, or a second WLAN beacon received signal strength indicator (RSSI).

Example 32 includes an apparatus to perform the method of any of examples 27-
20 31.

Example 33 includes one or more non-transitory, computer-readable media having instructions that, when executed, cause an eNB to perform the methods of any of examples 27-31.

The description herein of illustrated implementations, including what is described
25 in the Abstract, is not intended to be exhaustive or to limit the present disclosure to the precise forms disclosed. While specific implementations and examples are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the disclosure, as those skilled in the relevant art will recognize. These modifications may be made to the disclosure in light of the above detailed description.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. One or more computer-readable media having instructions that, when executed, cause a user equipment ("UE") to:
 - 5 determine, based on a radio resource control ("RRC") connection reconfiguration message or a system information block message, radio access network ("RAN") assistance parameters for access network selection and traffic steering between an evolved universal terrestrial radio access network ("EUTRAN") and a wireless local area network ("WLAN"), wherein the RAN assistance parameters include: a WLAN beacon
10 received signal strength indicator ("RSSI") threshold; and an EUTRAN reference signal received power ("RSRP") threshold or an EUTRAN reference signal received quality ("RSRQ") threshold;
determine an EUTRAN RSRP or an EUTRAN RSRQ;
determine, based on a beacon in the WLAN, a WLAN RSSI;
 - 15 determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI being greater than the WLAN beacon RSSI threshold;
steer traffic from a first radio of the UE that communicates via the EUTRAN to a
20 second radio of the UE that communicates via the WLAN based on said determination that the plurality of steering conditions are met for the predetermined time interval.
2. The one or more computer-readable media of claim 1, wherein the instructions, when executed, further cause the user equipment to:
 - 25 determine, based on a message from an eNB of the EUTRAN, an identifier; and
identify the WLAN based on the identifier.
3. The one or more computer-readable media of claim 2, wherein the identifier is a service set identifier, a basic service set identifier, or a homogenous extended service set identifier.
4. The one or more computer-readable media of any one of claims 1 to 3, wherein
30 the RAN assistance parameters further include a WLAN channel utilization threshold and

the plurality of steering conditions further include a channel utilization of the WLAN being less than the WLAN channel utilization threshold.

5. The one or more computer-readable media of any one of claims 1 to 3, wherein the RAN assistance parameters further include a WLAN downlink backhaul rate threshold and the plurality of steering conditions further include an available downlink bandwidth of the WLAN being greater than the downlink WLAN backhaul rate threshold.
6. The one or more computer-readable media of any one of claims 1 to 3, wherein the RAN assistance parameters further include a WLAN uplink backhaul rate threshold and the plurality of steering conditions further include an available uplink bandwidth of the WLAN being greater than the uplink WLAN backhaul rate threshold.
7. The one or more computer-readable media of any one of claims 1 to 3, wherein the RAN assistance parameters further include a timer parameter to provide the predetermined time interval.
8. An apparatus comprising:
 - a wireless local area network (“WLAN”) radio to receive a beacon from a WLAN;
 - a cellular radio to receive a radio resource control (“RRC”) connection reconfiguration message or a system information block (“SIB”) message from an evolved universal terrestrial radio access network (“EUTRAN”); and
 - control circuitry coupled with the WLAN radio and the cellular radio, the control circuitry to:
 - determine, based on the RRC connection reconfiguration message or the SIB message, radio access network (“RAN”) assistance parameters for access network selection and traffic steering between the EUTRAN and the WLAN, wherein the RAN assistance parameters include: a WLAN beacon received signal strength indicator (“RSSI”) threshold; and an EUTRAN reference signal received power (“RSRP”) threshold or an EUTRAN reference signal received quality (“RSRQ”) threshold;
 - determine an EUTRAN RSRP or an EUTRAN RSRQ;
 - determine, based on the beacon, a WLAN RSSI;
 - determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the

EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI being greater than the WLAN beacon RSSI threshold; and

steer traffic from the cellular radio to the WLAN radio based on said determination that
5 the plurality of steering conditions are met for the predetermined time interval.

9. The apparatus of claim 8, wherein the control circuitry is further to:
determine, based on a message from an eNB of the EUTRAN, an identifier; and
identify the WLAN based on the identifier.

10. The apparatus of claim 9, wherein the identifier is a service set identifier, a basic
10 service set identifier, or a homogenous extended service set identifier.

11. The apparatus of any one of claims 8 to 10, wherein the RAN assistance
parameters further include: a WLAN channel utilization threshold and the plurality of
steering conditions further include a channel utilization of the WLAN being less than the
WLAN channel utilization threshold; a WLAN downlink backhaul rate threshold and the
15 plurality of steering conditions further include an available downlink bandwidth of the
WLAN being greater than the downlink WLAN backhaul rate threshold; or a WLAN
uplink backhaul rate threshold and the plurality of steering conditions further include an
available uplink bandwidth of the WLAN being greater than the uplink WLAN backhaul
rate threshold.

20 12. The apparatus of any one of claims 8 to 10, wherein the RAN assistance
parameters further include a timer parameter to provide the predetermined time interval.

13. An apparatus of a user equipment ("UE"), the apparatus comprising:
access stratum circuitry to:

25 determine, based on a radio resource control ("RRC") connection reconfiguration
message or a system information block message, radio access network ("RAN")
assistance parameters for access network selection and traffic steering between an
evolved universal terrestrial radio access network ("EUTRAN") and a wireless local
area network ("WLAN"), wherein the RAN assistance parameters include: a
WLAN beacon received signal strength indicator ("RSSI") threshold; and an

- EUTRAN reference signal received power (“RSRP”) threshold or an EUTRAN reference signal received quality (“RSRQ”) threshold;
determine an EUTRAN RSRP or an EUTRAN RSRQ;
determine, based on a beacon in the WLAN, a WLAN RSSI;
5 determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being less than the EUTRAN RSRP threshold or the EUTRAN RSRQ being less than the EUTRAN RSRQ threshold; and the WLAN RSSI being greater than the WLAN beacon RSSI threshold; and
10 non-access stratum circuitry to: receive an indication from the access stratum circuitry that the plurality of steering conditions are met for the predetermined time interval and steer traffic from a first radio of the UE that communicates via the EUTRAN to a second radio of the UE that communicates via the WLAN based on said indication.
14. The apparatus of claim 13, wherein the RAN assistance parameters further
15 include: a WLAN channel utilization threshold and the plurality of steering conditions further include a channel utilization of the WLAN being less than the WLAN channel utilization threshold; a WLAN downlink backhaul rate threshold and the plurality of steering conditions further include an available downlink bandwidth of the WLAN being greater than the downlink WLAN backhaul rate threshold; or a WLAN uplink backhaul
20 rate threshold and the plurality of steering conditions further include an available uplink bandwidth of the WLAN being greater than the uplink WLAN backhaul rate threshold.
15. The apparatus of claim 13 or 14, wherein the RAN assistance parameters further include a timer parameter to provide the predetermined time interval.
16. One or more computer-readable media having instructions that, when executed,
25 cause a user equipment (“UE”) to:
determine, based on a radio resource control (“RRC”) connection reconfiguration message or a system information block message, radio access network (“RAN”) assistance parameters for access network selection and traffic steering between an evolved universal terrestrial radio access network (“EUTRAN”) and a wireless local area
30 network (“WLAN”), wherein the RAN assistance parameters include: a WLAN beacon received signal strength indicator (“RSSI”) threshold; and an EUTRAN reference signal

received power (“RSRP”) threshold or an EUTRAN reference signal received quality (“RSRQ”) threshold;

determine an EUTRAN RSRP or an EUTRAN RSRQ;

determine, based on a beacon in the WLAN, a WLAN RSSI;

5 determine a plurality of steering conditions are met for a predetermined time interval, the plurality of steering conditions to include: the EUTRAN RSRP being greater than the EUTRAN RSRP threshold and the EUTRAN RSRQ being greater than the EUTRAN RSRQ threshold; and the WLAN RSSI being less than the WLAN beacon RSSI threshold;

10 steer traffic from a first radio of the UE that communicates via the WLAN to a second radio of the UE that communicates via the EUTRAN based on said determination that the plurality of steering conditions are met for the predetermined time interval.

17. The one or more computer-readable media of claim 16, wherein the instructions, when executed, further cause the user equipment to:

15 determine, based on a message from an eNB of the EUTRAN, an identifier; and identify the WLAN based on the identifier.

18. The one or more computer-readable media of claim 17, wherein the identifier is a service set identifier, a basic service set identifier, or a homogenous extended service set identifier.

20 19. The one or more computer-readable media of any one of claims 16 to 18, wherein the RAN assistance parameters further include: a WLAN channel utilization threshold and the plurality of steering conditions further include a channel utilization of the WLAN being greater than the WLAN channel utilization threshold; a WLAN downlink backhaul rate threshold and the plurality of steering conditions further include an available
25 downlink bandwidth of the WLAN being less than the downlink WLAN backhaul rate threshold; or a WLAN uplink backhaul rate threshold and the plurality of steering conditions further include an available uplink bandwidth of the WLAN being less than the uplink WLAN backhaul rate threshold.

20. The one or more computer-readable media of any one of claims 16 to 18, wherein the RAN assistance parameters further include a timer parameter to provide the predetermined time interval.

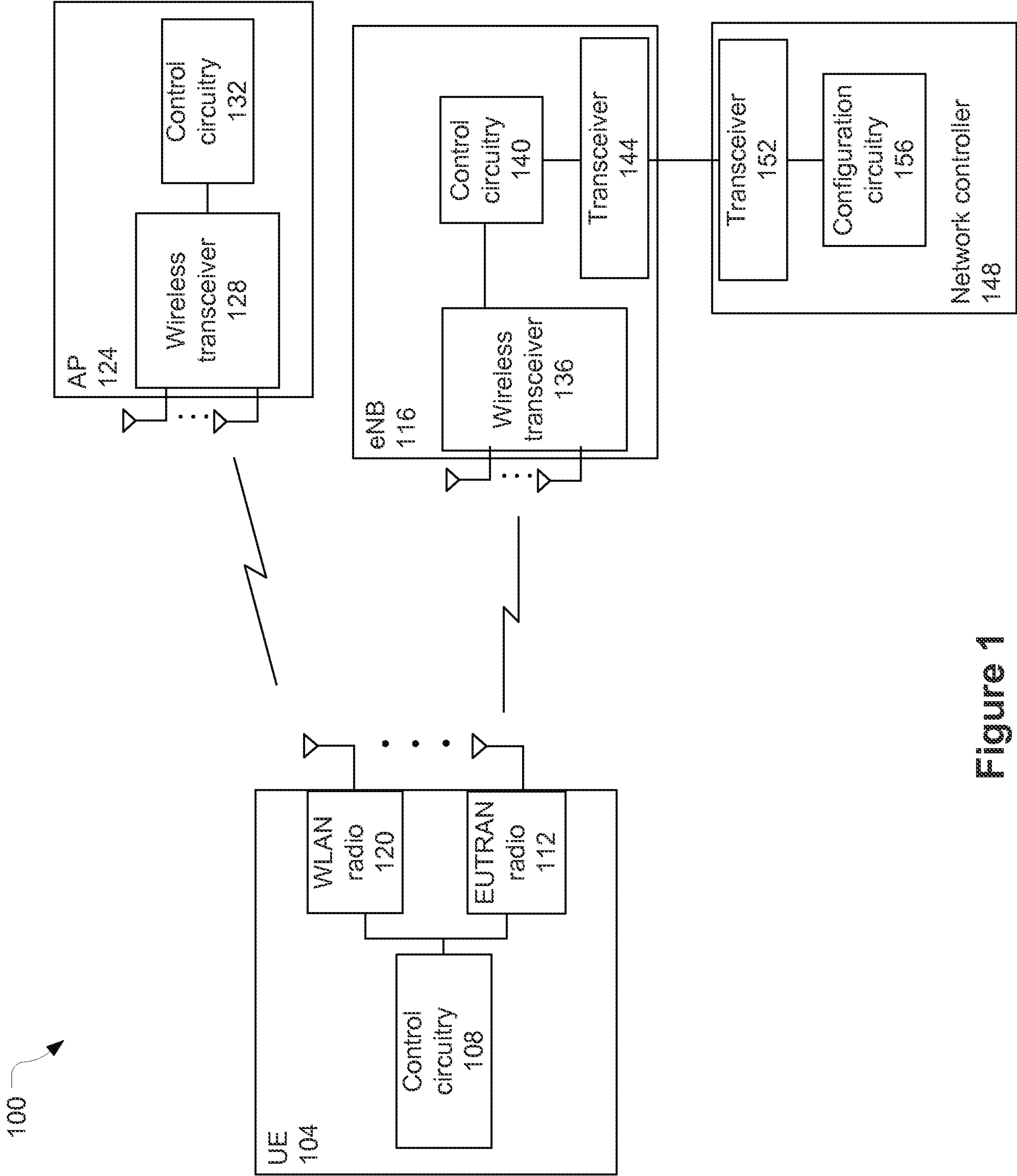
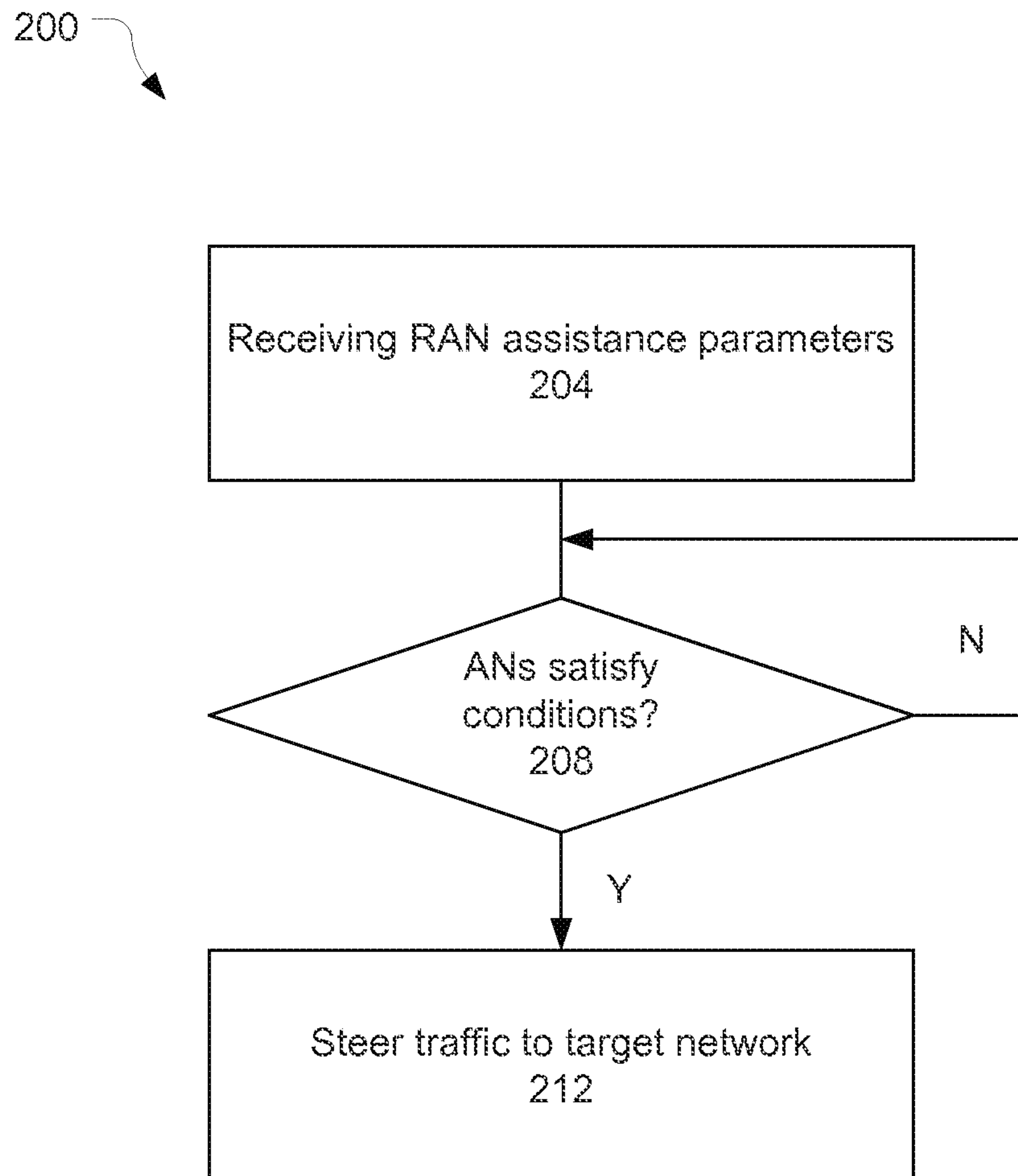
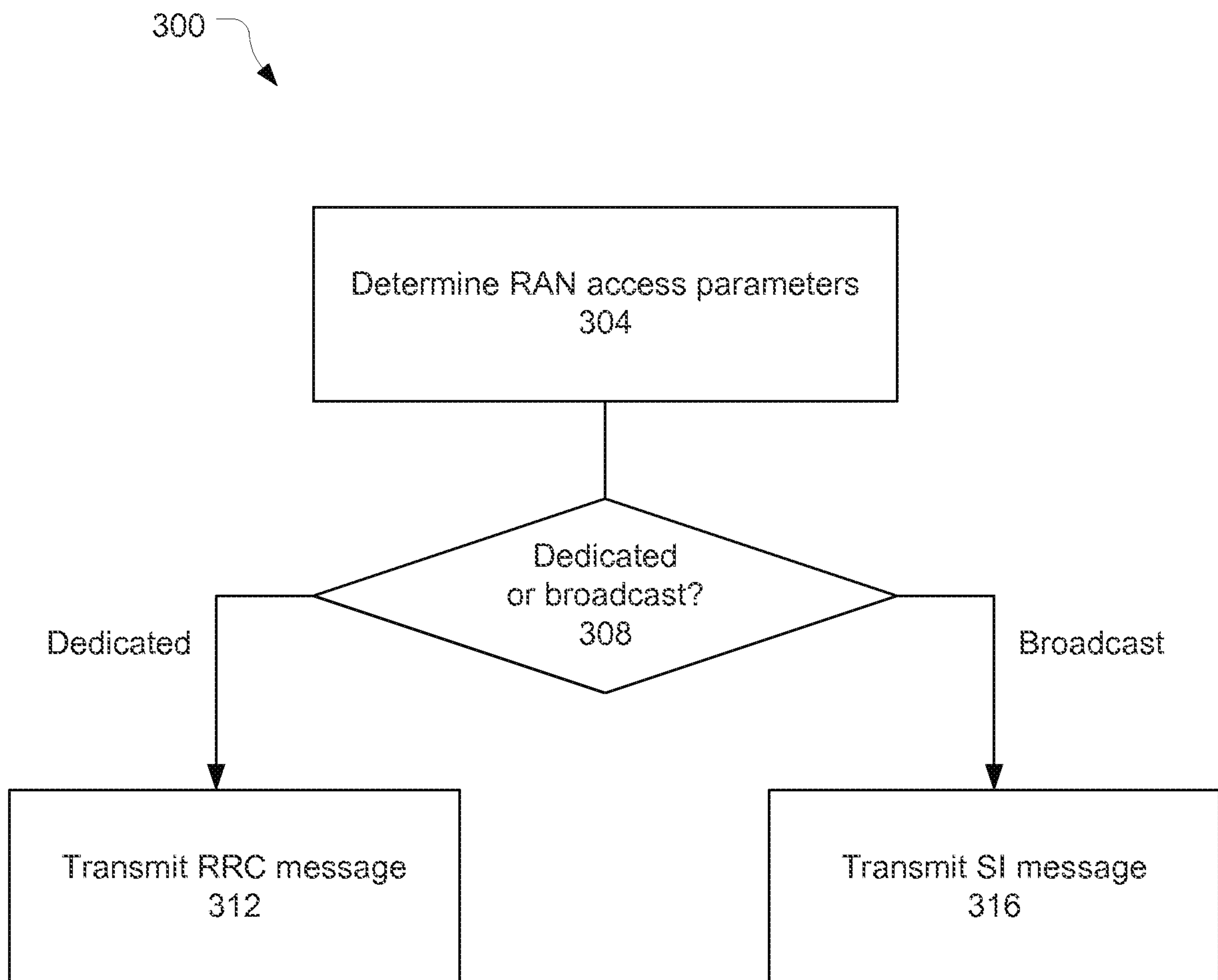


Figure 1

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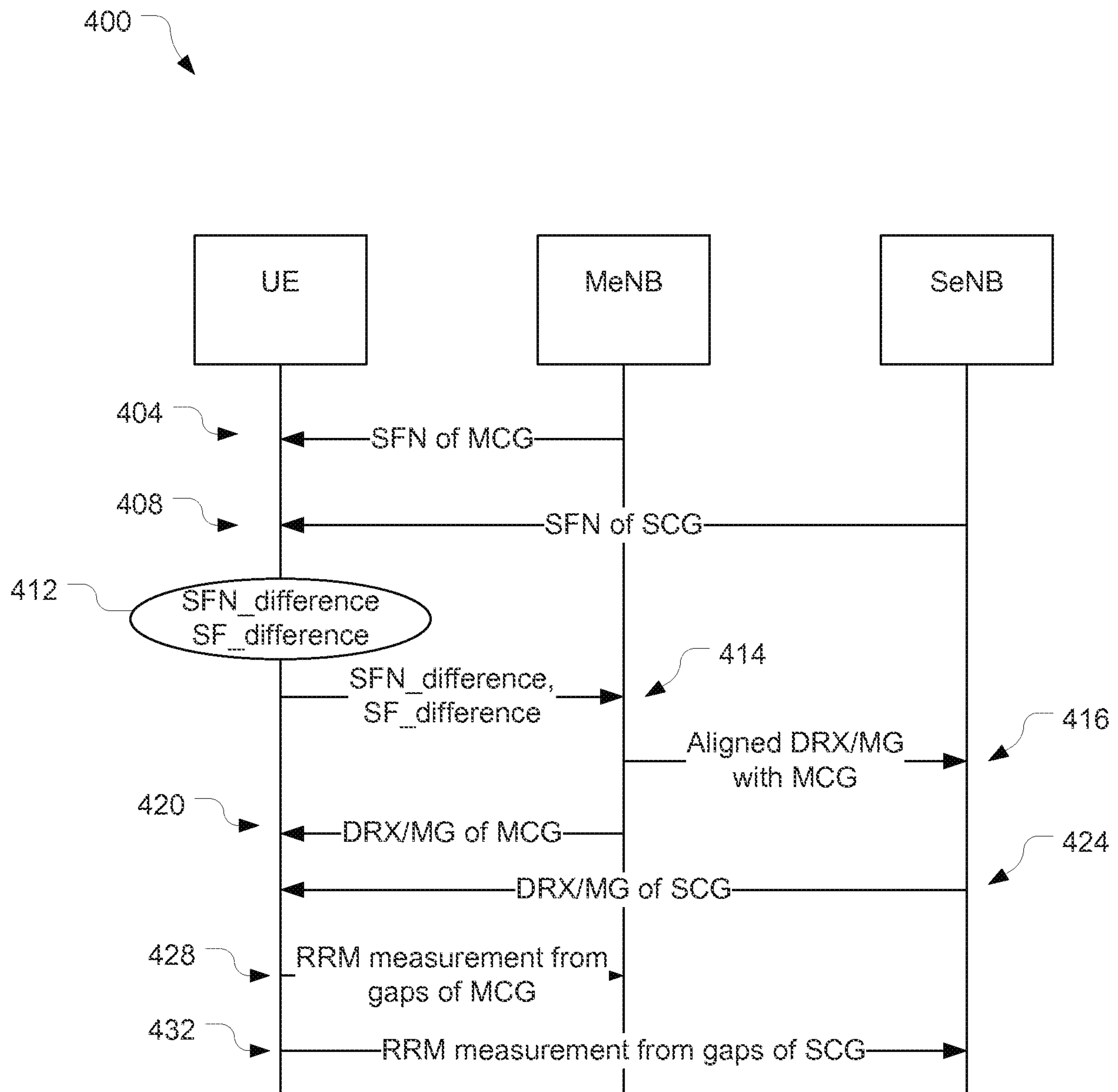


Figure 4

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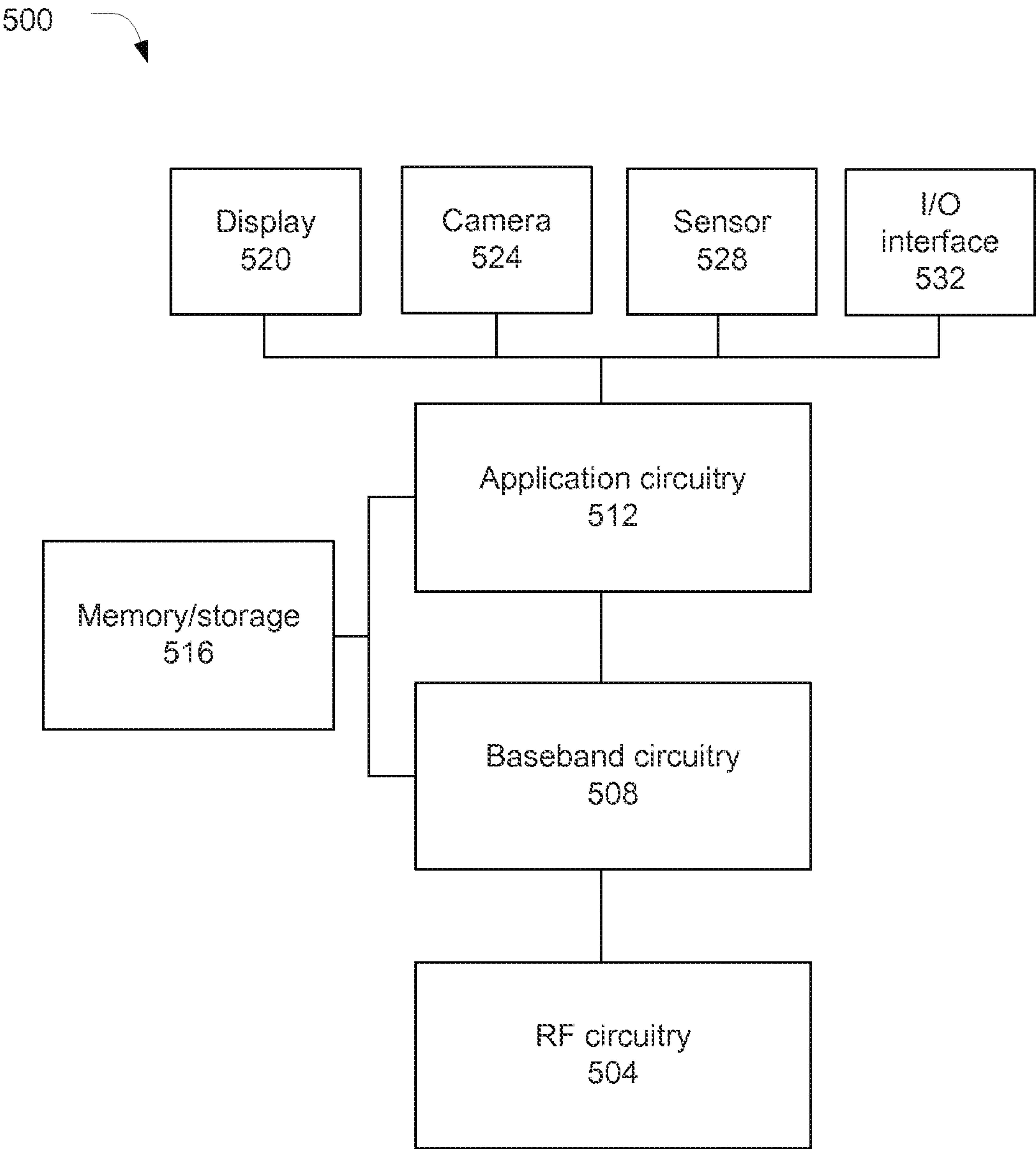


Figure 5

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