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(54) Title: DEVICE IDENTIFICATION IN INTERWORKING WLAN AND WIDE-AREA CELLULAR NETWORKS

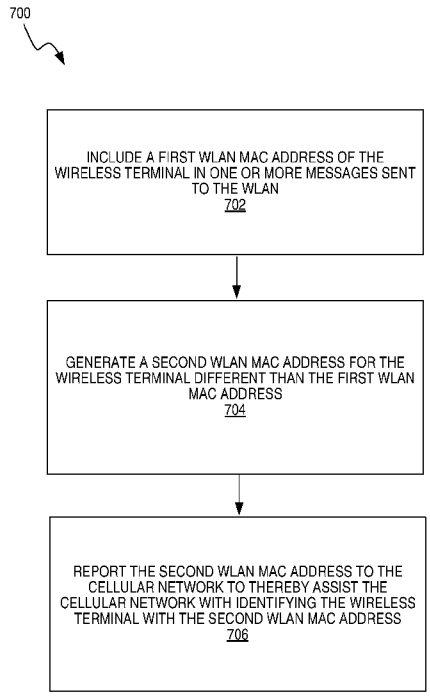

FIG. 7

(57) Abstract: According to one exemplary embodiment a wireless terminal configured for operation in a WLAN and in a wide-area cellular network includes (702) a first WLAN MAC address of the wireless terminal in one or more messages to the WLAN. The wireless terminal generates (704) a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address and reports (706) the second WLAN MAC address to the cellular network. According to other exemplary embodiments the wireless terminal refrains from generating the second WLAN MAC address for certain periods of time or while performing a certain type of WLAN operation. According to still other exemplary embodiments a network node determines that the first WLAN MAC address for the wireless termial has been replaced by a second WLAN MAC address and reports the second WLAN MAC address to the WLAN.

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DEVICE IDENTIFICATION IN INTERWORKING WLAN AND WIDE-AREA CELLULAR NETWORKS

TECHNICAL FIELD

The present invention generally relates to wireless communication networks, and particularly relates to wireless devices in interworking wireless local area network (WLAN) and wide-area cellular networks.

BACKGROUND

The WLAN technology known as "Wi-Fi" can be used to offload traffic from wide-area cellular networks, such as 3GPP cellular networks. Interest in cooperation between WLANs and cellular networks is rapidly increasing, since virtually all smartphones support Wi-Fi. In some Wi-Fi descriptions, the term "Station" (STA) might be used instead of user equipment (UE). Accordingly, any of the terms UE, STA and terminal may be used herein when describing wireless terminals that support both a cellular technology (such as Evolved Universal Terrestrial Radio Access, or E-UTRA) and WLAN.

In a simplified Wi-Fi architecture, the wireless terminal (UE/STA) is connected on the user plane to the Wi-Fi Access Point (AP), which can be directly connected to the Internet. In the control plane, an Access point Controller (AC) may handle the management of the AP. One AC usually handles the management of several APs. Security/authentication of users can be handled via an Authentication, Authorization and Accounting (AAA) entity, which may be a RADIUS server, for example. Remote Administration Dial In User Service (RADIUS) is the most widely used network protocol for providing a centralized AAA management (RFC 2865).

The Access Network Discovery and Selection Function (ANDSF) is an entity defined by 3GPP for providing access discovery information as well as mobility and routing policies to the UE. ANDSF is a new entity added to the 3GPP architecture in Release 8 of 3GPP TS 23.402. A simplified ANDSF architecture is depicted in Figure 1. As shown in the figure, the ANDSF server is only connected to the UE, and its main goal is to provide the UE with access network information in a resource efficient and secure manner. The communication between the UE and the ANDSF server is defined as an IP-based S14-interface.

By supplying information about both available 3GPP and non-3GPP access networks to the UE, the ANDSF enables an energy-efficient mechanism of network discovery, where the UE can avoid continuous and energy-consuming background scanning. Furthermore, ANDSF provides the mobile operators with a tool for the implementation of flexible and efficient UE steering of

access mechanisms, where policy control can guide UEs to select one particular Radio Access Network (RAN) over another.

The ANDSF supplies three types of information – discovery information, inter-system mobility policies (ISMP) and inter-system routing policies (ISRP). All of these are summarized and implemented via ANDSF managed objects (MO), which are communicated to the UEs via an over-the-top (OTT) signaling channel, as SOAP-XML messages.

The discovery information provides the UE with information regarding the availability of different RATs in the UE's vicinity. This helps the UE to discover available 3GPP access networks and non-3GPP access networks, without the burden of continuous background scanning. Inter-System Mobility Policies (ISMP) are policies that guide the UE to select the most preferable 3GPP or non-3GPP access. The ISMPs are used for UEs that access a single access (3GPP or Wi-Fi) at a time. The ISMP information specifies the behavior of UEs that can be connected to only one access network at a given time (either 3GPP, WLAN, WiMAX, etc.). If the UE, however, supports connection to several access networks at the same time, the operator can use the third type of information, ISRP, to increase the granularity of the RAN selection. In that case, the UEs will be provided with policies that specify how the traffic flows should be distributed over the different RAN. For example, voice might be only allowed to be carried over the 3GPP RAN, while Internet video streaming and best-effort traffic can be routed via WLAN. The ANDSF provides mobile operators with a tool to determine how the UEs connect to different RANs, and hence allows them to add more flexibility in their traffic planning.

The main difference between traffic steering to and from WLAN, as compared to steering between 3GPP networks (or 3GPP-"friendly" networks such as CDMA2000), is that in the former case it is generally the terminal that decides when it shall select a WLAN AP, while in the latter case it is the network that is in charge of the network access decisions. For technical and historical reasons, the WLAN deployment scenario is, in many cases, fundamentally different than cellular deployment. For this reason, special considerations have to be made when integrating WLAN to 3GPP networks.

3GPP has specified in Release 12 a feature/mechanism for WLAN/3GPP Radio interworking, which improves operator control with respect to how a UE performs access selection and traffic steering between 3GPP and WLANs belonging to the operator or its partners. It may be that the mechanism can be used for other, non-operator, WLANs as well, though this is not the main target. Version v12.4.0 (2014-01) of 3GPP TS 36.300 supports E-UTRAN assisted UE based bi-

directional traffic steering between E-UTRAN and WLAN for UEs in RRC_IDLE and RRC_CONNECTED.

This solution consists of E-UTRAN providing assistance parameters via broadcast and dedicated RRC signaling to the UE. The RAN assistance parameters may include E-UTRAN signal strength and quality thresholds, WLAN channel utilization thresholds, WLAN backhaul data rate thresholds, WLAN signal strength and quality thresholds and Offload Preference Indicator (OPI). E-UTRAN can also provide a list of WLAN identifiers to the UE via broadcast signaling. WLANs provided by E-UTRAN may include an associated priority.

The UE uses the RAN assistance parameters in the evaluation of traffic steering rules (3GPP TS 36.304) or ANDSF policies (3GPP TS 24.312) for traffic steering decisions between E-UTRAN and WLAN. An example of a traffic steering rule is shown below:

If (RSRP < RSRP_threshold_low) AND (RCPI > RCPI_threshold_high) AND (WLAN_utilization < WLAN_utilization_threshold_low) then
OFFLOAD FROM 3GPP TO WLAN
else
If (RSRP > RSRP_threshold_high) OR (RCPI < RCPI_threshold_low) OR (WLAN_utilization > WLAN_utilization_threshold_low) then
*OFFLOAD FROM WLAN TO 3G*PP.

The OPI is only used in ANDSF policies. WLAN identifiers are only used in traffic steering rules (3GPP TS 36.304). If the UE is provisioned with ANDSF policies, it shall forward the received RAN assistance parameters to upper layers; otherwise, it shall use them in the traffic steering rules (section 23.6.2, 3GPP TS 36.304). The traffic steering rules are applied only to the WLANs of which identifiers are provided by the E-UTRAN.

The UE in RRC_CONNECTED (Radio Resource Control -Connected) state shall apply the parameters obtained via dedicated signaling if such have been received from the serving cell; otherwise, the UE shall apply the parameters obtained via broadcast signaling.

The UE in RRC_IDLE state shall keep and apply the parameters obtained via dedicated signaling, until cell reselection or a timer has expired since the UE entered RRC_IDLE upon which the UE shall apply the parameters obtained via broadcast signaling. In the case of RAN sharing, each public land mobile network (PLMN) sharing the RAN can provide independent sets of RAN assistance parameters.

As mentioned above, a network-assisted WLAN interworking mechanism for Release 12 has been specified for 3GPP. In contrast, Figure 2 shows a fully network-controlled WLAN/3GPP interworking solution, which follows principles similar to CONNECTED mode operations in 3GPP, where several main steps are employed for traffic steering: measurement control configuration, measurement reporting and traffic steering.

Regarding measurement control configuration, the RAN sends information to the UE that includes details like the target WLAN(s) to be measured (e.g. specific identities such as service set identifiers (SSIDs)/basic SSIDs (BSSIDs)/homogenous extended SSIDs (HESSIDs) or more general information like operating frequencies), and events/thresholds for triggering measurement reports (e.g., when the WLAN signal becomes better/worse than a certain threshold or when the 3GPP signal becomes worse/better than another threshold, etc.). When the conditions for triggering thresholds are fulfilled, the UE sends a measurement report to the 3GPP RAN. Based on the measurement report, the RAN evaluates the received measurements and other relevant information obtained in an eNB/Radio Network Controller (RNC), and as a result of this, sends a traffic steering command to the UE, which can specify the traffic to be steered. This can be an explicit indication of each bearer to be moved (i.e. by specifying data radio bearers (DRB/RB-IDs) or more general like the QoS Class Identifier (QCI), which can apply to many bearers at once).

In a UE ACK/Response step, the UE indicates to the RAN whether or not the action dictated by the traffic steering command was successfully performed or not. UEs in IDLE mode can request to setup a RRC connection for the sake of sending measurement reports when the conditions of the measurement control configuration are satisfied. Alternatively, solutions that are equally applicable to both IDLE and CONNECTED UEs might be employed for handling IDLE UEs, while another solution is used only for CONNECTED UEs.

Regarding terminal identification in WLAN, the media access control (MAC) address of a station (STA) is a unique identifier (typically a layer 2 address) that is assigned to the wireless network interface. The MAC address has a length of 6 bytes, organized as shown in Figure 3. The STA's MAC address is exposed every time a STA decides to transmit a frame. In that sense, a WLAN network node can obtain the MAC address of the STA after the very first frame it receives from that STA.

In correlating a STA (UE) identity with an eNB, the UE reports UE-associated information to the eNB, which may include signaling a suitable UE identifier (an "Xw UE ID"). This is needed in order for the eNB to correlate the UE-associated information with the UE identity it already

knows. Two possible candidates for such a UE identifier are the UE international mobile subscriber identity (IMSI) and the UE WLAN MAC address.

Adopting the UE IMSI would require the UE to signal its IMSI to the WLAN node over the air interface so that it could be signaled over Xw, since the WLAN has currently no knowledge of the IMSI. This has a number of serious implications: it requires changes in the WLAN air interface, and furthermore it is not considered good security practice to signal IMSI over a network interface (in particular involving a non-3GPP node). Adopting the WLAN MAC address, on the other hand, has the added benefit of reusing already available information from the WLAN, and of not requiring any changes in the WLAN air interface node, since it is already signaled by the UE when it attaches to the WLAN.

An issue with adopting the UE WLAN MAC address is that currently a UE cannot signal its WLAN MAC address to the eNB. Without this information, it is not possible for the eNB to correlate this identifier with the UE identity it already knows. Signaling the WLAN MAC address over Uu, however, will involve new UE-eNB signaling.

An analysis of using the UE IMSI or the UE WLAN MAC address is summarized in Table 1.

	UE WLAN MAC Address as Xw UE ID	**UE IMSI as Xw UE ID**
Impacts Uu	**Y**	**N**
Impacts WLAN air interface	**N**	**Y**
Potential security implications	**-**	**Y**

Table 1 - Comparison table for potential Xw UE ID candidates.

SUMMARY

One problem arising from the use of a common UE/STA identification in WLAN, where the 3GPP network relies on the terminal's WLAN MAC address being reported in 3GPP, relates to the fact that some UEs/STAs may apply WLAN MAC randomization for privacy purposes, thus changing the WLAN MAC address for the terminal. MAC randomization for privacy protection can break the working of the interface between 3GPP and WLAN networks to communicate terminal specific information. Embodiments described herein address this problem.

In some aspects, a wireless terminal (e.g. UE) reports to the WLAN a wide-area cellular network (e.g. 3GPP) cell identity (e.g. E-CGI) so that the WLAN can identify to which 3GPP RAN node the UE is associated. In addition to this, the UE may report UE identities to a 3GPP RAN node,

so that the 3GPP RAN node is capable of identifying which UE associated to it is transmitting over WLAN. The described embodiments provide mechanisms to enable the 3GPP RAN (e.g. eNodeBs and RNCs) and WLAN APs to communicate terminal specific information even when the terminals use MAC randomization and change their MAC address from time to time.

According to some embodiments, a method, in a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, includes including a first WLAN MAC address of the wireless terminal in one or more messages to the WLAN, generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and reporting the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

According to some embodiments, a method, in a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, includes receiving a timer indication from the cellular network, starting a timer responsive to the timer indication, and refraining from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

According to some embodiments, a method, in a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, includes indicating a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, and then refraining from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network. The time T may be pre-configured, e.g., according to a specification, in some embodiments, or network-configured, i.e., according to a configuration message sent to the wireless terminal from the cellular network. The method further comprises generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and reporting the second WLAN MAC address to the cellular network.

According to still other embodiments, a method, in a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, includes indicating a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, and further includes determining that the wireless terminal is performing a first type of WLAN operation. The method further comprises refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation, and generating a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from

the first WLAN MAC address. Finally, the method includes reporting the second WLAN MAC address to the cellular network. This first type of WLAN operation may comprise aggregating WLAN traffic and cellular network traffic, such as LTE traffic, in some embodiments. Similarly, the first type of WLAN operation may comprise sending traffic to the cellular network via a tunnel over WLAN.

According to some embodiments, a method, in a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a WLAN, includes determining that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal, and reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

According to some embodiments, a wireless terminal configured for operation in a WLAN and in a wide-area cellular network includes a transceiver configured to send and receive communications in the WLAN and in the cellular network, and a processing circuit. The processing circuit is configured to include a first WLAN MAC address of the wireless terminal in one or more messages to the WLAN, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report, via the transceiver, the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

According to some embodiments, a wireless terminal configured for operation in a WLAN and in a wide-area cellular network includes a transceiver configured to send and receive communications in the WLAN and in the cellular network, and a processing circuit. The wireless terminal is associated with a first WLAN MAC address and the processing circuit is configured to receive, via the transceiver, a timer indication from the cellular network, start a timer responsive to the timer indication, and refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

According to still other alternative embodiments, a wireless terminal configured for operation in a WLAN and in a wide-area cellular network includes a transceiver configured to send and receive communications in the WLAN and in the cellular network, and a processing circuit. The processing circuit is configured to indicate a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, to determine that the wireless terminal is performing a first type of WLAN operation, and refrain from generating a second WLAN MAC

address for the wireless terminal while performing the first type of WLAN operation. The processing circuit is further configure to generate a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address. Finally, the processing circuit is configured to report the second WLAN MAC address to the cellular network.

According to still other alternative embodiments, a wireless terminal configured for operation in a WLAN and in a wide-area cellular network includes a transceiver configured to send and receive communications in the WLAN and in the cellular network, and a processing circuit. The processing circuit is configured to indicate a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, refrain from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report the second WLAN MAC address to the cellular network.

According to some embodiments, a wireless terminal for operation in a WLAN and in a wide-area cellular network. The wireless terminal is adapted to indicate a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, refrain from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report the second WLAN MAC address to the cellular network.

According to still other embodiments, a wireless terminal for operation in a WLAN and in a wide-area cellular network. The wireless terminal is adapted to indicate a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, determine that the wireless terminal is performing a first type of WLAN operation and refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation. The wireless terminal is further adapted to generate a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address. The wireless terminal is further adapted to report the second WLAN MAC address to the cellular network.

According to some embodiments, a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a WLAN includes a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN, and includes a processing circuit. The processing circuit is configured to determine that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal, and report the second WLAN MAC address to the WLAN, via the communication interface, to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

According to some embodiments, a non-transitory computer readable storage medium stores a computer program that includes program instructions that, when executed on a processing circuit of a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, cause the wireless terminal to include a first WLAN MAC address of the wireless terminal in one or more messages to the WLAN, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report, via a transceiver, the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

According to some embodiments, a non-transitory computer readable storage medium stores a computer program that includes program instructions that are executed on a processing circuit of a wireless terminal configured for operation in a WLAN and in a wide-area cellular network. The wireless terminal is associated with a first WLAN MAC address. The program instructions cause, when executed, the wireless terminal to receive, via a transceiver, a timer indication from the cellular network, start a timer responsive to the timer indication, and refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

According to some embodiments, a non-transitory computer readable storage medium stores a computer program that includes program instructions that, when executed on a processing circuit of a network node of a wide-area cellular network serving a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, cause the network node to determine that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal, and report the second WLAN MAC address to the WLAN, via a communication interface, to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

In another example, the wireless terminal (e.g., UE/STA) informs the wide-area cellular network (e.g., 3GPP network) whenever it performs WLAN MAC randomization. In some cases, this may be a notification that WLAN MAC randomization has taken place, tipping off the network to take action to determine the WLAN MAC address by which the wireless terminal is now known.

In a further example, if the UE is in connected mode in the 3GPP network (e.g. RRC_CONNECTED), it communicates the new MAC address via a new RRC message or uses any existing information element (IE) of any existing message (e.g. RRC measurement reports with WLAN information) from the UE to the 3GPP network.

In a further example, if the UE is in IDLE mode in the 3GPP network, it first establishes an RRC connection, and then sends the update via a new RRC message. In the new RRC message, the UE may include the old MAC address in addition to the new MAC address. The UE may also send the information in new IE's of existing RRC messages, e.g., an RRC connection request.

In another example, if the UE is in IDLE mode in the 3GPP network, the UE informs the WLAN network about its old MAC address that it has been using before MAC randomization resulted in a new MAC address. This can be performed during association/connection establishment with the WLAN, or later on after the connection has been established.

In a further example, the WLAN informs its neighboring eNB(s) about the change of the MAC address of that UE by providing the old and new MAC addresses. An eNB that receives such information checks to see if it is currently serving or had recently served a UE that used the indicated old MAC address. If so, it will replace that MAC address with the new MAC address and will use it in subsequent communication with the WLAN about that particular UE. On the other hand, if no such UE is found, the eNB ignores the message or responds with an error message to the WLAN indicating that no such UE has been found.

In a further example, the WLAN stores the old MAC address and its association with the new MAC address. Whenever the WLAN gets a request for information about a UE with the old MAC address, it will respond with the information related to the UE that is currently employing the new MAC address.

In an example, the 3GPP network configures the UE with a timer, such as *T_random_off*, when the UE establishes an RRC connection so that the UE shall not perform WLAN MAC randomization when the timer is running. In order to improve the privacy, different UE's may have different configurable values for the timer.

Of course, the present invention is not limited to the above features and advantages. Those of ordinary skill in the art will recognize additional features and advantages upon reading the following detailed description, and upon viewing the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a simplified ANDSF architecture.

Figure 2 illustrates network-controlled cellular/WLAN interworking.

Figure 3 illustrates a diagram of a MAC address.

Figure 4 illustrates a problem resulting from WLAN MAC randomization.

Figure 5 illustrates a block diagram of a wireless terminal, such as a user equipment, according to some embodiments.

Figure 6 illustrates a method in a wireless terminal for reporting WLAN MAC addresses, according to some embodiments.

Figure 7 illustrates another method in a wireless terminal for reporting WLAN MAC addresses, according to some embodiments.

Figure 8 illustrates a method in a wireless terminal for refraining from generating a second WLAN MAC address for the wireless terminal, according to some embodiments.

Figure 9 illustrates a block diagram of a network access node, such as a cellular network base station or a WLAN access point, according to some embodiments.

Figure 10 illustrates a method in a cellular network node for identifying a wireless terminal with a MAC WLAN address, according to some embodiments.

Figure 11 illustrates a method in a cellular network node for reporting a MAC WLAN address for a wireless terminal, according to some embodiments.

Figure 12 illustrates a method in a cellular network node for sending a timer to assist identification of a wireless terminal, according to some embodiments.

Figure 13 illustrates a method in a WLAN access point for identifying a wireless terminal with a MAC WLAN address, according to some embodiments.

Figure 14 illustrates a method in a WLAN access point for reporting a MAC WLAN address for a wireless terminal, according to some embodiments.

Figure 15 illustrates a functional implementation of a wireless terminal, according to some embodiments.

Figure 16 illustrates a functional implementation of a wireless terminal, according to some embodiments.

Figure 17 illustrates a functional implementation of a wireless terminal, according to some embodiments.

Figure 18 illustrates a functional implementation of a cellular network node, according to some embodiments.

Figure 19 illustrates a functional implementation of a cellular network node, according to some embodiments.

Figure 20 illustrates a functional implementation of a cellular network node, according to some embodiments.

Figure 21 illustrates a functional implementation of a WLAN access point, according to some embodiments.

Figure 22 illustrates a functional implementation of a WLAN access point, according to some embodiments.

Figure 23 illustrates another method in a wireless terminal, according to some embodiments.

Figure 24 illustrates still another method in a wireless terminal, according to some embodiments.

DETAILED DESCRIPTION

A cell in a wide-area cellular network, or 3GPP network, such as the Long Term Evolution (LTE) network, is associated with a RAN node. Although terminology from specifications for the LTE network (also referred to as the E-UTRAN) is used in this disclosure to exemplify embodiments of the inventive concepts, this should not be seen as limiting the scope of the presently disclosed techniques to only these systems. Wireless terminals designed for use in other wireless systems, including variations and successors of 3GPP LTE systems, and WCDMA (UMTS) systems, WiMAX (Worldwide Interoperability for Microwave Access), UMB (Ultra Mobile Broadband), HSDPA (High-Speed Downlink Packet Access), GSM (Global System for Mobile Communications), etc., may also benefit from exploiting embodiments disclosed herein.

A wireless terminal (e.g., UE) may be capable of aggregating multiple carriers from a single eNB or multiple eNBs In accordance with certain embodiments described herein, a UE is capable of aggregating a carrier from the LTE network with a carrier from a WLAN AP. It should be appreciated that the WLAN and AP are not part of the E-UTRAN architecture.

To implement some of the various embodiments described herein, a communication path is established between a WLAN AP and at least one node in an LTE network, so that a dedicated connection can be established between the nodes. It will be appreciated that this connection may typically be established via the WLAN AP's broadband connection, rather than there being a direct signaling connection between the AP and eNB, such as via an air interface. Similar interfaces may be established between one node in the LTE network and multiple WLAN APs. It will also be appreciated that where the AP is within the coverage area of several eNBs, the AP may have separate interfaces to each of those eNBs. Inter-node interfaces between pairs of nodes may use a peer-to-peer interface, i.e., an interface that connects the two nodes directly. Alternatively, inter-node interfaces that pass through other network nodes could connect the two nodes.

In 3GPP, the scope and requirements for a Multi-RAT Joint Coordination study item have been defined, with potential enhancements of RAN interfaces and procedures to support the joint operation among different RATs, including WLAN. Accordingly, an interface between the E-UTRAN and WLAN has been specified by 3GPP.

Certain mechanisms make it possible for the 3GPP RAN node to determine that UEs associated to it are connected to the WLAN, and vice versa. For example, a WLAN AP may report to the 3GPP network whether a UE has connected to the WLAN. In some cases, a UE reports to the WLAN a 3GPP cell identity (e.g. an E-CGI) so that the WLAN can identify to which 3GPP RAN node the terminal is associated. In addition to this, the UE may report its identity to a 3GPP RAN node, so that the 3GPP RAN node is capable of identifying which UE associated to it is transmitting over WLAN.

With these techniques, the 3GPP network node is given information regarding if and when a UE is connected to WLAN. Without this knowledge, the 3GPP RAN may not be able to set parameters in a suitable way. Of course, some other WLAN node, such as a WLAN Access Controller (AC), may report this information. The 3GPP RAN node may utilize the information received from the WLAN node in handling the connection between the 3GPP RAN node and the UE. For example, the 3GPP RAN node may release the connection between the 3GPP RAN and

the UE if it has been indicated to the 3GPP RAN node that the UE has successfully connected to a WLAN AP.

The WLAN AP (or other WLAN node) may consider the UE's connection status to the 3GPP network when determining whether to include a UE in the report. For example, if the terminal has an active connection to the 3GPP network (e.g., RRC CONNECTED state in LTE, any of CELL_DCH, CELL_FACH, and CELL_PCH states in UMTS, etc.), the 3GPP network can control the terminal using dedicated signaling. On the other hand, if the terminal is in an IDLE state, then no dedicated signaling is supported in 3GPP, as the 3GPP RAN is not aware of the terminal's presence in any given 3GPP cell.

The terminal may request the WLAN to indicate to the 3GPP RAN node that the terminal has connected to the WLAN. The terminal may indicate this to the WLAN node during the connection to the WLAN node. The terminal may determine whether to request the WLAN to include it in the report based on its configuration as established by signaling from the 3GPP network.

With the version of the traffic-steering mechanism described earlier, the 3GPP RAN is influencing, and to some degree controlling, the terminal's access network selection and/or traffic-steering decisions between 3GPP and WLAN. However, the 3GPP RAN has limited information regarding whether a terminal is selecting and/or steering traffic to WLAN, and with this limited information, the 3GPP RAN will not be able to make informed Radio Resource Management (RRM) decisions. For example, the 3GPP RAN may not be able to provide suitable thresholds to a terminal, due to this lack of knowledge. This can result in poor access selection and/or traffic steering decisions, and then result in a poor user experience. Furthermore, the 3GPP RAN may not know whether the connection between the 3GPP RAN and the terminal can be released or not.

In order for the 3GPP node to be able to identify to which UE the report is associated to, terminal identities should be in the report and recognizable at the 3GPP RAN node.

In some cases, the UE sends its 3GPP identity to WLAN during any steps of the authentication/association procedures. The report described earlier would contain this identity, and the 3GPP RAN node is capable of identifying which UE is transmitting to the WLAN AP sending the report.

In other cases, the UE reports its WLAN identity (e.g., a WLAN MAC address) during any steps of the radio connection setup in 3GPP, and the 3GPP RAN node associates with the UE context.

In these cases, the report from WLAN to 3GPP RAN node may also contain the WLAN MAC address (available in the AP after WLAN association) so that the 3GPP RAN node is capable of retrieving the UE context and identity of the UE that is transmitting over WLAN.

In other cases, the UE reports its WLAN identity (e.g. WLAN MAC address) to the 3GPP RAN in response to receiving a request message from the 3GPP RAN. This may be an RRC message (e.g., a UEInformationRequest).

In other cases, the UE reports its WLAN identity (e.g. WLAN MAC address) to the 3GPP RAN in response to receiving a configuration for performing WLAN operation. This may be performing aggregation of traffic (e.g., LTE-WLAN aggregation).

In other cases, the UE reports its WLAN identity (e.g., a WLAN MAC address) to the 3GPP RAN in response to receiving a configuration for performing WLAN measurements.

The reported WLAN identity in any of these cases may be a WLAN identity that the UE is currently applying. Alternatively, it may be a WLAN identity that the UE plans to apply at a later time, for example at a later time when the UE is configured to perform WLAN operation.

In some cases, a common identity is reported on both systems and associated to the UE context in 3GPP, so that when the report from WLAN to 3GPP RAN node is received, the eNB is capable of retrieving the UE context and can identify the UE. Any of several possible information elements may be included in the report sent by the WLAN node to the 3GPP node. For example, the WLAN AP may inform the 3GPP RAN of an identity for the UE. This may allow the 3GPP RAN to know not only that a UE has connected to WLAN, but also which UE has connected. Possible identities include 3GPP cell radio network temporary identifier (C-RNTI), IMSI, WLAN MAC, IP address, an identifier common for the terminals 3GPP and WLAN entity.

A generic identity may also be included in the report. This identity may be provided by the 3GPP RAN node. For example, the 3GPP RAN node indicates the generic identity to the terminal and the terminal then indicates this to the WLAN AP (e.g., during the connection procedure). The WLAN AP subsequently indicates this to the 3GPP RAN. The benefit of the generic identity is that it can be terminal-specific and yet be applicable regardless of the terminal's state in 3GPP. This would not be the case for the C-RNTI, for example, since the C-RNTI, while it is terminal-specific in a 3GPP cell, is released when the terminal moves from CONNECTED to IDLE mode and hence is not applicable in IDLE mode.

The WLAN AP may include an identity relevant for the WLAN network in the report. In the event that the 3GPP RAN node is not already aware of where the report comes from, i.e., from which WLAN AP the report comes, then including the WLAN network identity could help the 3GPP RAN to know from which WLAN AP the report comes and hence to which WLAN AP the terminal has connected. In some cases, the UE is adapted to report the 3GPP cell identity (e.g., the E-CGI) to the WLAN, e.g., during any steps of WLAN association/authentication.

In some cases, the UE sends its 3GPP identity and any other relevant information (such as PLMN, 3GPP cell ID, etc.) to the WLAN during any steps of the authentication/association procedures. The report described earlier may contain this identity, and the 3GPP RAN node is capable of identifying which UE is transmitting to the WLAN AP that sends the report. In other cases, the UE reports its WLAN identity (e.g., a WLAN MAC address) during any steps of the radio connection setup in 3GPP, and the 3GPP RAN node is then able to associate the WLAN identity with the UE context.

A major problem in any existing solution for common UE/STA identification in WLAN and 3GPP relying on the WLAN MAC being reported in 3GPP relates to the fact that some UEs/STAs may apply WLAN MAC randomization for privacy purposes.

Normally, the WLAN MAC address associated to a particular UE/STA was kept unchanged throughout the lifetime of the device (sort of a permanent device identity). However, recent events have shown that in some situations, using the same MAC address could compromise privacy and allow for user location tracking. In order to solve this problem, some mobile device vendors have come up with mechanisms that allow the mobile terminal to randomize its MAC address every time it has to open a new connection and by doing so preventing user tracking. This process of randomizing the WLAN MAC address is referred to herein as "WLAN MAC randomization" or "MAC randomization." One example of WLAN MAC randomization is Apple's iOS® 8 feature for MAC address randomization, which takes place every time a new connection is initiated.

MAC randomization for privacy protection can break the working of the interface between 3GPP and WLAN networks to communicate terminal specific information. This is illustrated in Figure 4. As shown in the figure, the wireless terminal communicates its MAC address to the eNB (either during connection establishment or afterwards). After a while, the wireless terminal performs MAC randomization, based on some implementation-specific behavior, and connects to an AP using this MAC address. This MAC randomization may be periodic, for example, or triggered based on certain other events. When MAC randomization is performed at the wireless

terminal, the eNB is aware of the old MAC address but not the new MAC address. Thus, if some information regarding the wireless terminal is sent or requested from the AP to the eNB or from the eNB to the AP, then that information/request will not be usable or answerable because the receiving end of this information (eNB or AP, respectively) will not be able to find a wireless terminal with that identification.

Described herein are techniques to assist the WLAN or 3GPP network in identifying a wireless terminal that has had, or will have, a change in its WLAN MAC address. For instance, in an example scenario, a wireless terminal is associated with and known by a first WLAN MAC address, perhaps through communications with the WLAN or 3GPP network. For security reasons, the wireless terminal performs WLAN MAC randomization to generate a second WLAN MAC address different than the first WLAN MAC address. The WLAN and/or 3GPP network may not be able to send requests or responses to the wireless terminal, because it cannot identify the wireless terminal with the second WLAN MAC address. The networks only know the wireless terminal by the first WLAN MAC address. The embodiments described herein provide for the networks to learn the second WLAN MAC address for the wireless terminal and identify the wireless terminal using the second WLAN MAC address.

To that end, Figure 5 illustrates a diagram of a wireless terminal, such as a user equipment 50, according to some embodiments, that can assist the networks by reporting the second WLAN MAC address, in some embodiments, or refraining from replacing the first WLAN MAC address with the second WLAN MAC address under certain circumstances. To ease explanation, the UE 50 may be considered to represent any wireless terminal that operates in a network, such as a UE in a cellular network or a station in a WLAN. The UE 50 can be any type of wireless device capable of communicating with a network node or another UE over radio signals or other interfaces. The UE 50 may also exemplify a radio communication device, a target device, a device-to-device (D2D) UE, a machine-type UE or UE capable of machine-to-machine communication (M2M), a sensor equipped with UE, a PDA (personal digital assistant), a wireless tablet, a mobile terminal, a smart phone, etc.

The UE 50 is configured to communicate with a radio node or base station in a wide-area cellular network and to communicate with an access point or other stations in a WLAN, via antennas 54 and a transceiver circuit 56. The transceiver circuit 56 may include transmitter circuits, receiver circuits, and associated control circuits that are collectively configured to transmit and receive signals according to a radio access technology, for the purposes of providing Wi-Fi or cellular communication services.

The UE 50 also includes one or more processing circuits 52 that are operatively associated with the radio transceiver circuit 56. The processing circuit 52 comprises one or more digital processing circuits, e.g., one or more microprocessors, microcontrollers, Digital Signal Processors or DSPs, Field Programmable Gate Arrays or FPGAs, Complex Programmable Logic Devices or CPLDs, Application Specific Integrated Circuits or ASICs, or any mix thereof. More generally, the processing circuit 52 may comprise fixed circuitry, or programmable circuitry that is specially adapted via the execution of program instructions implementing the functionality taught herein, or may comprise some mix of fixed and programmed circuitry. The processing circuit 52 may be multi-core.

The processing circuit 52 also includes a memory 64. The memory 64, in some embodiments, stores one or more computer programs 66 and, optionally, configuration data 68. The memory 64 provides non-transitory storage for the computer program 66 and it may comprise one or more types of computer-readable media, such as disk storage, solid-state memory storage, or any mix thereof. Here, "non-transitory" means permanent, semi-permanent, or at least temporarily persistent storage and encompasses both long-term storage in non-volatile memory and storage in working memory, e.g., for program execution. By way of non-limiting example, the memory 64 comprises any one or more of SRAM, DRAM, EEPROM, and FLASH memory, which may be in the processing circuit 52 and/or separate from processing circuit 52. In general, the memory 64 comprises one or more types of computer-readable storage media providing non-transitory storage of the computer program 66 and any configuration data 68 used by the user equipment 50.

In some embodiments, UE 50 can report a second WLAN MAC address, e.g., the outcome of WLAN MAC randomization, to the WLAN. The processor 62 of the processor circuit 52 may execute a computer program 66 stored in the memory 64 that configures the processor 62 to operate in a cellular network or a WLAN and to, for example, report WLAN MAC addresses. In some embodiments, the processor 62 is configured to include a first WLAN MAC address of the UE 50 (which may be referred to hereafter as the wireless terminal), in one or more messages sent to the WLAN, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report, via the transceiver circuit 56, the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address. In some cases, generation of the second WLAN MAC address includes performing WLAN MAC randomization or some other operation that changes or masks an earlier WLAN MAC address or identity of the wireless terminal.

In further cases, the first WLAN MAC address may be sent with the second WLAN MAC address, so as to assist the receiving entity with identifying the wireless terminal. For example, this may include an indication that the second WLAN MAC address has replaced the first WLAN MAC address of the wireless terminal as the identity of the wireless terminal. This indication may be simply the fact that the two WLAN MAC addresses sent together in a message. The indication may also be information in the same IE or in a separate IE of the same message. The indication may also be provided in another message, or a new message not yet specified.

The above example describes the wireless terminal reporting the second WLAN MAC address to the WLAN. The wireless terminal can also report the second WLAN MAC address to the cellular network, in some embodiments. The processor 62 is thus configured, in some embodiments, to include a first WLAN MAC address of the wireless terminal in one or more messages sent to the WLAN, generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and report, via the transceiver circuit 56, the second WLAN MAC address to the cellular network, to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

The wireless terminal can also postpone WLAN MAC address changes, in some embodiments. The processor 62 is configured, in some embodiments, to receive, via the transceiver circuit 56, a timer indication from the cellular network, start a timer responsive to the timer indication, and refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer. The wireless terminal may be configured to operate a timer, such as a timer *T_random_off*, that prevents generation or randomization of the WLAN MAC address, at least until expiration of the timer. Timer indications may include configuration values that configure the timer, such as a length of the timer or conditions for the timer. The timer indication may be the trigger to start the timer, perhaps for a certain time duration. The functionality of these embodiments may be performed at least by reporting circuitry 60 in processing circuit 52.

The wireless terminal may refrain from changing the WLAN MAC address while configured to perform WLAN operation, in some embodiments. According to particular embodiments, the UE may only consider certain types of WLAN operation such as when aggregating traffic over WLAN and LTE, or sending traffic to the cellular network via a tunnel where the tunnel may be an IP- or IPsec-tunnel which is at least partially over WLAN. This refraining step may occur when using the feature “LTE-WLAN aggregation” or a feature based on IP-tunnels carried over

WLAN, because the eNB must know the UE's WLAN MAC address for these features. So the eNB should, before starting "LTE-WLAN aggregation," ask the UE to give its MAC address and then the UE shall not change the MAC address, or else these features may not work. However, if the eNB sends the request but actually never starts "LTE-WLAN aggregation," then the UE shall be allowed to start MAC address changing/randomization after a certain time from the request.

According to particular embodiments, the terminal may refrain from changing the WLAN MAC address for a time interval of length T, from when the terminal has provided its WLAN MAC address to the cellular network. Alternatively, T may be a time from when the terminal has been requested to provide its WLAN MAC address to the cellular network. The value T may be pre-configured, for example specified in a specification. Alternatively, it may be configured by the cellular network. For example, the cellular network may provide the value T in the message used for requesting the WLAN MAC address, or an earlier message.

According to particular embodiments, an eNodeB may configure the terminal to use WLAN before T expires. Thus, the terminal is not allowed to change WLAN MAC address until T expires. According to these embodiments, the terminal may stay connected to the WLAN after T expires, but that may depend on a specific terminal's implementation.

According to alternative embodiments, if an eNodeB does not configure the UE to use WLAN before T expires, the terminal may change WLAN MAC address from the original one signaled to the eNB at any time. The WLAN MAC address change may be triggered by one or more conditions, other than time/T value, that depend on a specific terminal's implementation.

According to still other alternative embodiments, after indicating a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, the wireless terminal determines that the wireless terminal is performing a first type of WLAN operation and refrains from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation. The wireless terminal generates a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address. Finally, the wireless terminal reports the second WLAN MAC address to the cellular network. The first type of WLAN operation may comprise aggregating WLAN traffic and cellular network traffic, such as LTE traffic, in some embodiments. Similarly, the first type of WLAN operation may comprise sending traffic to the cellular network via a tunnel over WLAN.

The processing circuit 52 of UE 50 is configured to perform one or more methods for reporting WLAN MAC addresses or preventing a WLAN MAC address change, such as any combination of methods 600-800 of Figures 6-8 and methods 2300 and 2400 of Figures 23 and 24. For example, method 600, illustrated in Figure 6, is a method in a wireless terminal configured for operation in a WLAN and in a wide-area cellular network that includes including a first WLAN MAC address of the wireless terminal in one or more messages sent to the WLAN (block 602), generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address (block 604), and reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address (block 606). In some cases, if the wireless terminal is in an idle mode with respect to the cellular network, the wireless terminal establishes a WLAN connection and provides the second (and maybe also the first) WLAN MAC address to the WLAN.

In another example, method 700, which is illustrated in Figure 7, includes including a first WLAN MAC address of the wireless terminal in one or more messages to the WLAN (block 702), generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address (block 704), and reporting the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address (block 706). The reporting may include providing the second (and maybe first) WLAN MAC address in a new IE of an existing RRCE message, such as an RRC connection request. This may also include providing such information in a new RRC message.

In an example, the wireless terminal is associated with a first WLAN MAC address, and a method 800, illustrated in Figure 8, includes receiving a timer indication from the cellular network (block 802), starting a timer responsive to the timer indication (block 804), and refraining from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer (block 806).

In another example method, shown in Figure 23, the wireless terminal indicates a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network (block 2302), and then refrains from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network (block 2304). The time T may be pre-configured, e.g., according to a specification, in some embodiments, or network-configured, i.e., according to a configuration message sent to the wireless terminal from the cellular network. The wireless terminal subsequently generates a second WLAN MAC address for the wireless terminal different than

the first WLAN MAC address (block 2306), and reports the second WLAN MAC address to the cellular network (block 2308).

In still another example method, illustrated in Figure 24, the wireless terminal indicates a first WLAN MAC address of the wireless terminal in one or more messages sent to the cellular network, as shown at block 2402. The wireless terminal determines that it is performing a first type of WLAN operation (block 2404), and refrains from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation (block 2406). The wireless terminal generates a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address (block 2408). Finally, the wireless terminal reports the second WLAN MAC address to the cellular network. As discussed above, this first type of WLAN operation may comprise aggregating WLAN traffic and cellular network traffic, such as LTE traffic, in some embodiments. Similarly, the first type of WLAN operation may comprise sending traffic to the cellular network via a tunnel over WLAN.

Figure 9 illustrates a diagram of a network access node 30, according to some embodiments. The network access node 30 may be referred to as a node, network node or a radio network node. Network access node 30 can be any kind of network access node, referred to by any of such terms asbase station, radio base station, base transceiver station, evolved Node B (eNodeB), Node B, relay node, access point, WLAN access point, radio access point, UltraDense Network (UDN)/Software Defined Network (SDN) radio access node, Remote Radio Unit (RRU), Remote Radio Head (RRH), etc. In the non-limiting embodiments described below, the network access node 30 will be described as operating as a cellular network node. Then, the network access node 30 will be described as operating as a WLAN access point.

The network node 30 facilitates communication between wireless terminals, other network access nodes and/or the core network. The network access node 30 includes a communication interface circuit 38 that includes circuitry for communicating with other nodes in the core network (e.g., in the case of a network node that is part of a cellular communications network), other radio nodes, and/or other types of nodes in the network, for the purposes of providing data, WLAN and/or cellular communication services. The network access node 30 uses the communication interface circuit 38 to communicate with wireless terminals, such as with antennas 34 and a transceiver circuit 36, which may be considered part of the communication interface circuit 38 for ease of discussion. The transceiver circuit 36 may include transmitter

circuits, receiver circuits, and associated control circuits that are collectively configured to transmit and receive signals according to a radio access technology, for the purposes of providing WLAN and/or cellular communication services. The communication interface circuit 38 is configured to communicate with the cellular network and/or the WLAN using signals and/or interfaces that are setup between a cellular network and a WLAN.

The network access node 30 also includes one or more processing circuits 32 that are operatively associated with the communication interface circuit 38. The network access node 30 uses the communication interface circuit 38 to communicate with network nodes and the transceiver 36 to communicate with user equipments. For ease of discussion, the one or more processing circuits 32 are referred to hereafter as "the processing circuit 32." The processing circuit 32 comprises one or more digital processors 42, e.g., one or more microprocessors, microcontrollers, Digital Signal Processors or DSPs, Field Programmable Gate Arrays or FPGAs, Complex Programmable Logic Devices or CPLDs, Application Specific Integrated Circuits or ASICs, or any mix thereof. More generally, the processing circuit 32 may comprise fixed circuitry, or programmable circuitry that is specially configured via the execution of program instructions implementing the functionality taught herein, or may comprise some mix of fixed and programmed circuitry. The processor 42 may be multi-core, i.e., having two or more processor cores utilized for enhanced performance, reduced power consumption, and more efficient simultaneous processing of multiple tasks.

The processing circuit 32 also includes a memory 44. The memory 44, in some embodiments, stores one or more computer programs 46 and, optionally, configuration data 48. The memory 44 provides non-transitory storage for the computer program 46 and it may comprise one or more types of computer-readable media, such as disk storage, solid-state memory storage, or any mix thereof. By way of non-limiting example, the memory 44 comprises any one or more of SRAM, DRAM, EEPROM, and FLASH memory, which may be in the processing circuit 32 and/or separate from the processing circuit 32. In general, the memory 44 comprises one or more types of computer-readable storage media providing non-transitory storage of the computer program 46 and any configuration data 48 used by the network access node 30.

Processing circuitry 32, whether alone or in combination with other digital hardware, is configured to identify a wireless terminal using WLAN MAC addresses, notify other entities of WLAN MAC addresses for the wireless terminal, and/or postpone the change of a WLAN MAC address for a wireless terminal.

For example, the processor 42 of the processing circuit 32 of network access node 30 may execute a computer program 46 stored in the memory 44 that configures the processor 42 to operate the network access node 30 as a wide-area cellular network node that serves a wireless terminal configured for operation in both the cellular network and in a WLAN. The wireless terminal may be associated with a first WLAN MAC address. The processor 42 is configured to receive, via the communication interface circuit 38, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and identify the wireless terminal based on the second WLAN MAC address.

In some cases, the network access node 30, acting as a cellular network node, receives the second WLAN MAC address from a wireless terminal. In other cases, the cellular network node receives the second WLAN MAC address from the WLAN. Sometimes, upon receiving the second WLAN MAC address, the cellular network node checks to see if it is currently serving the wireless terminal, or has recently served the wireless terminal, using the old WLAN MAC address. If so, it will replace the first WLAN MAC address with the second WLAN MAC address with respect to the identity of the wireless terminal stored at the cellular network node. If, on the other hand, no such wireless terminal is found, the report of the second WLAN MAC address is ignored or is returned with an error message.

In some cases, upon receiving the second WLAN MAC address for the wireless terminal, the cellular network node will respond to messages or requests for the wireless terminal with either the first and/or second known WLAN MAC addresses for the wireless terminal. For example, if a request is addressed to a wireless terminal with the old WLAN MAC address, the cellular network node will respond based on information associated with any wireless terminal associated with the new, second WLAN MAC address.

In another example, the processor 42 is configured to determine that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal, and report the second WLAN MAC address to the WLAN, via the communication interface, to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address. This reporting may take place using signals or an interface set up between the cellular network node and the WLAN, such as with a WLAN access point or AC.

In an example, the processor 42 is configured to determine to send a timer value to direct the wireless terminal to refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer, and send, via the communication interface circuit 38, the timer value to the wireless terminal responsive to the

determination to send the timer value. The structure and functionality of these embodiments may be referred to as identification circuitry 40 in the processing circuit 32.

In some embodiments, the processing circuit 32 is configured to perform a method for identifying a wireless terminal, such as any combination of respective methods 1000-1200. For example, Figure 10 illustrates a method 1000 that includes receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address (block 1002), and identifying the wireless terminal based on the second WLAN MAC address (block 1004).

In another example, Figure 11 illustrates a method 1100 that includes determining that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal (block 1102), and reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address (block 1104).

In another example, Figure 12 illustrates a method 1200 that includes determining to send a timer value to direct the wireless terminal to refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer (block 1202), and sending the timer value to the wireless terminal responsive to the determination to send the timer value (block 1204).

Now, the network access node 30 will be described as operating as a WLAN access point. In such embodiments, the processor 42 of the processing circuit 32 of network access node 30 may execute a computer program 46 stored in the memory 44 that configures the processor 42 to operate the network access node 30 as a WLAN access point that serves a wireless terminal configured for operation in both the cellular network and in a WLAN. The wireless terminal may be associated with a first WLAN MAC address. In an example, the processor 42 is configured to receive, via the communication interface circuit 38, a first WLAN MAC address of the wireless terminal in one or more messages from the wireless terminal, receive, via the communication interface 38, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address, and identify the wireless terminal based on the second WLAN MAC address. As described above for the cellular network node, the access point may replace the old WLAN MAC address with the second WLAN MAC address as the known identity of the wireless terminal, as stored at the access point. The access point may also respond to messages or requests for the old WLAN MAC address, by taking action based on information for the wireless terminal associated with the second WLAN MAC address.

In another example, processor 42 is configured to determine that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal, and report, via the communication interface, the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address. This reporting may be similar to what was described above for the cellular network node, such as over cellular network/WLAN interfaces.

In some embodiments, the processing circuit 32 is configured to perform a method for identifying a wireless terminal, such as any combination of respective methods 1300 and 1400. For example, Figure 13 illustrates a method 1300 that includes receiving a first WLAN MAC address of the wireless terminal in one or more messages from the wireless terminal (block 1302), receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address (block 1304), and identifying the wireless terminal based on the second WLAN MAC address (block 1306).

In another example, Figure 14 illustrates a method 1400 that includes determining that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal (1402), and reporting the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address (1404).

Figure 15 illustrates an example functional module or circuit architecture as may be implemented in a wireless terminal, such as UE 50 based on the reporting circuitry 60. The illustrated embodiment at least functionally includes an including module 1502 for including a first WLAN MAC address of the wireless terminal in one or more messages sent to the WLAN. The embodiment also includes a generating module 1504 for generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address. The embodiment includes a reporting module 1506 for reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

Figure 16 illustrates another example functional module or circuit architecture as may be implemented in a wireless terminal, such as UE 50 based on the reporting circuitry 60. The illustrated embodiment at least functionally includes an including module 1602 for including a first WLAN MAC address of the wireless terminal in one or more messages sent to the WLAN.

The embodiment also includes a generating module 1604 for generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address. The embodiment includes a reporting module 1606 for reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

Figure 17 illustrates another example functional module or circuit architecture as may be implemented in a wireless terminal, such as UE 50 based on the reporting circuitry 60. The illustrated embodiment at least functionally includes a receiving module 1702 for receiving a timer indication from the cellular network. The embodiment includes a starting module 1704 for starting a timer responsive to the timer indication. The embodiment also includes a refraining module 1706 for refraining from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

Figure 18 illustrates an example functional module or circuit architecture as may be implemented in a network access node that serves a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, such as network access node 30 based on the identification circuitry 40 and configured to operate as a network node of the cellular network. The wireless terminal may be associated with a first WLAN MAC address. The illustrated embodiment at least functionally includes a receiving module 1802 for receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address. The embodiment includes an identifying module 1804 for identifying the wireless terminal based on the second WLAN MAC address.

Figure 19 illustrates another example functional module or circuit architecture as may be implemented in a network access node configured to operate as a network node of the cellular network. The illustrated embodiment at least functionally includes a determining module 1902 for determining that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal. The embodiment also includes a reporting module 1904 for reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

Figure 20 illustrates another example functional module or circuit architecture as may be implemented in a network access node configured to operate as a network node of the cellular network. The illustrated embodiment at least functionally includes a determining module 2002 for determining to send a timer value to direct the wireless terminal to refrain from generating a

second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer. The embodiment also includes a sending module 2004 for sending the timer value to the wireless terminal responsive to the determination to send the timer value.

Figure 21 illustrates an example functional module or circuit architecture as may be implemented in a network access node that serves a wireless terminal configured for operation in a WLAN and in a wide-area cellular network, such as network access node 30 based on the identification circuitry 40 and configured to operate as an access point of the WLAN. The wireless terminal may be associated with a first WLAN MAC address. The illustrated embodiment at least functionally includes a receiving module 2102 for receiving a first WLAN MAC address of the wireless terminal in one or more messages from the wireless terminal. The embodiment also includes a receiving module 2104 for receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address. The embodiment also includes an identifying module 2106 for identifying the wireless terminal based on the second WLAN MAC address.

Figure 22 illustrates another example functional module or circuit architecture as may be implemented in a network access node configured to operate as an access point of the WLAN. The illustrated embodiment at least functionally includes a determining module 2202 for determining that a first WLAN MAC address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal. The embodiment also includes a reporting module 2204 for reporting the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address.

The embodiments described herein provide a number of advantages. For example, reports and updates from the UE/STA, 3GPP network and/or the WLAN can help to solve the ambiguity that may exist in UE identification on both WLAN and 3GPP networks when WLAN MAC randomization occurs.

Example embodiments may include the following:

1. A method, in a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, comprising:

including a first WLAN media access control (MAC) address of the wireless terminal in one or more messages sent to the WLAN;

generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

2. The method of embodiment 1, wherein reporting the second WLAN MAC address comprises indicating to the WLAN that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

3. The method of embodiment 1, wherein generating the second WLAN MAC address comprises performing WLAN MAC randomization.

4. The method of embodiment 1, wherein reporting the second WLAN MAC address comprises, when the wireless terminal is in an idle mode in the cellular network:

establishing a connection to the WLAN; and

reporting the first and second WLAN MAC addresses of the wireless terminal to the WLAN.

5. A method, in a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, comprising:

including a first WLAN media access control (MAC) address of the wireless terminal in one or more messages to the WLAN;

generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

reporting the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

6. The method of embodiment 5, wherein reporting the second WLAN MAC address comprises indicating that the second WLAN MAC address has replaced the first WLAN MAC address as an identity of the wireless terminal.

7. The method of embodiment 5, wherein generating the new WLAN MAC address comprises performing WLAN MAC randomization.

8. The method of embodiment 5, wherein reporting the second WLAN MAC address comprises, when the wireless terminal is in a connected mode in the cellular network, reporting the second WLAN MAC address of the wireless terminal to the cellular network via a Radio Resource Control (RRC) message.

9. The method of embodiment 5, wherein reporting the second WLAN MAC address comprises, when the wireless terminal is in an idle mode in the cellular network:

establishing a Radio Resource Control (RRC) connection to the cellular network; and

reporting the second WLAN MAC address of the wireless terminal to the cellular network via a Radio Resource Control (RRC) message.

10. The method of embodiment 9, further comprising reporting the first WLAN MAC address of the wireless terminal to the cellular network via the RRC message.

11. A method, in a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, wherein the wireless terminal is associated with a first WLAN media access control (MAC) address, the method comprising:

receiving a timer indication from the cellular network;

starting a timer responsive to the timer indication; and

refraining from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

12. The method of embodiment 11, wherein refraining from generating the second WLAN MAC address comprises refraining from performing WLAN MAC randomization.

13. A method, in a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), for determining the identity of the wireless terminal associated with a first WLAN media access control (MAC) address, comprising:

receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identifying the wireless terminal based on the second WLAN MAC address.

14. The method of embodiment 13, wherein receiving the second WLAN MAC address comprises receiving the second WLAN MAC address via a Radio Resource Control (RRC) message from the wireless terminal.

15. The method of embodiment 13, wherein receiving the second WLAN MAC address comprises receiving the second WLAN MAC address in a message from the WLAN.

16. The method of embodiment 13, wherein receiving the second WLAN MAC address comprises receiving an indication that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

17. The method of embodiment 13, further comprising, responsive to determining that the cellular network node is currently serving the wireless terminal identified by the first WLAN MAC address, replacing the first WLAN MAC address with the second WLAN MAC address as the identity of the wireless terminal stored by the network node.

18. The method of embodiment 13, further comprising, responsive to receiving a message directed to the first WLAN MAC address, taking action based on information related to the wireless terminal employing the second WLAN MAC address.

19. A method, in a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), comprising:

determining that a first WLAN media access control (MAC) address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

reporting the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

20. The method of embodiment 19, wherein reporting the second WLAN MAC address to the WLAN comprises indicating to the WLAN that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

21. The method of embodiment 19, wherein reporting the second WLAN MAC address to

the WLAN further comprises reporting the first WLAN MAC address of the wireless terminal to the WLAN.

22. A method, in a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), for determining the identity of the wireless terminal associated with a first WLAN media access control (MAC) address, comprising:

determining to send a timer value to direct the wireless terminal to refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer; and

sending the timer value to the wireless terminal responsive to the determination to send the timer value.

23. A method, in an access point of a wireless local area network (WLAN) configured to serve a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, comprising:

receiving a first WLAN media access control (MAC) address of the wireless terminal in one or more messages from the wireless terminal;

receiving a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identifying the wireless terminal based on the second WLAN MAC address.

24. The method of embodiment 23, further comprising replacing the first WLAN MAC address with the second WLAN MAC address as the identity of the wireless terminal stored by the access point.

25. The method of embodiment 23, further comprising, responsive to receiving a message directed to the first WLAN MAC address, taking action based on information related to the wireless terminal employing the second WLAN MAC address.

26. A method, in an access point of a wireless local area network (WLAN) configured to serve a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, comprising:

determining that a first WLAN media access control (MAC) address for the wireless

terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

reporting the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address.

27. The method of embodiment 26, wherein reporting the second WLAN MAC address comprises indicating to the one or more neighboring cellular network nodes that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

28. The method of embodiment 26, wherein reporting the second WLAN MAC address further comprises reporting the first WLAN MAC address of the wireless terminal to the one or more neighboring cellular network nodes.

29. A wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, comprising:

a transceiver configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit configured to:

include a first WLAN media access control (MAC) address of the wireless terminal in one or more messages sent to the WLAN;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report, via the transceiver, the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

30. The wireless terminal of embodiment 29, wherein the processing circuit is configured to indicate to the WLAN, via the transceiver, that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

31. The wireless terminal of embodiment 29, wherein the processing circuit is configured to generate the second WLAN MAC address by performing WLAN MAC randomization.

32. The wireless terminal of embodiment 29, wherein the processing circuit is configured to, when the wireless terminal is in an idle mode in the cellular network:

establish, via the transceiver, a connection to the WLAN; and

report, via the transceiver, the first and second WLAN MAC addresses of the wireless terminal to the WLAN.

33. A wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, comprising:

a transceiver configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit configured to:

include a first WLAN media access control (MAC) address of the wireless terminal in one or more messages to the WLAN;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report, via the transceiver, the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

34. The wireless terminal of embodiment 33, wherein the processing circuit is configured to indicate to the cellular network, via the transceiver, that the second WLAN MAC address has replaced the first WLAN MAC address as an identity of the wireless terminal.

35. The wireless terminal of embodiment 33, wherein the processing circuit is configured to generate the second WLAN MAC address by performing perform WLAN MAC randomization.

36. The wireless terminal of embodiment 33, wherein the processing circuit is configured to, when the wireless terminal is in a connected mode in the cellular network, report, via the transceiver, the second WLAN MAC address of the wireless terminal to the cellular network via a Radio Resource Control (RRC) message.

37. The wireless terminal of embodiment 33, wherein the processing circuit is configured to, when the wireless terminal is in an idle mode in the cellular network:

establish, via the transceiver, a Radio Resource Control (RRC) connection to the cellular network; and

report, via the transceiver, the second WLAN MAC address of the wireless terminal to the cellular network via a Radio Resource Control (RRC) message.

38. The wireless terminal of embodiment 37, wherein the processing circuit is configured to report, via the transceiver, the first WLAN MAC address of the wireless terminal to the cellular network via the RRC message.

39. A wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, wherein the wireless terminal is associated with a first WLAN media access control (MAC) address, the method comprising:

a transceiver configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit configured to:

receive, via the transceiver, a timer indication from the cellular network;

start a timer responsive to the timer indication; and

refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

40. The wireless terminal of embodiment 39, wherein the processing circuit is configured to refrain from generating the second WLAN MAC address by refraining from performing WLAN MAC randomization.

41. A network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), wherein the wireless terminal is associated with a first WLAN media access control (MAC) address, comprising:

a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit configured to:

receive, via the communication interface, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identify the wireless terminal based on the second WLAN MAC address.

42. The network node of embodiment 41, wherein the processing circuit is configured to receive, via the communication interface, the second WLAN MAC address via a Radio Resource Control (RRC) message from the wireless terminal.

43. The network node of embodiment 41, wherein the processing circuit is configured to receive, via the communication interface, the second WLAN MAC address in a message from the WLAN.

44. The network node of embodiment 41, wherein the processing circuit is configured to receive, via the communication interface, an indication that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

45. The network node of embodiment 41, wherein the processing circuit is configured to, responsive to determining that the cellular network node is currently serving the wireless terminal identified by the first WLAN MAC address, replace the first WLAN MAC address with the second WLAN MAC address as the identity of the wireless terminal stored by the network node.

46. The network node of embodiment 41, wherein the processing circuit is configured to, responsive to receiving a message directed to the first WLAN MAC address, take action based on information related to the wireless terminal employing the second WLAN MAC address.

47. A network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), comprising:

a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit configured to:

determine that a first WLAN media access control (MAC) address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

report the second WLAN MAC address to the WLAN, via the communication interface, to thereby assist the WLAN with identifying the wireless

terminal with the second WLAN MAC address.

48. The network node of embodiment 47, wherein the processing circuit is configured to indicate to the WLAN, via the communication interface, that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

49. The network node of embodiment 47, wherein the processing circuit is configured to report, via the communication interface, the first WLAN MAC address of the wireless terminal to the WLAN.

50. A network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network (WLAN), wherein the wireless terminal is associated with a first WLAN media access control (MAC) address, the network node comprising:

a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit configured to:

determine to send a timer value to direct the wireless terminal to refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer; and

send, via the communication interface, the timer value to the wireless terminal responsive to the determination to send the timer value.

51. An access point of a wireless local area network (WLAN) configured to serve a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, comprising:

a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit configured to:

receive, via the communication interface, a first WLAN media access control (MAC) address of the wireless terminal in one or more messages from the wireless terminal;

receive, via the communication interface, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identify the wireless terminal based on the second WLAN MAC address.

52. The access point of embodiment 51, wherein the processing circuit is configured to replace the first WLAN MAC address with the second WLAN MAC address as the identity of the wireless terminal stored by the access point.

53. The access point of embodiment 51, wherein the processing circuit is configured to, responsive to receiving a message directed to the first WLAN MAC address, take action based on information related to the wireless terminal employing the second WLAN MAC address.

54. An access point of a wireless local area network (WLAN) configured to serve a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, comprising:

a communication interface configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit configured to:

determine that a first WLAN media access control (MAC) address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

report, via the communication interface, the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address.

55. The access point of embodiment 54, wherein the processing circuit is configured to indicate to the one or more neighboring cellular network nodes, via the communication interface, that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

56. The access point of embodiment 54, wherein the processing circuit is configured to report the first WLAN MAC address of the wireless terminal to the one or more neighboring cellular network nodes via the communication interface.

57. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a wireless

terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, cause the wireless terminal to:

include a first WLAN media access control (MAC) address of the wireless terminal in one or more messages sent to the WLAN;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report, via a transceiver, the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

58. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, cause the wireless terminal to:

include a first WLAN media access control (MAC) address of the wireless terminal in one or more messages to the WLAN;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report, via a transceiver, the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

59. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, the wireless terminal associated with a first WLAN media access control (MAC) address, cause the wireless terminal to:

receive, via a transceiver, a timer indication from the cellular network;

start a timer responsive to the timer indication; and

refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

60. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a network node

of a wide-area cellular network serving a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, the wireless terminal associated with a first WLAN media access control (MAC) address, cause the network node to:

receive, via a communication interface, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identify the wireless terminal based on the second WLAN MAC address.

61. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a network node of a wide-area cellular network serving a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, cause the network node to:

determine that a first WLAN media access control (MAC) address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

report the second WLAN MAC address to the WLAN, via a communication interface, to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

62. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of a network node of a wide-area cellular network serving a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, the wireless terminal associated with a first WLAN media access control (MAC) address, cause the network node to:

determine to send a timer value to direct the wireless terminal to refrain from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address during a duration of a timer; and

send, via a communication interface, the timer value to the wireless terminal responsive to the determination to send the timer value.

63. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of an access point of a wireless local area network (WLAN) serving a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, cause the access point to:

receive, via a communication interface, a first WLAN media access control (MAC)

address of the wireless terminal in one or more messages from the wireless terminal;

receive, via the communication interface, a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

identify the wireless terminal based on the second WLAN MAC address.

64. A non-transitory computer readable storage medium storing a computer program comprising program instructions that, when executed on a processing circuit of an access point of a wireless local area network (WLAN) serving a wireless terminal configured for operation in the WLAN and in a wide-area cellular network, cause the access point to:

determine that a first WLAN media access control (MAC) address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

report, via a communication interface, the second WLAN MAC address to one or more neighboring cellular network nodes to thereby assist the one or more neighboring cellular network nodes with identifying the wireless terminal with the second WLAN MAC address.

65. A computer program, comprising instructions which, when executed on at least one processing circuit, cause the at least one processing circuit to carry out the method according to any one of example embodiments 1 to 28.

66. A carrier containing the computer program of embodiment 65, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium.

67. A method, in a wireless terminal configured for operation in a wireless local area network (WLAN) and in a wide-area cellular network, comprising:

indicating a first WLAN media access control (MAC) address of the wireless terminal in one or more messages sent to the cellular network;

generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

reporting the second WLAN MAC address to cellular network.

68. The method according to embodiment 67 wherein the UE refrains from generating the second WLAN MAC address if the UE is configured for operation in a wireless local area

network (WLAN).

69. The method according to embodiment 68 wherein the UE refrains from generating the second WLAN MAC address if the UE is configured for a first type of operation in a wireless local area network (WLAN), but not for a second type of operation.

70. The method according to embodiment 69 wherein the first type of WLAN operation is aggregation of WLAN and LTE traffic (e.g. LTE-WLAN aggregation), and the second type of operation is another type.

71. The method according to embodiment 67 wherein the UE refrains from generating a second WLAN MAC address for a time T after when the UE has indicated the first WLAN MAC address to the cellular network.

72. The method according to embodiment 71 wherein the second WLAN MAC address is generated after the time T expires.

73. The method according to embodiment 67 wherein the UE refrains from generating a second WLAN MAC address a time T after when the UE has received a request to indicate the first WLAN MAC address to the cellular network.

74. The method according to embodiment 73 wherein the second WLAN MAC address is generated after the time T expires.

75. A method, in a wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the method comprising:
indicating a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;
refraining from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network;
generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and
reporting the second WLAN MAC address to the cellular network.

76. A method, in a wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the method comprising:
indicating a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;
determining that the wireless terminal is performing a first type of WLAN operation, and refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;
generating a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address; and
reporting the second WLAN MAC address to the cellular network.

77. The method according to embodiment 76, wherein the generating of the second WLAN MAC address is performed while the wireless terminal is operating in the WLAN but not while performing the first type of WLAN operation.

78. The method according to embodiment 76 or 77, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

79. The method according to embodiment 78, wherein the cellular network traffic is LTE traffic.

80. The method according to embodiment 76 or 77, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

81. A wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal comprising:
a transceiver configured to send and receive communications in the WLAN and in the cellular network; and
a processing circuit configured to:
indicate a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;
refrain from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network;
generate a second WLAN MAC address for the wireless terminal different than the first WLAN

MAC address; and

report the second WLAN MAC address to cellular network.

82. A wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal comprising:

a transceiver configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit configured to:

indicate a first WLAN media access control, MAC, address of the wireless terminal (50) in one or more messages sent to the cellular network;

determine that the wireless terminal is performing a first type of WLAN operation, and refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;

generate a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation , the second WLAN MAC address differing from the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

83. The wireless terminal according to embodiment 82, wherein the generating of the second WLAN MAC address is performed while the wireless terminal is operating in the WLAN but not while performing the first type of WLAN operation.

84. The wireless terminal according to embodiment 82 or 83, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

85. The wireless terminal according to embodiment 84, wherein the cellular network traffic is LTE traffic.

86. The wireless terminal according to embodiment 82 or 83, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

87. A wireless terminal for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal adapted to:

indicate a first WLAN media access control, MAC, address of the wireless terminal in one or

more messages sent to the cellular network;

refrain from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

88. A wireless terminal for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal adapted to:

indicate a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

determine that the wireless terminal is performing a first type of WLAN operation, and refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;

generate a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

89. The wireless terminal according to embodiment 88, wherein the generating of the second WLAN MAC address is performed while the wireless terminal is operating in the WLAN but not while performing the first type of WLAN operation.

90. The wireless terminal according to embodiment 88 or 89, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

91. The wireless terminal according to embodiment 90, wherein the cellular network traffic is LTE traffic.

92. The wireless terminal according to embodiment 88 or 89, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

93. A wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal comprising:

an indicating module for indicating a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

a refraining module for refraining from generating a second WLAN MAC address for a configured time *T* after indicating the first WLAN MAC address in one or more messages sent to the cellular network;

a generating module for generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

a reporting module for reporting the second WLAN MAC address to the cellular network.

94. A wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal comprising:

an indicating module for indicating a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

a determining module for determining that the wireless terminal is performing a first type of WLAN operation,

a refraining module for refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;

a generating module for generating a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address; and

a reporting module for reporting the second WLAN MAC address to the cellular network.

The modules of embodiments 93 and 94 may be implemented as one or more computer programs stored in memory (e.g. memory 64 of Figure 5) for execution by one or more processors (e.g. processor(s) 62 of Figure 5) of the wireless device.

Notably, modifications and other embodiments of the disclosed invention(s) will come to mind to one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention(s) is/are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of this disclosure. Although specific

terms may be employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

CLAIMS

What is claimed is:

1. A method, in a wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the method comprising:

including (602) a first WLAN media access control, MAC, address of the wireless terminal in one or more messages to the WLAN;

generating (604) a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

reporting (606) the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

2. The method of claim 1, wherein reporting the second WLAN MAC address comprises indicating that the second WLAN MAC address has replaced the first WLAN MAC address as an identity of the wireless terminal.

3. The method of claim 1, wherein generating the new WLAN MAC address comprises performing WLAN MAC randomization.

4. The method of claim 1, wherein reporting the second WLAN MAC address comprises, when the wireless terminal is in a connected mode in the cellular network, reporting the second WLAN MAC address of the wireless terminal to the cellular network via a Radio Resource Control, RRC, message.

5. The method of claim 1, wherein reporting the second WLAN MAC address comprises, when the wireless terminal is in an idle mode in the cellular network:

establishing a Radio Resource Control, RRC, connection to the cellular network; and

reporting the second WLAN MAC address of the wireless terminal to the cellular network via a RRC message.

6. The method of claim 5, further comprising reporting the first WLAN MAC address of the wireless terminal to the cellular network via the RRC message.

7. A method, in a wireless terminal configured for operation in a wireless local area network,

WLAN, and in a wide-area cellular network, wherein the wireless terminal is associated with a first WLAN media access control, MAC, address, the method comprising:

receiving (802) a timer indication from the cellular network;

starting (804) a timer responsive to the timer indication; and

refraining (806) from generating a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address for the duration of the timer.

8. The method of claim 7, wherein refraining (806) from generating the second WLAN MAC address comprises refraining from performing WLAN MAC randomization.

9. A method, in a network node of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network, WLAN, the method comprising:

determining (1102) that a first WLAN media access control, MAC, address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

reporting (1104) the second WLAN MAC address to the WLAN to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

10. The method of claim 9, wherein reporting (1104) the second WLAN MAC address to the WLAN comprises indicating to the WLAN that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

11. The method of claim 9, wherein reporting (1104) the second WLAN MAC address to the WLAN further comprises reporting the first WLAN MAC address of the wireless terminal to the WLAN.

12. A wireless terminal (50) configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal (50) comprising:

a transceiver (56) configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit (52) configured to:

include a first WLAN media access control, MAC, address of the wireless

terminal in one or more messages to the WLAN;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report, via the transceiver, the second WLAN MAC address to the cellular network to thereby assist the cellular network with identifying the wireless terminal with the second WLAN MAC address.

13. The wireless terminal (50) of claim 12, wherein the processing circuit (52) is configured to indicate to the cellular network , via the transceiver (56), that the second WLAN MAC address has replaced the first WLAN MAC address as an identity of the wireless terminal (50).

14. The wireless terminal (50) of claim 12, wherein the processing circuit (52) is configured to generate the second WLAN MAC address by performing WLAN MAC randomization.

15. The wireless terminal (50) of claim 12, wherein the processing circuit is (52) configured to, when the wireless terminal (50) is in an idle mode in the cellular network:

establish, via the transceiver (56), a Radio Resource Control, RRC, connection to the cellular network ; and

report, via the transceiver (56), the second WLAN MAC address of the wireless terminal (50) to the cellular network via a RRC message.

16. A wireless terminal (50) configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, wherein the wireless terminal (50) is associated with a first WLAN media access control, MAC, address, the wireless terminal (50) comprising:

a transceiver (56) configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit (52) configured to:

receive, via the transceiver (56), a timer indication from the cellular network;

start a timer responsive to the timer indication; and

refrain from generating a second WLAN MAC address for the wireless terminal (50) different than the first WLAN MAC address for the duration of the timer.

17. The wireless terminal (50) of claim 16, wherein the processing circuit (52) is configured to

refrain from generating the second WLAN MAC address by refraining from performing WLAN MAC randomization.

18. A network node (30) of a wide-area cellular network configured to serve a wireless terminal configured for operation in both the cellular network and in a wireless local area network, WLAN, the network node (30) comprising:

a communication interface (38) configured to communicate with the wireless terminal, the cellular network and the WLAN; and

a processing circuit (32) configured to:

determine that a first WLAN media access control, MAC, address for the wireless terminal has been replaced by a second WLAN MAC address as the identity of the wireless terminal; and

report the second WLAN MAC address to the WLAN, via the communication interface, to thereby assist the WLAN with identifying the wireless terminal with the second WLAN MAC address.

19. The network node (30) of claim 18, wherein the processing circuit (32) is configured to indicate to the WLAN, via the communication interface (38), that the second WLAN MAC address has replaced the first WLAN MAC address as the identity of the wireless terminal.

20. The network node (30) of claim 18, wherein the processing circuit (32) is configured to report, via the communication interface (38), the first WLAN MAC address of the wireless terminal to the WLAN.

21. A method, in a wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the method comprising:

indicating (2302) a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

refraining (2304) from generating a second WLAN MAC address for a configured time T after indicating the first WLAN MAC address in one or more messages sent to the cellular network;

generating (2306) a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

reporting (2308) the second WLAN MAC address to the cellular network.

22. A method, in a wireless terminal configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the method comprising:

indicating (2402) a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

determining (2404) that the wireless terminal is performing a first type of WLAN operation, and refraining (2406) from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;

generating (2408) a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation, the second WLAN MAC address differing from the first WLAN MAC address; and

reporting (2410) the second WLAN MAC address to the cellular network.

23. The method of claim 22, wherein the generating (2406) of the second WLAN MAC address is performed while the wireless terminal is operating in the WLAN but not while performing the first type of WLAN operation.

24. The method of claim 22 or 23, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

25. The method of claim 24, wherein the cellular network traffic is LTE traffic.

26. The method of claim 22 or 23, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

27. A wireless terminal (50) configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal (50) comprising:

a transceiver (56) configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit (52) configured to:

indicate a first WLAN media access control, MAC, address of the wireless terminal (50) in one or more messages sent to the cellular network;

refrain from generating a second WLAN MAC address for a configured time *T* after indicating the first WLAN MAC address in one or more messages sent to the cellular network;

generate a second WLAN MAC address for the wireless terminal (50) different than the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

28. A wireless terminal (50) configured for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal (50) comprising:

a transceiver (56) configured to send and receive communications in the WLAN and in the cellular network; and

a processing circuit (52) configured to:

indicate a first WLAN media access control, MAC, address of the wireless terminal (50) in one or more messages sent to the cellular network;

determine that the wireless terminal (50) is performing a first type of WLAN operation, and refraining from generating a second WLAN MAC address for the wireless terminal (50) while performing the first type of WLAN operation;

generate a second WLAN MAC address for the wireless terminal (50) at a time when the wireless terminal (50) is not performing the first type of WLAN operation , the second WLAN MAC address differing from the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

29. The wireless terminal (50) of claim 28, wherein the generating of the second WLAN MAC address is performed while the wireless terminal (50) is operating in the WLAN but not while performing the first type of WLAN operation .

30. The wireless terminal (50) of claim 28 or 29, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

31. The wireless terminal (50) of claim 30, wherein the cellular network traffic is LTE traffic.

32. The wireless terminal (50) of claim 28 or 29, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

33. A wireless terminal (50) for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal (50) adapted to:

indicate a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

refrain from generating a second WLAN MAC address for a configured time *T* after indicating the first WLAN MAC address in one or more messages sent to the cellular network;

generate a second WLAN MAC address for the wireless terminal different than the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

34. A wireless terminal (50) for operation in a wireless local area network, WLAN, and in a wide-area cellular network, the wireless terminal (50) adapted to:

indicate a first WLAN media access control, MAC, address of the wireless terminal in one or more messages sent to the cellular network;

determine that the wireless terminal is performing a first type of WLAN operation, and refraining from generating a second WLAN MAC address for the wireless terminal while performing the first type of WLAN operation;

generate a second WLAN MAC address for the wireless terminal at a time when the wireless terminal is not performing the first type of WLAN operation , the second WLAN MAC address differing from the first WLAN MAC address; and

report the second WLAN MAC address to cellular network.

35. The wireless terminal (50) of claim 34, wherein the generating of the second WLAN MAC address is performed while the wireless terminal (50) is operating in the WLAN but not while performing the first type of WLAN operation .

36. The wireless terminal (50) of claim 34 or 35, wherein the first type of WLAN operation comprises aggregating WLAN traffic and cellular network traffic.

37. The wireless terminal (50) of claim 36, wherein the cellular network traffic is LTE traffic.

38. The wireless terminal (50) of claim 34 or 35, wherein the first type of WLAN operation comprises sending traffic to the cellular network via a tunnel over WLAN.

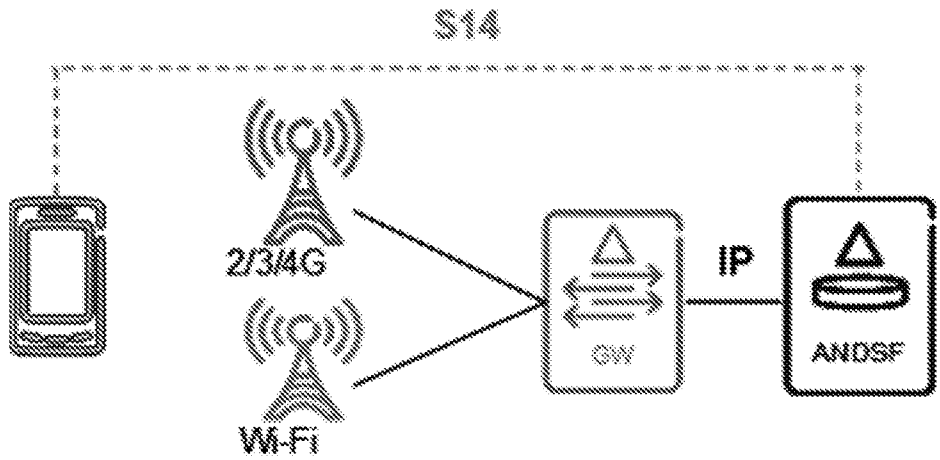

FIG. 1

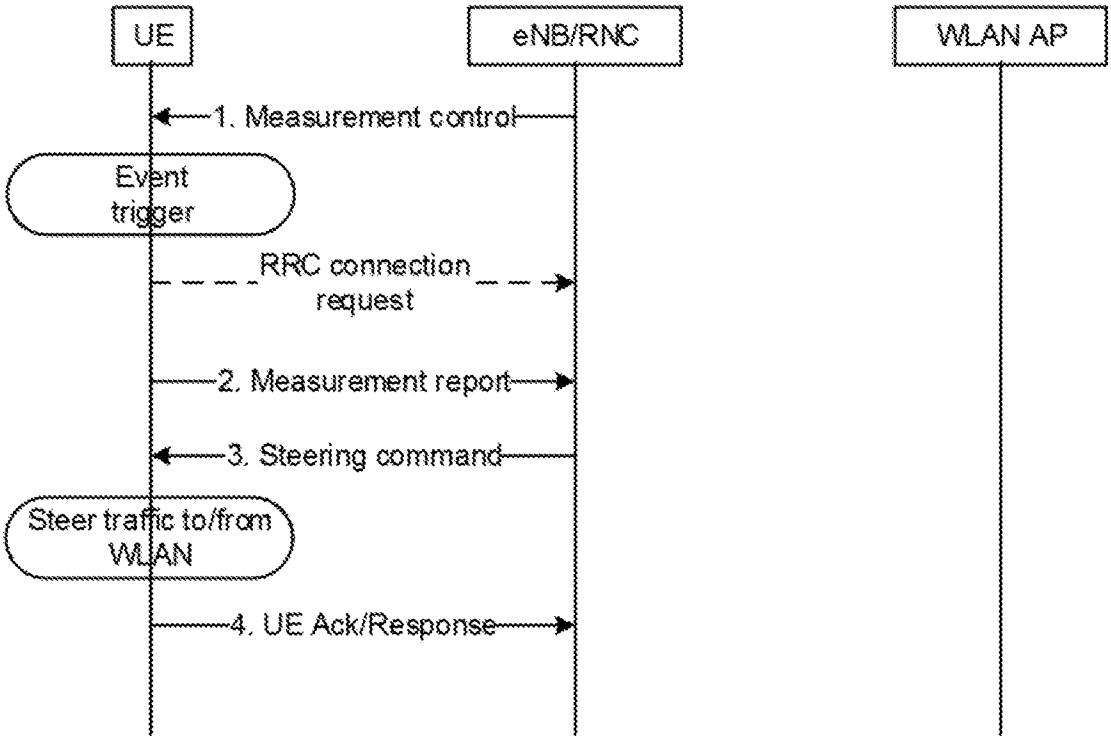
UE
eNB/RNC
WLAN AP
1. Measurement control
Event trigger
RRC connection request
2. Measurement report
3. Steering command
Steer traffic to/from WLAN
4. UE Ack/Response

FIG. 2

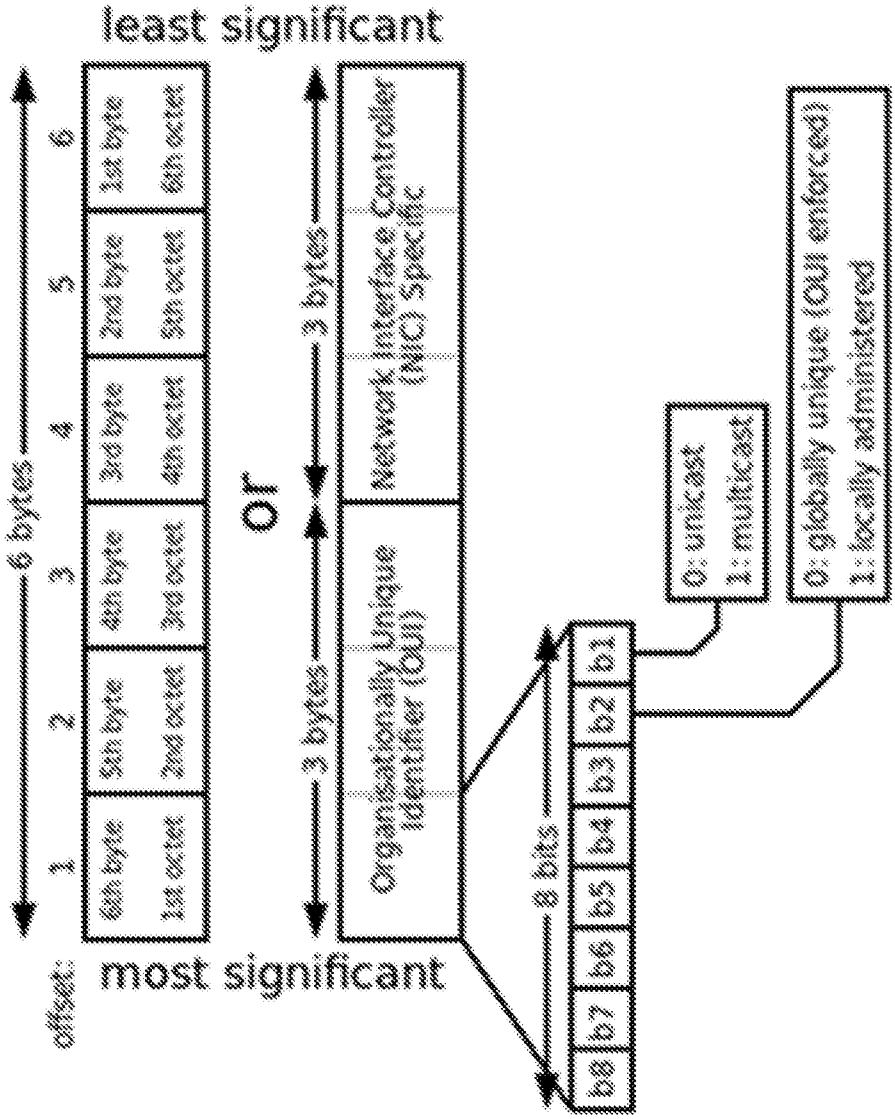
least significant
most significant
offset:
1
2
3
4
5
6
6th byte
1st octet
5th byte
2nd octet
4th byte
3rd octet
3rd byte
4th octet
2nd byte
5th octet
1st byte
6th octet
6 bytes
or
3 bytes
3 bytes
Organizationally Unique Identifier (OUI)
Network Interface Controller (NIC) Specific
8 bits
b0
b1
b2
b3
b4
b5
b6
b7
0: unicast
1: multicast
0: globally unique (OUI enforced)
1: locally administered

FIG. 3

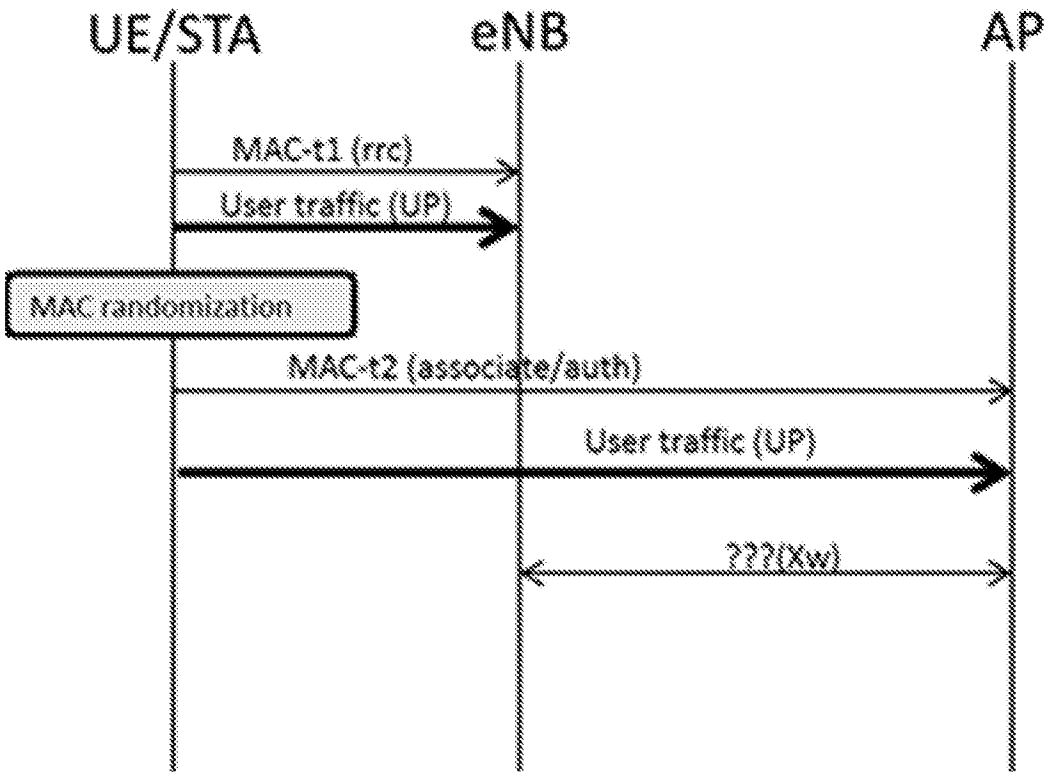
UE/STA
eNB
AP
MAC-t1 (rrc)
User traffic (UP)
MAC randomization
MAC-t2 (associate/auth)
User traffic (UP)
???(Xw)

FIG. 4

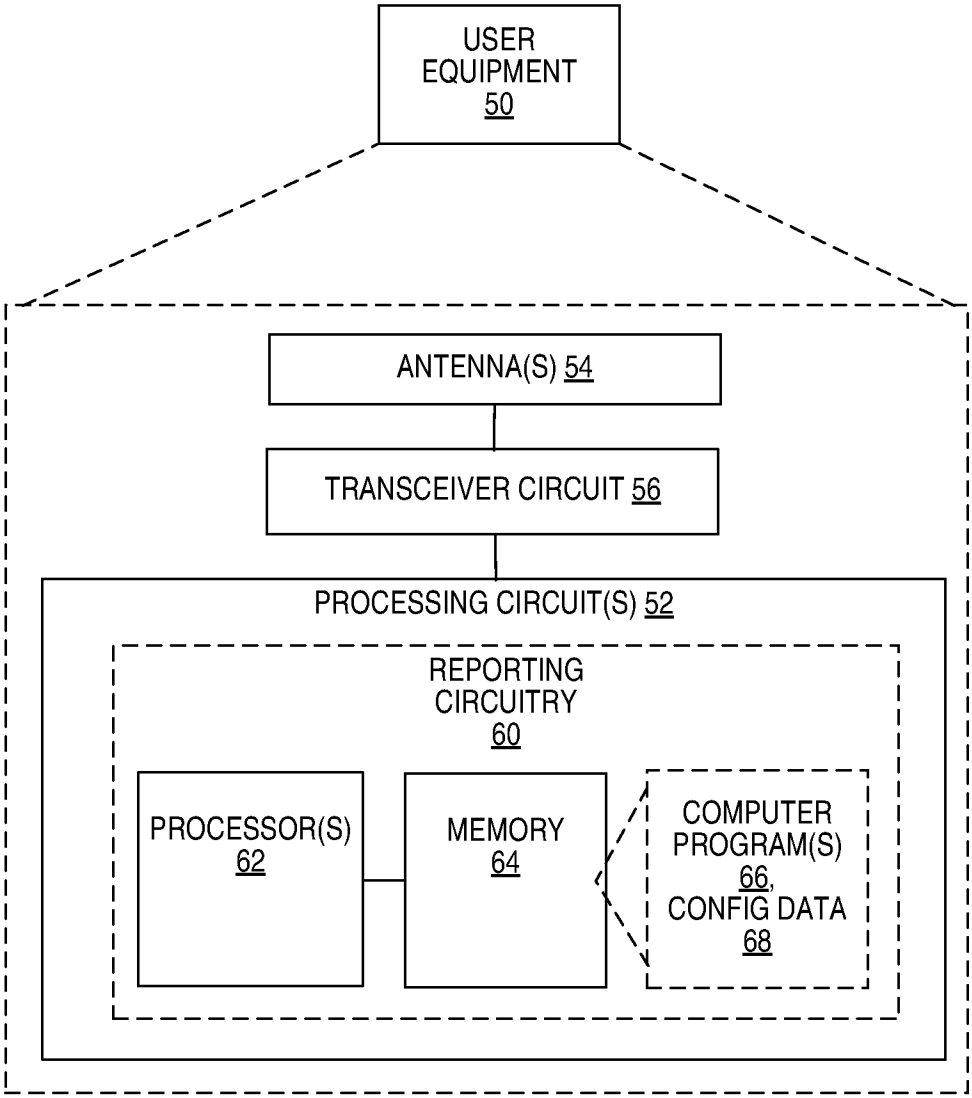
USER EQUIPMENT 50
ANTENNA(S) 54
TRANSCEIVER CIRCUIT 56
PROCESSING CIRCUIT(S) 52
REPORTING CIRCUITRY 60
PROCESSOR(S) 62
MEMORY 64
COMPUTER PROGRAM(S) 66, CONFIG DATA 68

FIG. 5

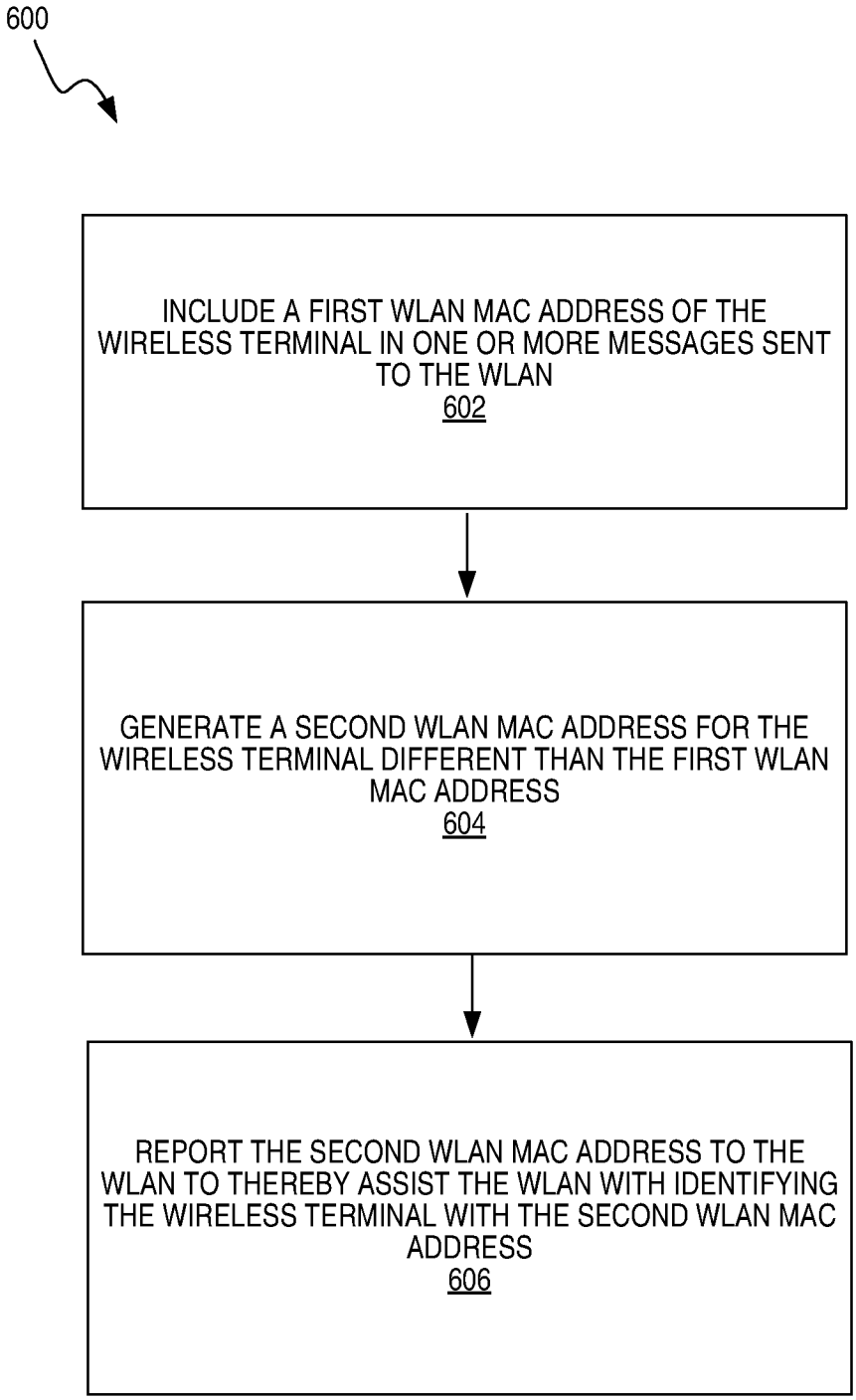
600
INCLUDE A FIRST WLAN MAC ADDRESS OF THE WIRELESS TERMINAL IN ONE OR MORE MESSAGES SENT TO THE WLAN
602
GENERATE A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS
604
REPORT THE SECOND WLAN MAC ADDRESS TO THE WLAN TO THEREBY ASSIST THE WLAN WITH IDENTIFYING THE WIRELESS TERMINAL WITH THE SECOND WLAN MAC ADDRESS
606

FIG. 6

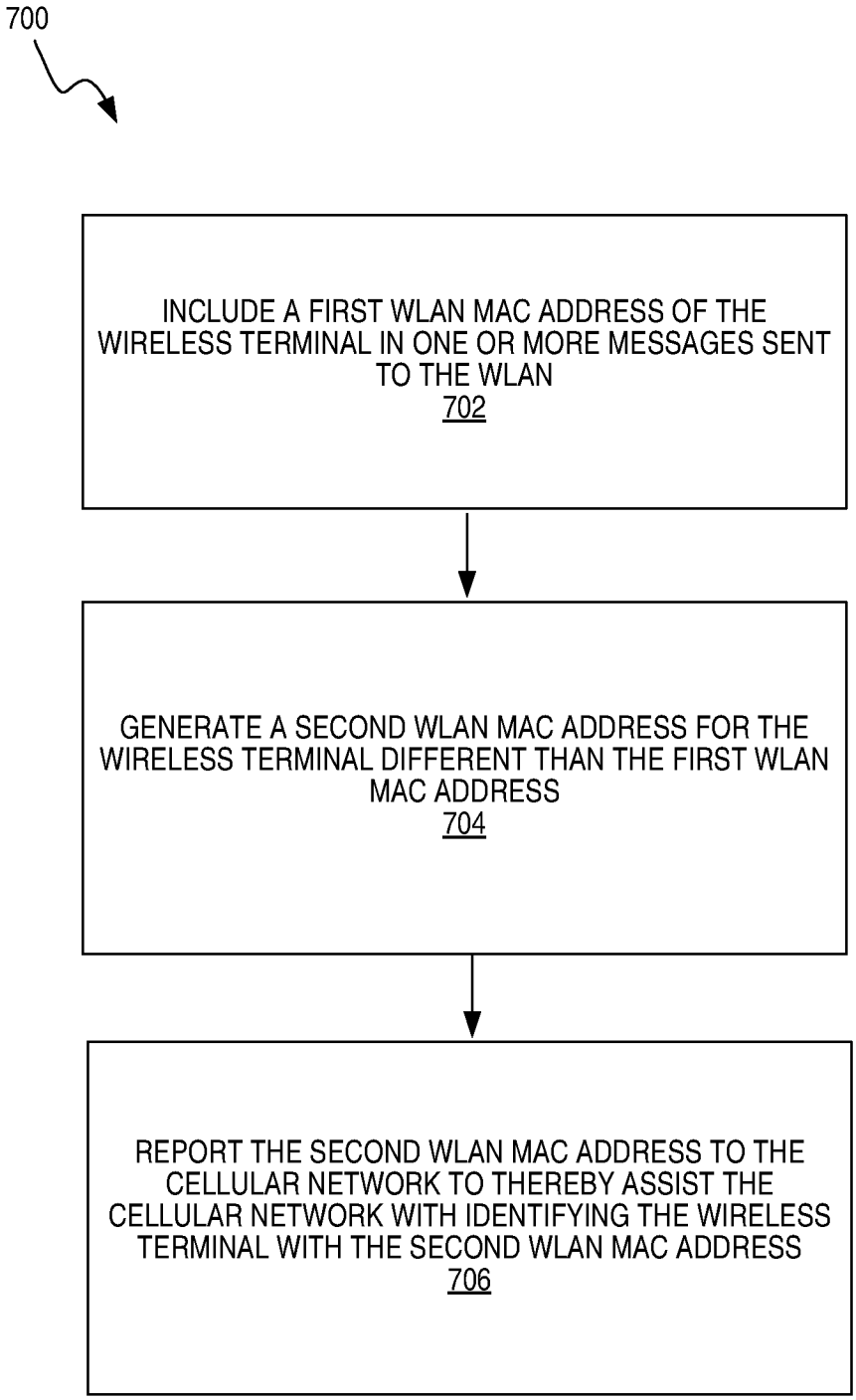
700
INCLUDE A FIRST WLAN MAC ADDRESS OF THE WIRELESS TERMINAL IN ONE OR MORE MESSAGES SENT TO THE WLAN
702
GENERATE A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS
704
REPORT THE SECOND WLAN MAC ADDRESS TO THE CELLULAR NETWORK TO THEREBY ASSIST THE CELLULAR NETWORK WITH IDENTIFYING THE WIRELESS TERMINAL WITH THE SECOND WLAN MAC ADDRESS
706

FIG. 7

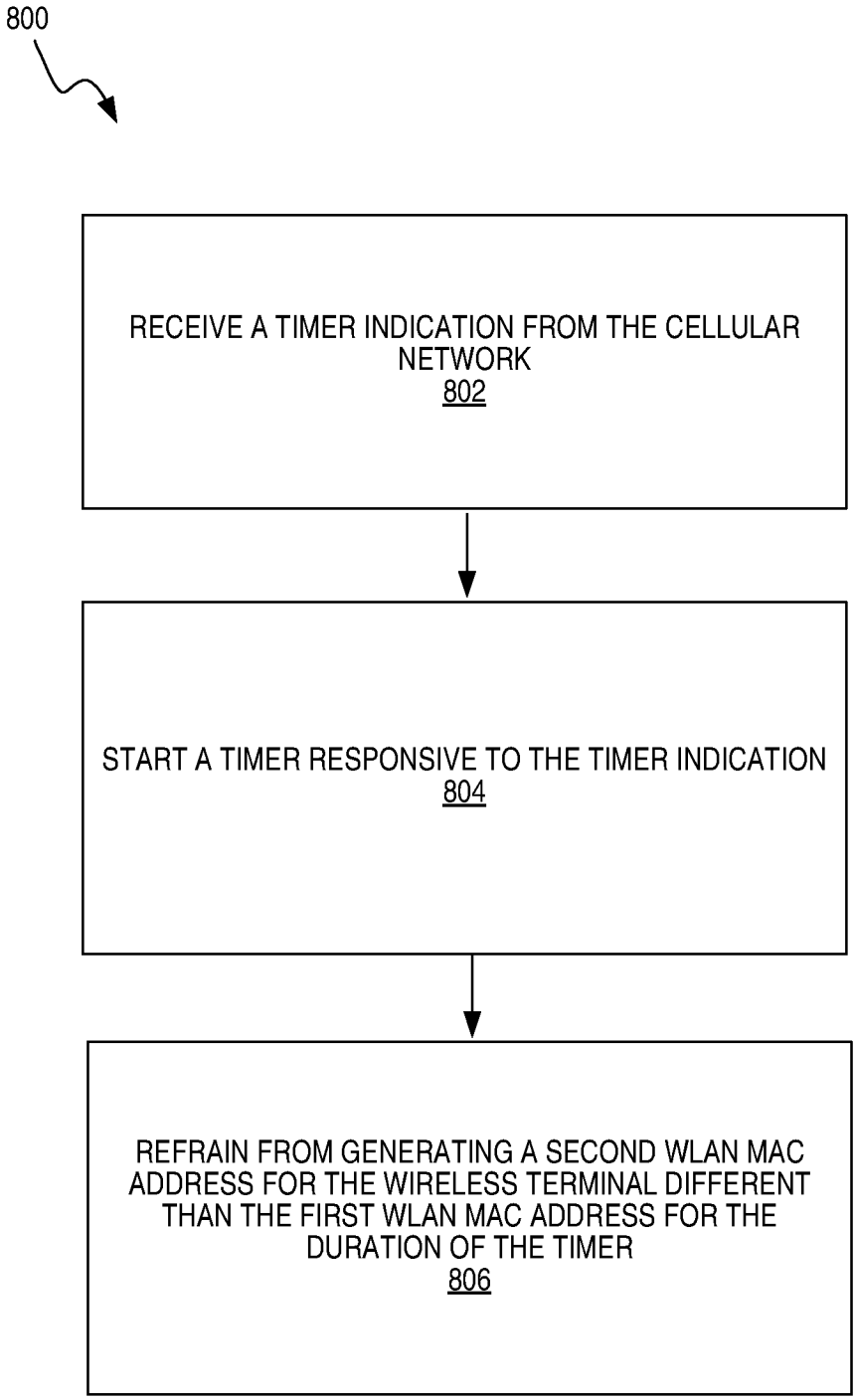
800
RECEIVE A TIMER INDICATION FROM THE CELLULAR NETWORK
802
START A TIMER RESPONSIVE TO THE TIMER INDICATION
804
REFRAIN FROM GENERATING A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS FOR THE DURATION OF THE TIMER
806

FIG. 8

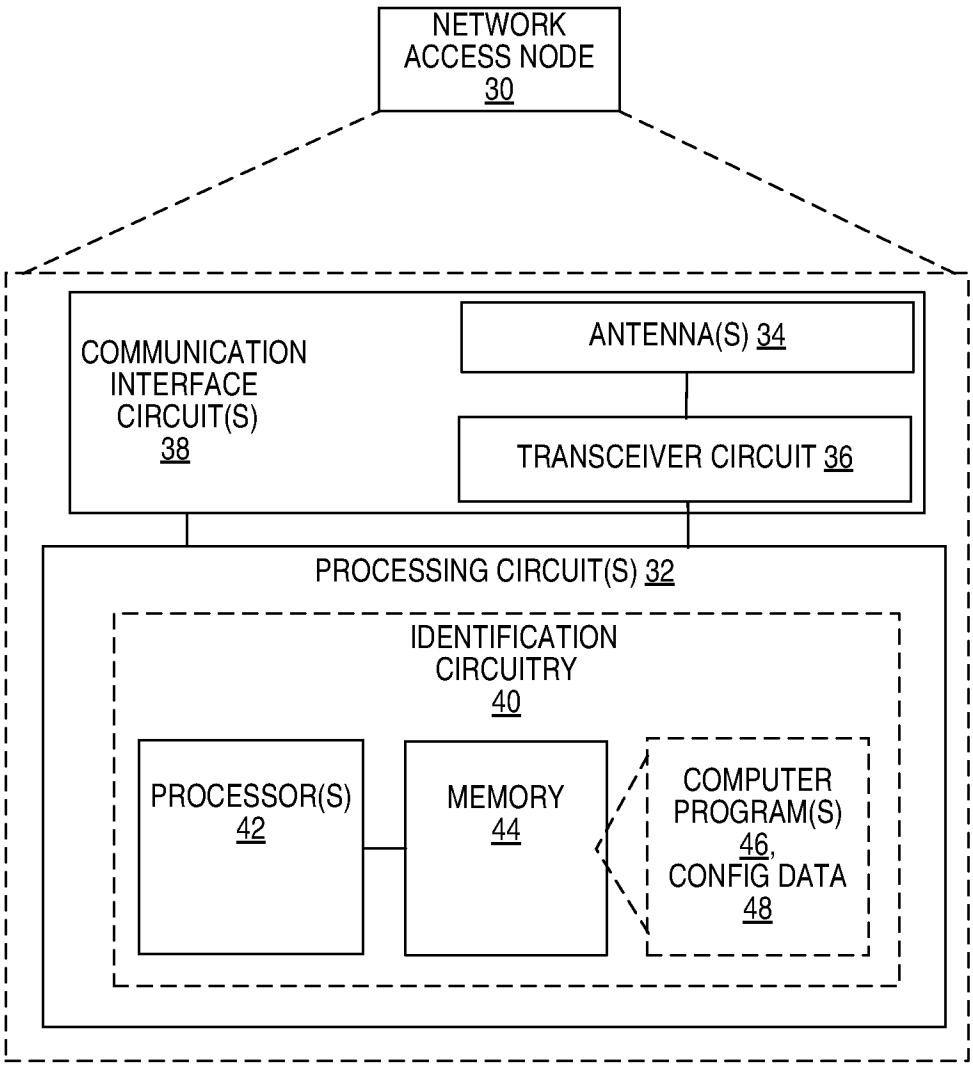
NETWORK ACCESS NODE 30
COMMUNICATION INTERFACE CIRCUIT(S) 38
ANTENNA(S) 34
TRANSCEIVER CIRCUIT 36
PROCESSING CIRCUIT(S) 32
IDENTIFICATION CIRCUITRY 40
PROCESSOR(S) 42
MEMORY 44
COMPUTER PROGRAM(S) 46, CONFIG DATA 48

FIG. 9

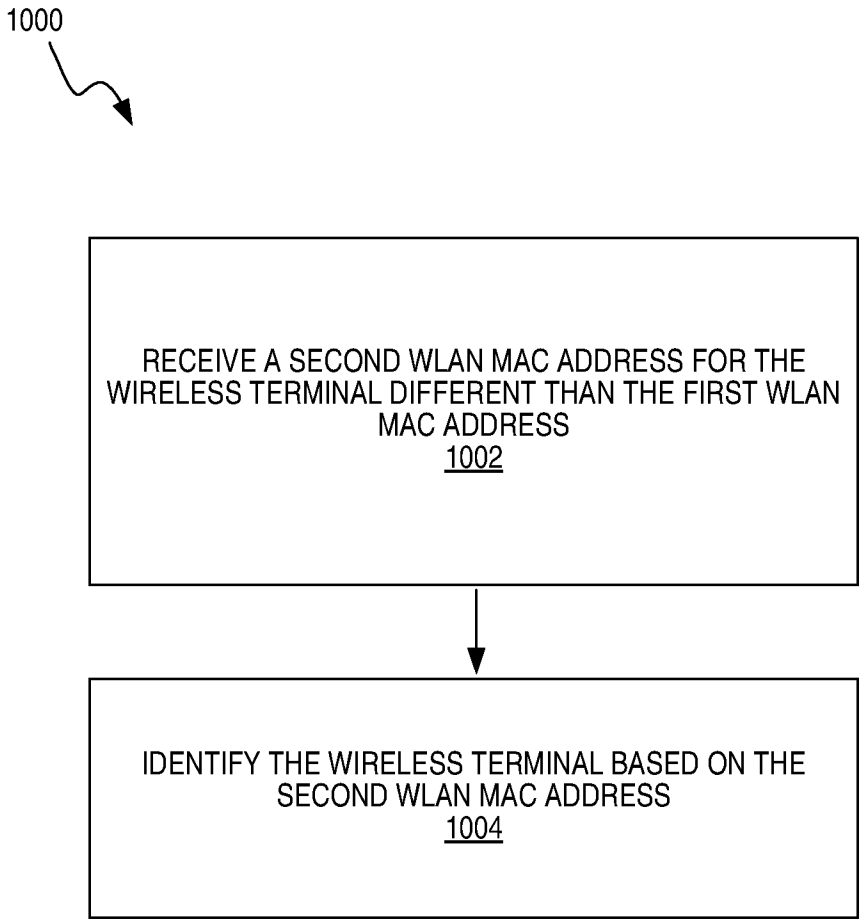
1000
RECEIVE A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS
1002
IDENTIFY THE WIRELESS TERMINAL BASED ON THE SECOND WLAN MAC ADDRESS
1004

FIG. 10

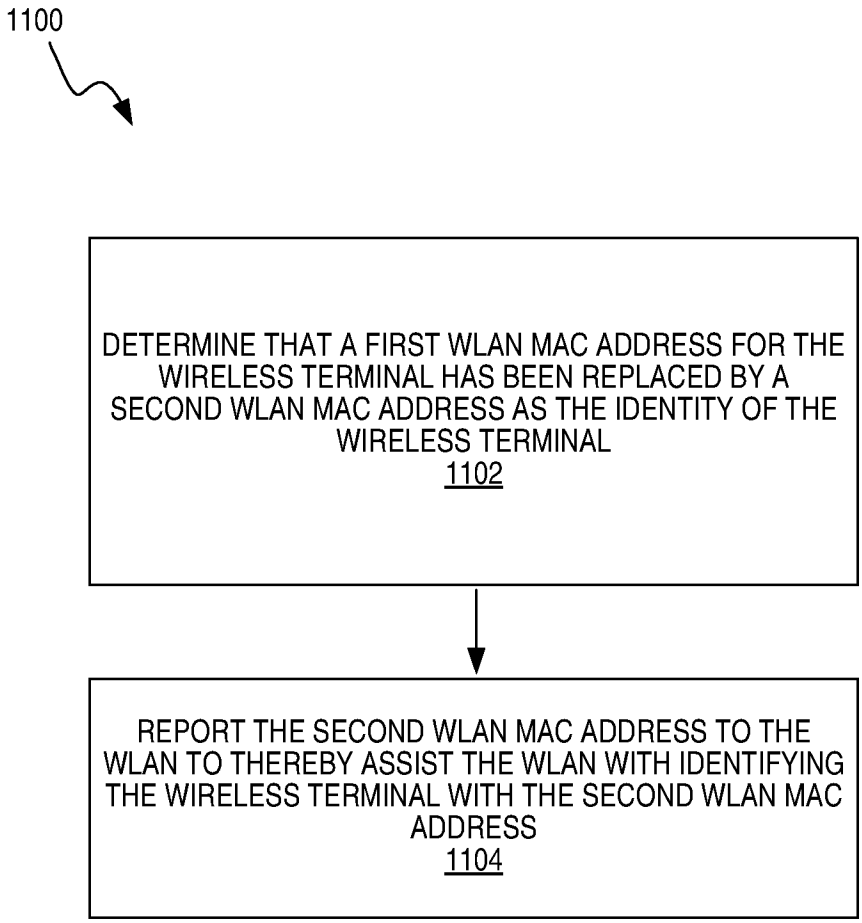
1100
DETERMINE THAT A FIRST WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL HAS BEEN REPLACED BY A SECOND WLAN MAC ADDRESS AS THE IDENTITY OF THE WIRELESS TERMINAL
1102
REPORT THE SECOND WLAN MAC ADDRESS TO THE WLAN TO THEREBY ASSIST THE WLAN WITH IDENTIFYING THE WIRELESS TERMINAL WITH THE SECOND WLAN MAC ADDRESS
1104

FIG. 11

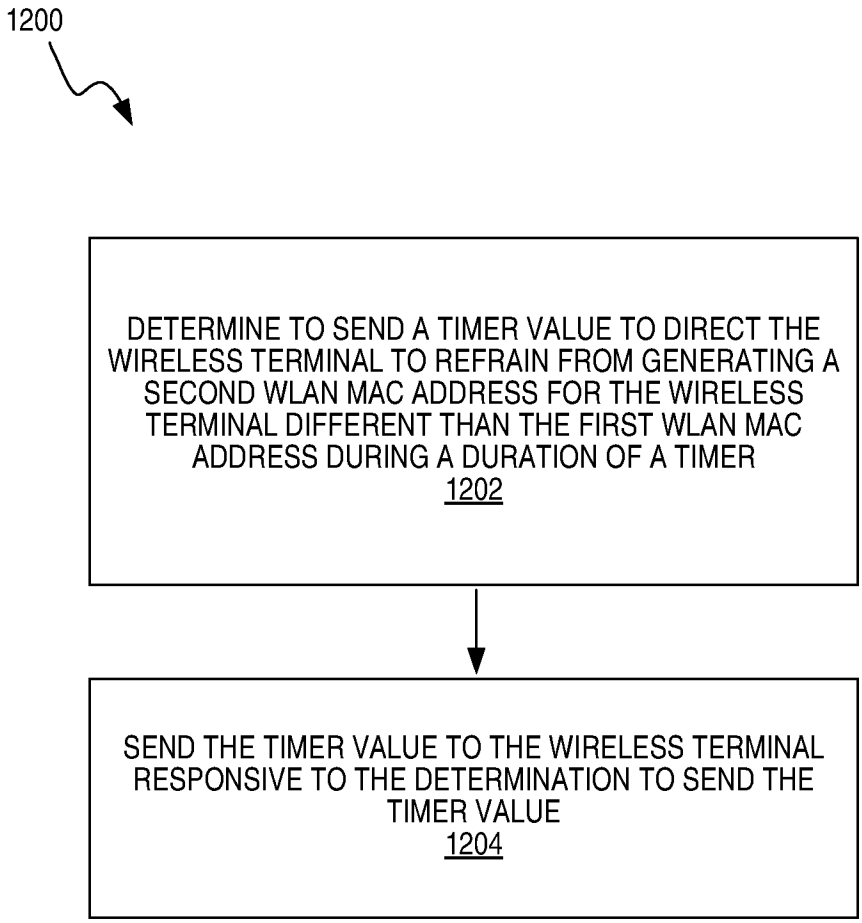
1200
DETERMINE TO SEND A TIMER VALUE TO DIRECT THE WIRELESS TERMINAL TO REFRAIN FROM GENERATING A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS DURING A DURATION OF A TIMER
1202
SEND THE TIMER VALUE TO THE WIRELESS TERMINAL RESPONSIVE TO THE DETERMINATION TO SEND THE TIMER VALUE
1204

FIG. 12

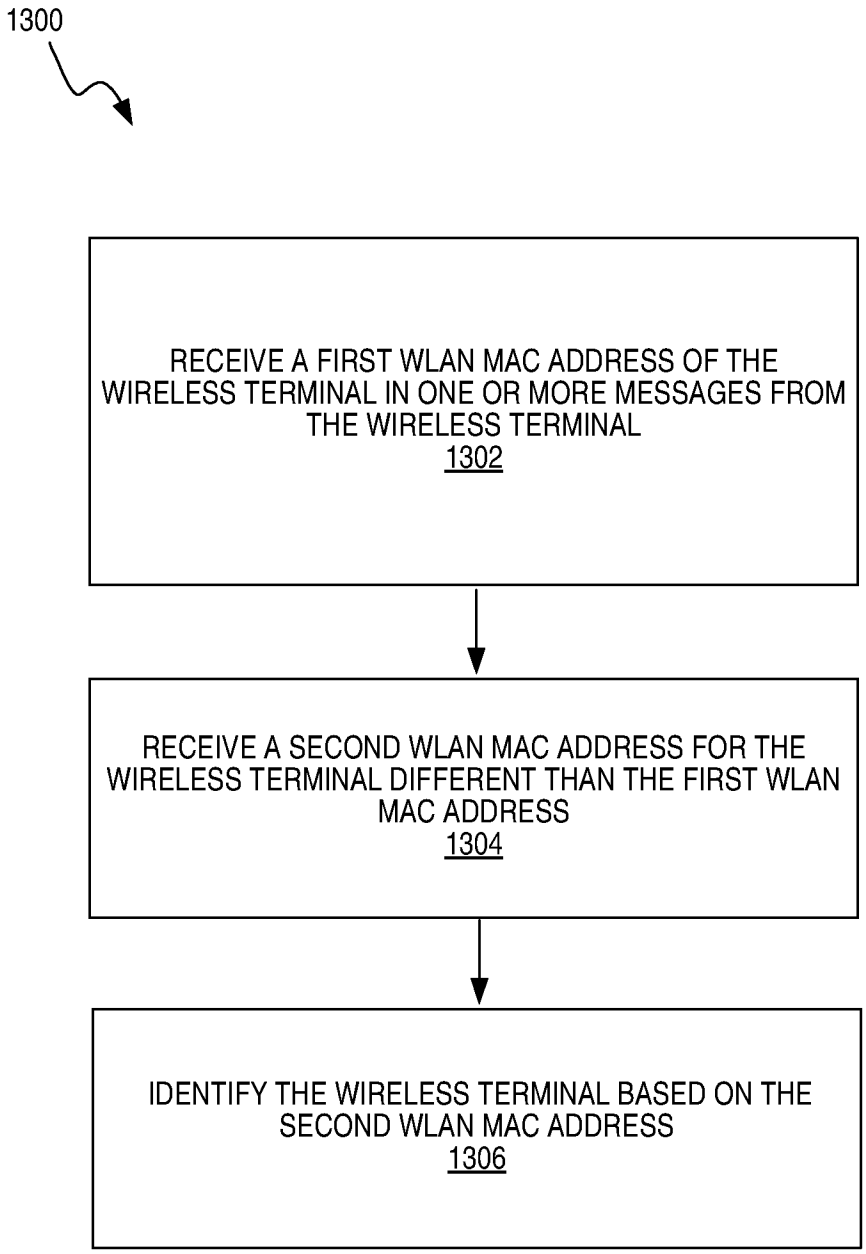
1300
RECEIVE A FIRST WLAN MAC ADDRESS OF THE WIRELESS TERMINAL IN ONE OR MORE MESSAGES FROM THE WIRELESS TERMINAL
1302
RECEIVE A SECOND WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL DIFFERENT THAN THE FIRST WLAN MAC ADDRESS
1304
IDENTIFY THE WIRELESS TERMINAL BASED ON THE SECOND WLAN MAC ADDRESS
1306

FIG. 13

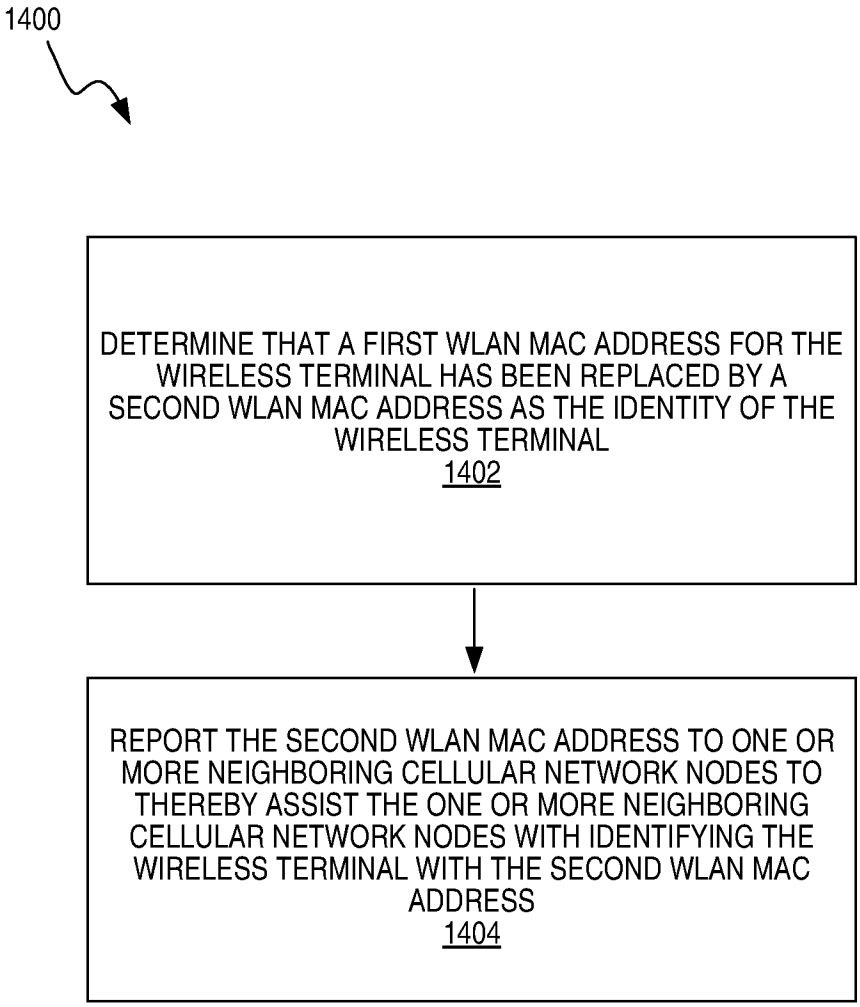
1400
DETERMINE THAT A FIRST WLAN MAC ADDRESS FOR THE WIRELESS TERMINAL HAS BEEN REPLACED BY A SECOND WLAN MAC ADDRESS AS THE IDENTITY OF THE WIRELESS TERMINAL
1402
REPORT THE SECOND WLAN MAC ADDRESS TO ONE OR MORE NEIGHBORING CELLULAR NETWORK NODES TO THEREBY ASSIST THE ONE OR MORE NEIGHBORING CELLULAR NETWORK NODES WITH IDENTIFYING THE WIRELESS TERMINAL WITH THE SECOND WLAN MAC ADDRESS
1404

FIG. 14

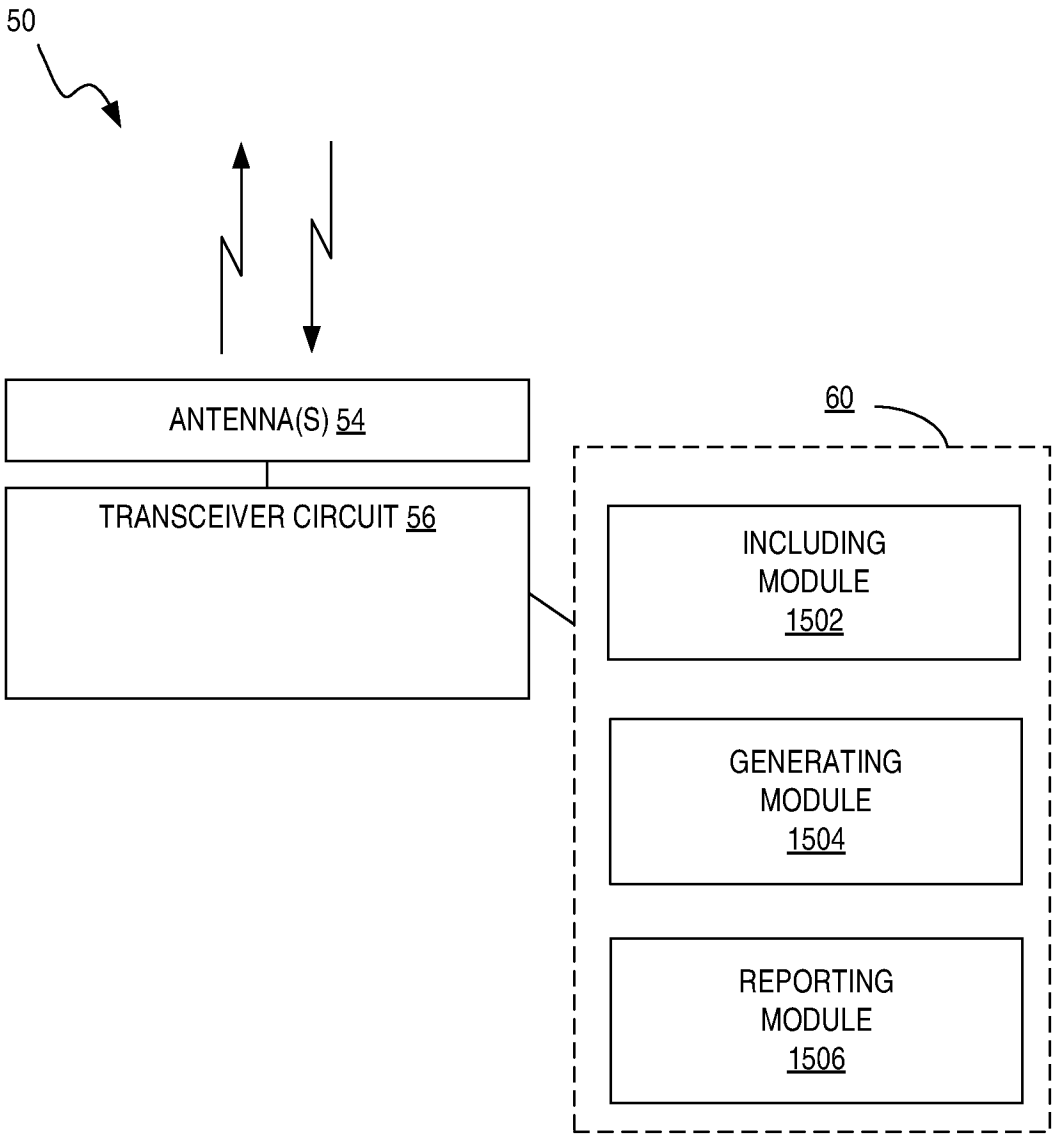
50
ANTENNA(S) 54
TRANSCEIVER CIRCUIT 56
60
INCLUDING MODULE 1502
GENERATING MODULE 1504
REPORTING MODULE 1506

FIG. 15

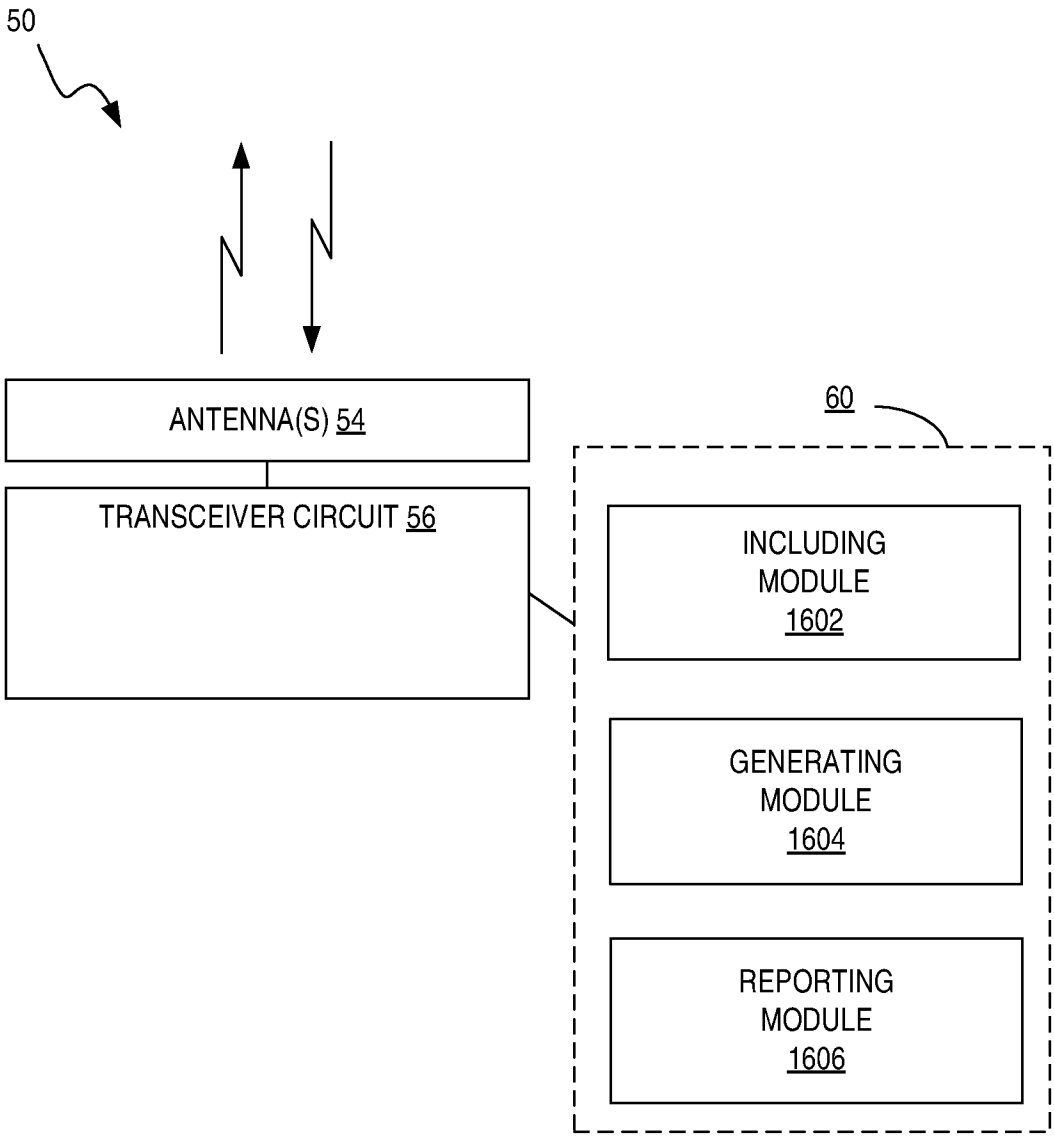
50
ANTENNA(S) 54
TRANSCEIVER CIRCUIT 56
60
INCLUDING MODULE 1602
GENERATING MODULE 1604
REPORTING MODULE 1606

FIG. 16

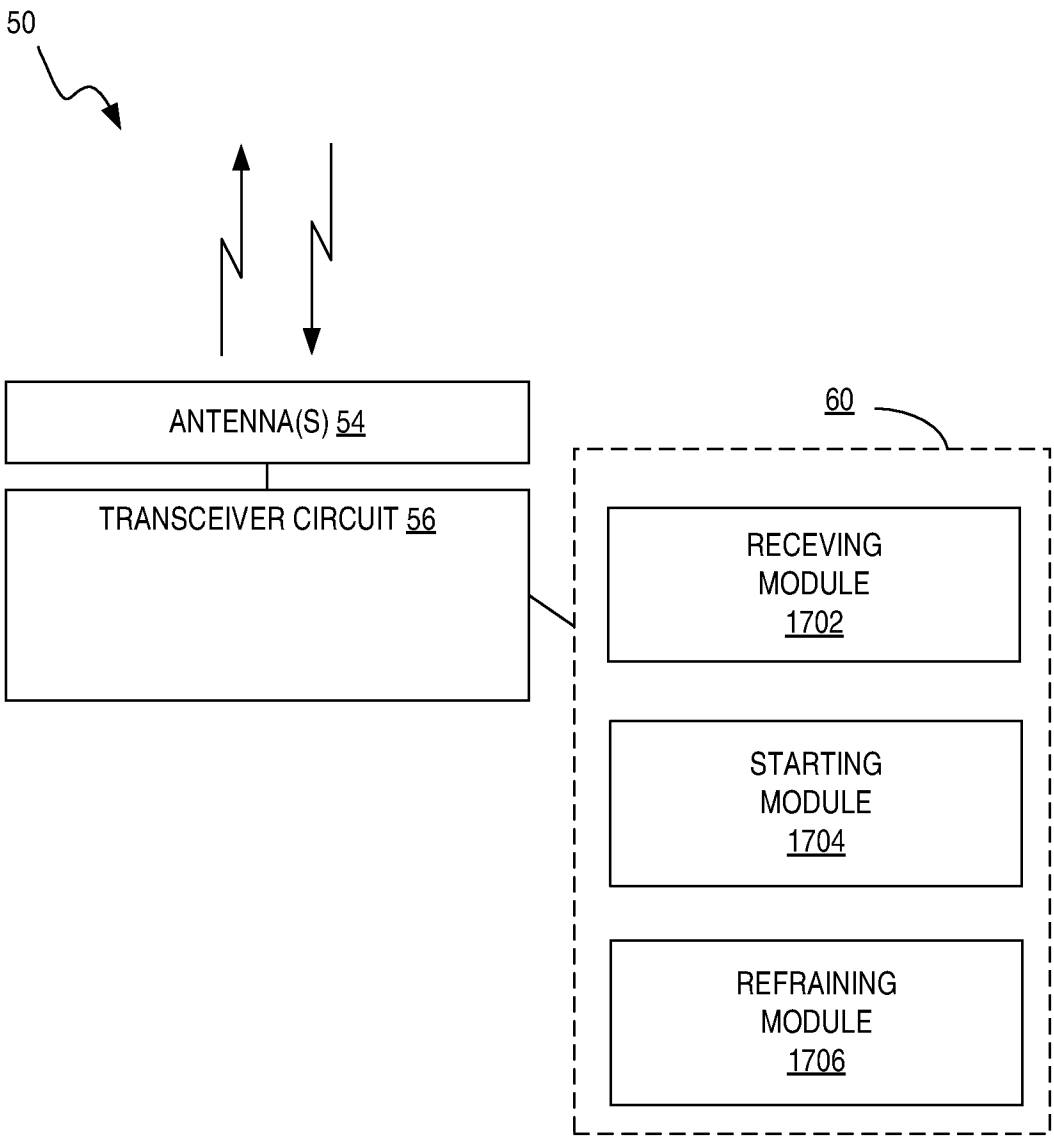
50
ANTENNA(S) 54
TRANSCEIVER CIRCUIT 56
60
RECEVING MODULE 1702
STARTING MODULE 1704
REFRAINING MODULE 1706

FIG. 17

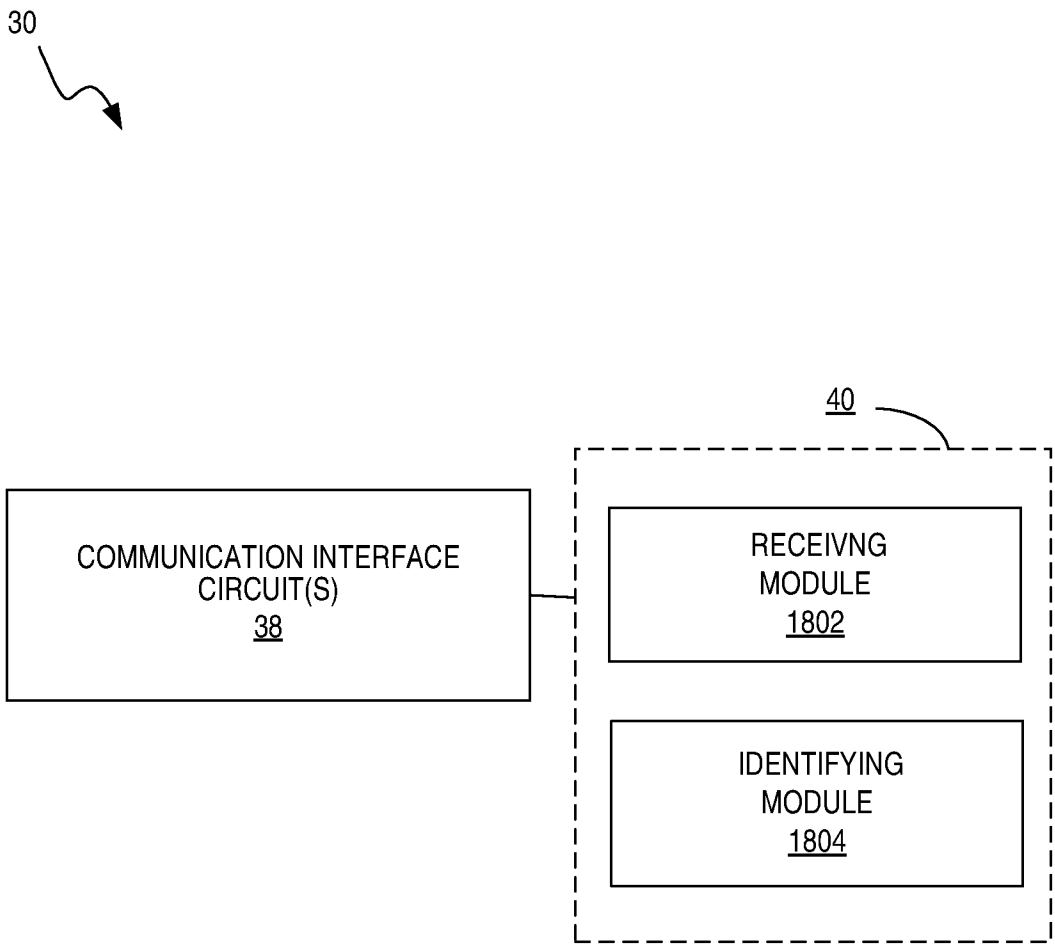
30
40
COMMUNICATION INTERFACE CIRCUIT(S)
38
RECEIVNG MODULE
1802
IDENTIFYING MODULE
1804

FIG. 18

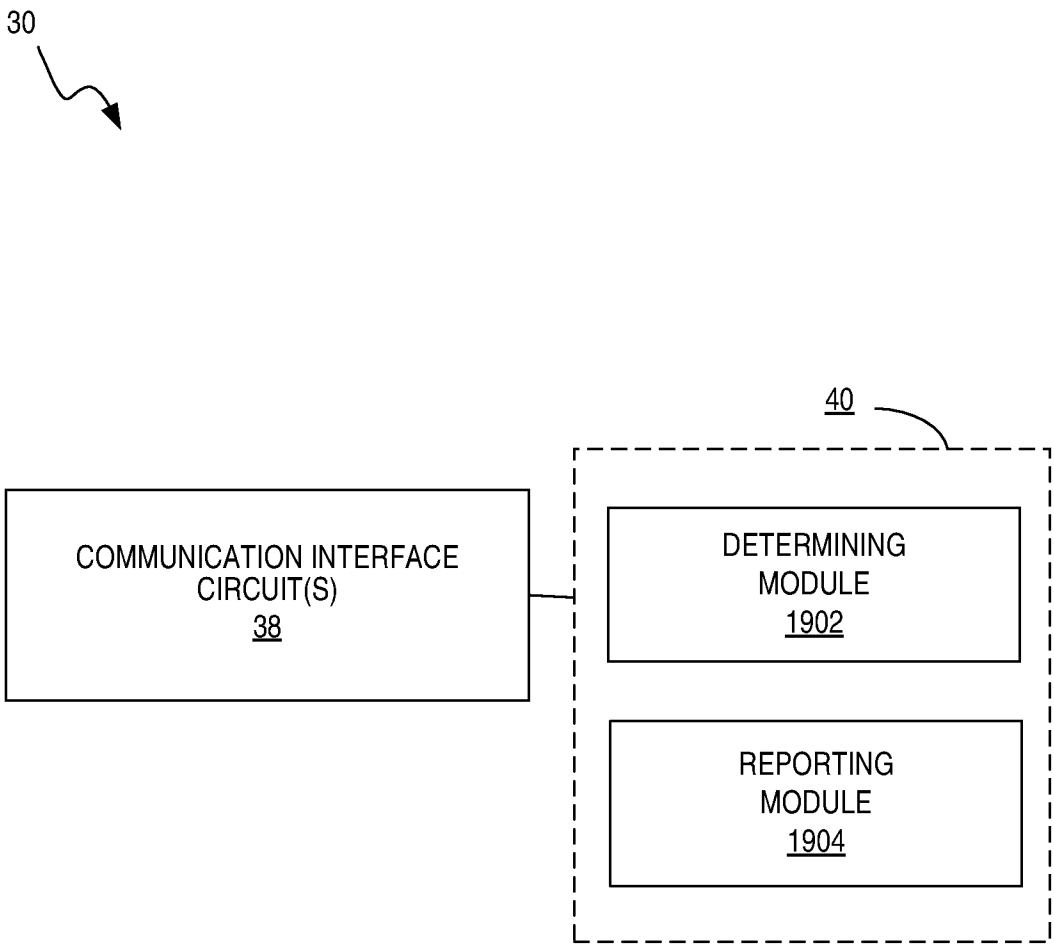
30
40
COMMUNICATION INTERFACE CIRCUIT(S)
38
DETERMINING MODULE
1902
REPORTING MODULE
1904

FIG. 19

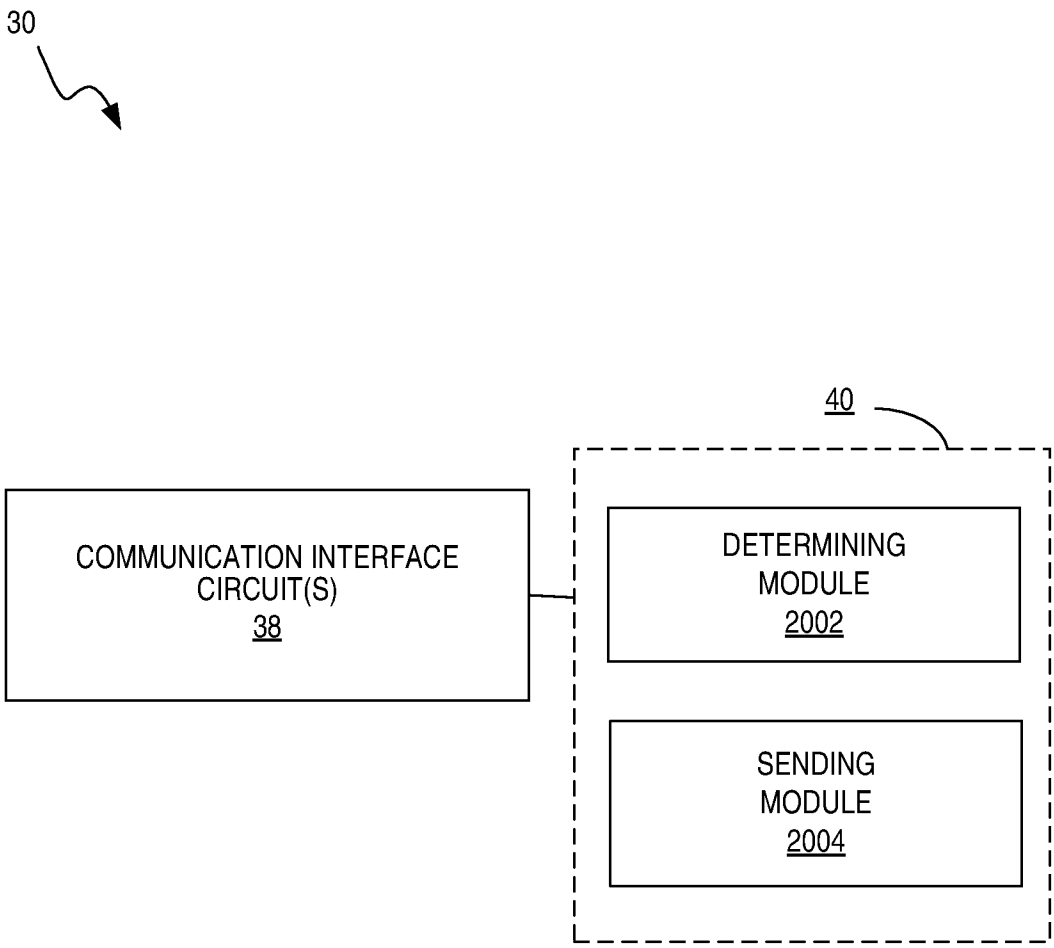
30
40
COMMUNICATION INTERFACE CIRCUIT(S)
38
DETERMINING MODULE
2002
SENDING MODULE
2004

FIG. 20

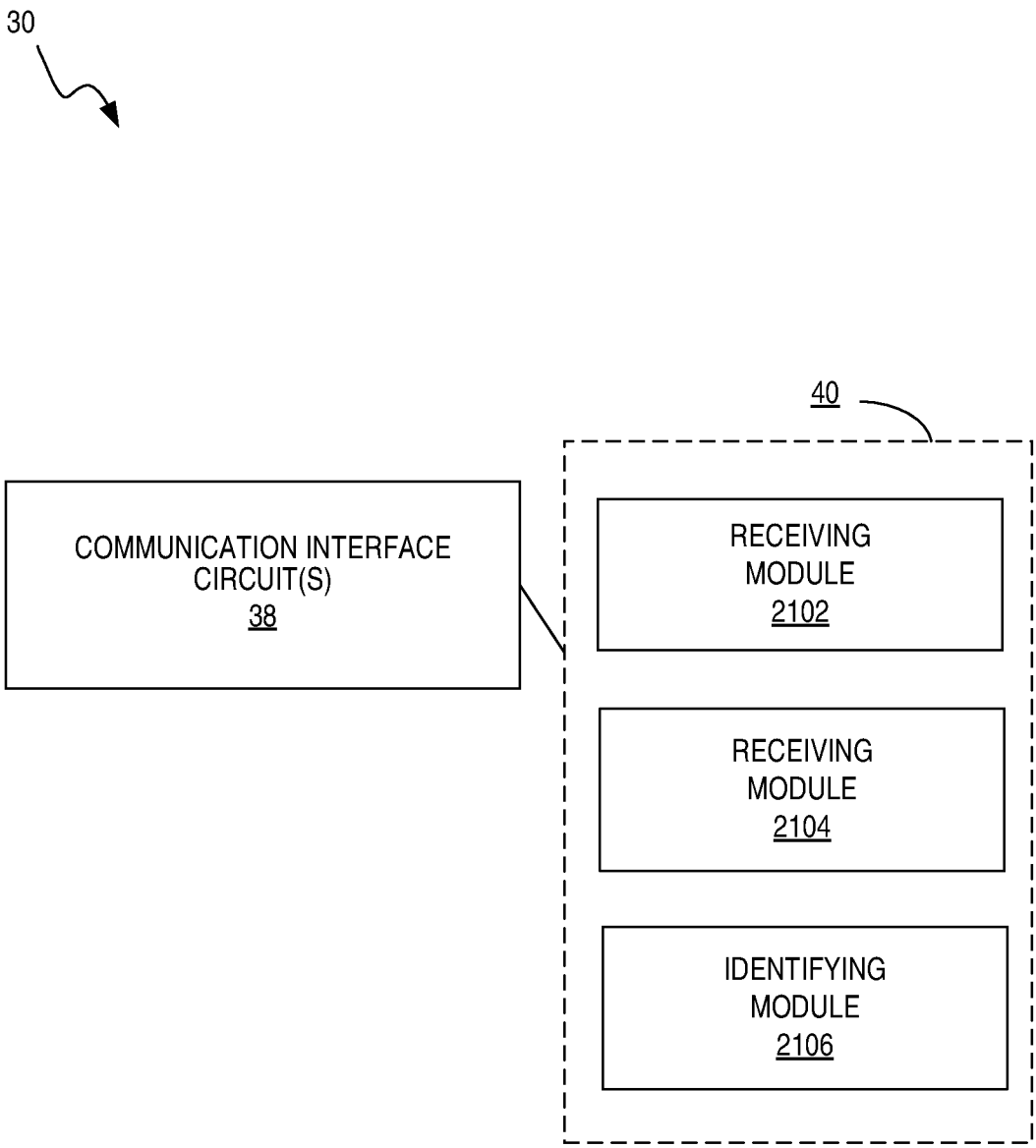
30
40
COMMUNICATION INTERFACE CIRCUIT(S)
38
RECEIVING MODULE
2102
RECEIVING MODULE
2104
IDENTIFYING MODULE
2106

FIG. 21

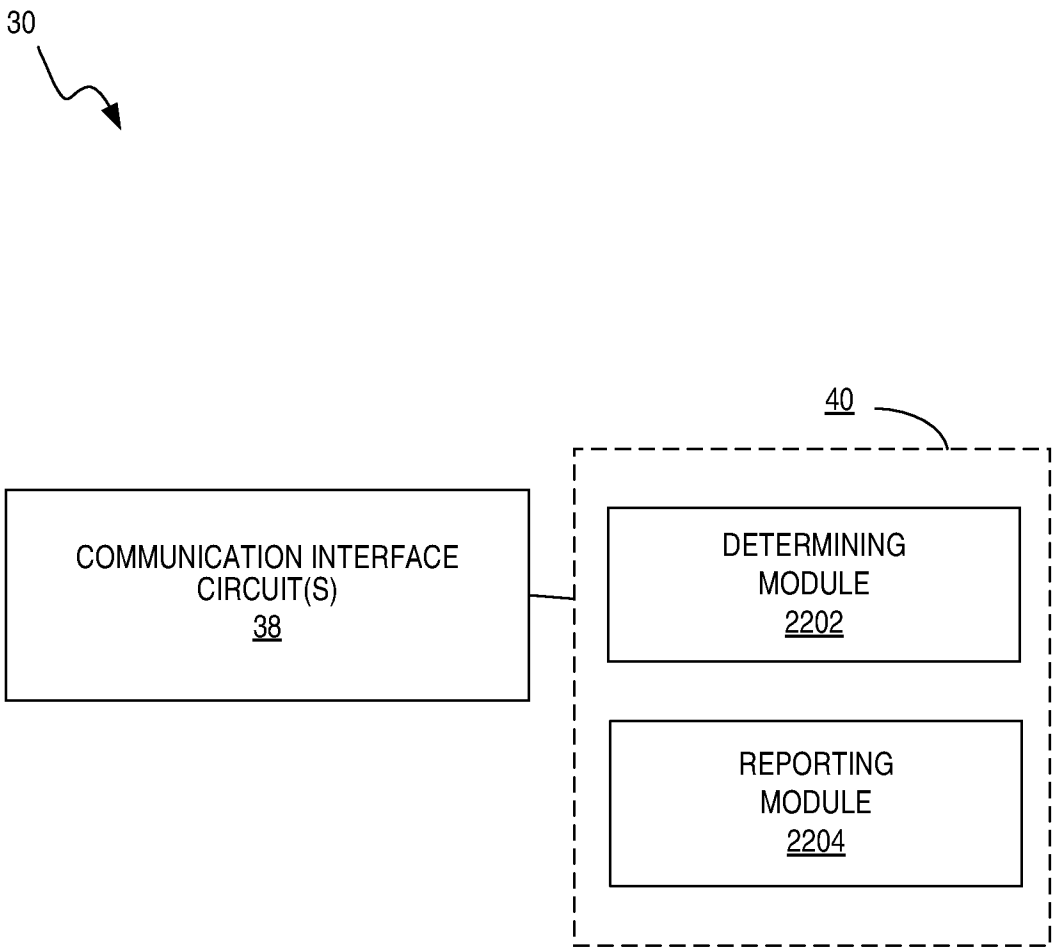
30
40
COMMUNICATION INTERFACE CIRCUIT(S)
38
DETERMINING MODULE
2202
REPORTING MODULE
2204

FIG. 22

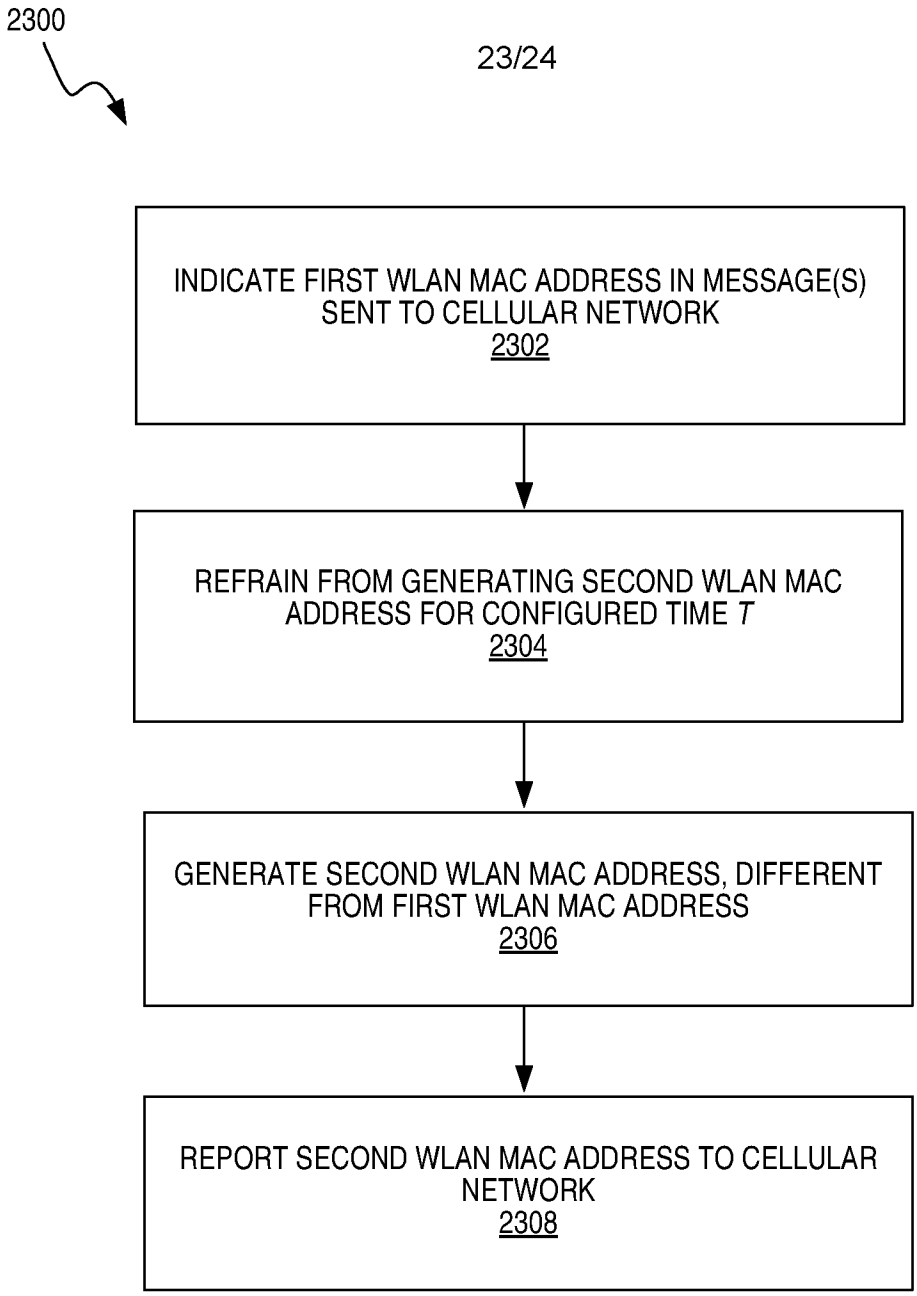
2300
INDICATE FIRST WLAN MAC ADDRESS IN MESSAGE(S) SENT TO CELLULAR NETWORK
2302
REFRAIN FROM GENERATING SECOND WLAN MAC ADDRESS FOR CONFIGURED TIME T
2304
GENERATE SECOND WLAN MAC ADDRESS, DIFFERENT FROM FIRST WLAN MAC ADDRESS
2306
REPORT SECOND WLAN MAC ADDRESS TO CELLULAR NETWORK
2308

FIG. 23

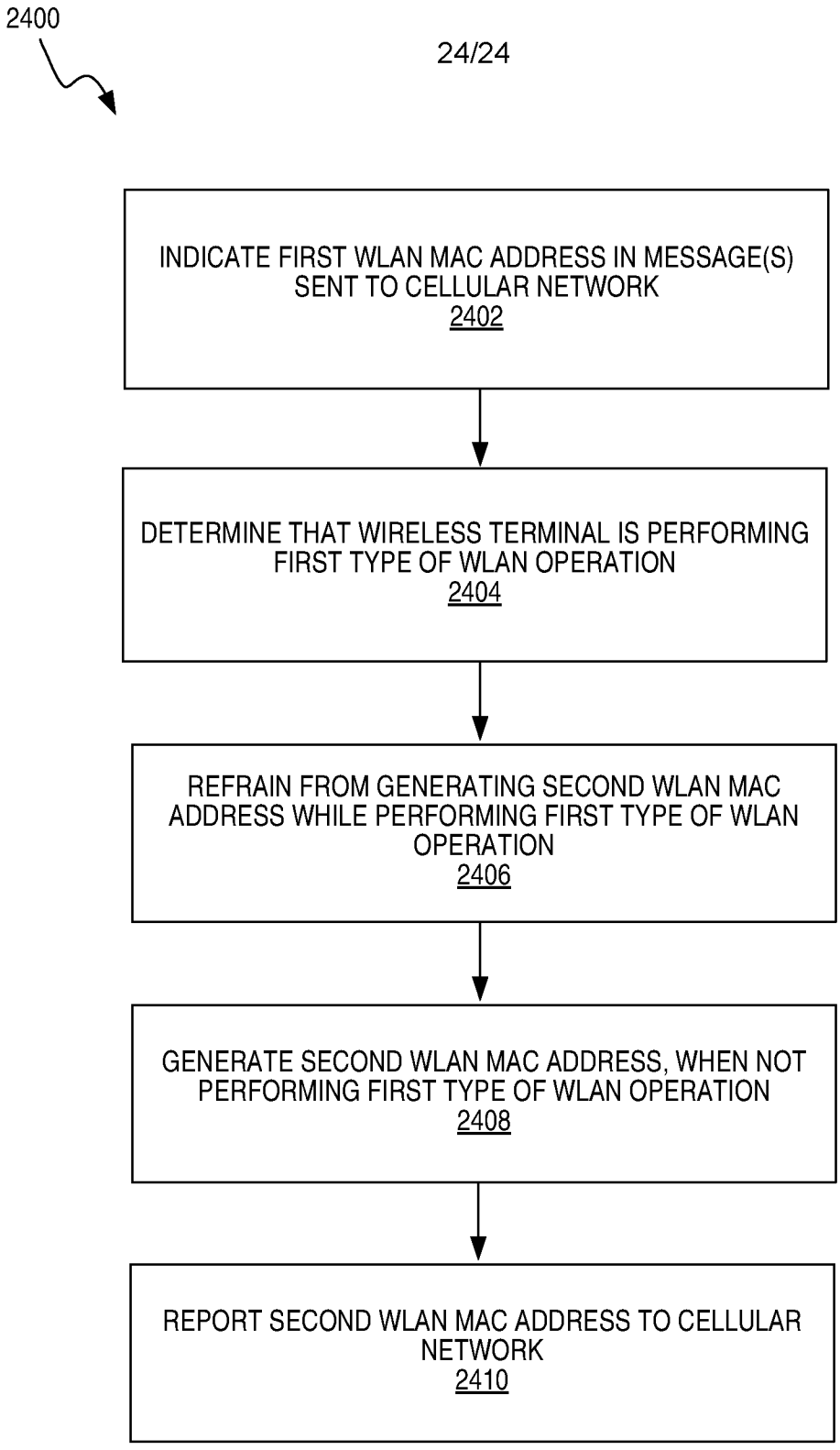
2400
INDICATE FIRST WLAN MAC ADDRESS IN MESSAGE(S) SENT TO CELLULAR NETWORK
2402
DETERMINE THAT WIRELESS TERMINAL IS PERFORMING FIRST TYPE OF WLAN OPERATION
2404
REFRAIN FROM GENERATING SECOND WLAN MAC ADDRESS WHILE PERFORMING FIRST TYPE OF WLAN OPERATION
2406
GENERATE SECOND WLAN MAC ADDRESS, WHEN NOT PERFORMING FIRST TYPE OF WLAN OPERATION
2408
REPORT SECOND WLAN MAC ADDRESS TO CELLULAR NETWORK
2410

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2016/050647

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W12/02 H04L29/12 H04W36/00 H04W88/06 H04W72/12
ADD.

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

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ERICSSON: "Sharing UE WLAN MAC Address Toward eNB", 3GPP DRAFT; R3-151058, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG3, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050968766, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN3/Docs/ [retrieved on 2015-05-24] the whole document ----- -/--	1-6, 12-15

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 October 2016	02/12/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Figiel, Barbara

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050647

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-6, 12-15

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ERICSSON ET AL: "Considerations on UE Identifiers between eNB and WLAN", 3GPP DRAFT; R3-150324, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG3, no. Athens, Greece; 20150209 - 20150213 8 February 2015 (2015-02-08), XP050937075, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN3/Docs/ [retrieved on 2015-02-08] the whole document -----	1-6, 12-15
A	"LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300 version 12.4.0 Release 12)", TECHNICAL SPECIFICATION, EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS ; FRANCE, vol. 3GPP RAN 2, no. V12.4.0, 1 February 2015 (2015-02-01), XP014248552, cited in the application paragraph [07.4] - paragraph [07.6] paragraph [23.6] -----	4-6,15

1

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 12-15

   generating by the mobile device a new WLAN MAC address and informing the cellular network

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2. claims: 7, 8, 16, 17

   allowing the cellular network to impose the delay for generating a new WLAN MAC address for the duration of the timer

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3. claims: 9-11, 18-20

   informing the WLAN about the WLAN MAC address change

   ---

4. claims: 21, 27, 33

   allowing the change of the WLAN MAC address only after the preconfigured time expires

   ---

5. claims: 22-26, 28-32, 34-38

   if the first type of WLAN operation is being performed by the terminal, generating a second WLAN MAC address should be forbidden

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