



(51) International Patent Classification:

H04W 36/32 (2009.01)

(21) International Application Number:

PCT/US2017/016093

(22) International Filing Date:

01 February 2017 (01.02.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/369,486 01 August 2016 (01.08.2016) US

(71) **Applicant:** INTEL IP CORPORATION [US/US]; 2200 Mission College Boulevard, Santa Clara, California 95054 (US).

(72) **Inventor:** YIU, Candy; 1750 SW Broadway Drive, Portland, Oregon 97201 (US).

(74) **Agent:** LEDELL, Brian; Ledell Ansari, LLP, 211 North Union Street, Suite 100, Alexandria, Virginia 22314 (US).

(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR,

KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

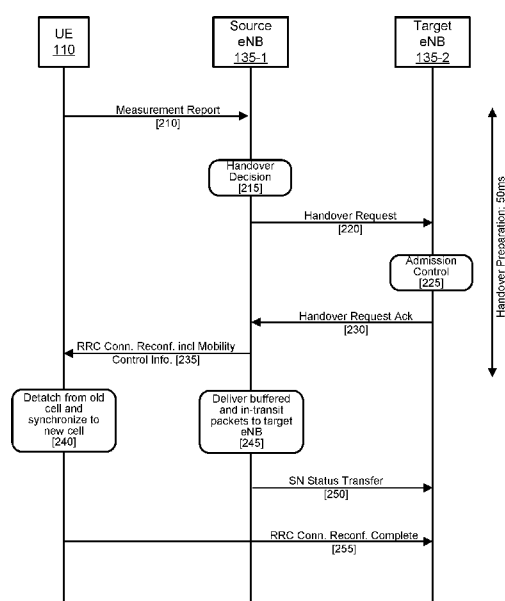
Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: HANDOVER BASED ON UE SPEED

**Fig. 2**

(57) **Abstract:** In a UE-based handover, the UE may initiate the handover procedure to a target cell without having received an explicit handover command from the network. In some implementations, a UE may be configured to potentially perform a UE-based handover when the current speed of the UE is greater than a threshold. Alternatively or additionally, a UE maintained timer may be used to enable the use of the UE-based handover. Advantageously, with the techniques described herein, situations in which UE is likely to move out of range of the source cell, before a network-based handover command can be communicated from the source cell to the UE, may be preemptively handled with a UE-based handover procedure.

HANDOVER BASED ON UE SPEED

RELATED APPLICATIONS

5 The present application claims the benefit of U.S. Provisional Patent Application No. 62/369,486, which was filed on August 1, 2016, the contents of which are hereby incorporated by reference as though fully set forth herein.

BACKGROUND

10 Cellular communications networks can provide for wirelessly connectivity, including high-speed data, for User Equipment (UE) such as mobile phones and data terminals. A cellular communication network may include a Radio Access Network (RAN) section and a "core" network section. The RAN section may handle the wireless (radio) communications with the mobile devices. The RAN portion may include a number of geographically distributed wireless transceivers, which may be included within base stations of the network. The core section may
15 handle control functionality relating to providing data services to the UEs.

 A handover (HO) is a mobility management technique in which radio connectivity for a UE is transferred from one base station to another. Ideally, the handover process should be seamless from the point of view of the user of the UE. That is, ongoing telephone conversations, data connections (e.g., for video playback), or other application level services should continue
20 uninterrupted.

 In the Third Generation Partnership Project (3GPP) standards for cellular networks, the RAN may be implemented using the 5G New Radio (NR) design. The NR design is an Orthogonal Frequency-Division Multiplexing (OFDM)-based air interface designed to support a wide variety of 5G device-types, services, deployments and spectrum. In NR high frequency
25 deployments, beamforming may be used to increase the signal-to-noise ratio (SNR) that can otherwise degrade due to high path loss at high frequencies. In particular, beam sweeping (e.g., using a sequence of radio beams to cover an area) may be used for cell measurements before communication is established between the UE and the network transmit and reception point (TRP) (e.g., a base station). The time delay required to perform the beam sweep operation can,
30 however, result in an increased risk of handover failure.

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

Fig. 1 is a diagram illustrating an example system in which systems and/or methods described herein may be implemented;

Fig. 2 is a diagram illustrating an example signaling sequence that illustrates an existing handover operation that may be performed when switching from a current (source) base station to a target base station;

Fig. 3 is a diagram illustrating a moving UE that is attempting to synchronize with a cell having a particular beamwidth;

Fig. 4 is a diagram illustrating a plot of four different UE speeds during a 130ms time frame;

Fig. 5 is a flowchart illustrating an example process for performing a UE-based handover operation;

Figs. 6A and 6B illustrate example signaling sequences illustrating UE-based handover procedures that are performed based on the expiration of a timer;

Figs. 7 and 8 are flowcharts illustrating example processes for performing a UE-based handover operation that is performed based on the speed of the UE;

Fig. 9 illustrates, for one embodiment, example components of an electronic device; and

Fig. 10 is a block diagram illustrating components, according to some example embodiments, able to read instructions from a machine-readable or computer-readable medium (e.g., a machine-readable storage medium) and perform any one or more of the methodologies discussed herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments is defined by the appended claims and their equivalents.

In a UE-based handover, the UE may initiate the handover procedure to a target cell without having received an explicit handover command from the network. Techniques described herein provide for UE-based handover procedures based on factors such as the speed of the UE. A moving UE may present a particularly challenging handover situation, as the UE may move out of range of the source cell before the typical network-based handover procedure can

effectively control the handover. Advantageously, with the techniques described herein, situations in which UE is likely to move out of range of the source cell may be preemptively handled with a UE-based handover procedure. Alternatively or additionally, in some implementations, a UE maintained timer may be used to enable the use of the UE-based
5 handover.

Fig. 1 is a diagram illustrating an example system 100 in which systems and/or methods described herein may be implemented. As illustrated, system 100 may include a number of UEs 110, which may obtain network connectivity from cellular network 120. In 3GPP, cellular network 120 may include both the Radio Access Network (RAN) 130 and the core portion of the
10 cellular network, which may be referred to as the Evolved Packet Core (EPC) 140.

UE 110 may include a portable computing and communication device, such as a personal digital assistant (PDA), a smart phone, a cellular phone, a laptop computer with connectivity to the wireless telecommunication network, an Internet of Things (IoT) device, a tablet computer, etc. UE 110 may also include a non-portable computing device, such as a desktop computer, a
15 consumer or business appliance, or another device that has the ability to connect to a RAN (e.g., the 3GPP RAN and/or the non-3GPP access network) of the wireless telecommunication network using radio transceiver circuitry that includes the 5G NR design. UE 110 may also include a computing and communication device that may be worn by a user (also referred to as a wearable device) such as a watch, a fitness band, a necklace, glasses, an eyeglass, a ring, a belt,
20 a headset, or another type of wearable device.

RAN 130 may particularly include base stations, which, in the context of a 3GPP network, may be referred to as Evolved NodeBs (eNBs) 135. eNBs 135 may provide the air (radio) interface for wireless connections with UEs 110. EPC 140 may include an Internet Protocol ("IP")-based network. EPC 140 may include a number of network devices, including a
25 Mobility Management Entity (MME) 142, a Serving Gateway (SGW) 144, a Home Subscriber Server (HSS) 146, and a packet data network gateway (PGW 148). Through EPC 140, UEs 110 may communicate with an external network, such as packet data network (PDN) 150.

eNBs 135 may each include one or more network devices that receive, process, and/or transmit traffic destined for and/or received from UE 110 (e.g., via an air interface). eNBs 135
30 may include antennas and other logic necessary to wirelessly communicate with UEs 110. eNBs 135 may additionally communicate with other network devices in the core portion of the wireless telecommunications network. Although referred to as an "eNB," eNB 135 may generally represent any base station and/or radio access technology (RAT) node that is implemented in a cellular network as a network device designed to wirelessly communicate with

UEs. In some situations, a single eNB 135 may be associated with multiple TRPs. Some of the operations that are described herein as being performed by an eNB may equivalently be performed by each TRP that is associated with the eNB. That is, the eNB may perform the operations for each of its TRPs.

5 MME 142 may include one or more computation and communication devices that act as a control node for eNBs 135 and/or other devices that provide the air interface for the wireless telecommunications network. For example, MME 142 may perform operations to register UEs 110 with the cellular network, to establish user plane bearer channels (e.g., traffic flows), to hand off UE 110 to different eNBs 135, MME, or another network, and/or to perform other
10 operations. MME 142 may perform policing operations on traffic destined for and/or received from UEs 110.

SGW 144 may aggregate traffic received from one or more eNBs 135 and may send the aggregated traffic to an external network or device via PGW 148. Additionally, SGW 144 may aggregate traffic received from one or more PGWs 148 and may send the aggregated traffic to
15 one or more eNBs 135. SGW 144 may operate as an anchor for the user plane during inter-eNB handovers and as an anchor for mobility between different telecommunication networks.

HSS 146 may include one or more devices that may manage, update, and/or store, in a memory associated with HSS 146, profile information associated with a subscriber (e.g., a subscriber associated with UE 110). The profile information may identify applications and/or
20 services that are permitted for and/or accessible by the subscriber; a Mobile Directory Number (MDN) associated with the subscriber; bandwidth or data rate thresholds associated with the applications and/or services; and/or other information. The subscriber may be associated with UE 110. Additionally, or alternatively, HSS 146 may perform authentication, authorization, and/or accounting operations associated with the subscriber and/or a communication session
25 with UE 110.

PGW 148 may include one or more network devices that may aggregate traffic received from one or more SGWs 144, and may send the aggregated traffic to an external network. PGW 148 may also, or alternatively, receive traffic from the external network and may send the traffic toward UE 110 (via SGW 144 and/or eNB 135).

30 PDN 150 may include one or more packet networks, such as an Internet Protocol (IP) based packet network. PDN 150 may include a wide area network (WAN), a local area network (LAN), and/or combinations of WANs and LANs. Application servers or other computing devices, designed to control or aggregate data from UEs 110, may be connected to PDN 150.

A number of communication interfaces, between the various components of system 100, are illustrated in Fig. 1. The communication interfaces may include 3GPP standardized interfaces. As illustrated, the interfaces may include: an S1-U interface between eNB 135 and SGW 144, an X2 interface between different eNBs, an S1-MME interface between eNB 135 and MME 142, an S6a interface between MME 142 and HSS 146, and an S5/S8 interface between SGW 144 and PGW 148.

The quantity of devices and/or networks, illustrated in Fig. 1, is provided for explanatory purposes only. In practice, there may be additional devices and/or networks; fewer devices and/or networks; different devices and/or networks; or differently arranged devices and/or networks than illustrated in Fig. 1. Alternatively, or additionally, one or more of the devices of system 100 may perform one or more functions described as being performed by another one or more of the devices of system 100.

Fig. 2 is a diagram illustrating an example signaling sequence that illustrates an existing handover operation that may be performed when switching from a current (source) eNB 135-1 to a next (target) eNB 135-2.

As shown in Fig. 2, UE 110 may, at certain times, generate and transmit measurement reports to source eNB 135-1 (at 210, "Measurement Reports"). The measurement report is the mechanism used by UE 110 to inform source eNB 135-1 of measurements (or other information) relating to the surrounding network. The measurement report may include, for example, particular measurements that were previously requested by source eNB 135-1 (such as in a measurement control message). Examples of measurements may include measurements relating to Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and/or Signal-to-Noise-plus-Interference (SINR) values of neighboring cells in the measured frequencies.

Based on the measurement report, and potentially on other information, source eNB 135-1 may, at some point, make a handover decision to cause UE 110 to connect to target eNB 135-2 (at 215, "Handover Decision"). Source eNB 135-1 may issue a handover request to target eNB 135-2 (at 220, "Handover Request"). As part of the handover request, source eNB 135-1 may pass necessary information to prepare the handover at target eNB 135-2. The information may include context information, such as U2 X2 signaling context information and UE S1 EPC signaling context information. Admission Control may be performed by target eNB 135-2 to determine if the needed resources can be granted by target eNB 135-2 (at 225, "Admission Control"). Target eNB 135-2 may prepare for the handover and transmit a handover request acknowledgement (ACK) to source eNB 135-1 (at 230, "Handover Request Ack"). The

handover request acknowledge message may include information that is to be sent to UE 110 as an RRC message and that causes UE 100 to perform the handover. The information may include mobility control information. The handover request acknowledge message may be sent over the X2 interface.

5 Source eNB 135-1 may generate an RRC message (e.g., RRC Connection Reconfiguration message) to cause the handover to be performed by UE 110 (at 235, "RRC Conn. Reconf. incl Mobility Control Info."). The RRC message may include the mobility control information (i.e., handover parameters that the UE may need to connect with target eNB 135-2) relating to target eNB 135-2. The RRC Connection Reconfiguration message, from the
10 UE's perspective, may be considered to be the handover command from the network and to the UE.

 UE 110 may detach from the old cell (provided by source eNB 135-1) and synchronize with the new cell (provided by target eNB 135-2) (at 240, "Detach from old cell and synchronize to new cell"). During the handover procedure, source eNB 135-1 may buffer packets received
15 for UE 110. When UE 110 has synchronized with target eNB 135-2, source eNB 135-1 may deliver the buffered and in transit packets to target eNB 135-2 (at 245, "Deliver buffered and in-transit packets to target eNB"). Source eNB 135-1 may transmit a Sequence Number (SN) status transfer message to target eNB 135-2 (at 250, "SN Status Transfer"). The SN status transfer message may convey uplink Packet Data Convergence Protocol (PDCP) SN receiver status and
20 downlink PDCP SN transmitter status of E-Radio Access Bearer (E-RABs) for which PDCP status preservation applies. When UE 110 has successfully accessed the target cell, UE 110 may send the RRC Connection Reconfiguration Complete message to confirm the handover (at 255, "RRC Conn. Reconf. Complete").

 The total time duration for the handover preparation operations in 210-235 may take, for
25 example, approximately 50 milliseconds (ms). In NR, the beam sweeping mechanism, which may be needed to be performed before UE 110 can synchronize with target eNB 135-2, can result in an extra delay that can cause the handover operation to fail, particularly in the case where the UE is moving.

 Fig. 3 is a diagram illustrating a moving UE that is attempting to synchronize with a cell
30 in which the beamwidth is 12 degrees. UE 110 may begin in the center of the beam. In most of the cases for a moving UE, this may be a worst case scenario because UE 110 will be closer to the cell edge in order to trigger handover. In addition to the 50 ms handover preparation time, UE 110 may experience measurement delay relating to the beam sweeping mechanism. During a network-based handover procedure, UE 110 also needs to be connected with source eNB 135-1

to receive the handover command to initiate the handover procedure. As is shown in Fig. 3, greater distances between the UE and the TRP correspond to a larger area, in which the UE can move, and still be within the beam coverage area. For example, if the UE starts at point 310 (in the middle of the beam coverage), there is a limited movement distance (shown by the dashed lines in Fig. 3), until the UE moves out of the beam coverage area.

Fig. 4 is a diagram illustrating a plot of four different UE speeds during a 130ms time frame, which assumes a required beam sweep time of 90ms and an handover preparation time of 40ms. The horizontal dotted lines correspond to the distance the UE traverse based on the speed of the UE. For example, because the delay time in Fig. 4 is assumed to be 130ms, a UE moving at 120 kilometer per hour (km/h) moves 4.3 meters (m) during the 130ms time frame. If the UE is located at the peak of the antenna gain (in the middle of the beam) when the measurement starts, the intersection of the horizontal 120 km/h line (the 4.3 meter line) and the line for the half beam width occurs at approximately 41m. Thus, 41m is the threshold distance away from the TRP, where the UE, when moving at 120 km/h will still be within the TRP coverage area after 130ms. As can be seen from Fig. 4, faster UE speeds require that the UE be farther from the TRP for the UE to stay within a particular beam coverage area for both the beam sweep time and the handover preparation time to complete. However, in the above example, if the UE is located closer than 41 meters from the TRP, the UE may not be able to receive the handover command because it will be outside of the coverage area of the source TRP after the measurement and handover delay.

In the example shown in Figs. 3 and 4, 90% of UEs travelling at 30km/h may receive the handover command, 80% of UEs travelling at 60km/h may receive the handover command, and only 59% of UEs travelling at 120km/h may receive the handover command. In other words, in some cases, some UEs will not receive the handover command on time before it loses the signal from the serving TRP. Techniques described herein may provide mechanisms to solve these problems and provide for successful handover in NR.

In some implementations described herein, UE 110 may initiate a handover operation without receiving the handover command (i.e., the RRC Connection Reconfiguration message) from the network. This can be particularly useful in situations where the handover command is not received by the UE (e.g., because the UE moves out of range of the TRP). In some implementations, a UE initiated handover may be performed by UE 110 based on a particular mobility state or speed of the UE and/or based on the expiration of a timer at the UE. In some implementations, parameters relating to a UE initiated handover may be configured by the network (e.g., by eNB 135).

Fig. 5 is a flowchart illustrating an example process 500 for performing a UE-based handover operation. Process 500 may be performed by, for example, UE 110.

Process 500 may include starting a timer based on the sending of the measurement report (block 510). The timer may be started concurrently with the sending of the measurement report.

5 In one implementation, the timer expiration value may be configured by the network (e.g., via a message received from eNB 135). The timer expiration value may, for example, be configured to expire at approximately the expected round trip time for which UE 110, after sending the measurement report, expect to receive the handover command. As an example, the timer expiration value may be set at 140 ms.

10 Process 500 may further include determining whether the handover command was received from the network before the expiration of the timer (block 520). As previously mentioned, the handover command may be included in an RRC Connection Reconfiguration message. When the handover command is received (block 520 - Yes), the timer may be canceled and a network-based handover operation may be performed (block 530).

15 When the handover command is not received before the expiration of the timer (block 520 - No), process 500 may include, in response to detection of the timer expiration without having received the handover command, initiating a UE-based handover (block 540). As previously mentioned, the handover command may not be received by UE 110 due to the UE moving out of range of the beam coverage area of the source eNB 135-1. Thus, in this situation,
 20 the radio conditions may have been good enough for the source eNB 135-1 to receive and decode the Measurement Report from the UE (and thus prepare the target cell for the handover), but not sufficient for the UE to receive the handover command. Upon expiration of the timer, UE 110 may search for a target cell and attempt to reestablish a connection with the target cell.

Figs. 6A and 6B illustrate example signaling sequences illustrating UE-based handover procedures that are performed based on the expiration of a timer. In Fig. 6A, the handover
 25 command is illustrated as being successfully received (and thus a network-based handover procedure is performed), while in Fig. 6B, the handover command is illustrated as not being successfully received (e.g., because the UE moves out of the beam coverage area of the TRP) and thus a UE-based handover procedure is performed.

30 As shown in Fig. 6A, UE 110 may generate and transmit a measurement reports to source eNB 135-1 (at 610, "Measurement Reports"). UE 110 may initiate a timer when the measurement report is sent (at 605, "Start Timer"). Based on the measurement report, source eNB 135-1 may make a handover decision to cause UE 110 to connect to target eNB 135-2 (at 615, "Handover Decision"). Source eNB 135-1 may issue a handover request to target eNB 135-

2 (at 620, "Handover Request"). As part of the handover request, source eNB 135-1 may pass necessary information to prepare the handover at target eNB 135-2. Admission Control may be performed by target eNB 135-2 to determine if the needed resources can be granted by target eNB 135-2 (at 625, "Admission Control"). Target eNB 135-2 may prepare for the handover and
 5 transmit a handover request acknowledgement (ACK) to source eNB 135-1 (at 630, "Handover Request Ack").

Source eNB 135-1 may generate an RRC message (i.e., the handover command) to cause the handover to be performed by UE 110 (at 635, "RRC Conn. Reconf. incl Mobility Control Info."). The RRC message may include the mobility control information (i.e., handover
 10 parameters that the UE may need to connect with target eNB 135-2) relating to target eNB 135-2.

In response to receiving the handover command, UE 110 may stop or disregard the timer (at 640, "Stop the timer and use network-based handover"). UE 110 may detach from the old cell (provided by source eNB 135-1) and synchronize with the new cell (provided by target eNB
 15 135-2) (at 645, "Detach from old cell and synchronize to new cell"). When UE 110 has synchronized with target eNB 135-2, source eNB 135-1 may deliver the buffered and in transit packets to target eNB 135-2 (at 650, "Deliver buffered and in-transit packets to target eNB"). Source eNB 135-1 may transmit a Sequence Number (SN) status transfer message to target eNB 135-2 (at 655, "SN Status Transfer"). The SN status transfer message may convey uplink Packet
 20 Data Convergence Protocol (PDCP) SN receiver status and downlink PDCP SN transmitter status of E-Radio Access Bearer (E-RABs) for which PDCP status preservation applies. When UE 110 has successfully accessed the target cell, UE 110 may send the RRC Connection Reconfiguration Complete message to confirm the handover (at 660, "RRC Conn. Reconf. Complete").

25 Fig. 6B illustrates a handover procedure when the handover command is not successfully received at UE 110. The unsuccessful reception of the handover command is indicated by the crossed-out label "RRC Conn. Reconf. incl Mobility Control Info." Certain of the operations in Fig. 6B are similar to those in Fig. 6A and thus, for brevity, may not be re-described in detail.

As shown in Fig. 6B, UE 110 may start the timer when it transmits the measurement
 30 report (at 605 and 610). The network may correspondingly make a handover decision and transmit the handover command to UE 110 (at 615-635). As mentioned, in this example, assume that the handover command is not received and decoded by UE 110. For instance, UE 110 may be moving and may move out of the beam coverage area of source eNB 135-1 by the time the handover command is transmitted to UE 110.

At the expiration of the time, UE 110 may initiate a UE-based handover instead of the network-based handover that was discussed with respect to Fig. 6A (at 665, "Timer expired. Perform UE-based handover"). Source eNB 135-1 may continue to deliver the buffered and in transit packets to target eNB 135-2 (at 650, "Deliver buffered and in-transit packets to target eNB"). UE 110 may perform the UE-based handover with the target cell (at 670, "UE-based handover"). As part of the UE-based handover procedure, UE 110 may search for a target cell and attempt to reestablish a connection with the target cell. Ideally, the target cell selected by UE 110 is the same cell to which source eNB 135-1 transmitted the handover request.

Target eNB 135-2 may, if a SN status transfer message is not received from source eNB 135-1, transmit a request for the SN status transfer message (at 675, "SN Status Transfer request if not received from source eNB"). Source eNB 135-1 may thus transmit a Sequence Number (SN) status transfer message to target eNB 135-2 (at 655, "SN Status Transfer"). The SN status transfer message may convey uplink PDCP SN receiver status and downlink PDCP SN transmitter status of EE-RABs for which PDCP status preservation applies. When UE 110 has successfully accessed the target cell, UE 110 may send the RRC Connection Reconfiguration Complete message to confirm the handover (at 660, "RRC Conn. Reconf. Complete").

In some embodiments, a UE-based handover may be performed based on the speed of the UE. In these embodiments, the speed or mobility state of the UE may be measured by the UE and/or by the network.

Fig. 7 is a flowchart illustrating an example process 700 for performing a UE-based handover operation that is performed based on the speed of the UE. Process 700 may be performed by, for example, UE 110.

Process 700 may include receiving, from the network (e.g., from eNB 135), a threshold value of the UE speed needed to trigger UE-based handovers (block 710). For example, the UE speed threshold may be indicated in terms of traditional speed measurements (e.g., km/h) or indicated more coarsely as a speed or mobility state, such as "High-mobility", "Medium-mobility", or "Normal-mobility" state. In some implementations, instead of or in addition to receiving a threshold value from the network, the threshold value may be defined ahead of time, such as during initial provisioning or manufacturer of the UE.

From the perspective of the network, the threshold value may be determined in a number of ways. For example, the beam coverage area of the TRPs, in the vicinity of UE 110, may be a factor in calculating the threshold value. For example, a calculation similar to that described above, for Fig. 4, may be performed to estimate the risk, of a UE moving at a particular speed,

of not receiving the handover command. When the risk is greater than a particular threshold, UE-based handover procedures may be configured.

Process 700 may further include monitoring the speed of the UE (block 720). In one of implementation, the UE may continuously estimate its speed. For example, the UE may use GPS measurements, changes in radio signal strength measurements, accelerometer measurements, or measurements from other sensors associated with the UE, to determine or estimate the current speed of the UE. As previously mentioned, in some implementations, the UE may coarsely estimate its speed such as by determining whether the UE is stationary (low mobility), is being carried by a walking user (medium mobility), or is in a vehicle (high mobility).

In one implementation, the coarse estimation of the speed of the UE may be made based on a Mobility State Estimation (MSE) that is performed by UE 110. The mobility state estimation may be made based on the number of handovers or cell reselection or beam switch or TRP switching, performed by the UE, during a recent particular time period. The number of handovers during the time period may be used to classify the UE's mobility state as "High-mobility," "Medium-mobility," or "Normal-mobility" state.

The UE may compare the current speed of the UE to the threshold value (block 730). When the current speed of the UE is greater than the threshold (block 730 - Yes), process 700 may include performing handover procedures using UE-based handover procedures (block 740). For instance, as discussed with respect to the description of Fig. 6B, UE 110 may search for a target cell and attempt to establish a connection with the target cell. The UE-based handover procedure may be initiated by UE 110 based on received signal strength measurements and without receiving an explicit handover command from the network. In some implementations, when the current speed of the UE is greater than the threshold value, the handover procedure may be based on both UE-based handovers and on network-based handovers.

When the current speed of the UE is less than the threshold (block 730 - No), process 700 may include performing handover procedures using network-based handover procedures (block 750). In this situation, UE 110 may not perform a handover procedure unless UE 110 receives the handover command from the network.

Fig. 8 is a flowchart illustrating an example process 800 for performing a UE-based handover operation that is performed based on the speed of the UE, as estimated by the network. Process 800 may be performed by, for example, one or more eNBs 135.

Process 800 may include estimating the speed of a UE (block 810). The network may estimate the movement speed of the UE based on information provided by the UE and/or based on other information associated with the UE. For example, eNB 135 may periodically or

occasional receive or estimate the location of UE 110. Based on a sequence of locations, determined for the UE, and elapsed time values between each observation of the location of the UE, eNB 135 may estimate a movement speed of the UE.

5 Process 800 may further include dynamically configuring the UE, based on the estimated speed, to perform UE-based handovers or network-based handovers (block 820). For example, in one implementation, if the UE is estimated to be traveling at a speed greater than a particular threshold, eNB 135 may indicate, such as via an RRC message, that the UE should perform UE-based handovers. In this situation, network-based handovers may still be performed. However, if the UE is estimated to be traveling at a speed below the particular threshold, eNB 135 may
10 configure UE 110 to refrain from performing UE-based handovers and only perform network-based handovers.

In some implementations, based on the network estimation of the UE speed, eNB 135 may also configure the timer value for the UE. For example, the indication to perform UE-based handovers may include an indication of a timer value to use.

15 In some implementations, the estimation of the speed of the UE may be made based on a MSE state estimation that is performed by UE 110. The mobility state estimation may be made based on the number of handovers, performed by the UE, during a recent particular time period. The number of handovers during the time period may be used to classify the UE's mobility state as "High-mobility," "Medium-mobility," or "Normal-mobility" state.

20 In some implementations, the dynamic configuration of the UE may include configuring the UE to conditionally perform UE-based handovers. For example, the condition may be speed-based, so that the UE will only initiate a UE-based handover when the UE detects that it is traveling above a certain speed or is in a certain MSE state, such as the High-mobility state..

As used herein, the term "circuitry" or "processing circuitry" may refer to, be part of, or
25 include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented
30 by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. Fig. 9 illustrates, for one embodiment, example components of an electronic device 900. In embodiments, the electronic device 900 may be a

mobile device (e.g., a UE), a RAN node (e.g., an eNB or other TRP), and/or a network controller. In some embodiments, the electronic device 900 may include application circuitry 902, baseband circuitry 904, Radio Frequency (RF) circuitry 906, front-end module (FEM) circuitry 908 and one or more antennas 960, coupled together at least as shown. In embodiments
5 in which a radio interface is not needed for electronic device 900 (e.g., a data gateway, network controller, etc.), the RF circuitry 906, FEM circuitry 908, and antennas 960 may be omitted. In other embodiments, any of said circuitries can be included in different devices.

Application circuitry 902 may include one or more application processors. For example, the application circuitry 902 may include circuitry such as, but not limited to, one or more
10 single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system. The memory/storage may include, for example,
15 computer-readable medium 903, which may be a non-transitory computer-readable medium. Application circuitry 902 may, in some embodiments, connect to or include one or more sensors, such as environmental sensors, cameras, etc.

Baseband circuitry 904 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 904 may include one or more
20 baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 906 and to generate baseband signals for a transmit signal path of the RF circuitry 906. Baseband processing circuitry 904 may interface with the application circuitry 902 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 906. For example, in some embodiments, the baseband circuitry
25 904 may include a second generation (2G) baseband processor 904a, third generation (3G) baseband processor 904b, fourth generation (4G) baseband processor 904c, and/or other baseband processor(s) 904d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 9G, etc.). The baseband circuitry 904 (e.g., one or more of baseband processors 904a-d) may handle various radio control functions that
30 enable communication with one or more radio networks via the RF circuitry 906. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some implementations, the functionality of baseband circuitry 904 may be wholly or partially implemented by memory/storage devices

configured to execute instructions stored in the memory/storage. The memory/storage may include, for example, a non-transitory computer-readable medium 904h.

In some embodiments, modulation/demodulation circuitry of the baseband circuitry 904 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 904 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

In some embodiments, the baseband circuitry 904 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), radio resource control (RRC) elements, and/or Non-Access Stratum (NAS) elements. A central processing unit (CPU) 904e of the baseband circuitry 904 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers, and/or NAS. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 904f. The audio DSP(s) 904f may include elements for compression/decompression and echo cancellation and may include other suitable processing elements in other embodiments.

Baseband circuitry 904 may further include memory/storage 904g. The memory/storage 904g may be used to load and store data and/or instructions for operations performed by the processors of the baseband circuitry 904. Memory/storage 904g may particularly include a non-transitory memory. Memory/storage for one embodiment may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 904g may include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. The memory/storage 904g may be shared among the various processors or dedicated to particular processors.

Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 904 and the application circuitry 902 may be implemented together such as, for example, on a system on a chip (SOC).

In some embodiments, the baseband circuitry 904 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 904 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 904 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

RF circuitry 906 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 906 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 906 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 908 and provide baseband signals to the baseband circuitry 904. RF circuitry 906 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 904 and provide RF output signals to the FEM circuitry 908 for transmission. RF circuitry 906 may include circuitry to implement high frequency 5G NR radios.

In some embodiments, the RF circuitry 906 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 906 may include mixer circuitry 906a, amplifier circuitry 906b and filter circuitry 906c. The transmit signal path of the RF circuitry 906 may include filter circuitry 906c and mixer circuitry 906a. RF circuitry 906 may also include synthesizer circuitry 906d for synthesizing a frequency for use by the mixer circuitry 906a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 906a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 908 based on the synthesized frequency provided by synthesizer circuitry 906d. The amplifier circuitry 906b may be configured to amplify the down-converted signals and the filter circuitry 906c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals.

Output baseband signals may be provided to the baseband circuitry 904 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 906a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 906a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 906d to generate RF output signals for the FEM circuitry 908. The baseband signals may be provided by the baseband circuitry 904 and may be filtered by filter circuitry 906c. The filter circuitry 906c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

In some embodiments, the mixer circuitry 906a of the receive signal path and the mixer circuitry 906a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 906a of the receive signal path and the mixer circuitry 906a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 906a of the receive signal path and the mixer circuitry 906a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 906a of the receive signal path and the mixer circuitry 906a of the transmit signal path may be configured for super-heterodyne operation.

In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 906 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 904 may include a digital baseband interface to communicate with the RF circuitry 906.

In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

In some embodiments, the synthesizer circuitry 906d may be a fractional-N synthesizer or a fractional $N/N+6$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 906d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

The synthesizer circuitry 906d may be configured to synthesize an output frequency for use by the mixer circuitry 906a of the RF circuitry 906 based on a frequency input and a divider

control input. In some embodiments, the synthesizer circuitry 906d may be a fractional $N/N+6$ synthesizer.

In some embodiments, frequency input may be provided by a voltage-controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by
5 either the baseband circuitry 904 or the applications processor 902 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 902.

Synthesizer circuitry 906d of the RF circuitry 906 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a
10 dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+6$ (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be
15 configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

In some embodiments, synthesizer circuitry 906d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a
20 multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (f_{LO}). In some embodiments, the RF circuitry 906 may include an IQ/polar converter.

FEM circuitry 908 may include a receive signal path which may include circuitry
25 configured to operate on RF signals received from one or more antennas 960, amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 906 for further processing. FEM circuitry 908 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF
30 circuitry 906 for transmission by one or more of the one or more antennas 960.

In some embodiments, the FEM circuitry 908 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received

RF signals as an output (e.g., to the RF circuitry 906). The transmit signal path of the FEM circuitry 908 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 906), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 960).

5 In some embodiments, the electronic device 900 may include additional elements such as, for example, memory/storage, display, camera, sensors, and/or input/output (I/O) interface. In some embodiments, the electronic device of Fig. 9 may be configured to perform one or more methods, processes, and/or techniques such as those described herein.

Fig. 10 is a block diagram illustrating components, according to some example
10 embodiments, able to read instructions from a machine-readable or computer-readable medium (e.g., a machine-readable storage medium) and perform any one or more of the methodologies discussed herein. Specifically, Fig. 10 shows a diagrammatic representation of hardware resources 1000 including one or more processors (or processor cores) 1010, one or more memory/storage devices 1020, and one or more communication resources 1030, each of which
15 are communicatively coupled via a bus 1040.

The processors 1010 (e.g., a central processing unit (CPU), a reduced instruction set computing (RISC) processor, a complex instruction set computing (CISC) processor, a graphics processing unit (GPU), a digital signal processor (DSP) such as a baseband processor, an application specific integrated circuit (ASIC), a radio-frequency integrated circuit (RFIC),
20 another processor, or any suitable combination thereof) may include, for example, a processor 1012 and a processor 1014. The memory/storage devices 1020 may include main memory, disk storage, or any suitable combination thereof.

The communication resources 1030 may include interconnection and/or network interface components or other suitable devices to communicate with one or more peripheral
25 devices 1004 and/or one or more databases 1006 via a network 1008. For example, the communication resources 1030 may include wired communication components (e.g., for coupling via a Universal Serial Bus (USB)), cellular communication components, Near Field Communication (NFC) components, Bluetooth® components (e.g., Bluetooth® Low Energy), Wi-Fi® components, and other communication components.

30 Instructions 1050 may comprise software, a program, an application, an applet, an app, or other executable code for causing at least any of the processors 1010 to perform any one or more of the methodologies discussed herein. The instructions 1050 may reside, completely or partially, within at least one of the processors 1010 (e.g., within the processor's cache memory), the memory/storage devices 1020, or any suitable combination thereof. Furthermore, any portion

of the instructions 1050 may be transferred to the hardware resources 1000 from any combination of the peripheral devices 1004 and/or the databases 1006. Accordingly, the memory of processors 1010, the memory/storage devices 1020, the peripheral devices 1004, and the databases 1006 are examples of computer-readable and machine-readable media.

5 A number of examples, relating to implementations of the techniques described above, will next be given.

 In a first example, a UE for a cellular communication network may comprise a computer-readable medium containing processing instructions; and one or more processors, to execute the processing instructions to: estimate a current movement speed of the UE; determine
10 if the current movement speed exceeds a threshold value; control handover operations, for the UE and when the current movement speed is determined to exceed the threshold value, using UE-based handover procedures; and control handover operations, for the UE and when the current movement speed is determined to not exceed the threshold value, using network-based handover procedures.

15 In example 2, the subject matter of example 1, or any of the examples herein, wherein the movement speed of the UE is estimated as a Mobility State Estimation (MSE) state of UE.

 In example 3, the subject matter of example 2, or any of the examples herein, wherein the MSE state includes three possible states and a current MSE state of the UE is
20 determined based on a number of previous handovers that were performed in a particular time period.

 In example 4, the subject matter of any of examples 1, 2, or 3, or any of the examples herein, wherein, when handover operations are to be performed using the UE-based handover procedures, the one or more processors are further to execute the processing
25 instructions to: start a timer based on the transmission of a Measurement Report to a source evolved NodeB (eNB); and initiate, when the time expires without receiving a handover command from the source eNB, a UE-based handover operation.

 In example 5, the subject matter of example 4, or any of the examples herein, wherein the one or more processors are further to execute the processing instructions to: stop the
30 timer based on the reception of a handover command from the source eNB.

 In example 6, the subject matter of any of examples 1, 2, or 3, or any of the examples herein, wherein the one or more processors are further to execute the processing instructions to: receive the threshold value from the cellular communication network.

In a seventh example, an apparatus for a baseband processor of UE for a cellular communication network may comprise: a computer-readable medium containing processing instructions; and one or more processors, to execute the processing instructions to: determine a current mobility state of the UE; perform handover operations, for the UE and when the current mobility state is associated with a first mobility state, using UE-based handover procedures; and
5 perform handover operations, for the UE and when the current mobility state is associated with a second set mobility state, using network-based handover procedures, wherein the first mobility state is different than the second mobility state.

In example 8, the subject matter of example 7, or any of the examples herein,
10 wherein the mobility state includes three possible states and the current mobility state is determined based on a number of previous handovers that were performed in a particular time period.

In example 9, the subject matter of any of examples 7 or 8, or any of the examples herein, wherein, when handover operations are to be performed using the UE-based handover
15 procedures, the one or more processors are further to execute the processing instructions to: start a timer based on the transmission of a Measurement Report or event triggers to a source evolved NodeB (eNB); and initiate, when the time expires without receiving a handover command from the source eNB, a UE-based handover operation.

In example 10, the subject matter of example 9, or any of the examples herein,
20 wherein the one or more processors are further to execute the processing instructions to: stop the timer based on the reception of a handover command from the source eNB.

In example 11, the subject matter of example 7, or any of the examples herein, wherein the one or more processors are further to execute the processing instructions to: receive,
25 from the cellular communication network, an indication when the UE-based handover procedures are supported.

In a 12th example, a TRP, for a cellular network, may comprise: radio frequency (RF) transmission circuitry; a non-transitory computer-readable medium containing program instructions; and one or more processors to execute the program instructions to: cause
30 communication, using the RF transmission circuitry, with User Equipment (UE) that is connected to a cell provided by the TRP; estimate, based on the communications with the UE, a movement speed of the UE; determine, based on the estimated movement speed of the UE, whether the UE should perform handovers using UE-based handover procedures; and configure the UE, using the RF transmission circuitry and when it is determined the UE should perform

handovers using UE-based handover procedures, to initiate handover operations without receiving an explicit handover command.

In example 13, the subject matter of example 12, or any of the examples herein, wherein the RF transmission circuitry implements a 5G New Radio (NR) standard.

5 In example 14, the subject matter of example 2, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a speed of the UE is above a threshold.

10 In example 15, the subject matter of example 12, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform only network-based handover procedures when the speed of the UE is below the threshold.

In example 16, the subject matter of example 12, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a Mobility State Estimation (MSE) state of the UE is in a certain state or set of states.

15 In a 17th example, a base station may comprise: radio frequency (RF) transmission circuitry; and circuitry to: cause communication, using the RF transmission circuitry, with User Equipment (UE) that is connected to a cell provided by the TRP; estimate, based on the communications with the UE, a mobility state of the UE; determine, based on the estimated mobility state of the UE, whether the UE should perform handovers using UE-based handover
20 procedures; configure the UE, using the RF transmission circuitry and when it is determined the UE should perform handovers using UE-based handover procedures, to initiate handover operations without receiving an explicit handover command.

In example 18, the subject matter of example 17, or any of the examples herein, wherein the RF transmission circuitry implements a 5G New Radio (NR) standard.

25 In example 19, the subject matter of example 17, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a speed of the UE is above a threshold.

30 In example 20, the subject matter of example 17, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when the mobility state of the UE is in a certain state or set of states

In a 21st example, a method, implemented by User Equipment (UE), may comprise: estimating, by the UE, a current movement speed of the UE; determining if the current movement speed exceeds a threshold value; performing handover operations, for the UE and when the current movement speed is determined to exceed the threshold value, using UE-based

handover procedures; and performing handover operations, for the UE and when the current movement speed is determined to not exceed the threshold value, using network-based handover procedures.

5 In example 22, the subject matter of example 21, or any of the examples herein, wherein the movement speed of the UE is estimated as a Mobility State Estimation (MSE) state of the UE.

10 In example 23, the subject matter of example 22, or any of the examples herein, wherein the MSE state includes three possible states and a current mobility state of the UE is determined based on a number of previous handovers that were performed in a particular time period.

15 In example 24, the subject matter of any of examples 21, 22, or 23, or any of the examples herein, wherein, when handover operations are to be performed using the UE-based handover procedures, the method further includes: starting a timer based on the transmission of a Measurement Report to a source evolved NodeB (eNB); and initiating, when the time expires without receiving a handover command from the source eNB, a UE-based handover operation.

In example 25, the subject matter of example 24, or any of the examples herein, wherein the one or more processors are further to execute the processing instructions to: stop the timer based on the reception of a handover command from the source eNB.

20 In a 26th example, a device may comprise: means for estimating a current movement speed of User Equipment (UE); means for determining if the current movement speed exceeds a threshold value; means for performing handover operations, for the UE and when the current movement speed is determined to exceed the threshold value, using UE-based handover procedures; and means for performing handover operations, for the UE and when the current movement speed is determined to not exceed the threshold value, using network-based handover
25 procedures.

In example 27, the subject matter of example 26, or any of the examples herein, wherein the movement speed of the UE is estimated as a Mobility State Estimation (MSE) state of the UE.

30 In example 28, the subject matter of example 27, or any of the examples herein, wherein the mobility state includes three possible states and a current mobility state of the UE is determined based on a number of previous handovers that were performed in a particular time period.

In example 29, the subject matter of any of examples 26, 27, or 28, or any of the examples herein, wherein the device further includes: means for starting a timer based on the

transmission of a Measurement Report to a source evolved NodeB (eNB); and means for initiating, when the time expires without receiving a handover command from the source eNB, a UE-based handover operation.

5 In example 30, the subject matter of example 29, or any of the examples herein, further comprising means for stopping the timer based on the reception of a handover command from the source eNB.

10 In a 31st example, an apparatus for a baseband processor of UE for a cellular communication network may comprise: an interface to application circuitry; and one or more baseband processors to: determine, via the interface with the application circuitry, a current mobility state of the UE; perform handover operations, for the UE and when the current mobility state is associated with a first mobility state, using UE-based handover procedures; and perform handover operations, for the UE and when the current mobility state is associated with a second set mobility state, using network-based handover procedures, wherein the first mobility state is different than the second mobility state.

15 In example 32, the subject matter of example 31, or any of the examples herein, wherein the mobility state includes three possible states and the current mobility state is determined based on a number of previous handovers that were performed in a particular time period.

20 In example 33, the subject matter of examples 31 or 32, or any of the examples herein, wherein, when handover operations are to be performed using the UE-based handover procedures, the one or more baseband processors are further to: start a timer based on the transmission of a Measurement Report or event triggers to a source evolved NodeB (eNB); and initiate, when the time expires without receiving a handover command from the source eNB, a UE-based handover operation.

25 In example 34, the subject matter of example 31, or any of the examples herein, wherein the one or more baseband processors are further to: stop the timer based on the reception of a handover command from the source eNB.

30 In example 35, the subject matter of example 31, or any of the examples herein, wherein the one or more baseband processors are further to: receive, from the cellular communication network, an indication when the UE-based handover procedures are supported.

In a 36th example, an apparatus for a transmission and reception point (TRP) for a cellular network may comprise an interface to radio frequency (RF) circuitry; and one or more baseband processors to: estimate, based on the communications with User Equipment (UE), a movement speed of the UE; determine, based on the estimated movement speed of the UE,

whether the UE should perform handovers using UE-based handover procedures; cause configuration of the UE, via the interface to the RF transmission circuitry and when it is determined the UE should perform handovers using UE-based handover procedures, to initiate handover operations without receiving an explicit handover command.

5 In example 37, the subject matter of example 36, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a speed of the UE is above a threshold.

 In example 38, the subject matter of example 36, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform only network-based
10 handover procedures when the speed of the UE is below the threshold.

 In example 39, the subject matter of example 36, or any of the examples herein, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a Mobility State Estimation (MSE) state of the UE is in a certain state or set of states.

15 In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

20 For example, while series of signals and/or operations have been described with regard to Figs. 2, 5, 6A, 6B, 7, and 8, the order of the signals/operations may be modified in other implementations. Further, non-dependent signals may be performed in parallel.

 It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in
25 the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

 Even though particular combinations of features are recited in the claims and/or
30 disclosed in the specification, these combinations are not intended to be limiting. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

 No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and,"

as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used.

5

WHAT IS CLAIMED IS:

1. User Equipment (UE) for a cellular communication network, the UE including:
a computer-readable medium containing processing instructions; and
one or more processors, to execute the processing instructions to:
 - 5 estimate a current movement speed of the UE;
 - determine if the current movement speed exceeds a threshold value;
 - control handover operations, for the UE and when the current movement speed is
determined to exceed the threshold value, using UE-based handover procedures; and
 - control handover operations, for the UE and when the current movement speed is
10 determined to not exceed the threshold value, using network-based handover procedures.
2. The UE of claim 1, wherein the movement speed of the UE is estimated as a
Mobility State Estimation (MSE) state of UE.
- 15 3. The UE of claim 2, wherein the MSE state includes three possible states and a
current MSE state of the UE is determined based on a number of previous handovers that were
performed in a particular time period.
4. The UE of claim 1, 2, or 3, wherein, when handover operations are to be
20 performed using the UE-based handover procedures, the one or more processors are further to
execute the processing instructions to:
 - start a timer based on the transmission of a Measurement Report to a source evolved
NodeB (eNB); and
 - initiate, when the time expires without receiving a handover command from the source
25 eNB, a UE-based handover operation.
5. The UE of claim 4, wherein the one or more processors are further to execute the
processing instructions to:
 - stop the timer based on the reception of a handover command from the source eNB.
- 30 6. The UE of claim 1, 2, or 3, wherein the one or more processors are further to
execute the processing instructions to:
 - receive the threshold value from the cellular communication network.

7. An apparatus for a baseband processor of User Equipment (UE) for a cellular communication network, the apparatus comprising:

a computer-readable medium containing processing instructions; and

one or more processors, to execute the processing instructions to:

- 5 determine a current mobility state of the UE;
 perform handover operations, for the UE and when the current mobility state is
associated with a first mobility state, using UE-based handover procedures; and
 perform handover operations, for the UE and when the current mobility state is
associated with a second set mobility state, using network-based handover procedures, wherein
10 the first mobility state is different than the second mobility state.

8. The apparatus of claim 7, wherein the mobility state includes three possible states
and the current mobility state is determined based on a number of previous handovers that were
performed in a particular time period.

15

9. The apparatus of claim 7 or 8, wherein, when handover operations are to be
performed using the UE-based handover procedures, the one or more processors are further to
execute the processing instructions to:

20 start a timer based on the transmission of a Measurement Report or event triggers to a
source evolved NodeB (eNB); and

 initiate, when the time expires without receiving a handover command from the source
eNB, a UE-based handover operation.

10. The apparatus of claim 9, wherein the one or more processors are further to
25 execute the processing instructions to:

 stop the timer based on the reception of a handover command from the source eNB.

11. The apparatus of claim 7, wherein the one or more processors are further to
execute the processing instructions to:

30 receive, from the cellular communication network, an indication when the UE-based
handover procedures are supported.

12. A transmission and reception point (TRP), for a cellular network, comprising:
radio frequency (RF) transmission circuitry;

a non-transitory computer-readable medium containing program instructions; and
one or more processors to execute the program instructions to:

cause communication, using the RF transmission circuitry, with User Equipment
(UE) that is connected to a cell provided by the TRP;

5 estimate, based on the communications with the UE, a movement speed of the
UE;

determine, based on the estimated movement speed of the UE, whether the UE
should perform handovers using UE-based handover procedures;

configure the UE, using the RF transmission circuitry and when it is determined
10 the UE should perform handovers using UE-based handover procedures, to initiate handover
operations without receiving an explicit handover command.

13. The TRP of claim 12, wherein the RF transmission circuitry implements a 5G
New Radio (NR) standard.

15

14. The TRP of claim 12, wherein the configuration of the UE includes configuring
the UE to perform UE-based handover procedures only when a speed of the UE is above a
threshold.

20

15. The TRP of claim 12, wherein the configuration of the UE includes configuring
the UE to perform only network-based handover procedures when the speed of the UE is below
the threshold.

16. The TRP of claim 12, wherein the configuration of the UE includes configuring
25 the UE to perform UE-based handover procedures only when a Mobility State Estimation (MSE)
state of the UE is in a certain state or set of states.

17. A base station comprising:
radio frequency (RF) transmission circuitry;
30 circuitry to:

cause communication, using the RF transmission circuitry, with User Equipment
(UE) that is connected to a cell provided by the TRP;

estimate, based on the communications with the UE, a mobility state of the UE;

determine, based on the estimated mobility state of the UE, whether the UE should perform handovers using UE-based handover procedures;

configure the UE, using the RF transmission circuitry and when it is determined the UE should perform handovers using UE-based handover procedures, to initiate handover operations without receiving an explicit handover command.

18. The base station of claim 17, wherein the RF transmission circuitry implements a 5G New Radio (NR) standard.

10 19. The base station of claim 17, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when a speed of the UE is above a threshold.

15 20. The base station of claim 17, wherein the configuration of the UE includes configuring the UE to perform UE-based handover procedures only when the mobility state of the UE is in a certain state or set of states.

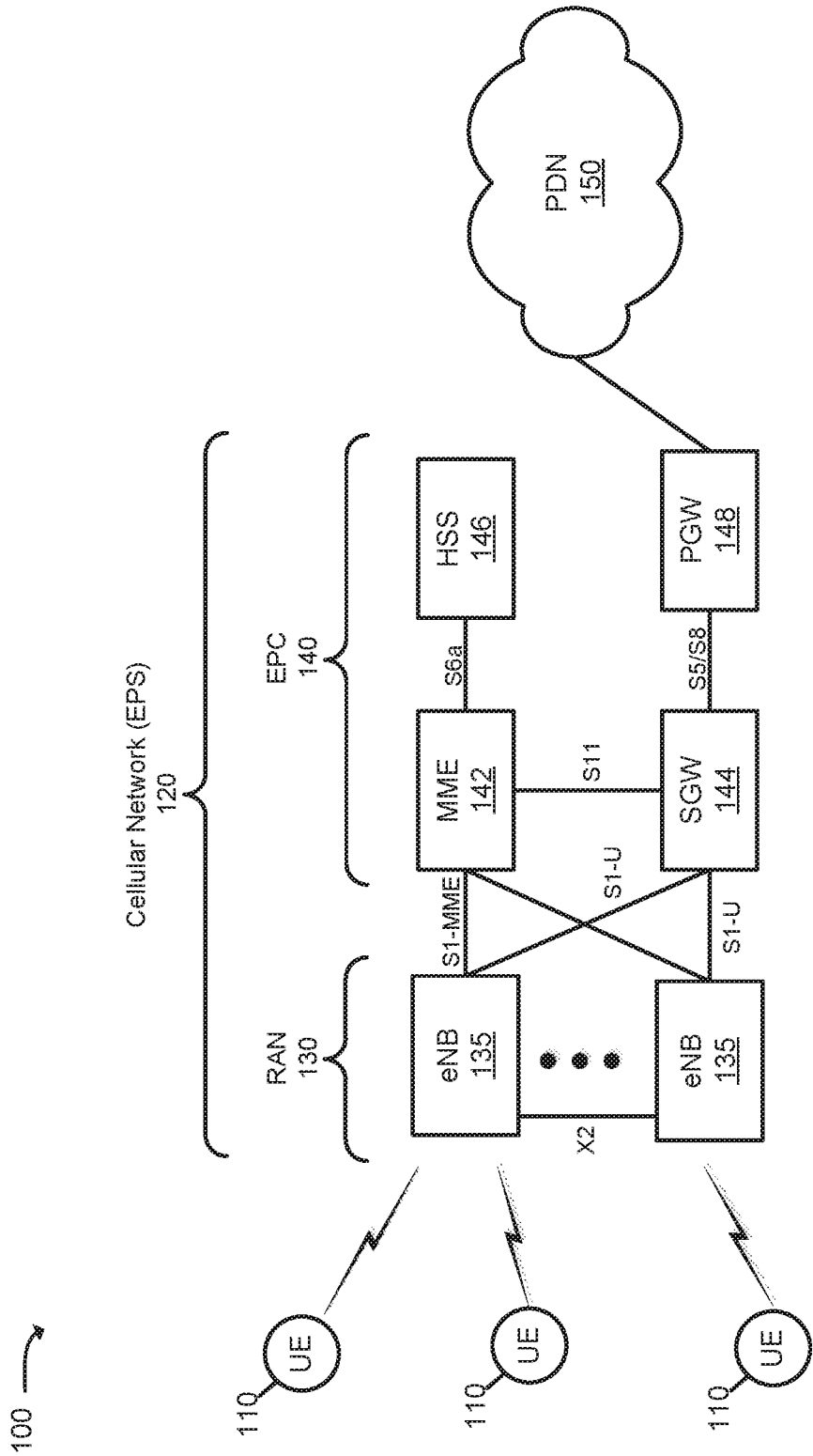
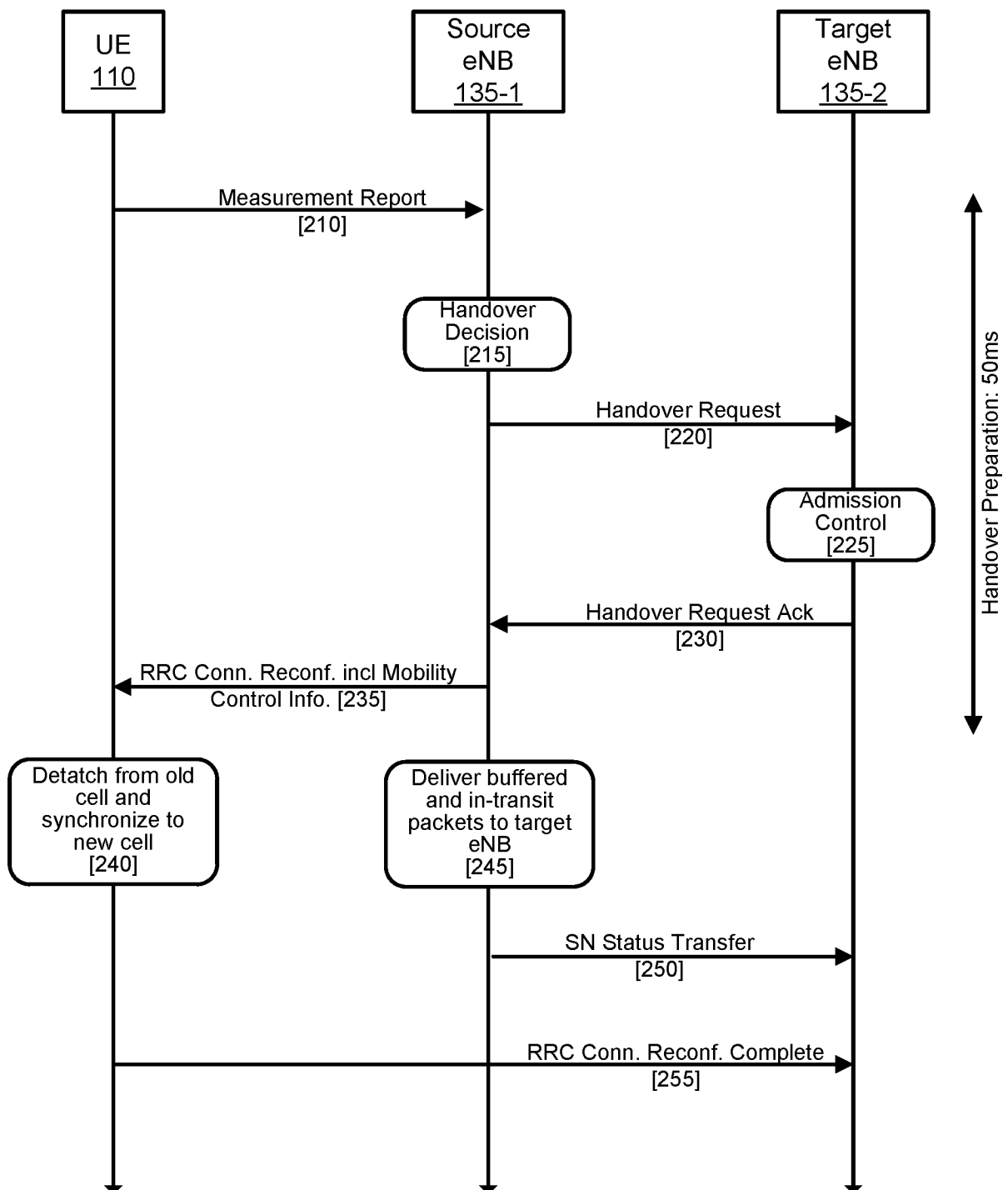
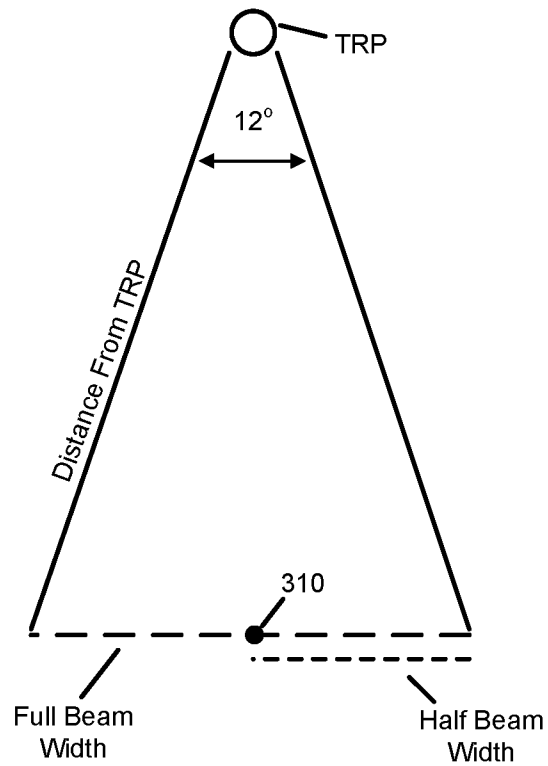


Fig. 1

2/11

**Fig. 2**

3/11

**Fig. 3**

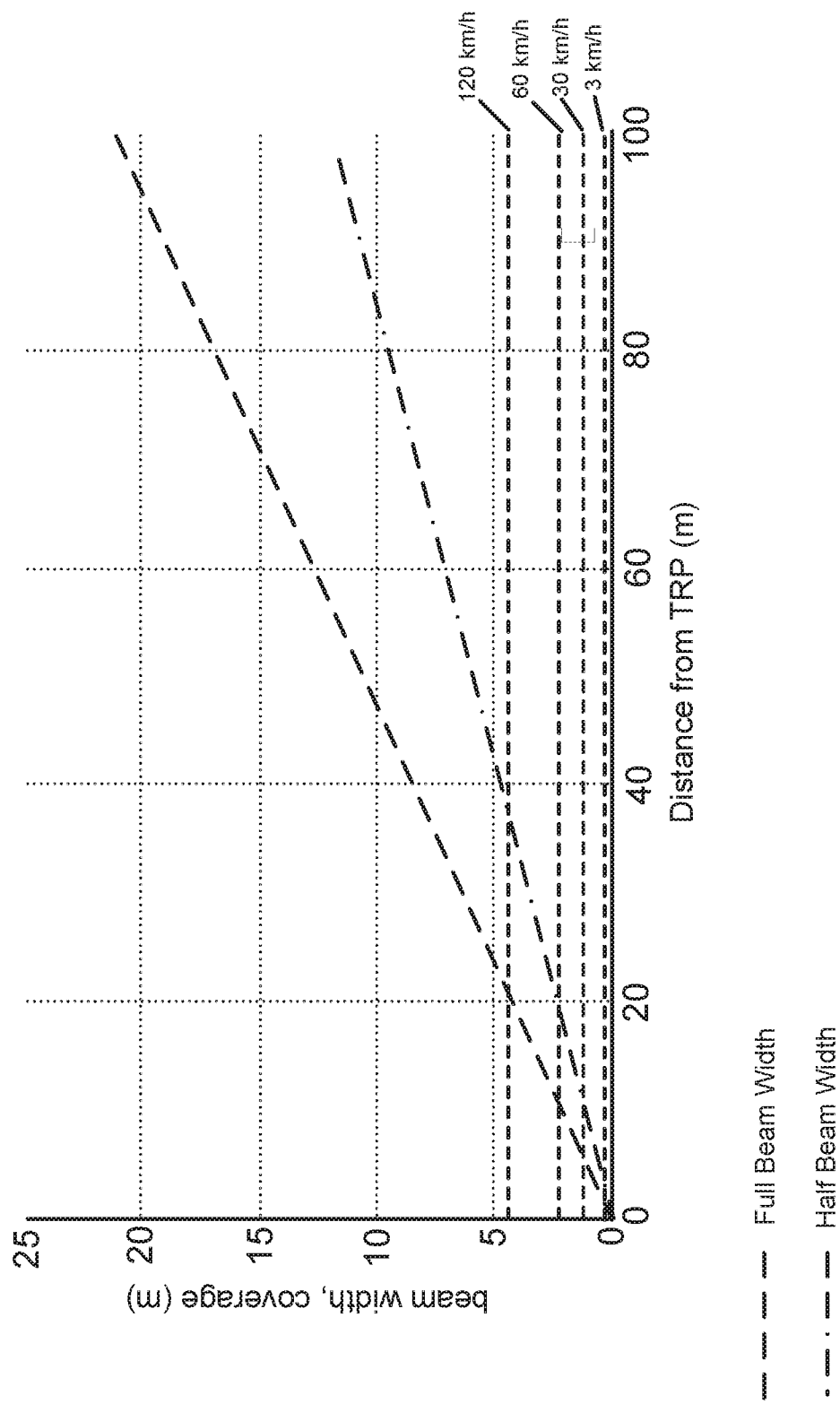
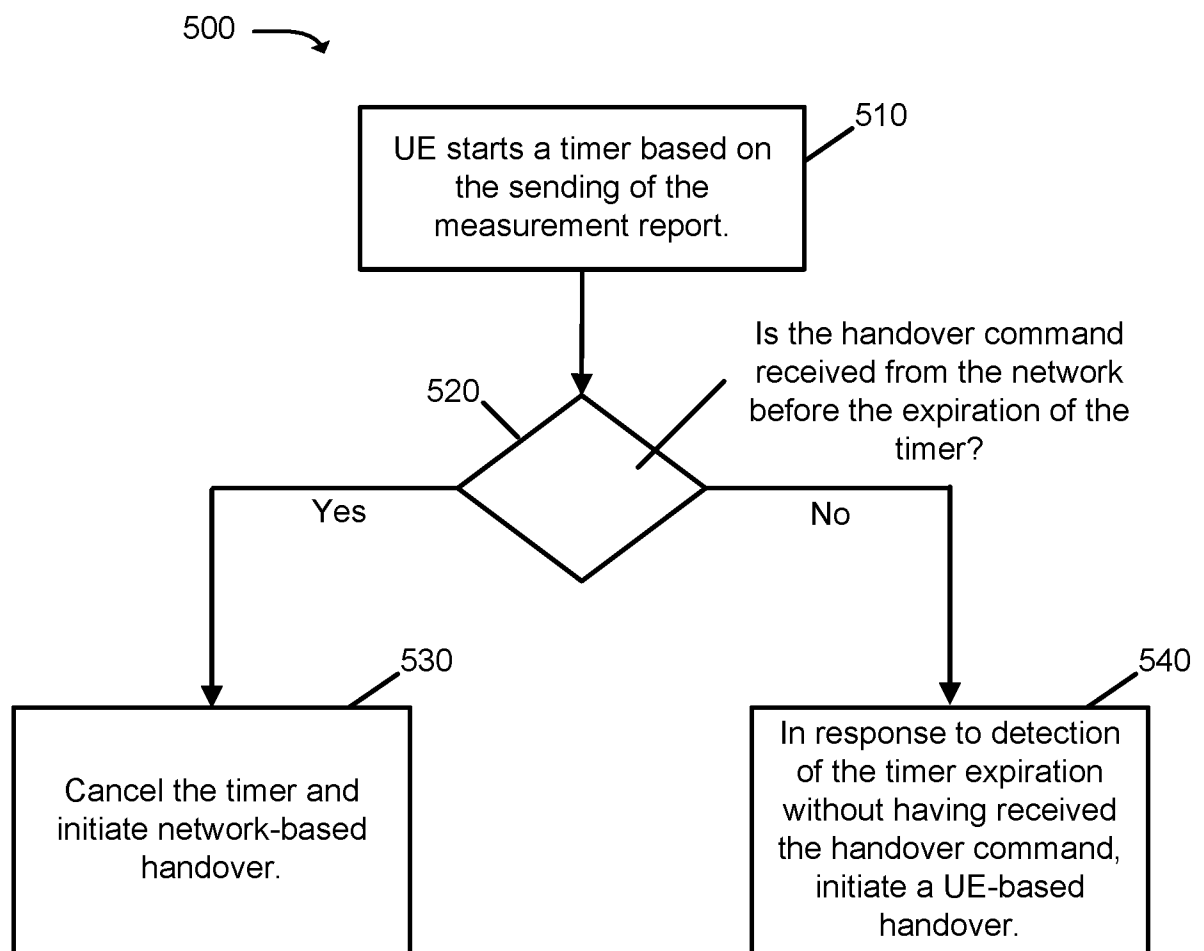
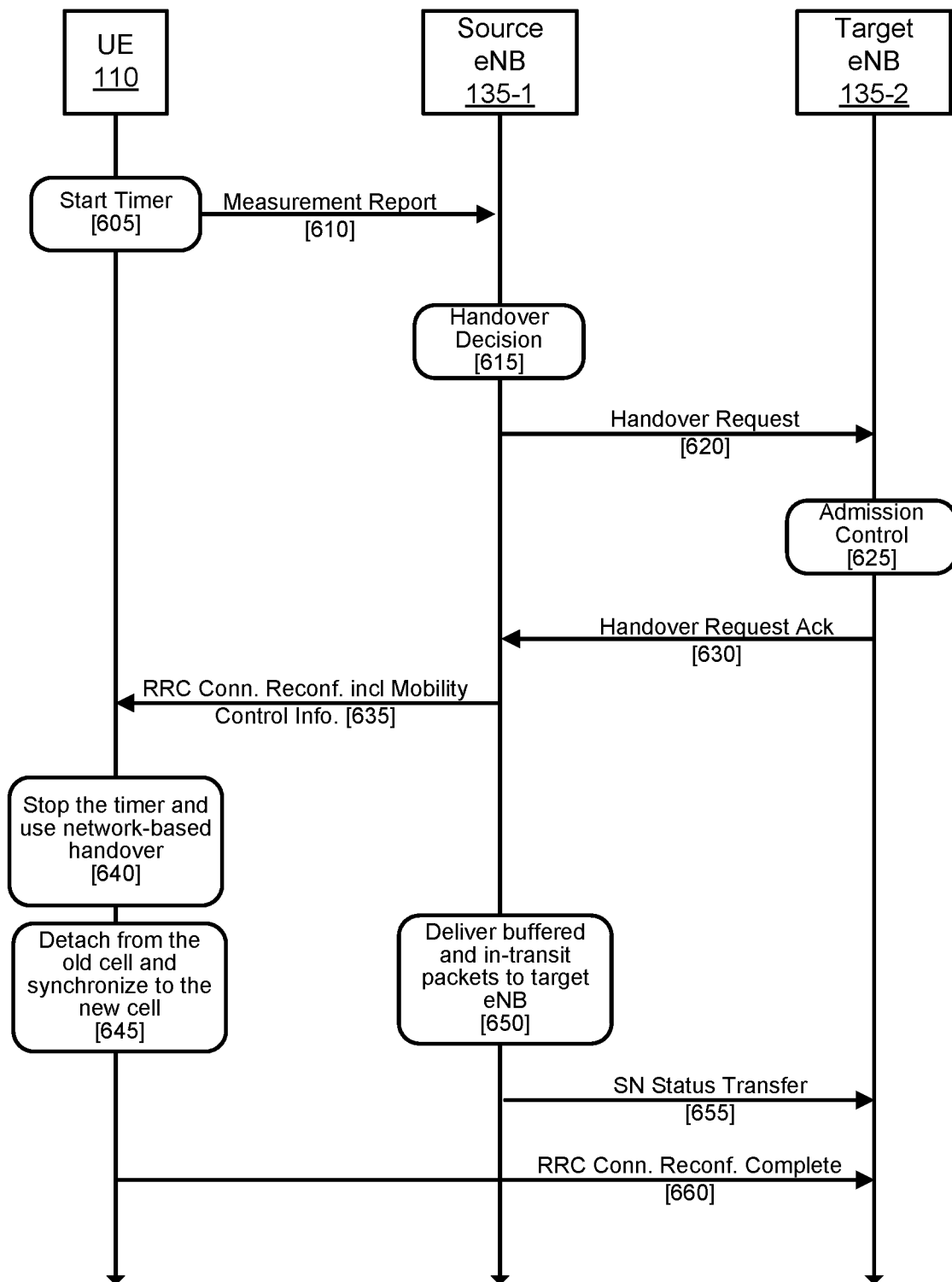


Fig. 4

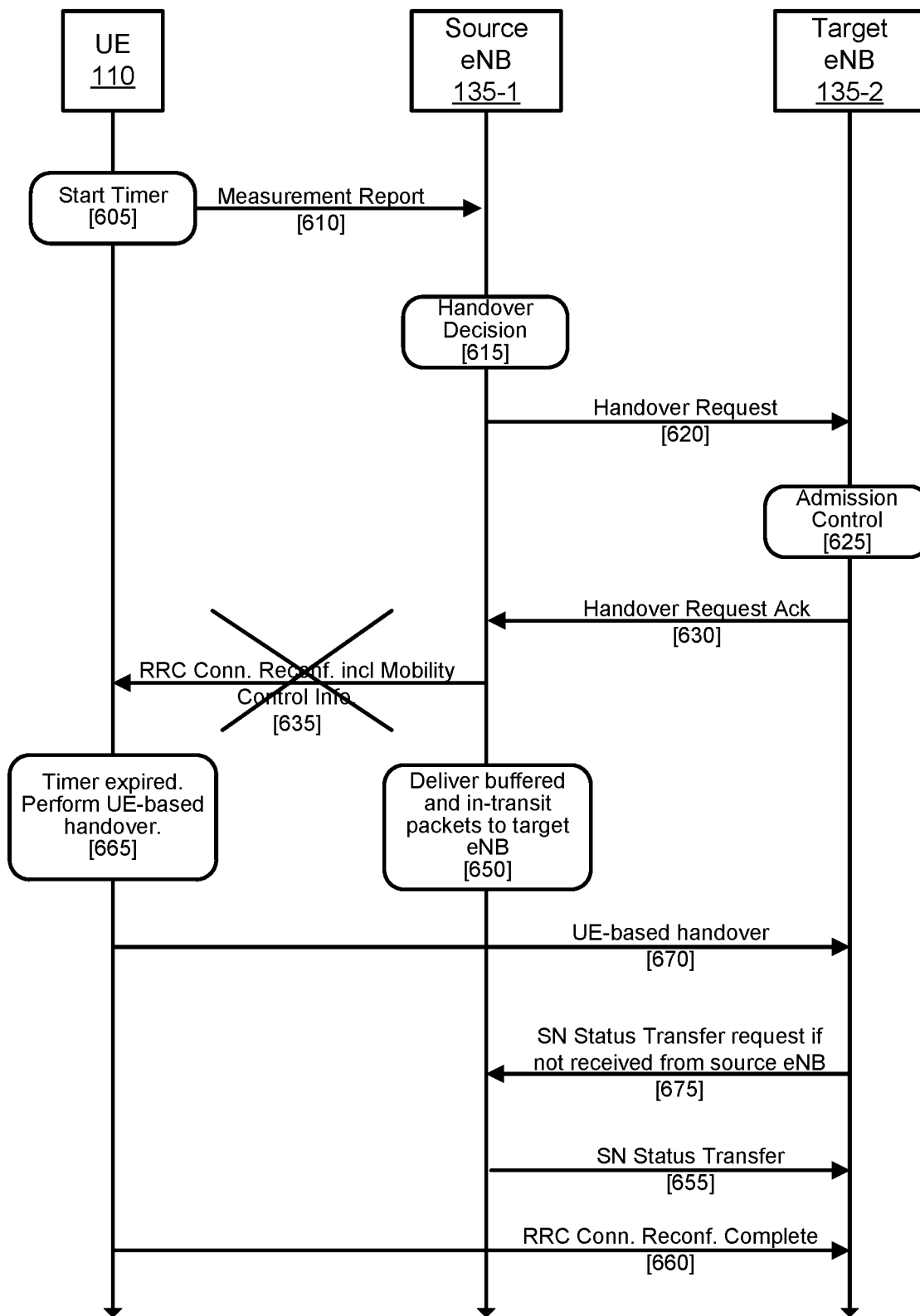
5/11

**Fig. 5**

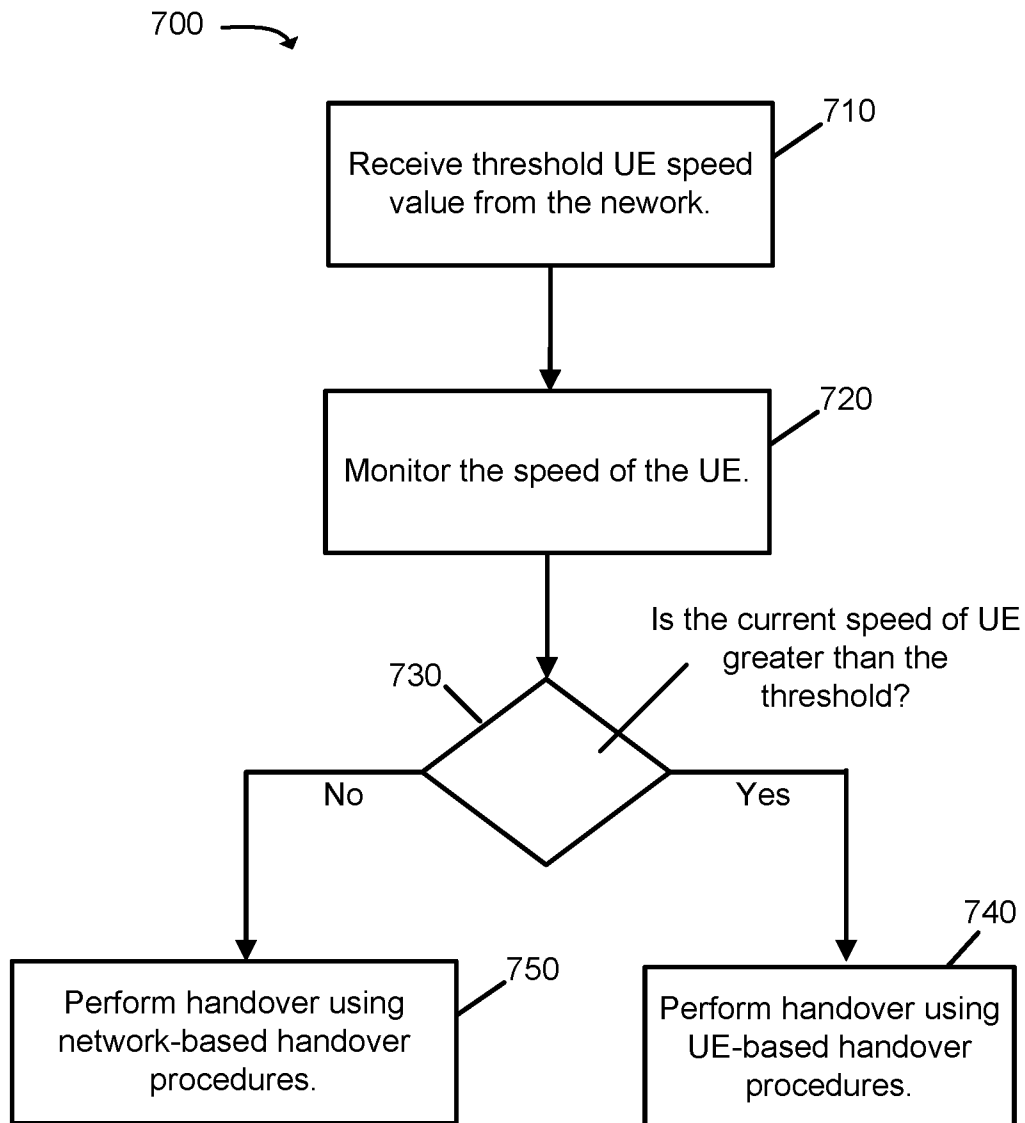
6/11

**Fig. 6A**

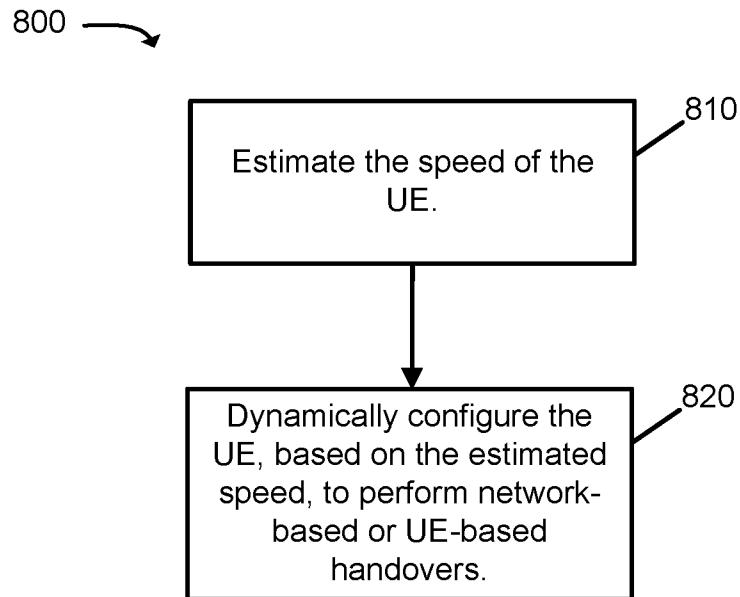
7/11

**Fig. 6B**

8/11

**Fig. 7**

9/11

**Fig. 8**

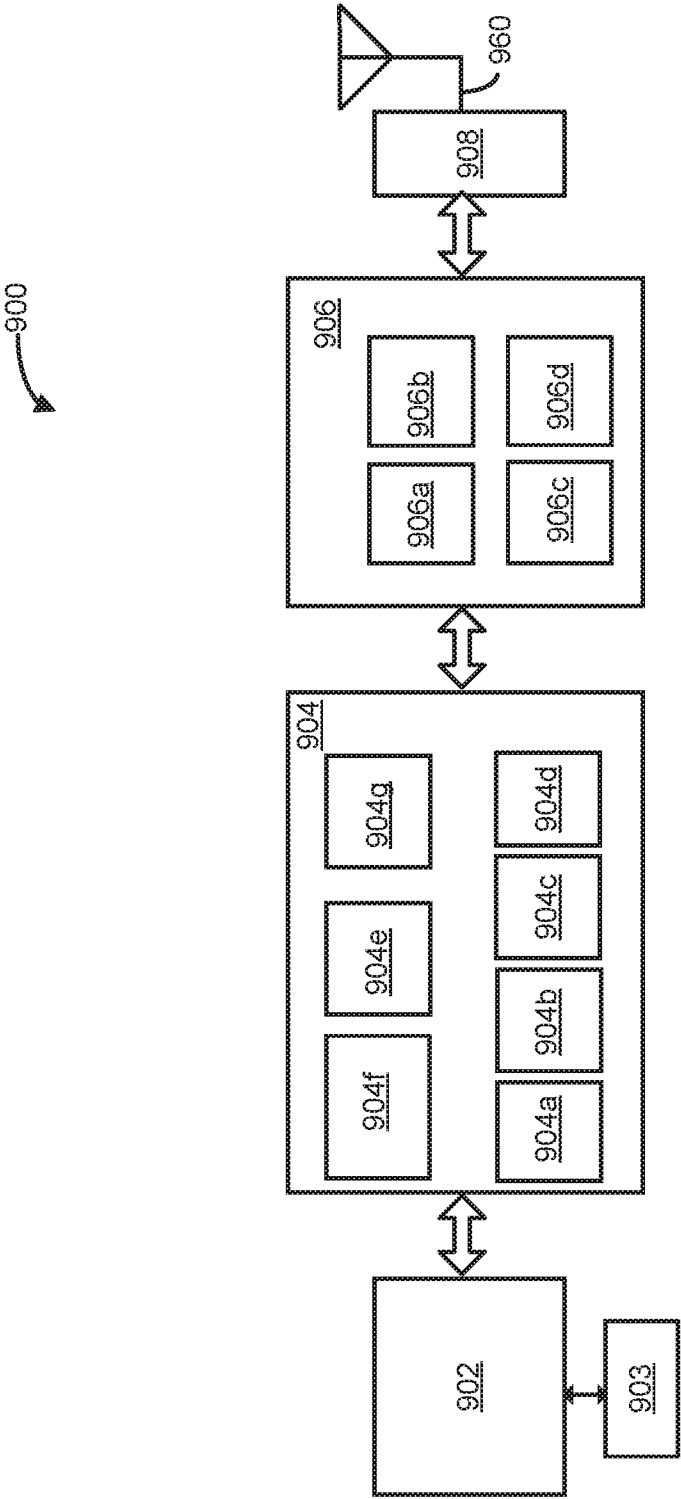


Fig. 9

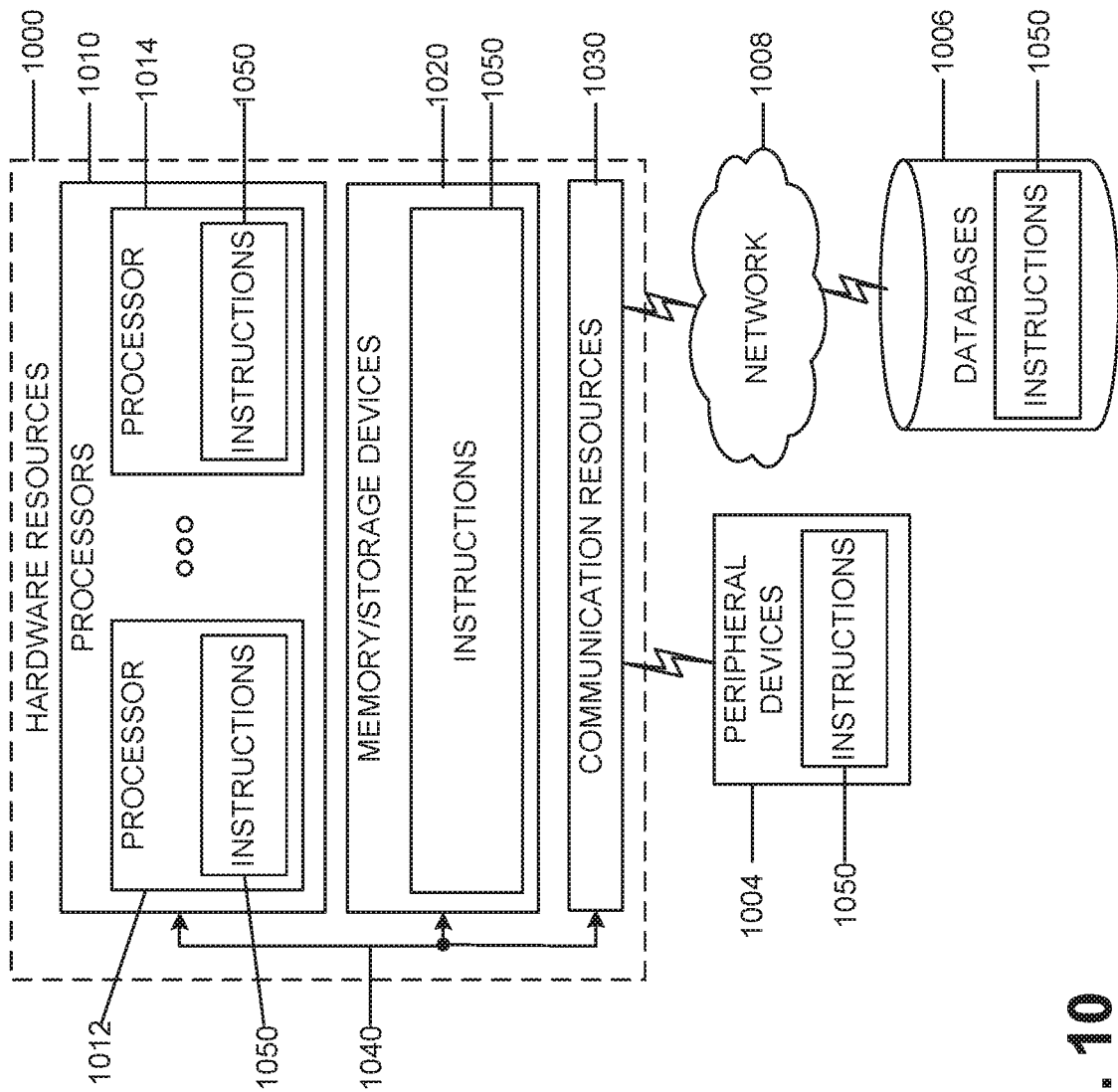


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/016093

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/32
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

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)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/269462 A1 (SAEGFORS MATS [FI] ET AL) 3 November 2011 (2011-11-03) paragraphs [0005], [0019] - [0071] -----	1-20
A	US 2016/050598 A1 (DALSGAARD LARS [FI] ET AL) 18 February 2016 (2016-02-18) paragraphs [0106] - [0119] -----	1-20
A	US 2015/045040 A1 (LAI XIAOMING [CA] ET AL) 12 February 2015 (2015-02-12) paragraphs [0005] - [0026] -----	1-20

☐

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

31 March 2017

Date of mailing of the international search report

13/04/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Pasini, Enrico

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/016093

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011269462 A1	03-11-2011	EP 2564637 A1	06-03-2013
		US 2011269462 A1	03-11-2011
		WO 2011136716 A1	03-11-2011

US 2016050598 A1	18-02-2016	CN 105432120 A	23-03-2016
		EP 2982176 A1	10-02-2016
		US 2016050598 A1	18-02-2016
		WO 2014162172 A1	09-10-2014

US 2015045040 A1	12-02-2015	EP 3033909 A1	22-06-2016
		US 2015045040 A1	12-02-2015
		US 2017034758 A1	02-02-2017
		WO 2015022625 A1	19-02-2015
