US012096481B2

(12) **United States Patent**
Comstock

(10) **Patent No.: US 12,096,481 B2**
(45) **Date of Patent: *Sep. 17, 2024**

(54) **METHODS FOR TRIGGERING A BASE STATION TO TRANSMIT A MAC MESSAGE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 137 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/953,989**

(22) Filed: **Sep. 27, 2022**

(65) **Prior Publication Data**

US 2023/0019689 A1 Jan. 19, 2023

Related U.S. Application Data

(63) Continuation of application No. 17/021,575, filed on Sep. 15, 2020, now Pat. No. 11,490,427, which is a (Continued)

(51) **Int. Cl.**

H04L 12/28 (2006.01)
H04L 5/00 (2006.01)
(Continued)

(52) **U.S. Cl.**

CPC .... ***H04W 74/0833*** (2013.01); ***H04L 5/00*** (2013.01); ***H04L 5/001*** (2013.01); (Continued)

(58) **Field of Classification Search**

CPC H04W 36/0005; H04W 36/0072; H04W 36/0069; H04L 5/0053
(Continued)

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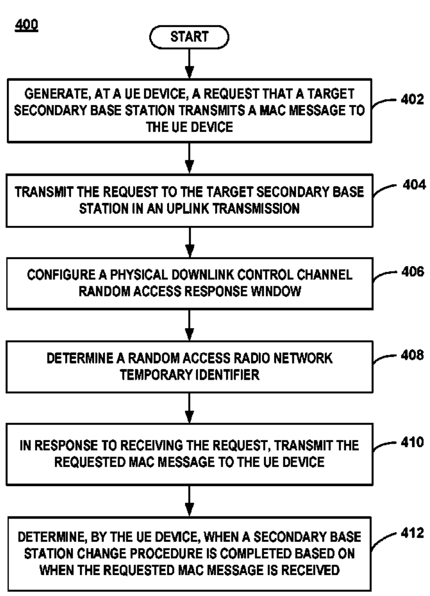
(Continued)

Primary Examiner — John Pezzlo

(57) **ABSTRACT**

The examples described herein provide for a Secondary Base Station (SeNB) Change procedure in a system configured to provide Dual Connectivity, where the SeNB Change procedure does not include the RACH procedure. As part of the SeNB Change procedure, a UE device generates a request that the Target Secondary base station (Target SeNB) is to send a Media Access Control (MAC) message to the UE device. In some examples, the request can be configured to specify a particular MAC Control Element that the Target SeNB should send in response to receiving the request. Upon receipt of the request, the Target SeNB transmits the requested MAC message to the UE device, along with TA information, if required. The UE device determines when the SeNB Change procedure has been completed, based at least partially on when the requested MAC message is received from the Target SeNB.

6 Claims, 4 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/347,103, filed as application No. PCT/US2017/059838 on Nov. 3, 2017, now Pat. No. 10,887,923.

(60) Provisional application No. 62/417,507, filed on Nov. 4, 2016.

(51) **Int. Cl.**

H04W 36/00	(2009.01)
H04W 74/08	(2009.01)
H04W 74/0833	(2024.01)
H04W 76/20	(2018.01)
H04J 1/16	(2006.01)
H04W 16/32	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 36/0069*** (2018.08); ***H04W 74/08*** (2013.01); ***H04W 76/20*** (2018.02); *H04L 5/0048* (2013.01); *H04L 5/0053* (2013.01); *H04W 16/32* (2013.01)

(58) **Field of Classification Search**

USPC 370/252, 329, 331

See application file for complete search history.

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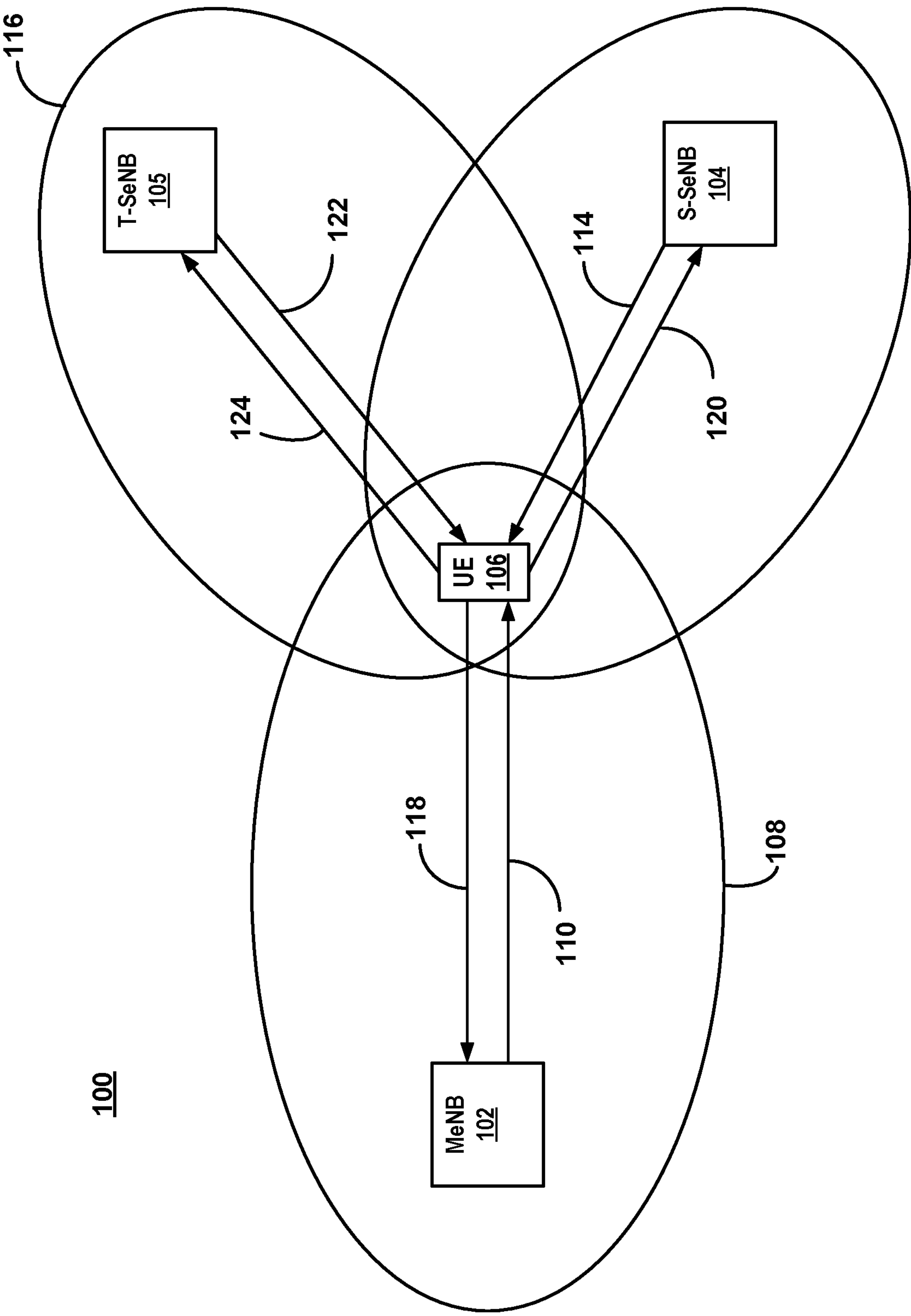
100
116
T-SeNB
105
122
124
114
S-SeNB
104
112
120
UE
106
118
110
108
MeNB
102

FIG. 1

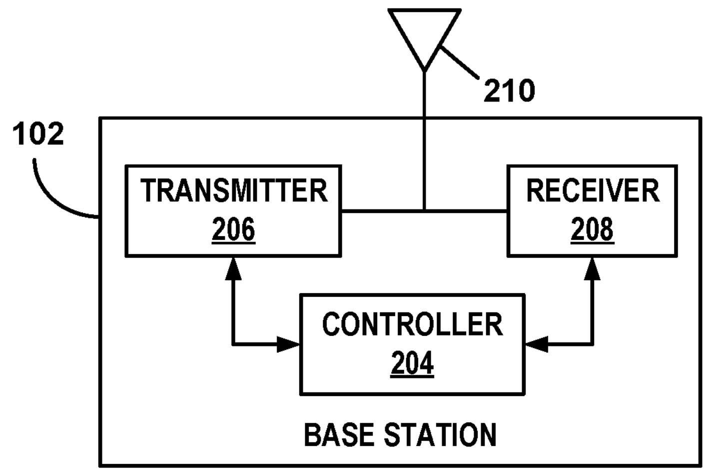
210
102
TRANSMITTER
206
RECEIVER
208
CONTROLLER
204
BASE STATION

FIG. 2A

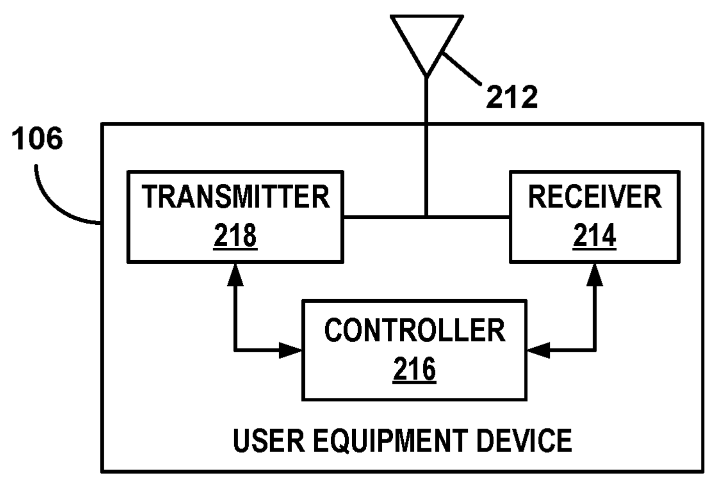
212
106
TRANSMITTER
218
RECEIVER
214
CONTROLLER
216
USER EQUIPMENT DEVICE

FIG. 2B

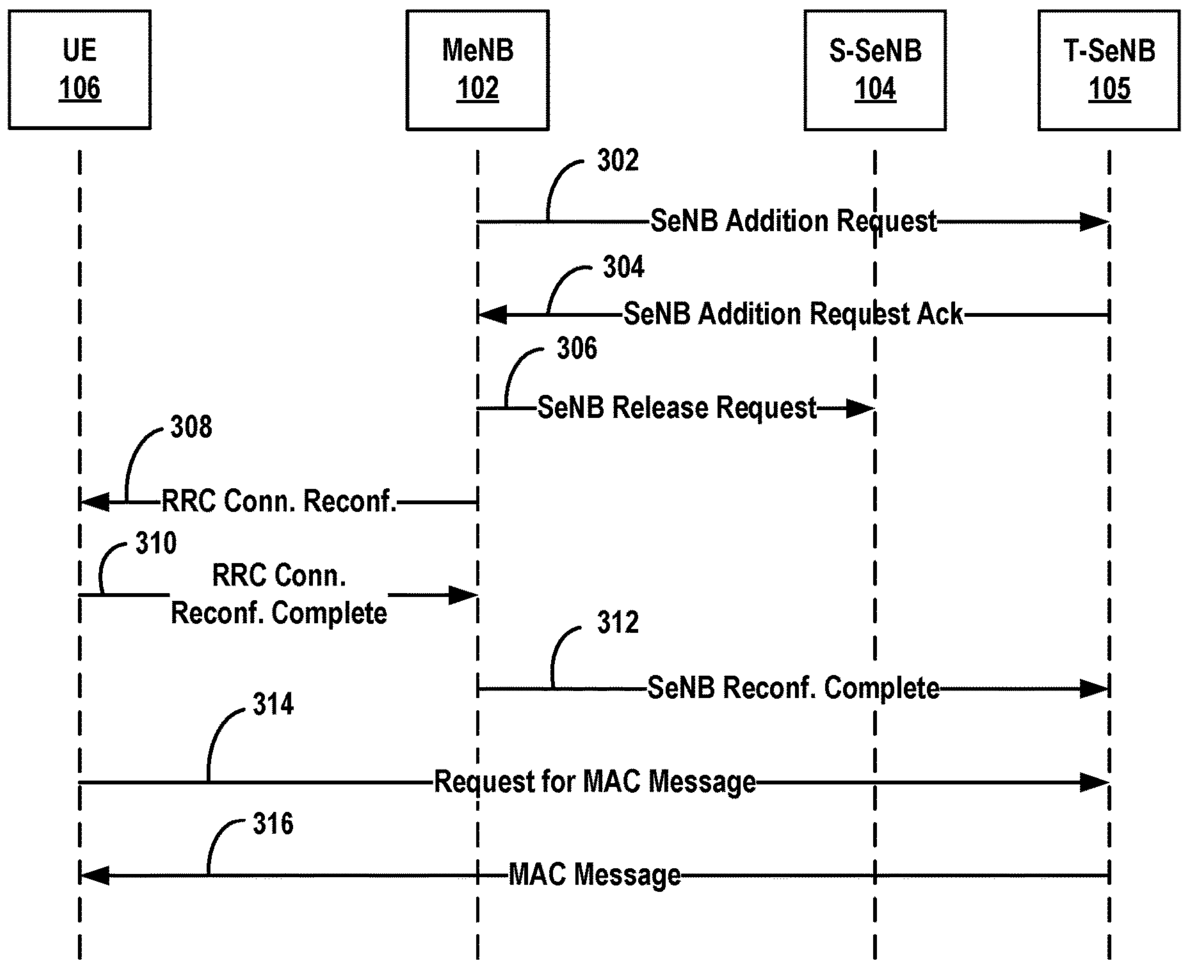
UE
106
MeNB
102
S-SeNB
104
T-SeNB
105
302
SeNB Addition Request
304
SeNB Addition Request Ack
306
SeNB Release Request
308
RRC Conn. Reconf.
310
RRC Conn.
Reconf. Complete
312
SeNB Reconf. Complete
314
Request for MAC Message
316
MAC Message

FIG. 3A

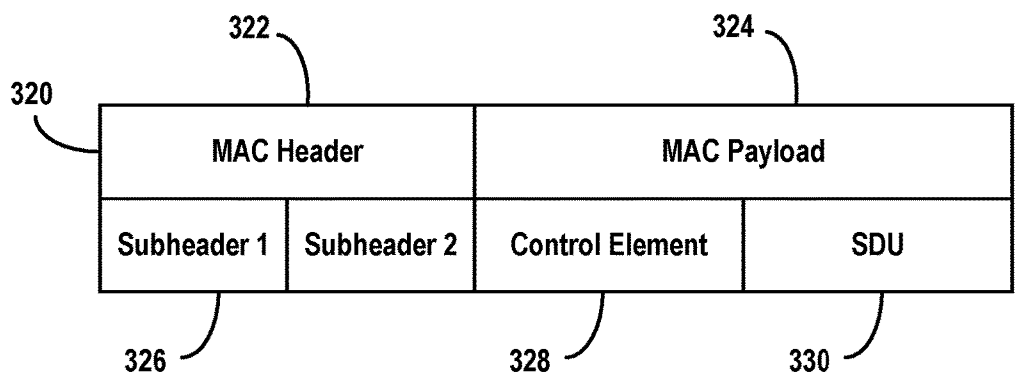
320
322
324
MAC Header
MAC Payload
Subheader 1
Subheader 2
Control Element
SDU
326
328
330

FIG. 3B

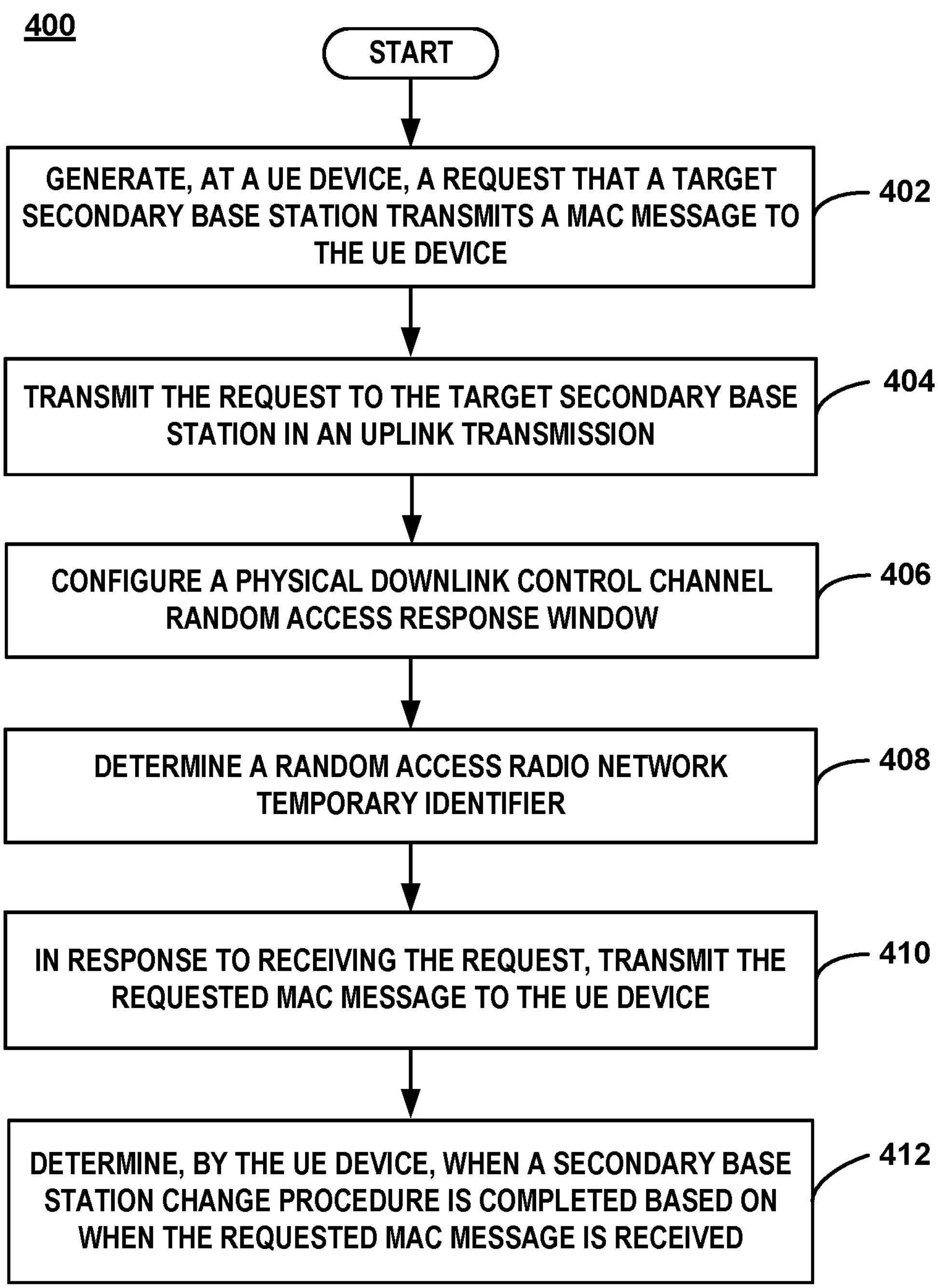
400
START
GENERATE, AT A UE DEVICE, A REQUEST THAT A TARGET SECONDARY BASE STATION TRANSMITS A MAC MESSAGE TO THE UE DEVICE
402
TRANSMIT THE REQUEST TO THE TARGET SECONDARY BASE STATION IN AN UPLINK TRANSMISSION
404
CONFIGURE A PHYSICAL DOWNLINK CONTROL CHANNEL RANDOM ACCESS RESPONSE WINDOW
406
DETERMINE A RANDOM ACCESS RADIO NETWORK TEMPORARY IDENTIFIER
408
IN RESPONSE TO RECEIVING THE REQUEST, TRANSMIT THE REQUESTED MAC MESSAGE TO THE UE DEVICE
410
DETERMINE, BY THE UE DEVICE, WHEN A SECONDARY BASE STATION CHANGE PROCEDURE IS COMPLETED BASED ON WHEN THE REQUESTED MAC MESSAGE IS RECEIVED
412

FIG. 4

METHODS FOR TRIGGERING A BASE STATION TO TRANSMIT A MAC MESSAGE

CLAIM OF PRIORITY

The present application is a continuation of U.S. application Ser. No. 17/021,575, filed Sep. 15, 2020 and entitled "METHODS FOR TRIGGERING A BASE STATION TO TRANSMIT A MAC MESSAGE"; which is a continuation of U.S. application Ser. No. 16/347,103, filed May 2, 2019 and entitled "METHODS FOR TRIGGERING A BASE STATION TO TRANSMIT A MAC MESSAGE"; which is a national stage application of PCT/US2017/059838, filed Nov. 3, 2017 and entitled "METHODS FOR TRIGGERING A BASE STATION TO TRANSMIT A MAC MESSAGE"; which claims priority to Provisional Application No. 62/417,507, entitled "METHODS FOR TRIGGERING AN ENB TO TRANSMIT A MAC MESSAGE"; filed Nov. 4, 2016, all of which are assigned to the assignee hereof, and hereby expressly incorporated by reference.

FIELD

This invention generally relates to wireless communications and more particularly to user equipment devices requesting messages from base stations.

BACKGROUND

In conventional systems, a handover of a user equipment (UE) device from a source base station (e.g., source eNB) to a target base station (e.g., target eNB) involves the source base station transmitting a Handover Request message to the target base station (e.g., to initiate a handover) and the target base station transmitting a message in response. The source base station signals target base station uplink resources to the UE device, which utilizes the uplink resources for a Random-Access Channel (RACH) procedure. After the UE device is handed over to the target base station, the UE device transmits an uplink signal to the target base station as part of the RACH procedure. The target base station uses the uplink signal received from the UE device to calculate a Timing Advance (TA), which is needed in order for the UE device's uplink transmissions to be synchronized to the target base station after handover. The target base station signals the TA in the Random Access Response (RAR) message, along with uplink resources needed for the UE device to obtain uplink access to the target base station as part of the handover procedure. The UE device determines when the handover procedure is completed for the UE device, based upon when the UE device receives the RAR message. In conventional systems configured to provide Dual Connectivity, a Secondary Base Station (SeNB) Change of a UE device from a source SeNB to a target SeNB makes use of a similar RACH procedure.

SUMMARY

The examples described herein provide for a Secondary Base Station (SeNB) Change procedure in a system configured to provide Dual Connectivity, where the SeNB Change procedure does not include the RACH procedure. As part of the SeNB Change procedure, a UE device generates a request that the Target Secondary base station (Target SeNB) is to send a Media Access Control (MAC) message to the UE device. In some examples, the request can be configured to specify a particular MAC Control Element that the Target

SeNB should send in response to receiving the request. Upon receipt of the request, the Target SeNB transmits the requested MAC message to the UE device, along with TA information, if required. The UE device determines when the SeNB Change procedure has been completed based at least partially on when the requested MAC message is received from the Target SeNB.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a communication system for an example in which a UE device requests that a target secondary base station transmits a MAC message to the UE device.

FIG. **2**A is a block diagram of an example of the base stations shown in FIG. **1**.

FIG. **2**B is a block diagram of an example of the UE device shown in FIG. **1**.

FIG. **3**A is a messaging diagram of an example of the messages exchanged between the various system components shown in FIG. **1**.

FIG. **3**B is a block diagram of an example of a MAC Protocol Data Unit structure.

FIG. **4** is a flowchart of an example of a method in which a UE device requests that a target secondary base station transmits a MAC message to the UE device.

DETAILED DESCRIPTION

The Timing Advance (TA) provided by a target base station to a UE device during a handover in conventional systems is needed in order for the UE device's uplink transmissions to be synchronized to the target base station after handover. If the uplink transmissions are not properly synchronized to the target base station, the target base station will not be able to detect and decode the transmissions. However, one drawback of conventional systems is that the TA determination step increases the amount of time required to complete the handover procedure in examples when the TA may not need to be determined during a handover.

RACH-less handovers can be used in examples when the TA does not need to be determined during a handover, in order to reduce the time required to complete the handover procedure. As used herein, the term "RACH-less handover" refers to skipping the transmission of the Random-Access Channel (RACH) by the user equipment (UE) device to the target base station (e.g., target eNB) during handover, which significantly improves the delay for the handover procedure since the RACH procedure is a substantial part of the handover delay. However, if the RACH procedure is not performed, any alternative method must provide a way for the UE device to be able to determine when a handover of the UE device has been successfully completed, which is determined by receiving the RAR message in conventional systems.

Besides the foregoing requirements, a RACH-less handover procedure performed in a 3rd Generation Partnership Project Long Term Evolution (3GPP LTE) system that is configured to provide Dual Connectivity to UE devices requires similar considerations. For example, Dual Connectivity (DC) allows UE devices to exchange data simultaneously from different base stations, also referred to as eNodeBs (eNBs), in order to boost the performance in a heterogeneous network with dedicated carrier deployment. Dual Connectivity in an LTE network can significantly improve per-user throughput and mobility robustness by allowing users to be connected simultaneously to a master cell group (MCG) and a secondary cell group (SCG) via a Master eNB (MeNB) and Secondary eNB (SeNB), respectively. In such a system, as a UE device moves or radio conditions change, the UE device may maintain a primary connection with the same MeNB but may have a secondary connection that is handed over from a first SeNB (e.g., Source SeNB) to a second SeNB (e.g., Target SeNB). This type of handover in a system that provides Dual Connectivity is known as a Secondary base station (SeNB) Change procedure.

The examples described herein illustrate various techniques for performing RACH-less SeNB Change procedures. For example, the MeNB transmits an uplink grant to the UE device in a Radio Resource Control (RRC) Connection Reconfiguration message. The uplink grant provides the resources for the UE device to transmit an uplink transmission to a Target SeNB. Upon receipt of the RRC Connection Reconfiguration message from the Master eNB, the UE device generates a request that the Target SeNB is to send a MAC message to the UE device. The UE device transmits the request using the uplink grant received in the RRC Connection Reconfiguration message.

Upon receipt of the request, the Target SeNB transmits the requested MAC message to the UE device, along with TA information, if required. The UE device determines when the SeNB Change procedure has been completed, based at least partially on when the requested MAC message is received from the Target SeNB. Any unnecessary information received in the MAC message may be discarded by the UE device.

FIG. **1** is a block diagram of a communication system for an example in which a UE device requests that a target secondary base station (Target SeNB) transmits a MAC message to the UE device. The communication system **100** is part of a radio access network (not shown) that provides various wireless services to UE devices that are located within the respective service areas of the various base stations that are part of the radio access network.

In the interest of clarity and brevity, communication system **100** is shown as having only one Master base station (MeNB) **102** and only two Secondary base stations (SeNBs) **104**, **105**. However, in other examples, communication system **100** could have any suitable number of Master base stations and Secondary base stations. In the example of FIG. **1**, at least a portion of the service area (cell) for Master base station **102** is represented by cell **108**. At least a portion of the respective service areas (cells) for Secondary base stations **104**, **105** are represented by cells **112**, **116**. Cells **108**, **112**, **116** are represented by ovals, but a typical communication system **100** would have a plurality of cells, each having variously shaped geographical service areas. Moreover, although cell **108** is shown as only partially overlapping cells **112**, **116** in the example of FIG. **1**, one, or both, of cells **112**, **116** may be located entirely within cell **108**, in other examples.

Base stations **102**, **104**, **105**, sometimes referred to as eNodeBs or eNBs, communicate with the wireless user equipment (UE) device **106** by respectively transmitting downlink signals **110**, **114**, **122** when connected to UE device **106**. Base stations **102**, **104**, **105** respectively receive uplink signals **118**, **120**, **124** transmitted from the UE device **106** when connected to UE device **106**. The UE device **106** is any wireless communication device such as a mobile phone, a transceiver modem, a personal digital assistant (PDA), a tablet, or a smartphone, for example.

Base stations **102**, **104**, **105** are connected to the network through a backhaul (not shown) in accordance with known techniques. As shown in FIG. **2**A, Master base station **102** comprises controller **204**, transmitter **206**, and receiver **208**, as well as other electronics, hardware, and code. Although FIG. **2**A specifically depicts the circuitry and configuration of Master base station **102**, the same base station circuitry and configuration that is shown and described in connection with Master base station **102** is also utilized for Secondary base stations **104**, **105**, in the example shown in FIG. **1**. In other examples, one, or both, of the Secondary base stations **104**, **105** may have circuitry and/or a configuration that differs from that of the Master base station **102**.

The Master base station **102** is any fixed, mobile, or portable equipment that performs the functions described herein. The various functions and operations of the blocks described with reference to the Master base station **102** may be implemented in any number of devices, circuits, or elements. Two or more of the functional blocks may be integrated in a single device, and the functions described as performed in any single device may be implemented over several devices.

For the example shown in FIG. **2**A, the Master base station **102** may be a fixed device or apparatus that is installed at a particular location at the time of system deployment. Examples of such equipment include fixed base stations or fixed transceiver stations. In some situations, the Master base station **102** may be mobile equipment that is temporarily installed at a particular location. Some examples of such equipment include mobile transceiver stations that may include power generating equipment such as electric generators, solar panels, and/or batteries. Larger and heavier versions of such equipment may be transported by trailer. In still other situations, the Master base station **102** may be a portable device that is not fixed to any particular location. Accordingly, the Master base station **102** may be a portable user device such as a UE device in some circumstances.

The controller **204** includes any combination of hardware, software, and/or firmware for executing the functions described herein as well as facilitating the overall functionality of the Master base station **102**. An example of a suitable controller **204** includes code running on a microprocessor or processor arrangement connected to memory. The transmitter **206** includes electronics configured to transmit wireless signals. In some situations, the transmitter **206** may include multiple transmitters. The receiver **208** includes electronics configured to receive wireless signals. In some situations, the receiver **208** may include multiple receivers. The receiver **208** and transmitter **206** receive and transmit signals, respectively, through an antenna **210**. The antenna **210** may include separate transmit and receive antennas. In some circumstances, the antenna **210** may include multiple transmit and receive antennas.

The transmitter **206** and receiver **208** in the example of FIG. **2**A perform radio frequency (RF) processing including modulation and demodulation. The receiver **208**, therefore, may include components such as low noise amplifiers (LNAs) and filters. The transmitter **206** may include filters and amplifiers. Other components may include isolators, matching circuits, and other RF components. These components in combination or cooperation with other components perform the base station functions. The required components may depend on the particular functionality required by the base station.

The transmitter **206** includes a modulator (not shown), and the receiver **208** includes a demodulator (not shown). The modulator modulates the signals to be transmitted as part of the downlink signals **110** and can apply any one of a plurality of modulation orders. The demodulator demodulates any uplink signals **118** received at the Master base station **102** in accordance with one of a plurality of modulation orders.

Returning to FIG. **1**, the communication system **100** provides various wireless services to UE device **106** via base stations **102**, **104**, **105**. For the examples herein, the communication system **100** operates in accordance with at least one revision of the 3rd Generation Partnership Project Long Term Evolution (3GPP LTE) communication specification. UE device **106** is initially served by Master base station **102** and by Source SeNB (S-SeNB) **104**. Thus, UE device **106** receives downlink signals **110**, **114** via antenna **212** and receiver **214**, as shown in FIG. **2**B. Besides antenna **212** and receiver **214**, UE device **106** further comprises controller **216** and transmitter **218**, as well as other electronics, hardware, and code. UE device **106** is any fixed, mobile, or portable equipment that performs the functions described herein. The various functions and operations of the blocks described with reference to UE device **106** may be implemented in any number of devices, circuits, or elements. Two or more of the functional blocks may be integrated in a single device, and the functions described as performed in any single device may be implemented over several devices.

The controller **216** includes any combination of hardware, software, and/or firmware for executing the functions described herein as well as facilitating the overall functionality of a UE device. An example of a suitable controller **216** includes code running on a microprocessor or processor arrangement connected to memory. The transmitter **218** includes electronics configured to transmit wireless signals. In some situations, the transmitter **218** may include multiple transmitters. The receiver **214** includes electronics configured to receive wireless signals. In some situations, the receiver **214** may include multiple receivers. The receiver **214** and transmitter **218** receive and transmit signals, respectively, through antenna **212**. The antenna **212** may include separate transmit and receive antennas. In some circumstances, the antenna **212** may include multiple transmit and receive antennas.

The transmitter **218** and receiver **214** in the example of FIG. **2**B perform radio frequency (RF) processing including modulation and demodulation. The receiver **214**, therefore, may include components such as low noise amplifiers (LNAs) and filters. The transmitter **218** may include filters and amplifiers. Other components may include isolators, matching circuits, and other RF components. These components in combination or cooperation with other components perform the UE device functions. The required components may depend on the particular functionality required by the UE device.

The transmitter **218** includes a modulator (not shown), and the receiver **214** includes a demodulator (not shown). The modulator can apply any one of a plurality of modulation orders to modulate the signals to be transmitted as part of the uplink signals **118**, **120**, **124** which are shown in FIG. **1**. The demodulator demodulates the downlink signals **110**, **114**, **122** in accordance with one of a plurality of modulation orders.

At the beginning of operation of the example shown in FIG. **1**, the UE device **106** is being served by Master base station **102** and Source SeNB **104**. Thus, upon receipt of the downlink signals **110**, **114**, the UE device **106** demodulates the downlink signals **110**, **114**, which yields encoded data packets that contain data pertaining to at least one of the wireless services that the Master base station **102** and the Source SeNB **104** are providing to the UE device **106**. The UE device **106** decodes the encoded data packets, using controller **216**, to obtain the data.

When the Secondary base station (SeNB) Change procedure criteria are met, the SeNB Change procedure is initiated. The SeNB Change procedure criteria may include, for example, radio congestion at Source SeNB **104**, poor/deteriorating signal quality for the uplink/downlink signals for UE device **106**, and/or underutilization of available resources by Target SeNB **105**. However, any other suitable criteria could be used. As mentioned above, when performing the SeNB Change procedure, the UE device **106** maintains its primary connection with the Master base station **102** but hands over its secondary connection from the Source SeNB **104** to the Target SeNB **105**.

To initiate the SeNB Change procedure, the Master base station **102** transmits an SeNB Addition Request to Target SeNB **105** via a wired (e.g., X2) or a wireless communication link. If the transmission is wireless, Master base station **102** uses transmitter **206** and antenna **210** to transmit the SeNB Addition Request, and Target SeNB **105** receives the wireless transmission of the SeNB Addition Request via its antenna **210** and receiver **208**. The transmission of the SeNB Addition Request to the Target SeNB **105** is represented in FIG. **3**A by signal **302**.

If the Target SeNB **105** agrees to serve as the SeNB for UE device **106**, the Target SeNB **105** sends an SeNB Addition Request Acknowledgement message to the Master base station **102** via a wired connection or a wireless connection. The transmission of the SeNB Addition Request Acknowledgement is represented in FIG. **3**A by signal **304**. Upon receipt of the SeNB Addition Request Acknowledgement, the Master base station **102** transmits an SeNB Release Request to Source SeNB **104** via a wired (e.g., X2) or a wireless communication link, which informs the Source SeNB **104** that the secondary connection of the UE device **106** is being handed over to Target SeNB **105**. The transmission of the SeNB Release Request message is represented in FIG. **3**A by signal **306**.

The Master base station **102** transmits a Radio Resource Control (RRC) Connection Reconfiguration message to the UE device **106**. The RRC Connection Reconfiguration message includes uplink grant information, which the UE device **106** will utilize to send a request that the Target SeNB **105** transmits a Media Access Control (MAC) message to the UE device **106**. The RRC Connection Reconfiguration message may also include information that is used by the UE device **106** to detect and decode the MAC message that the Target SeNB **105** will send to the UE device **106**. The RRC Connection Reconfiguration message may also include information regarding the length of a window during which the UE device **106** should monitor the Physical Downlink Control Channel (PDCCH) for a RAR message that will be sent by the Target SeNB **105**. The transmission of the RRC Connection Reconfiguration message is represented in FIG. **3**A by signal **308**.

Once the RRC Connection is reconfigured, the UE device **106** transmits an RRC Connection Reconfiguration Complete message to the Master base station **102**. The RRC Connection Reconfiguration Complete message is represented in FIG. **3**A by signal **310**. Upon receipt of the RRC Connection Reconfiguration Complete message, the Master base station **102** transmits an SeNB Reconfiguration Complete message to Target SeNB **105** to inform Target SeNB **105** that (1) UE device **106** has been reconfigured to switch its secondary connection from Source SeNB **104** to Target SeNB **105**, and (2) Target SeNB **105** should be prepared to receive an uplink transmission from UE device **106**. The SeNB Reconfiguration Complete message is represented in FIG. **3**A by signal **312**.

Upon receipt of the RRC Connection Reconfiguration message, the UE device **106** generates a request that the Target SeNB **105** transmits a MAC message to the UE device **106**. In some examples, the request comprises a Logical Channel Identifier (LCID) located in a subheader of a MAC Protocol Data Unit (PDU) that will be transmitted to the Target SeNB **105**. FIG. **3**B shows an example of a MAC PDU structure **320**, which comprises a MAC header **322** and a MAC payload **324**. The MAC header **322** comprises one or more subheaders **326** that identify the type of information contained in the MAC payload **324**. There is a subheader **326** associated with each entry in the MAC payload **324**. As can be seen in FIG. **3**B, the first part of the MAC payload **324** contains one or more MAC Control Elements **328** that are followed by one or more MAC Service Data Units (SDUs) **330**. The MAC SDUs include control data, such as an RRC message, and user data. For the example shown in FIG. **3**B, subheader 1 is associated with MAC Control Element **328**, and subheader 2 is associated with MAC SDU **330**.

In some examples, the LCID, itself, is defined to request that the Target SeNB **105** transmits a specific MAC Control Element, such as a UE Contention Resolution Identity MAC Control Element, to the UE device **106**. For these examples, only the LCID located in a subheader (e.g., subheader 1) is used to request a specific MAC Control Element or other MAC message, and no payload information is needed for the request. In other examples, the request is that the Target SeNB **105** is to transmit a Random Access Response (RAR) message to the UE device **106**.

Alternatively, the LCID can be a generic MAC Command Request, indicating that a MAC Control Element located in the MAC payload **324** identifies the requested command. For example, the LCID, which is included in a subheader **326** of the MAC PDU **320**, is set to the MAC Command Request value, and the specific MAC Control Element or MAC message being requested (e.g., UE Contention Resolution Identity or RAR) is identified by a value located in a MAC SDU **330** that corresponds with the subheader that contains the MAC Command Request LCID.

In some examples, any MAC message transmitted to the Target SeNB **105** using the uplink grant information received in the RRC Connection Reconfiguration message of the SeNB Change procedure is a request that the Target SeNB **105** transmits a MAC message to the UE device **106**. In some examples, receiving the SeNB Reconfiguration Complete message is a request that the Target SeNB **105** transmits a MAC message to the UE device **106**.

For the examples described herein, MAC messages contain control information that originates and terminates in peer MAC layer (Layer **2**) protocol entities, such as specified in the 3rd Generation Partnership Project Long Term Evolution (3GPP LTE) MAC specification, for example, and includes MAC messages, such as the Random Access Response (RAR) message, as well as MAC Control Elements.

Regardless of the format of the request that the Target SeNB **105** is to transmit a MAC message, the UE device **106** transmits, via transmitter **218** and antenna **212**, the request to the Target SeNB **105** in an uplink transmission **124**. In these examples, the transmission of the request to the Target SeNB **105** is represented in FIG. **3**A by signal **314**.

The Target SeNB **105** receives the request via antenna **210** and receiver **208**. Upon receipt of the request, the Target SeNB **105** utilizes controller **204** to generate a MAC message in accordance with the received request. More specifically, in some examples, the Target SeNB **105** generates a MAC message that contains the specific MAC Control Element indicated in the request from the UE device **106**. For example, if the request was for a UE Contention Resolution Identity MAC Control Element, then the Target SeNB **105** would generate a MAC message containing a UE Contention Resolution Identity MAC Control Element. Likewise, if the request was for a RAR, then the Target SeNB **105** would generate a MAC message containing a RAR.

The Target SeNB **105** transmits, via transmitter **206** and antenna **210**, the MAC message containing the requested MAC message (e.g., a UE Contention Resolution Identity MAC Control Element or a RAR) to the UE device **106**. The transmission of the MAC message is represented in FIG. **3**A by signal **316**.

After transmission of the request, the UE device **106** monitors the Physical Downlink Control Channel (PDCCH) to receive the MAC transmission that is sent by the Target SeNB **105** in response to the request. In an embodiment where the request was for a Random Access (RA) Response, the UE device **106** monitors the PDCCH during a PDCCH Random Access (RA) Response window that has a size that is obtained from System Information or from Mobility Control Information contained in the RRC Connection Reconfiguration message. In some examples, the PDCCH RA Response window starts at a subframe in which the request was transmitted to the Target SeNB **105** or at a point relative to a subframe in which the request was transmitted to the Target SeNB **105**. For example, the PDCCH RA Response window can be configured to start at the subframe that contains the end of the request (e.g., MAC message) transmitted by the UE device **106** or at the subframe that contains the end of the request (e.g., MAC message) transmitted by the UE device **106** plus three subframes. In other examples, the PDCCH RA Response window starts at a subframe value included in Random Access Channel (RACH) parameters provided by the Target SeNB **105** or at the subframe value included in the RACH parameters provided by the Target SeNB **105** plus three subframes. The three additional subframes referenced in the foregoing examples are based on current LTE specifications. However, any other suitable subframe offsets (e.g., a different number of additional subframes) may be used.

For the UE device **106** to receive the RAR message via antenna **212** and receiver **214** during the PDCCH RA Response window, the UE device **106** utilizes controller **216** to determine a Random Access Radio Network Temporary Identifier (RA-RNTI) using a subframe index associated with a subframe in which the request was transmitted by the UE device **106**. In other examples, the UE device **106** utilizes controller **216** to determine the RA-RNTI using a subframe index associated with a subframe value included in Random Access Channel (RACH) parameters provided by the Target SeNB **105**. Regardless of the method used to determine the RA-RNTI, the RA-RNTI indicates which UE device is the target of the RAR message transmitted by the Target SeNB **105**. Thus, the UE device **106** utilizes the RA-RNTI to confirm that the received RAR message is, in fact, intended for the UE device **106**.

In an embodiment where the request was for a MAC message or a MAC Control Element, the UE device **106** monitors the PDCCH to receive a downlink assignment on the Physical Downlink Shared Channel (PDSCH) that contains the MAC message.

Based at least partially upon when the UE device **106** receives the requested MAC message, the UE device **106** uses controller **216** to determine when the SeNB Change procedure (e.g., from Source SeNB **104** to Target SeNB **105**) is completed for the UE device **106**.

FIG. **3**A is a messaging diagram of an example of the messages exchanged between the various system components shown in FIG. **1**. In this example, the Master base station **102** transmits an SeNB Addition Request to Target SeNB **105**, via signal **302**. In response, Target SeNB **105** transmits an SeNB Addition Request Acknowledgement to the Master base station **102** via signal **304**. Upon receipt of the SeNB Addition Request Acknowledgement, the Master base station **102** transmits an SeNB Release Request to the Source SeNB **104** via signal **306**.

The Master base station **102** transmits an RRC Connection Reconfiguration message to the UE device **106**, which is represented by signal **308**. As mentioned above, the RRC Connection Reconfiguration message may contain (1) uplink grant information required by the UE device **106**, (2) information that is used by the UE device **106** to detect and decode the MAC message that the Target SeNB **105** will send to the UE device **106**, and (3) information regarding the length of a window during which the UE device **106** should monitor the Physical Downlink Control Channel (PDCCH) for a RAR message that will be sent by the Target SeNB **105**.

Once the RRC Connection is reconfigured, the UE device **106** transmits an RRC Connection Reconfiguration Complete message to the Master base station **102** via signal **310**. Upon receipt of the RRC Connection Reconfiguration Complete message, the Master base station **102** transmits an SeNB Reconfiguration Complete message to Target SeNB **105** to inform Target SeNB **105** that (1) UE device **106** has been reconfigured to switch its secondary connection from Source SeNB **104** to Target SeNB **105**, and (2) Target SeNB **105** should be prepared to receive an uplink transmission from UE device **106**. The SeNB Reconfiguration Complete message is represented in by signal **312**.

Upon receipt of the RRC Connection Reconfiguration message, the UE device **106** generates a request that the Target SeNB **105** is to transmit a MAC message to the UE device **106**, as discussed above. The UE device **106** transmits the request to the Target SeNB **105** in an uplink transmission **124**. The transmission of the request to the Target SeNB **105** is represented by signal **314**.

Upon receipt of the request, the Target SeNB **105** generates the specific MAC message indicated in the request from the UE device **106**. The Target SeNB **105** transmits the requested MAC message (e.g., a UE Contention Resolution Identity MAC Control Element or a RAR) to the UE device **106**. The transmission of the MAC message is represented by signal **316**. In some examples, the MAC message also contains the TA information needed for the UE device **106** to synchronize its uplink transmissions to the Target SeNB after the SeNB Change procedure is complete.

FIG. **4** is a flowchart of an example of a method in which a UE device requests that a Target SeNB transmits a MAC message to the UE device. The steps of method **400** may be performed in a different order than described herein and shown in the example of FIG. **4**. Furthermore, in some examples, one or more of the steps may be omitted. Moreover, in other examples, one or more additional steps may be added.

The method **400** begins at step **402** with generating, at UE device **106**, a request that Target SeNB **105** is to transmit, to the UE device **106**, a specific MAC message. At step **404**, the UE device **106** transmits the request to the Target SeNB **105** in an uplink transmission. At step **406**, a Physical Downlink Control Channel (PDCCH) Random Access (RA) Response window is configured, and the UE device **106** monitors the PDCCH for the requested MAC message during the PDCCH RA Response window.

At step **408**, the UE device **106** determines a Random Access Radio Network Temporary Identifier (RA-RNTI), which is used to confirm that the MAC message received from the Target SeNB **105** is intended for the UE device **106**. At step **410**, in response to receiving the request, the Target SeNB **105** generates the requested MAC message and transmits the requested MAC message to the UE device **106**. At step **412**, the UE device **106** determines when the SeNB Change procedure (e.g., from Source SeNB **104** to Target SeNB **105**) is completed for the UE device **106**, based at least partially upon when the UE device **106** receives the requested MAC message.

Clearly, other embodiments and modifications of this invention will occur readily to those of ordinary skill in the art in view of these teachings. The above description is illustrative and not restrictive. This invention is to be limited only by the following claims, which include all such embodiments and modifications when viewed in conjunction with the above specification and accompanying drawings. The scope of the invention should, therefore, be determined not with reference to the above description, but instead should be determined with reference to the appended claims along with their full scope of equivalents.

The invention claimed is:

1. An apparatus for controlling a user equipment (UE) device, the apparatus comprising a processor and a memory, the processor configured to receive UE Contention Resolution Identity from a Target Secondary base station in a Secondary base station Change procedure without transmitting Random Access Channel (RACH) to the Target Secondary base station, wherein the Secondary base station Change procedure is completed for the UE device when the processor receives the UE Contention Resolution Identity.

2. The apparatus of claim **1**, wherein the processor is further configured to transmit an uplink signal, the UE Contention Resolution Identity transmitted in response to receiving the uplink signal at the Target Secondary base station.

3. The apparatus of claim **2**, wherein the processor is further configured to receive a Radio Resource Control (RRC) Connection Reconfiguration message from a Master base station, the RRC Connection Reconfiguration message including uplink grant information, the uplink signal transmitted based on the uplink grant information.

4. A base station comprising:

a transceiver configured to transmit UE Contention Resolution Identity to a user equipment (UE) device in a Secondary base station Change procedure without receiving Random Access Channel (RACH) from the UE device, wherein

the Secondary base station Change procedure is completed for the UE device when the UE device receives the UE Contention Resolution Identity.

5. The base station of claim **4**, wherein the transceiver is further configured to receive an uplink signal from the UE device, the UE Contention Resolution Identity transmitted in response to receiving the uplink signal.

6. The base station of claim **5**, wherein the transceiver is further configured to receive a Secondary Base Station Reconfiguration Complete message from a Master base station, the uplink signal transmitted after the Secondary Base Station Reconfiguration Complete message is received.

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