US009271207B1

(12) **United States Patent**
Narendran et al.

(10) **Patent No.: US 9,271,207 B1**
(45) **Date of Patent: Feb. 23, 2016**

(54) **WIRELESS NETWORK TRANSITION BY A WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(72) Inventors: **Rajveen Narendran**, Olathe, KS (US); **Sreekar Marupaduga**, Overland Park, KS (US)

(73) Assignee: **Sprint Communications Company L.P.**, Overland Park, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 191 days.

(21) Appl. No.: **14/064,640**

(22) Filed: **Oct. 28, 2013**

(51) **Int. Cl.**
H04Q 9/00 (2006.01)
H04W 36/14 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 36/14*** (2013.01)

(58) **Field of Classification Search**
CPC ... H04W 36/00; H04W 36/14; H04W 36/026; H04W 36/0022
USPC 370/329; 455/443
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,285,291 B2 * 10/2012 Dinan et al. 455/443
8,351,944 B2 1/2013 Lee et al.
8,396,039 B2 3/2013 Pawar et al.
2006/0105766 A1 * 5/2006 Azada et al. 455/432.1
2011/0141939 A1 6/2011 Medapalli
2011/0189997 A1 8/2011 Tiwari et al.
2013/0016630 A1 * 1/2013 Bhushan et al. 370/255

FOREIGN PATENT DOCUMENTS

EP 2540103 9/2011
WO 2011106359 9/2011

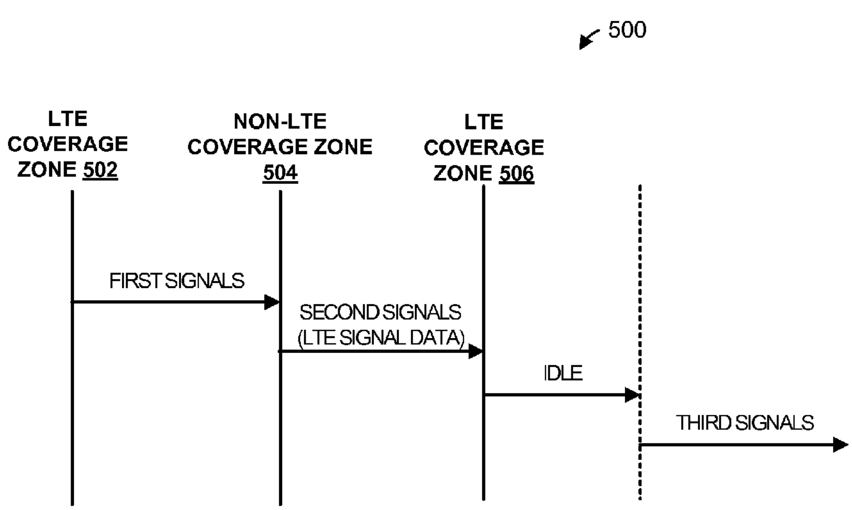
* cited by examiner

Primary Examiner — Wanda Z Russell

(57) **ABSTRACT**

Examples disclosed herein provide systems, methods, and software for transitioning between wireless communication networks. In one example, a method of operating a wireless communication device to transition between wireless communication networks includes exchanging first wireless communication signals with a Long Term Evolution (LTE) network for an application in the wireless communication device. The method further includes transitioning from exchanging the first wireless communication signals with the LTE network, to exchanging second wireless communication signals with at least one non-LTE base station for the application in the wireless communication device, and identifying LTE network status data to estimate an LTE network data rate. Based at least on the LTE network data rate, the method provides identifying an eNodeB sector and frequency carrier. Upon identifying the eNodeB sector and frequency carrier, the wireless communication device will drop to an idle mode before returning to an active mode connected to the LTE communication network.

20 Claims, 6 Drawing Sheets



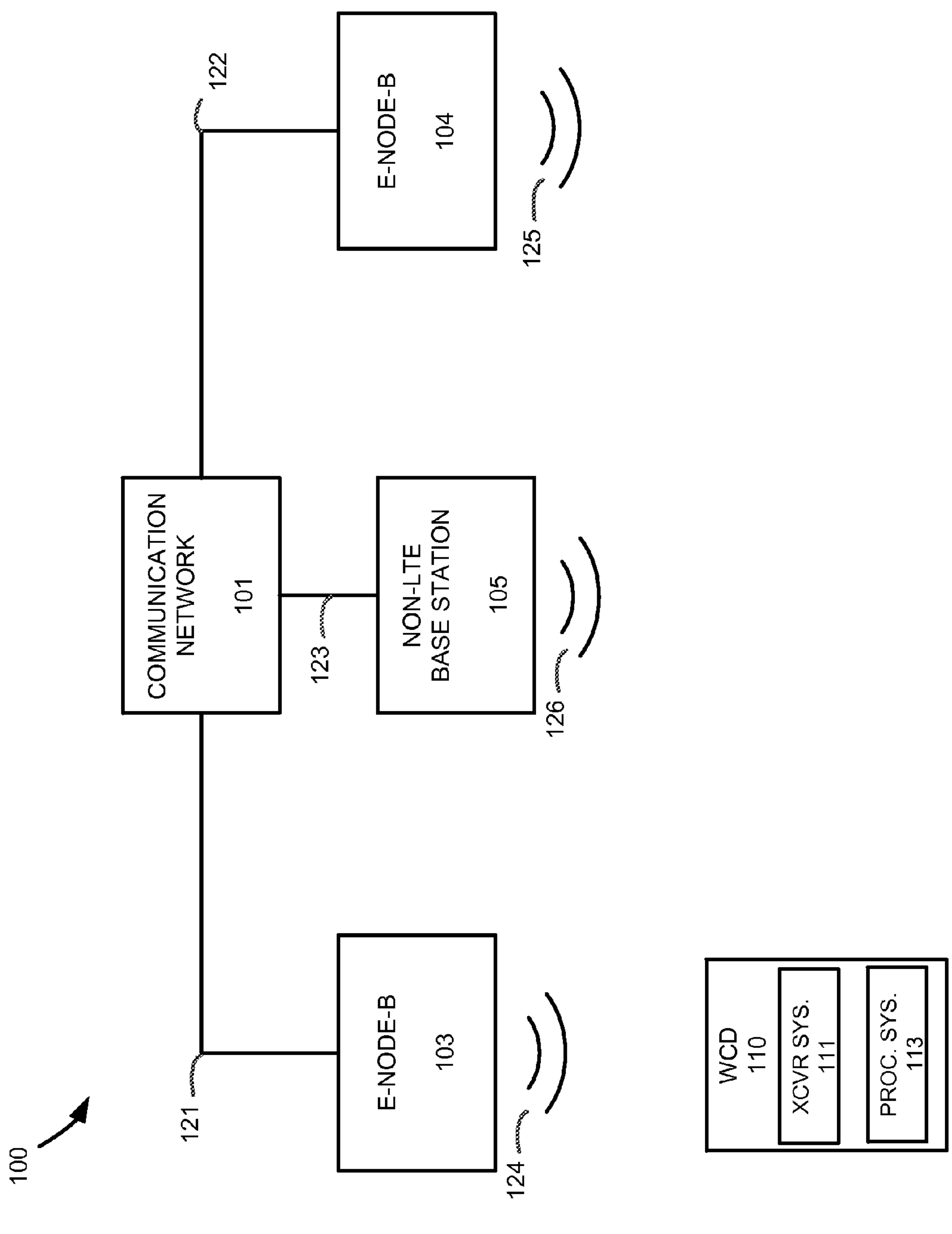

100
COMMUNICATION NETWORK
101
E-NODE-B
103
E-NODE-B
104
NON-LTE BASE STATION
105
121
122
123
124
125
126
WCD
110
XCVR SYS.
111
PROC. SYS.
113

FIGURE 1

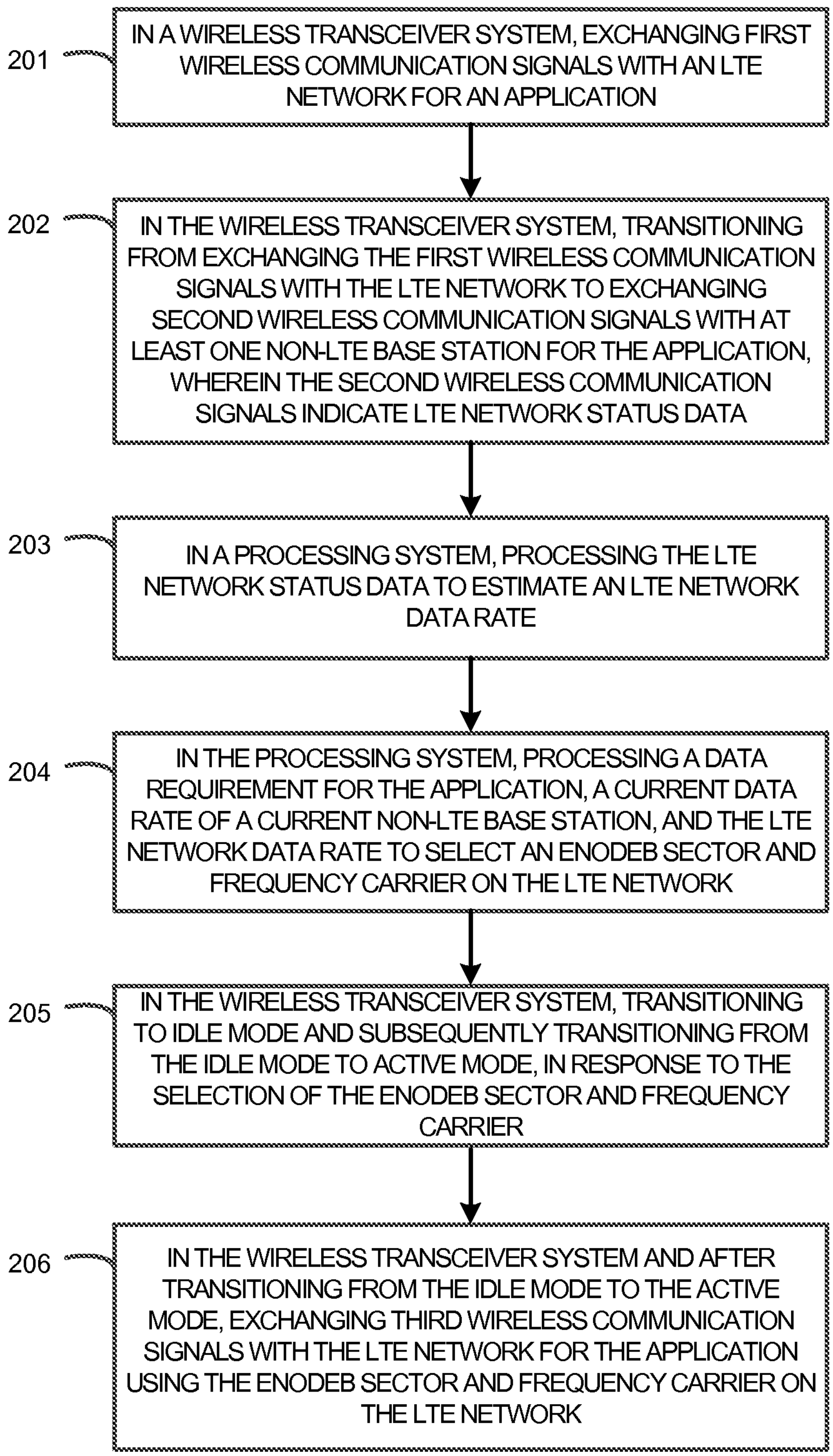
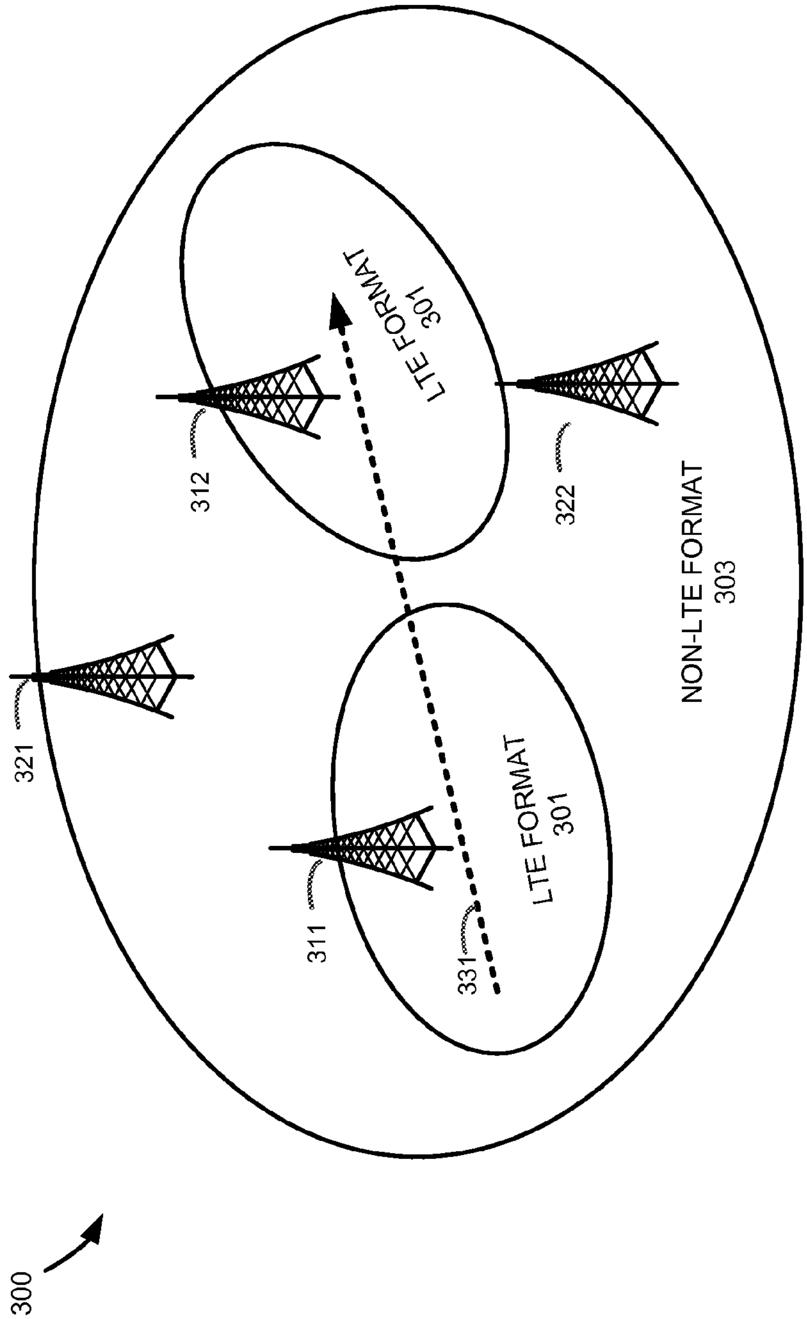

201
IN A WIRELESS TRANSCEIVER SYSTEM, EXCHANGING FIRST WIRELESS COMMUNICATION SIGNALS WITH AN LTE NETWORK FOR AN APPLICATION
202
IN THE WIRELESS TRANSCEIVER SYSTEM, TRANSITIONING FROM EXCHANGING THE FIRST WIRELESS COMMUNICATION SIGNALS WITH THE LTE NETWORK TO EXCHANGING SECOND WIRELESS COMMUNICATION SIGNALS WITH AT LEAST ONE NON-LTE BASE STATION FOR THE APPLICATION, WHEREIN THE SECOND WIRELESS COMMUNICATION SIGNALS INDICATE LTE NETWORK STATUS DATA
203
IN A PROCESSING SYSTEM, PROCESSING THE LTE NETWORK STATUS DATA TO ESTIMATE AN LTE NETWORK DATA RATE
204
IN THE PROCESSING SYSTEM, PROCESSING A DATA REQUIREMENT FOR THE APPLICATION, A CURRENT DATA RATE OF A CURRENT NON-LTE BASE STATION, AND THE LTE NETWORK DATA RATE TO SELECT AN ENODEB SECTOR AND FREQUENCY CARRIER ON THE LTE NETWORK
205
IN THE WIRELESS TRANSCEIVER SYSTEM, TRANSITIONING TO IDLE MODE AND SUBSEQUENTLY TRANSITIONING FROM THE IDLE MODE TO ACTIVE MODE, IN RESPONSE TO THE SELECTION OF THE ENODEB SECTOR AND FREQUENCY CARRIER
206
IN THE WIRELESS TRANSCEIVER SYSTEM AND AFTER TRANSITIONING FROM THE IDLE MODE TO THE ACTIVE MODE, EXCHANGING THIRD WIRELESS COMMUNICATION SIGNALS WITH THE LTE NETWORK FOR THE APPLICATION USING THE ENODEB SECTOR AND FREQUENCY CARRIER ON THE LTE NETWORK

FIGURE 2



LTE FORMAT
301
LTE FORMAT
301
NON-LTE FORMAT
303
311
312
321
322
331
300

FIGURE 3

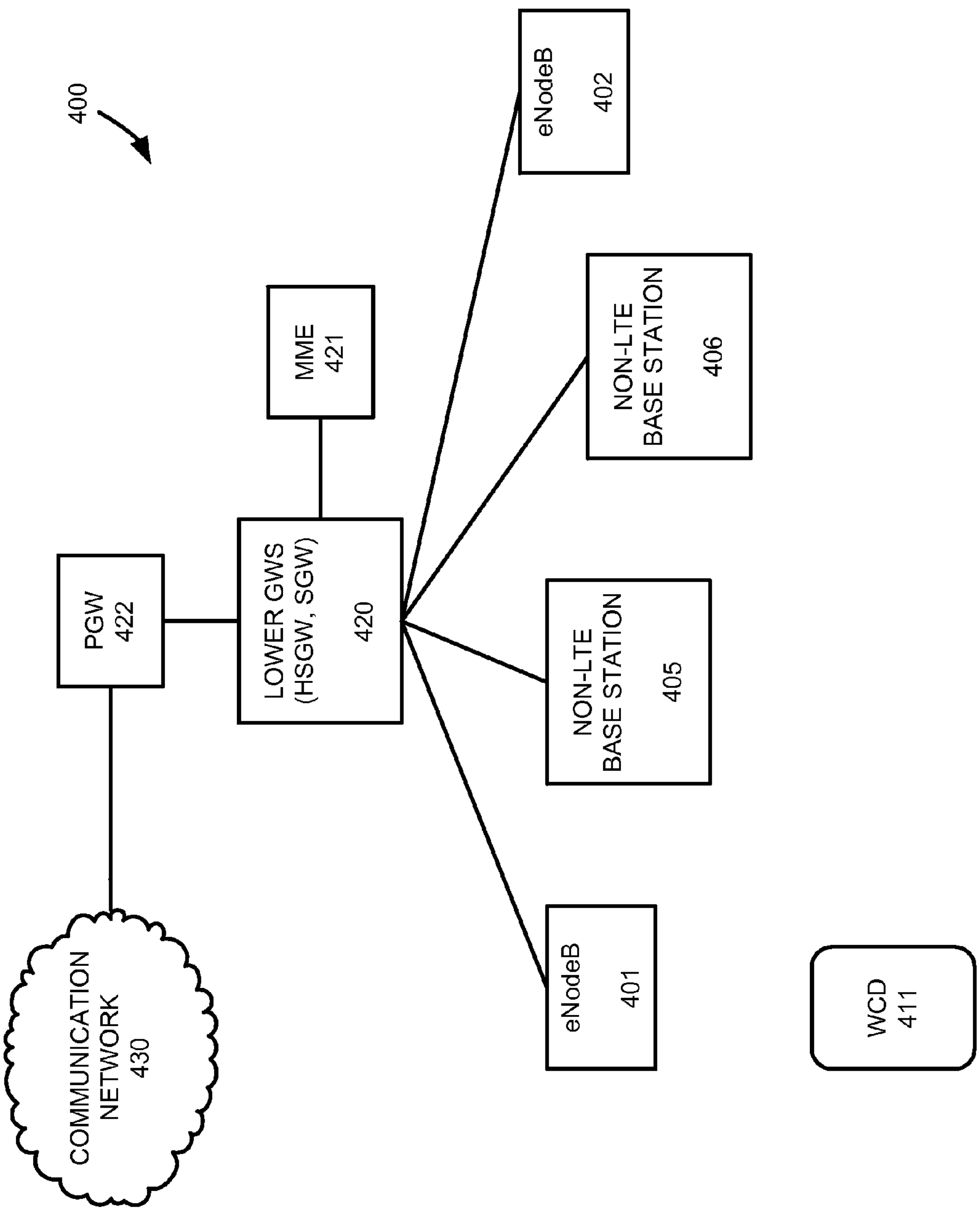

400
eNodeB
402
NON-LTE
BASE STATION
406
MME
421
PGW
422
LOWER GWS
(HSGW, SGW)
420
NON-LTE
BASE STATION
405
eNodeB
401
WCD
411
COMMUNICATION
NETWORK
430

FIGURE 4

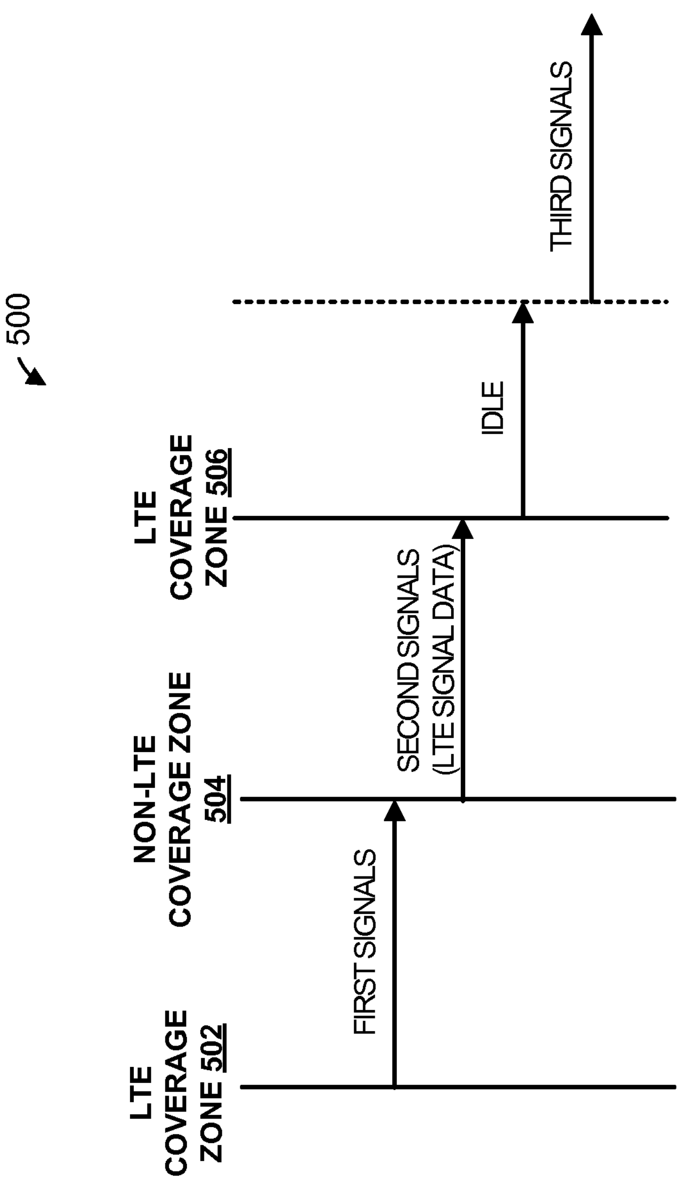

500
LTE COVERAGE ZONE 502
NON-LTE COVERAGE ZONE 504
LTE COVERAGE ZONE 506
FIRST SIGNALS
SECOND SIGNALS (LTE SIGNAL DATA)
IDLE
THIRD SIGNALS

FIGURE 5

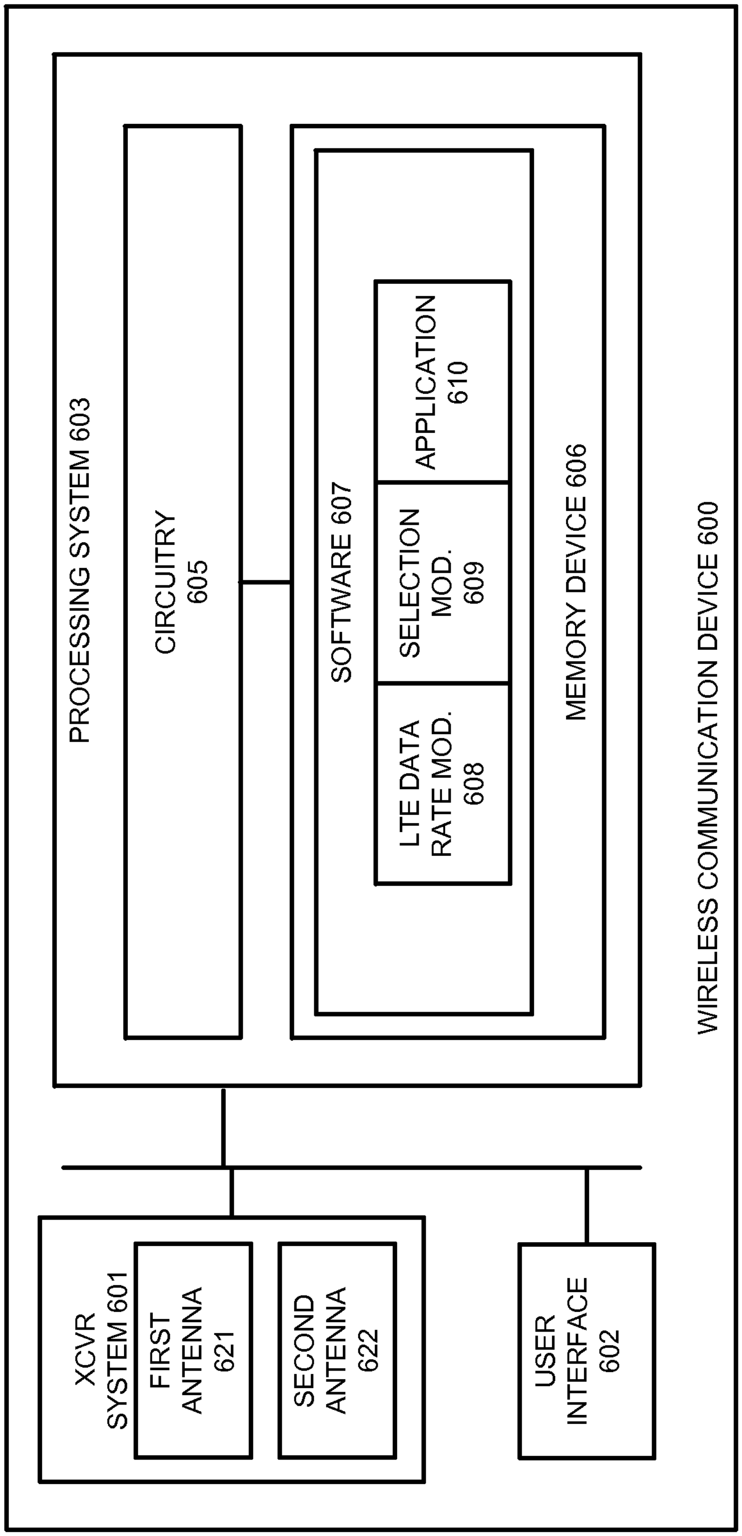

PROCESSING SYSTEM 603
CIRCUITRY 605
SOFTWARE 607
APPLICATION 610
SELECTION MOD. 609
LTE DATA RATE MOD. 608
MEMORY DEVICE 606
WIRELESS COMMUNICATION DEVICE 600
XCVR SYSTEM 601
FIRST ANTENNA 621
SECOND ANTENNA 622
USER INTERFACE 602

FIGURE 6

WIRELESS NETWORK TRANSITION BY A WIRELESS COMMUNICATION DEVICE

TECHNICAL BACKGROUND

Many modern wireless communication devices are capable of switching from a faster data connection, such as Long Term Evolution (LTE), to a slower connection, such as Enhanced Voice-Data Optimized (EVDO). These switches occur seamlessly when a user moves from a location with the faster data connection to a location with the slower data connection. For example, if a user makes a data connection while in an LTE coverage zone, the data connection will seamlessly switch to the slower connection when the user leaves the LTE zone.

The switch to the slower connection is efficient for users. However, there are currently no methods to seamlessly switch back to the faster data connection when the user approaches another faster connection zone. Instead, the device will typically wait for the user to cease communications on the device, and then switch the device back into the faster data connection mode during this down period. This can be extremely inefficient for users as some data connections may last for long periods of time preventing the switch back to the faster data connection.

Overview

Examples disclosed herein provide systems, methods, and software for transitioning between wireless communication networks. In one example, a method of operating a wireless communication device to transition between wireless communication networks includes exchanging first wireless communication signals with a Long Term Evolution (LTE) network for an application in the wireless communication device, and transitioning from exchanging the first wireless communication signals with the LTE network to exchanging second wireless communication signals with at least one non-LTE base station for the application in the wireless communication device, wherein the second wireless communication signals identify LTE network status data. The method further includes processing the LTE network status data to estimate an LTE network data rate, and processing a data requirement of the current application, a current data rate of non-LTE network data, and the LTE network data rate to select an eNodeB sector and frequency carrier on the LTE network. The method also includes transitioning to idle mode and subsequently transitioning from the idle mode to active mode, and exchanging third wireless communication signals with the LTE network for the application using the eNodeB sector and frequency carrier on the LTE network.

In an alternative example, a wireless communication device includes a wireless transceiver system configured to exchange first wireless communication signals with a Long Term Evolution (LTE) network for an application in the wireless communication device, and transition from exchanging the first wireless communication signals with the LTE network to exchanging second wireless communication signals with at least one non-LTE base station for the application in the wireless communication device, wherein the second wireless communication signals identify LTE network status data. The wireless transceiver system is further configured to, based on a selection of an eNodeB sector and frequency carrier on the LTE network, transition to idle mode and subsequently transition from the idle mode to active mode, and, after transitioning from the idle mode to the active mode, exchange third wireless communication signals with the LTE network for the application using the eNodeB sector and frequency carrier on the LTE network. The wireless communication device further includes a processing system configured to process the LTE network status data to estimate an LTE network data rate, and process a data requirement of the current application, a current data rate of non-LTE network data, and the LTE network data rate to select the eNodeB sector and frequency carrier on the LTE network.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a wireless communication system with multiple wireless communication networks.

FIG. **2** illustrates a method of operating a wireless communication device to transition between wireless communication networks.

FIG. **3** illustrates an overview of operating a wireless communication device to transition between wireless communication networks.

FIG. **4** illustrates a wireless communication system with multiple wireless communication networks.

FIG. **5** illustrates a timing diagram for transitioning between wireless communication networks.

FIG. **6** illustrates a wireless communication device capable of wireless communication transitions.

DETAILED DESCRIPTION

The following description and associated figures teach the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects of the best mode may be simplified or omitted. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Thus, those skilled in the art will appreciate variations from the best mode that fall within the scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific examples described below, but only by the claims and their equivalents.

FIG. **1** illustrates a wireless communication system **100** for transitioning between wireless communication networks. Wireless communication system **100** includes communication network **101**, eNodeBs **103-104**, non-LTE base station **105**, and wireless communication device (WCD) **110**. WCD **110** further includes transceiver system **111**, which may comprise multiple antennas or transceivers in some examples, and processing system **113**. Communication network **101** is configured to communicate with eNodeBs **103-104** and non-LTE base station **105** using communication links **121-123**. ENodeBs **103-104** are configured to communicate with WCD **110** using wireless communication links **124-125**, and non-LTE base station **105** is configured to communicate with WCD **110** using communication link **126**.

In operation, WCD **110** is a mobile device that may move in and out of communication network coverage zones. In the present example, eNodeB **103** and eNodeB **104** provide faster Long Term Evolution (LTE) communication to WCD **110**, and non-LTE base station **105** provides another form of wireless communication. These other forms of wireless communication may include evolved High-Rate Packet Data (eHRPD), evolved High-Speed Packet Access (eHSPA), and Wireless Fidelity (WiFi), among other types of non-LTE communication.

When WCD **110** requires a data communication within an LTE coverage zone, the device will typically remain on that network for as long as possible until the signal strength drops below a certain threshold. At that time, device **110** will continue with the communication, but drop into a secondary wireless communication format. Although the second communication format allows the device to continue the communication, the device is typically incapable of returning to the faster network upon return to an LTE coverage zone. As a result, although WCD **110** may require a faster data connection for the communication, the device will remain on the slower connection until the data communication ceases. At that point, WCD **110** will go idle and return in an LTE mode.

In contrast to waiting for the communication to cease before transitioning back to LTE coverage, FIG. **2** is provided to illustrate a method of transferring between communication networks on a wireless communication device, such as WCD **110**. The method includes in a wireless transceiver system, such as transceiver system **111**, exchanging first wireless communication signals with an LTE network for an application (**201**). As depicted in communication system **100**, WCD **110** may communicate with eNodeBs **103-104** in LTE communication format to exchange data for an application on the device. The method further provides, in the wireless transceiver system, transitioning from exchanging the first wireless communication signals with the LTE network to exchanging second wireless communication signals with at least one non-LTE base station for the application (**202**). This transition may occur due to device movement that results in a lower LTE signal strength. For example, WCD **110** may initiate a communication for an application using eNodeB **103**, however, as the device moves father away from eNodeB, the signal strength may diminish or include a variety of noise elements. As a result, WCD **110** may transition to communicating the application data using secondary signals with non-LTE base station **105**.

Although the application data may be communicated with non-LTE base station **105**, WCD **110** may continue to seek LTE coverage with the secondary signals. To accomplish this task, WCD **110** may contain two separate antennas. The first antenna may be used for the data communication on the device between the eNodeBs and the non-LTE base stations. The second antenna, however, may be used to scan for LTE network status data to determine when the device has reentered an LTE coverage zone. This LTE network status data may include LTE signal strength, the number of users on the eNodeB, the amount of noise in the signal, amongst a variety of other network status data.

Based on the LTE network status data, processing system **113** will estimate an LTE network data rate (**203**). Such an estimation could be based on a table stored on WCD **110**, could be based on an algorithm that is executed on WCD **110**, or could be estimated using any other operation. Following the estimation of the LTE network data rate, processing system **113** will process a data requirement for the application, a current data rate of the current non-LTE base station, and the estimated LTE network data rate to select an eNodeB sector and frequency carrier on the LTE network (**204**). In some examples, an application may require a faster data connection, such as a video streaming application. In such instances, the threshold for changing back to the LTE network may be lower to allow a smooth representation to the end user. In other examples, the application may require a lower amount of data to operate, such as a social networking site or a music streaming application. In contrast to video streaming, these applications may not require the switch back to LTE to continue operation, and instead may remain on the non-LTE network. In determining whether the application will transition back to LTE communication format, WCD **110** may employ a table stored on the device, an algorithm configured to execute on the device, or any other operation to determine whether to transition to LTE format.

Based on the selection of an eNodeB sector and frequency carrier, wireless transceiver system **111** may transition into an idle mode and subsequently transition from the idle mode to an active mode (**205**). In some examples, prior to going into the idle mode, WCD **110** may send a message to the non-LTE base station identifying that the device is going to transition back to LTE communication format. This message may identify the eNodeB sector or specific eNodeB, and the frequency carrier for which the device is expecting to return to. Further, the message may also ensure that the IP address that was granted to the device to begin transmission using LTE may be saved at the time the device goes into idle mode to ensure that the device may return to the communication where it left off. In some instances, the source of the application data may also be paused to account for the transceiver idle time on the device, allowing the communication to continue when the device returns to active mode. In other occurrences, a delay may be instituted in the communication to account for the idle time on the device.

Following the transition from the idle mode to the active mode, transceiver system **111** will exchange third wireless communication signals with the LTE network for the application using the eNodeB sector and frequency carrier on the LTE network (**206**). In some examples, WCD **110** may return to the original eNodeB from which the communication began, however, in other situations, WCD **110** may move to an entirely new eNodeB. For example, WCD could initiate a communication using eNodeB **103**, transition to non-LTE base station **105**, and then return to eNodeB **103**. Additionally, WCD **110** could initiate a communication using eNodeB **103**, transition to non-LTE base station **105**, and then move on to eNodeB **104**.

Referring now to FIG. **3**, FIG. **3** illustrates an overview **300** of operating a wireless communication device to transition between communication networks. Overview **300** includes eNodeBs **311-312**, non-LTE base stations **321-322**, LTE communication format **301**, non-LTE communication format **303**, and wireless communication device path **331**.

In operation, a wireless communication device may require a data communication for an application on the device. As illustrated in the present example with wireless communication device path **331**, this communication may be initialized in an LTE coverage zone resulting in the device communicating using LTE communication format. However, as the device progresses along the path **331**, the device may leave LTE coverage and enter non-LTE communication format **303**. Non-LTE communication format **303** may include evolved High-Rate Packet Data (eHRPD), evolved High-Speed Packet Access (eHSPA), and Wireless Fidelity (WiFi), among other types of non-LTE communication. As a result of the transition out of LTE communication format **301**, the device will transition to communicating using non-LTE format **303**. Often, the non-LTE format may be a slower communication protocol than LTE, which may cause lag or other issues with the devices communication. Thus, the communication device, as well as the user of the device, may prefer that the device revert to LTE format at the earliest possible availability.

To accomplish this task, the present example provides that as the communication devise traverses path **331** in non-LTE format zone **303**, the device will exchange signals that indicate LTE network status data. This network status data may include the LTE signal strength, the number of users on the eNodeB, the amount of noise within the signal, amongst other data—including combinations thereof. The device may then use this data to generate an estimate of the LTE network data rate. Upon the determination of an estimated LTE network data rate, the wireless communication device may then process a data requirement for the application, a data rate for the non-LTE communication format, and the estimated LTE network data rate to select an eNodeB sector and frequency carrier for the wireless communication device.

Once the eNodeB sector and frequency carrier are selected, such as when the device enters the range of eNodeB **312**, the device will then enter an idle mode before coming back in an active LTE mode. In some examples, prior to dropping into the idle mode, the device may communicate a message in the non-LTE format indicating the eNodeB sector and frequency that the device expects to connect to. In response to this transmission, the IP address may be saved for the device and the data communication briefly delayed while the device is in the idle state. When the device returns to the active state, the device may resume exchanging third signals on LTE network **303** using the defined eNodeB sector and carrier frequency.

FIG. **4** illustrates a communication system **400** for transitioning between wireless communication networks. Communication system **400** includes eNodeBs **401-402**, non-LTE base stations **405-406**, wireless communication device (WCD) **411**, lower gateways **420**, mobility management entity (MME) **421**, packet data network gateway (PGW) **422**, and communication network **430**. Lower gateways **420** may include HRPD serving gateways (HSGW), serving gateway (SGW), among other possible lower gateways. ENodeBs **401-402** are configured to provide an LTE communication network to one or more wireless communication devices, and non-LTE base stations **405-406** are used to provide a non-LTE wireless communication network. The non-LTE base stations may be used to provide eHRPD, eHSPA, or other similar wireless communication.

In operation, WCD **411** contains applications that may require a wireless data communication. Upon initiation of a data communication, WCD **411** will transmit signals with an eNodeB to provide the communication so long as an eNodeB is available to the device. As soon as WCD **411** moves far enough away from the eNodeBs, LTE may no longer be available and the device may begin communicating using the non-LTE communication format. Often, but not necessarily always, the non-LTE coverage area will be larger than the LTE network coverage area. As a result, the device may often fall back onto the non-LTE format when LTE becomes unavailable.

If a device does fall back on the non-LTE network, or non-LTE base stations **405-406**, the application may prefer to return to LTE as soon as the faster network becomes available. To accomplish the transition from non-LTE communication to LTE communication, WCD **411** will gather LTE network status data while the device communicates the application data. In some examples, to gather the LTE network status data, WCD **411** may contain more than one antenna. A first antenna may be used to communicate the data necessary for the application on the device, but the second antenna may be linked to LTE circuitry that scans for availability data, such as signal strength, signal noise, number of users on the LTE network, among other data. The device may then use this data to determine an estimated LTE data rate, which can then be compared with an ideal data rate for the application and a current data rate for the non-LTE communication network. If the application requires a faster data connection, like a video streaming service, the device may be more willing to revert to LTE communication. In contrast, if the application requires a smaller data rate, then the device may remain on the non-LTE communication network to finish the communication.

Once WCD **411** has determined that it is appropriate to transition the device back to LTE communication, WCD **411** will identify an eNodeB sector and frequency carrier to continue the communication. In some examples, this information may be passed in the form of a message through the current non-LTE base station **405** or **406**, which can then be forwarded to the identified eNodeB to prepare for WCD **411** in an active state. Also based on this message, in some instances, MME **421** may save various settings for WCD **411**. Some of these settings may include the IP address for the device, the current state of the data transmission among other data.

After the eNodeB and the frequency carrier has been determined for WCD **411**, the device may then drop communications into an idle state. This idle state allows the device to change over to LTE circuitry and become active on the LTE communication network. Once active, the device will communicate with the selected eNodeB sector and frequency carrier and resume transmission of the application data.

FIG. **5** illustrates a timing diagram **500** for transitioning a wireless communication device between wireless communication networks. As illustrated in timing diagram **500**, when the wireless communication device is in LTE coverage zone **502** and requires a data communication, the wireless communication device will communicate using first wireless communication signals. These signals will be communicated with an eNodeB and provide the data connection that the application requires.

Upon the wireless communication device leaving an LTE coverage zone, the wireless communication device will transition into a non-LTE coverage zone **504** and continue the data communication using second wireless communication signals. Non-LTE coverage zone **504** may communicate using eHRPD, eHSPA, WIFI or other similar wireless communication format. While communicating using the non-LTE format, the wireless communication device will continue to identify LTE network status data. In some examples, the wireless communication device may include a second antenna in the wireless transceiver system. Thus, as the device is communicating the data necessary for the application using the first antenna, the second antenna may continue to search for LTE network status data. LTE network status data may include signal strength, the number of users on a particular eNodeB, the amount of noise in the signal, among other data—including combinations thereof. Based on this network status data, the wireless communication device may estimate an LTE network data rate for the device. This estimated data rate may then be used in combination with the non-LTE format data rate and the application required data rate to select an eNodeB sector and frequency carrier for the device.

If the application does not require a large amount of data, the device may determine that the communication may be better served by remaining on the non-LTE network. However, if the application requires a large amount of data, such as for a video streaming application, the wireless device may identify the appropriate eNodeB sector and frequency carrier for the device.

Once the sector and frequency carrier have been determined for LTE coverage zone **506**, the wireless communication device may drop into an idle mode before returning to active on the appropriate eNodeB and frequency. Once in the active mode, the device may continue the data communication using third wireless communication signals. In some examples, prior to dropping into the idle state, the wireless communication device may transmit a message to a non-LTE base station indicating the expected eNodeB sector and carrier frequency upon return. The message may then be passed on to the appropriate eNodeB to ensure that the LTE base station expects the transfer of the wireless communication device. Further, the message indicating the switch back to LTE may also be used to delay the data communication for the application on the wireless device. Thus, when the device returns to the active state, the communication may continue from the appropriate point.

FIG. **6** illustrates a wireless communication device **600** capable of transitioning between multiple communication networks. Wireless communication device **600** is an example of wireless communication devices **110** or **411**, although devices **110** and **411** could use alternative configurations. Wireless communication device **600** includes transceiver system **601**, user interface **602**, and processing system **603**. Processing system **603** is linked to transceiver system **601** and user interface **602**. Processing system **603** includes processing circuitry **605** and memory device **606** that stores operating software **607**. Wireless communication device **600** may include other well-known components such as a battery and enclosure that are not shown for clarity. Wireless communication device **600** may be a telephone, computer, e-book, mobile Internet appliance, media player, game console, wireless network interface card, or some other wireless communication apparatus—including combinations thereof.

Transceiver system **601** comprises RF communication circuitry and antennas **621** and **622**. The RF communication circuitry typically includes an amplifier, filter, RF modulator, and signal processing circuitry. Transceiver system **601** may also include a memory device, software, processing circuitry, or some other communication device. Transceiver system **601** uses at least LTE communication protocol, but may further use other protocols, such as CDMA, EVDO, WIMAX, GSM, LTE, WIFI, HSPA, eHSPA, eHRPD, or some other wireless communication format. In the present example, transceiver system **601** includes first antenna **621** and second antenna **622**. In the operation of wireless communication device **600**, an application, such as application **609**, may require a wireless data communication. When in an LTE coverage area, wireless communication device **600** will communicate first signals using LTE communication format. However, when the device leaves the LTE coverage area, device **600** will transition to communicating signals using a non-LTE communication format. In some examples, this communication may use one of antennas **621** or **622** to communicate the application data. At the same time, separate circuitry in transceiver system **601** and the alternative antenna could be used to search for LTE signal data. This signal data may then be processed in processing system **603** to determine if wireless communication device **600** should revert back to LTE communication.

User interface **602** comprises components that interact with a user to receive user inputs and to present media and/or information. User interface **602** may include a speaker, microphone, buttons, lights, display screen, touch screen, touch pad, scroll wheel, communication port, or some other user input/output apparatus—including combinations thereof. User interface **602** may omitted in some examples.

Processing circuitry **605** comprises microprocessor and other circuitry that retrieves and executes operating software **607** from memory device **606**. Memory device **606** comprises a non-transitory storage medium, such as a disk drive, flash drive, data storage circuitry, or some other memory apparatus. Processing circuitry **605** is typically mounted on a circuit board that may also hold memory device **606** and portions of communication interface **601** and user interface **602**. Operating software **607** comprises computer programs, firmware, or some other form of machine-readable processing instructions. Operating software **607** includes LTE data rate module **608**, selection module **609**, and application **610**. Operating software **607** may further include an operating system, utilities, drivers, network interfaces, applications, or some other type of software. When executed by processing circuitry **605**, operating software **607** directs processing system **603** to operate wireless communication device **600** as described herein.

In particular, application **610** or some other application on wireless communication device **606** may require a data connection within an LTE coverage zone. In response to this need, transceiver system **601** will communicate using first LTE signals to accomplish the particular data request. However, due to the movement of wireless communication device **600**, the device may leave the LTE coverage zone and as a result revert to communicating using second signals on a non-LTE communication protocol. These second signals may include the data communication for application **610**, as well as LTE signal data to determine when the device reenters an LTE coverage area. In some examples, one of antennas **621-622** may be used for communicating the data for the application, and the other antenna may be used for determining the LTE signal data.

Based on the gathered LTE signal data, LTE data rate module **608** may process the data to determine an estimated data rate on the LTE network. This estimated data rate may take into account a variety of LTE signal data, such as the strength of the signal, the amount of users using the eNodeB, the amount of noise in the signal, amongst other considerations—including combinations thereof. Once an estimated LTE data rate has been determined, selection module **609** may use that rate to select an eNodeB sector and frequency carrier for the LTE network. In some examples, selection module **609** may further consider the data rate required for the application, as well as the data rate of the non-LTE communication network.

Following the determination of the eNodeB sector and frequency carrier, wireless communication device **600** will drop into an idle communication mode before returning to an active mode on the LTE network. In some instances, prior to dropping into the idle mode that ceases communication with both the non-LTE network and the LTE network, the device will transmit a message to the current non-LTE base station identifying the eNodeB sector and frequency that device **600** will expect when it returns from the idle state. The non-LTE base station may then ensure that the device IP address and other information are briefly preserved such that when the device resumes communication using third signals on the LTE network, the communication can resume where it left off.

Returning to FIG. **1**, communication network **101** comprises network elements that provide communications services to wireless device **110** through eNodeBs **103-104** and non-LTE base station **105**. Communication network **101** may comprise switches, wireless access nodes, Internet routers, network gateways, application servers, computer systems, communication links, or some other type of communication equipment—including combinations thereof.

ENodeBs **103-104** each comprise RF communication circuitry and an antenna. The RF communication circuitry typically includes an amplifier, filter, RF modulator, and signal processing circuitry. ENodeBs **103-104** may also comprise a router, server, memory device, software, processing circuitry, cabling, power supply, network communication interface, structural support, or some other communication apparatus. Though shown as directly connected to communication network **101**, eNodeBs **103-104** may communicate with communication network **101** through other networks and systems, such as the Internet.

Non-LTE base station **105** comprises RF communication circuitry and an antenna. The RF communication circuitry typically includes an amplifier, filter, RF modulator, and signal processing circuitry. Non-LTE base station **105** may also comprise a router, server, memory device, software, processing circuitry, cabling, power supply, network communication interface, structural support, or some other communication apparatus. Although eNodeBs **103-104** and non-LTE base station **105** include similar components, non-LTE base station **105** typically, but not necessarily, services a larger wireless coverage area than the eNodeBs.

WCD **110** comprises Radio Frequency (RF) communication circuitry and at least one antenna. The RF communication circuitry typically includes an amplifier, filter, modulator, and signal processing circuitry. WCD **110** may also include a user interface, memory device, software, processing systems **113**, or some other communication components. WCD **110** may be a telephone, computer, e-book, mobile Internet appliance, wireless network interface card, media player, game console, or some other wireless communication apparatus—including combinations thereof. In some examples, transceiver system **111** includes multiple antennas for data communication and identifying LTE network status data.

Wireless communication links **124-125** include wireless links that use the air or space as transport media, and communicate with WCD **110** using LTE format. Wireless communication link **126** can communicate with WCD **110** using air or space as the transport media. Wireless link **126** may use various protocols, such as Code Division Multiple Access (CDMA), Evolution Data Only (EVDO), Worldwide Interoperability for Microwave Access (WIMAX), Global System for Mobile Communication (GSM), Long Term Evolution (LTE), Wireless Fidelity (WIFI), High Speed Packet Access (HSPA), evolved High-Speed Packet Access (eHSPA), evolved High-Rate Packet Data (eHRPD), or some other wireless communication format.

Communication links **121-123** could use various communication protocols, such as Time Division Multiplex (TDM), Internet Protocol (IP), Ethernet, communication signaling, CDMA, EVDO, WIMAX, GSM, LTE, WIFI, HSPA, or some other communication format—including combinations thereof. Communication links **121-123** could be direct links or may include intermediate networks, systems, or devices.

The above description and associated figures teach the best mode of the invention. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Those skilled in the art will appreciate that the features described above can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific embodiments described above, but only by the following claims and their equivalents.

What is claimed is:

1. A method of operating a wireless communication device to transition between wireless communication networks comprising:

in a wireless transceiver system, exchanging first wireless communication signals with a Long Term Evolution (LTE) network for an application in the wireless communication device;

in the wireless transceiver system, transitioning from exchanging the first wireless communication signals with the LTE network to exchanging second wireless communication signals with at least one non-LTE base station associated with a non-LTE network for the application in the wireless communication device, wherein the second wireless communication signals identify LTE network status data;

in a processing system, processing the LTE network status data to estimate an LTE network data rate;

determining whether the LTE network is preferable over the non-LTE network based on a data requirement of the application, a current data rate of non-LTE network data, and the LTE network data rate;

in the processing system, if the LTE network is preferable over the non-LTE network, processing the data requirement of the application, the current data rate of non-LTE network data, and the LTE network data rate to select an eNodeB sector and frequency carrier on the LTE network;

in the wireless transceiver system and after selecting the eNodeB sector and frequency carrier, transmitting a notification message to the non-LTE network indicating a transition from the non-LTE network to the LTE network, wherein the notification message comprises an instruction to preserve an internet protocol (IP) address for the wireless communication device;

in the wireless transceiver system and after transmitting the message, transitioning to idle mode and subsequently transitioning from the idle mode to active mode;

in the wireless transceiver system and after transitioning from the idle mode to the active mode, exchanging third wireless communication signals with the LTE network for the application using the eNodeB sector and frequency carrier on the LTE network.

2. The method of claim **1** wherein the message indicates the eNodeB and the frequency carrier.

3. The method of claim **1** wherein the at least one non-LTE base station communicates using evolved High-Rate Packet Data (eHRPD).

4. The method of claim **1** wherein the at least one non-LTE base station communicates using evolved High-Speed Packet Access (eHSPA).

5. The method of claim **1** wherein the at least one non-LTE base station communicates using Wireless Fidelity (WiFi).

6. The method of claim **1** wherein the LTE network status data comprises at least a number of users and signal strength.

7. The method of claim **6** wherein the LTE network status data further comprises signal noise.

8. The method of claim **1** wherein the LTE network status data is obtained using a secondary LTE antenna.

9. The method of claim **1** wherein the secondary wireless communication signals comprise signals for the application in the wireless communication device and signals that identify the LTE network status data.

10. The method of claim **1** wherein the first wireless communication signals are communicated with a first eNodeB and the third wireless communication signals are communicated with a second eNodeB.

11. A wireless communication device comprising:

a wireless transceiver system configured to:

exchange first wireless communication signals with a Long Term Evolution (LTE) network for an application in the wireless communication device;

transition from exchanging the first wireless communication signals with the LTE network to exchanging second wireless communication signals with at least one non-LTE base station associated with a non-LTE network for the application in the wireless communication device, wherein the second wireless communication signals identify LTE network status data;

in response to selecting the eNodeB sector and frequency carrier, transmitting a notification message to the non-LTE network indicating a transition from the non-LTE network to the LTE network, wherein the notification message comprises an instruction to preserve the (IP) address for the wireless communication device;

after transmitting the message, transition to idle mode and subsequently transition from the idle mode to active mode; and

after transitioning from the idle mode to the active mode, exchange third wireless communication signals with the LTE network for the application using the eNodeB sector and frequency carrier on the LTE network; and

a processing system configured to:

process the LTE network status data to estimate an LTE network data rate;

determine whether the LTE network is preferable over the non-LTE network based on a data requirement of the application, a current data rate of non-LTE network data, and the LTE network data rate; and

if the LTE network is preferable over the non-LTE network, process the data requirement of the application, the current data rate of non-LTE network data, and the LTE network data rate to select the eNodeB sector and frequency carrier on the LTE network.

12. The wireless communication device of claim **11** wherein the message indicates the eNodeB and the frequency carrier.

13. The wireless communication device of claim **11** wherein the at least one non-LTE base station communicates using evolved High-Rate Packet Data (eHRPD).

14. The wireless communication device of claim **11** wherein the at least one non-LTE base station communicates using evolved High-Speed Packet Access (eHSPA).

15. The wireless communication device of claim **11** wherein the at least one non-LTE base station communicates using Wireless Fidelity (WiFi).

16. The wireless communication device of claim **11** wherein the LTE network status data comprises at least a number of users and signal strength.

17. The wireless communication device of claim **16** wherein the LTE network status data further comprises signal noise.

18. The wireless communication device of claim **11** wherein the LTE network status data is obtained using a secondary LTE antenna.

19. The wireless communication device of claim **11** wherein the secondary wireless communication signals comprise signals for the application in the wireless communication device and signals that identify the LTE network status data.

20. The wireless communication device of claim **11** wherein the first wireless communication signals are communicated with a first eNodeB and the third wireless communication signals are communicated with a second eNodeB.

* * * * *