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(54) Title: PRIORITY BASED RESELECTION RULES FOR HANDLING NON-AUTHORIZED CELLS

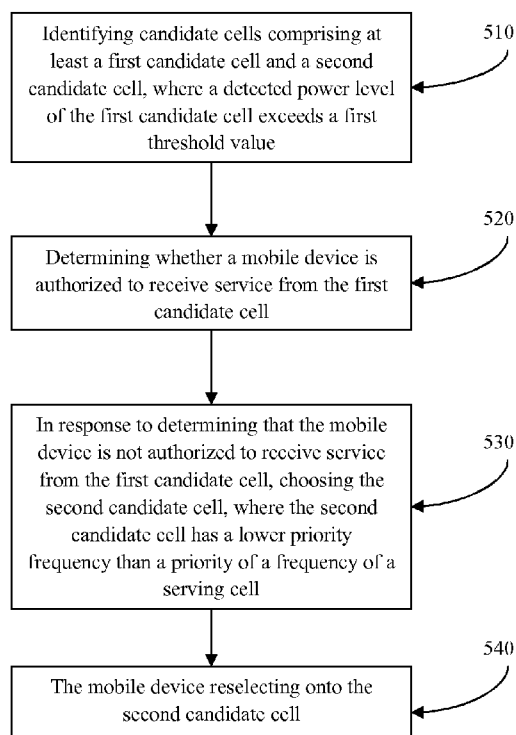


Figure 5

(57) Abstract: A method for providing cell re-selection rules for handling non-authorized cells is described. The method includes identifying candidate cells including a first candidate cell and a second candidate cell. The method also includes determining whether a detected power level of the first candidate cell exceeds a first threshold value. Determining whether the priority of a frequency of the second candidate cell is lower than a priority of a frequency of a serving cell is included. Determining whether the mobile device is authorized to receive service from the first candidate cell in response to determining that the detected power level of the first candidate cell exceeds the first threshold value and that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the method. The method also includes, choosing the second candidate cell in response to determining that the mobile device is not authorized to receive service from the first candidate cell. Reselecting the mobile device to the second candidate cell is included. Apparatus and computer readable media are also disclosed.



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PRIORITY BASED RESELECTION RULES FOR HANDLING NON-AUTHORIZED CELLS

TECHNICAL FIELD:

5 The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, relate to providing cell reselection rules for handling non-authorized cells.

BACKGROUND:

10 This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

The following abbreviations that may be found in the specification and/or the drawing figures are defined as follows:

20	3GPP	third generation partnership project
	CSG	closed subscriber group
	DL	downlink (eNB towards UE)
	eNB	EUTRAN Node B (evolved Node B)
	EPC	evolved packet core
25	E-UTRAN	evolved UTRAN (LTE)
	FDMA	frequency division multiple access
	IFRI	intra-frequency cell reselection indicator
	LTE	long term evolution
	MAC	medium access control
30	MM/MME	mobility management/mobility management entity
	Node B	base station
	OFDMA	orthogonal frequency division multiple access
	O&M	operations and maintenance

	PDCP	packet data convergence protocol
	PHY	physical
	RAT	radio access technology
	RLC	radio link control
5	RRC	radio resource control
	S-GW	serving gateway
	SC-FDMA	single carrier, frequency division multiple access
	UE	user equipment
	UL	uplink (UE towards eNB)
10	UTRAN	universal terrestrial radio access network

A communication system known as evolved UTRAN (E-UTRAN, also referred to as UTRAN-LTE or as E-UTRA) is currently under development within the 3GPP. As presently specified the DL access technique will be OFDMA, and the UL access
 15 technique will be SC-FDMA.

One specification of interest is 3GPP TS 36.300, V8.6.0 (2008-09), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial
 20 Access Network (E-UTRAN); Overall description; Stage 2 (Release 8), incorporated by reference herein in its entirety.

Figure 1 reproduces Figure 4.1 of 3GPP TS 36.300, and shows the overall architecture of the E-UTRAN system. The EUTRAN system includes eNBs, providing
 25 the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other by means of an X2 interface. The eNBs are also connected by means of an S1 interface to an EPC, more specifically to a MME (Mobility Management Entity) by means of a S1 MME interface and to a Serving Gateway (SGW) by means of a S1 interface. The S1
 30 interface supports a many to many relationship between MMEs/Serving Gateways and eNBs.

The eNB hosts the following functions:

- functions for Radio Resource Management: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs in both uplink and downlink (scheduling);
- IP header compression and encryption of the user data stream;
- 5 • selection of a MME at UE attachment;
- routing of User Plane data towards the Serving Gateway;
- scheduling and transmission of paging messages (originated from the MME);
- scheduling and transmission of broadcast information (originated from the MME or O&M); and
- 10 • a measurement and measurement reporting configuration for mobility and scheduling.

In general, a registered owner of a Home eNB or a CSG cell may add subscribers to its user group, and it is those members of the user group that are allowed access to the CSG cell. One or more home eNBs or CSG cells can be linked to form more than one CSG cell contiguous with one another, which may be referred to as a CSG network.

A CSG network is a network composed of one or more cells with access permissions managed by final consumers, the network provider and/or the network operator. Those subscribers registered as members of the user group are CSG members. Once a CSG member is a wireless service (cellular) user is registered to the CSG network by the CSG administrator, the CSG member is allowed to access the CSG network. Those users or devices not registered to the CSG are not allowed access to it, hence the term closed subscriber group.

25 In CSG networks, only the devices (user equipment or UEs) that have been granted permission to access the CSG network may camp or connect to that network. Examples of CSG cells include a Home eNB (LTE cells that are purchased by the consumer), corporate cells (cells that are hired or owned by a company), and "commercial" cells (cells that are owned by retailing companies, supermarkets, etc). It is the responsibility of the CSG administrator to register a user as a CSG member. While the CSG network can control and modify the subscribers that form its user group quickly, access is restricted to registered subscribers and closed to other users.

Mobility of the user group members between the CSG network and other cells that are 'open' (non-CSG cells, whether they be E-UTRAN, UTRAN, GERAN, or others) is possible.

The concept of the CSG networks may be considered useful in the context of, for example, a corporate or university campus, or a retail establishment. The corporation or university allows its employees/students free or low cost access to the CSG by enrolling them into the appropriate user group while restricting others from accessing the service.

Further reference may be made to U.S. Provisional Patent Application No. 61/197,987.

E-UTRAN Idle mode specification 36.304 V 8.3.0 (2008-09), provides intra-frequency, inter-frequency and inter-RAT reselection rules. Inter-frequency and inter-RAT cell reselection rules use priority based reselection. For example, section 5.2.4.5 (E-UTRAN Inter-frequency and inter-RAT Cell Reselection criteria) provides a first criteria that a cell selection RX level (or signal level) value of an evaluated cell on an evaluated frequency is greater than a first threshold value for a specific time interval.

Section 5.2.4.5 provides:

Criteria 1 is: the $S_{\text{nonServingCell},x}$ of a cell on evaluated frequency is greater than $\text{Thresh}_{x, \text{high}}$ during a time interval $T_{\text{reselectionRAT}}$.

Cell reselection to a cell on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- A cell of a higher priority E-UTRAN frequency or inter-RAT frequency fulfills criteria 1; and
- more than one second has elapsed since the UE camped on the current serving cell.

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on serving frequency or on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority

E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and

- more than one second has elapsed since the UE camped on the current serving cell.

- 5 $S_{\text{ServingCell}}$ is the cell selection RX level value of the serving cell and $S_{\text{nonServingCell},x}$ is the cell selection RX level value of a non-serving cell. $\text{Thresh}_{\text{serv}, \text{low}}$ and $\text{Thresh}_{x, \text{low}}$ are threshold values.

- Under section 5.2.4.5, cell reselection of the UE to a new cell on a higher priority
10 E-UTRAN frequency or inter-RAT frequency than the serving frequency shall be performed if the new cell fulfills the first criteria and more than one second has elapsed since the UE camped on the current serving cell.

- Cell reselection of the UE to a new cell on a lower priority E-UTRAN frequency or inter-RAT frequency than the serving frequency shall be performed if no cells on the
15 serving frequency or on a higher priority E-UTRAN frequency or inter-RAT frequency than the serving frequency fulfills the first criteria; and the cell selection RX level value of the serving cell is less than a second threshold (e.g., $\text{Thresh}_{\text{serv}, \text{low}}$) value and the cell selection RX level value of the lower priority E-UTRAN frequency or inter-RAT frequency is greater than a third threshold value (e.g., $\text{Thresh}_{x, \text{low}}$) for the specific time
20 interval (e.g., $\text{Treselection}_{\text{RAT}}$), and more than one second has elapsed since the UE camped on the current serving cell

Cell reselection to a cell on an equal priority E-UTRAN frequency is based on ranking, such as used for intra-frequency cell reselection (see section 5.2.4.6 in 3GPP TS 36.304).

- 25 The value of the specific time interval may be scaled when the UE is in a medium or high mobility state. If more than one cell meets the above criteria, the UE shall reselect a cell ranked as the best cell among the cells satisfying the criteria on the highest priority RAT or the highest priority frequency.

- 30 In E-UTRAN the intra-frequency cell reselection indicator (IFRI) is not available for CSG cells. Therefore, if the UE is in a CSG co-channel deployment scenario (e.g., CSG and macro cells are located on same carrier frequency) and ranks a CSG cell as the highest cell, the UE shall attempt to reselect to this cell. However, if the UE does

not have access rights to the CSG cell (e.g., the CSG identity is not in the list of allowed CSG cells or identities), the UE may not be able to obtain normal service from the CSG cell (e.g., when normal camping on suitable cell is not possible). The UE should, if possible, reselect to another cell where normal service is possible, i.e. the UE is not allowed to camp on a CSG cell if the CSG identity is not in the UE's list of allowed CSG's and another cell is available for camping.

E-UTRAN Idle mode specification 36.304 V 8.3.0 (2008-09), does not properly address UE behavior when the UE determines (or ranks) a non-accessible CSG (or other non-suitable cell) as the highest or best ranked candidate for intra-frequency cell reselection. A problem arises when the UE is camped on the highest (available) priority frequency layer or RAT and would need to reselect to a lower priority frequency layer or RAT due to the highest or best ranked cell is a non-allowed CSG cell or otherwise non-suitable cell. However, due to the first criteria, this may not be possible as there may still be one or more cells on the current frequency fulfilling the first criteria even though these cells may not be the highest ranked cell. Therefore the UE would not currently be allowed to reselect to another cell on a lower priority frequency layer or RAT.

When the highest ranked cell on the currently camped frequency layer is a non-accessible CSG cell, the UE may attempt to perform reselection away from the frequency or RAT (e.g., perform either inter-frequency or inter-RAT cell reselection). However, with the described rules this is not possible and the UE would get stuck in its current frequency or RAT layer on a non-suitable cell.

The described problem is not limited to CSG use. Similar problem exist for normal macro cell scenario if the cell is non-suitable and when the IFRI is set to 'not allowed'. If the cell is not suitable, e.g., due to being barred, and the IFRI is set to 'not allowed' a similar problem as described using the CSG scenario above will occur.

SUMMARY

The below summary section is intended to be merely exemplary and non-limiting.

The foregoing and other problems are overcome, and other advantages are realized,

by the use of the exemplary embodiments of this invention.

In a first aspect thereof an exemplary embodiment of this invention provides a method for providing cell reselection rules for handling non-authorized cells. The method includes identifying candidate cells including at least a first candidate cell and a second candidate cell. The method also includes determining whether a detected power level of the first candidate cell (e.g., $S_{\text{nonServingCell},x}$) exceeds a first threshold value (e.g., $\text{Thresh}_{x, \text{high}}$). Determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the method. Determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the method. The method also includes, choosing the second candidate cell in response to determining that the mobile device is not authorized to receive service from the first candidate cell. Reselecting the mobile device to the second candidate cell is included in the method.

In another aspect thereof an exemplary embodiment of this invention provides a computer readable medium tangibly embodied with instruction for providing cell reselection rules for handling non-authorized cells. The instructions include identifying candidate cells including at least a first candidate cell and a second candidate cell. The instructions also include determining whether a detected power level of the first candidate cell exceeds a first threshold value. Determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the instructions. Determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the instructions. The instructions also include choosing the second candidate cell in response to determining that the mobile device is not authorized to receive service from the first candidate cell. Reselecting the mobile device to the second candidate cell is included in the instructions.

In a further aspect thereof an exemplary embodiment of this invention provides an apparatus for providing cell reselection rules for handling non-authorized cells. The apparatus includes at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to perform actions. The actions include identifying candidate cells including at least a first candidate cell and a second candidate cell. The actions also include determining whether a detected power level of the first candidate cell exceeds a first threshold value. Determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the actions. Determining whether the apparatus is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the actions. The actions also include choosing the second candidate cell in response to determining that the apparatus is not authorized to receive service from the first candidate cell. Reselecting the apparatus to the second candidate cell is included in the actions.

In another aspect thereof an exemplary embodiment of this invention provides an apparatus for providing cell reselection rules for handling non-authorized cells. The apparatus includes means for identifying candidate cells including at least a first candidate cell and a second candidate cell. The apparatus also includes means for determining whether a detected power level of the first candidate cell exceeds a first threshold value. Means for determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the apparatus. The apparatus also includes means for determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell. Means for choosing the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell is included in the apparatus. The apparatus also includes means for reselecting the mobile

device onto the second candidate cell.

BRIEF DESCRIPTION OF THE DRAWINGS

In the attached Drawing Figures:

5 Figure 1 reproduces Figure 4 of 3GPP TS 36.300, and shows the overall architecture of the E-UTRAN system.

Figure 2 shows a simplified block diagram of various exemplary electronic devices that are suitable for use in practicing the exemplary embodiments of this invention.

Figure 3 shows a more particularized block diagram of an exemplary user
10 equipment such as that shown at Figure 2.

Figure 4 illustrates an exemplary wireless system suitable for use in practicing the exemplary embodiments of this invention.

Figure 5 is a logic flow diagram that illustrates the operation of a method, and a result of execution of computer program instructions embodied on a computer readable
15 memory, in accordance with the exemplary embodiments of this invention.

DETAILED DESCRIPTION

Exemplary embodiments in accordance with this invention provide priority based inter-frequency and inter-RAT reselection rules to allow for an UE to reselect to a
20 lower priority frequency layer or RAT when the highest ranked cell on the current frequency layer is not acceptable and a cell on a higher priority based frequency layer or RAT is not available. A candidate cell may be not acceptable (or otherwise non-suitable) due to any number of circumstances (e.g., the UE is not allowed access to the CSG, the UE is denied access to camp on the cell due to the IFRI being set to 'not-
25 allowed', etc.).

Before describing in further detail the exemplary embodiments of this invention, reference is made to Figure 2 for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practicing the exemplary
30 embodiments of this invention.

In the wireless system 230 of Figure 2, a wireless network 235 is adapted for communication over a wireless link 232 with an apparatus, such as a mobile communication device which may be referred to as a UE 210, via a network access

node, such as a Node B (base station), and more specifically an eNB 220. The network 235 may include a network control element (NCE) 240 that may include the MME/SGW functionality shown in Figure 1, and which provides connectivity with a network, such as a telephone network and/or a data communications network (e.g., the internet 238).

The UE 210 includes a controller, such as a computer or a data processor (DP) 214, a computer-readable memory medium embodied as a memory (MEM) 216 that stores a program of computer instructions (PROG) 218, and a suitable wireless interface, such as radio frequency (RF) transceiver 212 for bidirectional wireless communications with the eNB 220 via one or more antennas.

The eNB 220 also includes a controller, such as a computer or a data processor (DP) 224, a computer-readable memory medium embodied as a memory (MEM) 226 that stores a program of computer instructions (PROG) 228, and a suitable wireless interface, such as RF transceiver 222 for communication with the UE 210 via one or more antennas. The eNB 220 is coupled via a data/control path 234 to the NCE 240. The path 234 may be implemented as the S1 interface shown in Figure 1. The eNB 220 may also be coupled to another eNB via data/control path 236, which may be implemented as the X2 interface shown in Figure 1.

The NCE 240 includes a controller, such as a computer or a data processor (DP) 244, a computer-readable memory medium embodied as a memory (MEM) 246 that stores a program of computer instructions (PROG) 248.

At least one of the PROGs 218, 228 and 248 is assumed to include program instructions that, when executed by the associated DP, enable the device to operate in accordance with the exemplary embodiments of this invention, as will be discussed below in greater detail.

That is, the exemplary embodiments of this invention may be implemented at least in part by computer software executable by the DP 214 of the UE 210; by the DP 224 of the eNB 220; and/or by the DP 244 of the eNB 240, or by hardware, or by a combination of software and hardware (and firmware).

The UE 210 and the eNB 220 may also include dedicated processors, for example cell reselection processor 215 and access control processor 225.

In general, the various embodiments of the UE 210 can include, but are not limited to, cellular telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

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The computer readable MEMs 216, 226 and 246 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The DPs 214, 224 and 244 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multicore processor architecture, as non-limiting examples. The wireless interfaces (e.g., RF transceivers 212 and 222) may be of any type suitable to the local technical environment and may be implemented using any suitable communication technology such as individual transmitters, receivers, transceivers or a combination of such components.

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Figure 3 illustrates further detail of an exemplary UE in both plan view (left) and sectional view (right), and the invention may be embodied in one or some combination of those more function-specific components. At Figure 3 the UE 210 has a graphical display interface 320 and a user interface 322 illustrated as a keypad but understood as also encompassing touch-screen technology at the graphical display interface 320 and voice-recognition technology received at the microphone 324. A power actuator 326 controls the device being turned on and off by the user. The exemplary UE 210 may have a camera 328 which is shown as being forward facing (e.g., for video calls) but may alternatively or additionally be rearward facing (e.g., for capturing images and video for local storage). The camera 328 is controlled by a shutter actuator 330 and

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optionally by a zoom actuator 332 which may alternatively function as a volume adjustment for the speaker(s) 334 when the camera 328 is not in an active mode.

Within the sectional view of Fig. 3 are seen multiple transmit/receive antennas 336
5 that are typically used for cellular communication. The antennas 336 may be multi-band for use with other radios in the UE. The operable ground plane for the antennas 336 is shown by shading as spanning the entire space enclosed by the UE housing though in some embodiments the ground plane may be limited to a smaller area, such as disposed on a printed wiring board on which the power chip 338 is formed. The
10 power chip 338 controls power amplification on the channels being transmitted and/or across the antennas that transmit simultaneously where spatial diversity is used, and amplifies the received signals. The power chip 338 outputs the amplified received signal to the radio-frequency (RF) chip 340 which demodulates and downconverts the signal for baseband processing. The baseband (BB) chip 342 detects the signal which is
15 then converted to a bit-stream and finally decoded. Similar processing occurs in reverse for signals generated in the apparatus 210 and transmitted from it.

Signals to and from the camera 328 pass through an image/video processor 344 which encodes and decodes the various image frames. A separate audio processor 346
20 may also be present controlling signals to and from the speakers 334 and the microphone 324. The graphical display interface 320 is refreshed from a frame memory 348 as controlled by a user interface chip 350 which may process signals to and from the display interface 320 and/or additionally process user inputs from the keypad 322 and elsewhere.

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Certain embodiments of the UE 210 may also include one or more secondary radios such as a wireless local area network radio WLAN 337 and a Bluetooth® radio 339, which may incorporate an antenna on-chip or be coupled to an off-chip antenna. Throughout the apparatus are various memories such as random access memory RAM
30 343, read only memory ROM 345, and in some embodiments removable memory such as the illustrated memory card 347. The various programs 218 are stored in one or more of these memories. All of these components within the UE 210 are normally powered by a portable power supply such as a battery 349.

Processors 338, 340, 342, 344, 346, 350, if embodied as separate entities in a UE 210 or eNB 220, may operate in a slave relationship to the main processor 214, 224, which may then be in a master relationship to them. Embodiments of this invention are most relevant to the cell reselection processor 215, though it is noted that other embodiments need not be disposed there but may be disposed across various chips and memories as shown or disposed within another processor that combines some of the functions described above for Figure 3. Any or all of these various processors of Fig. 3 access one or more of the various memories, which may be on-chip with the processor or separate therefrom. Similar function-specific components that are directed toward communications over a network broader than a piconet (e.g., components 336, 338, 340, 342-345 and 347) may also be disposed in exemplary embodiments of the access node 220, which may have an array of tower-mounted antennas rather than the two shown at Fig. 3.

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Note that the various chips (e.g., 338, 340, 342, etc.) that were described above may be combined into a fewer number than described and, in a most compact case, may all be embodied physically within a single chip.

20 An exemplary embodiment in accordance with this invention provides a priority based inter-frequency and inter-RAT reselection rule to allow for an UE to reselect to a lower priority frequency layer or RAT when the highest ranked cell on the current frequency layer is not acceptable, or otherwise not suitable, and a cell on a higher priority based frequency layer or RAT is not available.

25 Cell reselection of the UE to a candidate cell on a lower priority E-UTRAN frequency or inter-RAT frequency than the serving frequency may be performed if a) the cell selection RX level value of the serving cell is less than a threshold value and the cell selection RX level value of a cell on the lower priority E-UTRAN frequency or inter-RAT frequency is greater than the second threshold value for a specific time interval, b) more than one second has elapsed since the UE camped on the current serving cell and c) at least one of: 1) no cell on the serving frequency or on a higher priority E-UTRAN frequency or inter-RAT frequency than the serving frequency has a cell selection RX level value that is greater than a first threshold value for a specific

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time interval., 2) the highest ranked cell on the serving frequency is a CSG cell which is not included on a whitelist for the UE (e.g., the CSG cell is non-available or non-allowed to the UE) or 3) the highest ranked cell on the serving frequency is indicated as not suitable or not available to the UE and the intra-frequency cell reselection indicator (IFRI) is set to 'not-allowed' (e.g., a 'intraFrequencyReselection' in the 'cellAccessRelatedInformation' of the 'SystemInformationBlockType1' set to 'not allowed').

For example, if a first cell is ranked as the highest/best cell and the IFRI is set to 'not-allowed', the UE is normally restricted to reselecting to the first cell. However, if the first cell is a CSG cell which is not included on a whitelist (e.g., a list of authorized cells) for the UE, the UE may not receive access to the CSG cell (thus, the first cell is not suitable/not available). Therefore, under an exemplary embodiment in accordance with this invention, the UE may reselect to a second cell which is a lower ranked cell than the first cell even though the IFRI is set to 'not-allowed'.

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The inter-frequency and inter-RAT reselection rule of the exemplary embodiment provides clear instructions for priority based reselection and help avoid situations where the UE may otherwise get stuck on a non-suitable cell.

20 In an exemplary embodiment in accordance with this invention, the rule from section 5.2.4.5 of 3GPP TS 36.304 v8.3.0 could be rewritten as:

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on serving frequency or on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; or

- *Highest ranked cell on the serving frequency is a CSG cell not part of the UEs whitelist; or*

- *Highest ranked cell on the serving frequency is not suitable and has the intraFrequencyReselection in the cellAccessRelatedInformation in the SystemInformationBlockType1 set to "not allowed"; or*

- $S_{\text{ServingCell}} < \text{Thresh}_{\text{serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $T_{\text{reselectionRAT}}$; and

- more than one second has elapsed since the UE camped on the current serving cell.

In another exemplary embodiment in accordance with this invention, the rule from
5 section 5.2.4.5 of 3GPP TS 36.304 v8.3.0 could be rewritten as:

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than serving frequency shall be performed if:

- No cell on serving frequency or on a higher priority E-UTRAN frequency or inter-RAT frequency than serving frequency fulfills the criteria 1; and
- 10 - $S_{\text{ServingCell}} < \text{Thresh}_{\text{Serving, low}}$ and the $S_{\text{nonServingCell},x}$ of a cell of a lower priority E-UTRAN frequency or inter-RAT frequency is greater than $\text{Thresh}_{x, \text{low}}$ during a time interval $\text{Treselection}_{\text{RAT}}$; and
- more than one second has elapsed since the UE camped on the current serving cell.

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Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than the serving frequency shall also be performed if the highest ranked cell on the serving frequency is a CSG cell which is not part of the whitelist for the UE or if the highest ranked cell on the serving frequency is not suitable and has the
20 *intraFrequencyReselection* in the *cellAccessRelatedInformation* in the *SystemInformationBlockType1* set to "not allowed".

In a further exemplary embodiment of the two examples above, the IFRI parameter may be used for the CSG cell (e.g., explicitly indicated via signaling or statement in the
25 specification or implicitly by agreement). This could be implemented with changes to above exemplary embodiments:

- *Highest ranked cell on the serving frequency is a CSG cell not part of the UE's whitelist and has the *intraFrequencyReselection* in the *cellAccessRelatedInformation* in the *SystemInformationBlockType1* set to "not allowed";*
- 30

Cell reselection to a cell on a lower priority E-UTRAN frequency or inter-RAT frequency than the frequency of the serving cell shall also be performed if a) the highest ranked cell on the serving frequency is a CSG cell not part of the UEs whitelist

and has the *intraFrequencyReselection* in the *cellAccessRelatedInformation* in the *SystemInformationBlockType1* set to "not allowed" or b) the highest ranked cell on the serving frequency is not suitable and has the *intraFrequencyReselection* in the *cellAccessRelatedInformation* in the *SystemInformationBlockType1* set to "not allowed".

Figure 4 illustrates an exemplary wireless system 230 suitable for use in practicing exemplary embodiments in accordance with this invention. As shown, eNB 220 is associated with cell 425. Likewise, access node 430 is associated with cell 435 and access node 440 is associated with cell 445. These individual cells may overlap physically. Additionally, the access nodes may be based on different radio access technologies (RAT) and, thus, may provide different services or levels of services. The UE 210 is shown as located within both cells 435 and 445.

The associated RATs of cells 425, 435 and 445 may be prioritized such that the UE 210 may use a set of rules when determining which RAT to select/reselect based on the priority of the available RATs. The priorities may be signaled to the UE 210 by a serving node, or otherwise communicated to the UE 210.

The UE 210 may be allowed preferential access to certain cells (e.g., be subscribed to a closed subscriber group (CSG) for access node 445). Alternatively, UE 210 may be denied access to cells (e.g., not be subscribed to a CSG for access node 435). The UE 210 may store a whitelist of cells included in the CSG in a suitable memory or may otherwise be able to determine whether a cell is accessible (e.g., based on transmissions from the eNB, etc.).

Access to service from cells 425, 435 and 445 may also be controlled using an indicator (e.g., an IFRI, *intraFrequencyReselection*, etc.). A UE 210 may receive the indicator from the associated eNB/access node for the given cell. The indicator indicates whether the UE 210 is allowed to camp on cells other than the highest/best ranked cell. If the indicator indicates that access to a cell other than the highest/best ranked cell is not allowed (e.g., set to 'not allowed') the UE 210 may not receive service from any cell other than the best/highest ranked cell (certain exceptions may apply for emergency calls, etc.). If the indicator indicates that access to the cell is allowed (e.g., set to 'allowed') the UE 210 may receive service from any cell even one that is not the highest/best ranked cell.

Due to changed circumstance the UE 210 may determine that a cell reselection may be preferred (e.g., the UE 210 travels away from a serving cell, etc.). In such a situation, the UE 210 may determine to reselect to one of the possible candidate cells. This determination may include monitoring the nearby cells/candidate cells, (e.g., cells
5 435 and 445) and determining a priority for the candidate cells.

Monitoring the candidate cells may further include determining an indication of the power level of the candidate cell (e.g., an RX level value). The indication of the power level of candidate cells may be determined over a specified time interval. When prioritizing the candidate cells, the UE 210 may compare the power level indication to
10 threshold values. These threshold values may be assigned by a serving access node. Prioritization may also be based on the RAT level of the candidate cell.

Additionally, the UE 210 may determine whether access to the candidate cell is allowed (e.g., the candidate cell is found on a whitelist for the UE 210, indicated in transmissions from the access node, etc.). The UE 210 may reselect to the highest
15 prioritized candidate cell which is accessible to the UE 210.

Based on the foregoing it should be apparent that the exemplary embodiments of this invention provide a method, apparatus and computer program(s) to providing cell reselection rules for handling non-accessible cells.

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Figure 5 is a logic flow diagram that illustrates the operation of a method, and a result of execution of computer program instructions, in accordance with the exemplary embodiments of this invention. In accordance with these exemplary embodiments a method performs, at Block 510, identifying candidate cells comprising at least a first
25 candidate cell and a second candidate cell, where a detected power level of the first candidate cell exceeds a first threshold value. The method includes determining whether a mobile device is authorized to receive service from the first candidate cell at Block 520. At Block 530, the method performs, in response to determining that the mobile device is not authorized to receive service from the first candidate cell,
30 choosing the second candidate cell, where the second candidate cell has a lower priority frequency than a priority of a frequency of a serving cell. The method also includes the mobile device reselecting onto the second candidate cell at Block 540.

The various blocks shown in Figure 5 may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s).

5 An exemplary embodiment in accordance with this invention is a method for providing cell reselection rules for handling non-authorized cells (e.g., CSG cells which a UE 210 is not authorized to use or an otherwise non-suitable cell). The method includes identifying (e.g., by a processor) candidate cells including at least a first candidate cell and a second candidate cell. The method also includes determining (e.g.,
10 by a processor) whether a detected power level of the first candidate cell (e.g., $S_{\text{nonServingCell},x}$) exceeds a first threshold value (e.g., $\text{Thresh}_{x, \text{high}}$). Determining (e.g., by a processor) whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the method. Determining (e.g., by a processor) whether the mobile device is authorized to receive
15 service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the method. The method also includes, choosing (e.g., by a processor) the second candidate cell in
20 response to determining that the mobile device is not authorized to receive service from the first candidate cell. Reselecting (e.g., by a processor) the mobile device to the second candidate cell is included in the method.

 In a further exemplary embodiment of the method above, a priority of a frequency or RAT of the first candidate cell is equal to or higher than the priority of the frequency
25 or RAT of the serving cell.

 In an additional exemplary embodiment of any one of the methods above, the method also includes monitoring at least the first candidate cell and the second candidate cell. Monitoring a candidate cell may include determining a detected power level of the candidate cell.

30 In a further exemplary embodiment of any one of the methods above, the method also includes determining whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second

candidate cell; determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; and choosing the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell. Determining the ranking of a candidate cell may be based at least in part on a detected power level of the candidate cell.

In an additional exemplary embodiment of any one of the methods above, the method also includes determining whether a detected power level of the serving cell (e.g., $S_{\text{ServingCell}}$) meets a second threshold value (e.g., $\text{Thresh}_{\text{Serving, low}}$). Identifying candidate cells is preformed in response to a determination that the detected power level of the serving cell does not meet the second threshold value

In a further exemplary embodiment of any one of the methods above, the method also includes determining whether a detected power level of the second candidate cell (e.g., $S_{\text{nonServingCell},x}$) meets or exceeds a third threshold value (e.g., $\text{Thresh}_{x, \text{low}}$) in response to choosing the second candidate cell. Reselecting the mobile device to the second candidate cell is performed in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

In an additional exemplary embodiment of any one of the methods above, determining whether service from the first candidate cell is available includes determining whether the first candidate cell is part of a list of authorized cells for the mobile device and/or determining whether a received indicator indicates that the mobile device is not authorized to receive service from a cell other than the highest/best ranked cell, where the first candidate cell is not suitable and is the highest/best ranked cell (e.g., the *intraFrequencyReselection* is set to 'not allowed').

In a further exemplary embodiment of any one of the methods above, the method also includes receiving an indication of a priority of a frequency or RAT of the first candidate cell, the priority of the frequency or RAT of the second candidate cell and the priority of the frequency or RAT of the serving cell. These priorities may be received in a single transmission or in multiple transmission.

In an additional exemplary embodiment of any one of the methods above, the first candidate cell is a closed service group cell.

In a further exemplary embodiment of any one of the methods above, the method also includes receiving instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting. Determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell may be performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting

An additional exemplary embodiment in accordance with this invention is a computer readable medium tangibly embodied with instruction for providing cell reselection rules for handling non-authorized cells (e.g., CSG cells which a UE 210 is not authorized to use). The instructions include identifying candidate cells including at least a first candidate cell and a second candidate cell. The instructions also include determining whether a detected power level of the first candidate cell (e.g., $S_{\text{nonServingCell},x}$) exceeds a first threshold value (e.g., $\text{Thresh}_{x, \text{high}}$). Determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the instructions. Determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the instructions. The instructions also include choosing the second candidate cell in response to determining that the mobile device is not authorized to receive service from the first candidate cell. Reselecting the mobile device to the second candidate cell is included in the instructions.

In a further exemplary embodiment of the computer readable medium above, a priority of a frequency or RAT of the first candidate cell is equal to or higher than the priority of the frequency or RAT of the serving cell.

In an additional exemplary embodiment of any one of the computer readable media above, the instructions also include monitoring at least the first candidate cell and the second candidate cell. Monitoring a candidate cell may include determining a detected power level of the candidate cell.

In a further exemplary embodiment of any one of the computer readable media

above, the instructions also include determining whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell; determining whether the mobile device is
5 authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; and choosing the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first
10 candidate cell. Determining the ranking of a candidate cell may be based at least in part on a detected power level of the candidate cell.

In an additional exemplary embodiment of any one of the computer readable media above, the instructions also include determining whether a detected power level of the serving cell (e.g., $S_{\text{ServingCell}}$) meets a second threshold value (e.g., $\text{Thresh}_{\text{serv}, \text{low}}$).
15 Identifying candidate cells is preformed in response to a determination that the detected power level of the serving cell does not meet the second threshold value

In a further exemplary embodiment of any one of the computer readable media above, the instructions also include determining whether a detected power level of the second candidate cell (e.g., $S_{\text{nonServingCell}, x}$) meets or exceeds a third threshold value
20 (e.g., $\text{Thresh}_{x, \text{low}}$) in response to choosing the second candidate cell. Reselecting the mobile device to the second candidate cell is performed in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

In an additional exemplary embodiment of any one of the computer readable media
25 above, determining whether service from the first candidate cell is available includes determining whether the first candidate cell is part of a list of authorized cells for the mobile device and/or determining whether a received indicator indicates that the mobile device is not authorized to receive service from a cell other than the highest/best ranked cell, where the first candidate cell is not suitable and is the highest/best ranked cell
30 (e.g., the *intraFrequencyReselection* is set to 'not allowed').

In a further exemplary embodiment of any one of the computer readable media above, the instructions also include receiving an indication of a priority of a frequency or RAT of the first candidate cell, the priority of the frequency or RAT of the second

candidate cell and the priority of the frequency or RAT of the serving cell. These priorities may be received in a single transmission or in multiple transmission.

In an additional exemplary embodiment of any one of the computer readable media above, the first candidate cell is a closed service group cell.

5 In a further exemplary embodiment of any one of the computer readable media above, the instructions also include receiving instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting. Determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell may be performed in response to receiving the
10 instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting

An additional exemplary embodiment in accordance with this invention is an apparatus for providing cell reselection rules for handling non-authorized cells (e.g.,
15 CSG cells which a UE 210 is not authorized to use). The apparatus includes at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to perform actions. The actions include identifying candidate cells including at least a first candidate cell and a second candidate cell. The
20 actions also include determining whether a detected power level of the first candidate cell (e.g., $S_{\text{nonServingCell},x}$) exceeds a first threshold value (e.g., $\text{Thresh}_{x, \text{high}}$). Determining whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the actions. Determining whether the apparatus is authorized to receive service from the first candidate cell in response to
25 a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell is included in the actions. The actions also include choosing the second candidate cell in response to determining that the apparatus is not authorized to receive service from the first
30 candidate cell. Reselecting the apparatus to the second candidate cell is included in the actions.

In a further exemplary embodiment of the apparatus above, a priority of a frequency or RAT of the first candidate cell is equal to or higher than the priority of the

frequency or RAT of the serving cell.

In an additional exemplary embodiment of any one of the apparatus above, the processing unit is further configured to monitor at least the first candidate cell and the second candidate cell. Monitoring a candidate cell may include determining a detected
5 power level of the candidate cell.

In a further exemplary embodiment of any one of the apparatus above, the processing unit is further configured to determine whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the
10 priority of the frequency of the second candidate cell; to determine whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; to choose the second candidate cell in
15 response to a determination that the mobile device is not authorized to receive service from the first candidate cell; and to reselect the mobile device to the second candidate cell. The processing unit may be configured to determine the ranking of a candidate cell based at least in part on a detected power level of the candidate cell.

In an additional exemplary embodiment of any one of apparatus above, the
20 processing unit is further configured to determine whether a detected power level of the serving cell (e.g., $S_{\text{ServingCell}}$) meets a second threshold value (e.g., $\text{Thresh}_{\text{Serving, low}}$). The processing unit is configured to identify candidate cells in response to a determination that the detected power level of the serving cell does not meet a second threshold value

In a further exemplary embodiment of any one of apparatus above, the processing
25 unit is further configured to determine whether a detected power level of the second candidate cell (e.g., $S_{\text{nonServingCell},x}$) meets or exceeds a third threshold value (e.g., $\text{Thresh}_{x, \text{low}}$) in response to choosing the second candidate cell. The processing unit is configured to reselect the mobile device to the second candidate cell in response to a determination that the detected power level of the second candidate cell meets or
30 exceeds the third threshold value.

In an additional exemplary embodiment of any one of the apparatus above, determining whether service from the first candidate cell is available includes determining whether the first candidate cell is part of a list of authorized cells for the

apparatus and/or determining whether a received indicator indicates that the apparatus is not authorized to receive service from a cell other than the highest/best ranked cell, where the first candidate cell is not suitable and is the highest/best ranked cell (e.g., the *intraFrequencyReselection* is set to 'not allowed').

- 5 In a further exemplary embodiment of any one of the apparatus above, the apparatus also includes a receiver configured to receive an indication of a priority of a frequency or RAT of the first candidate cell, the priority of the frequency or RAT of the second candidate cell and the priority of the frequency or RAT of the serving cell. These priorities may be received in a single transmission or in multiple transmission.
- 10 In an additional exemplary embodiment of any one of the apparatus above, the first candidate cell is a closed service group cell.
In a further exemplary embodiment of any one of the apparatus above, the apparatus also includes a receiver configured to receive instructions to reselect the apparatus to a candidate cell having a highest priority of a frequency when reselecting.
- 15 Determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell may be performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting
- 20 An exemplary embodiment in accordance with this invention is a apparatus for providing cell reselection rules for handling non-authorized cells (e.g., CSG cells which a UE 210 is not authorized to use or an otherwise non-suitable cell). The apparatus includes means for identifying (e.g., a processor) candidate cells including at least a first candidate cell and a second candidate cell. The apparatus also includes means for
25 determining (e.g., a processor) whether a detected power level of the first candidate cell (e.g., $S_{\text{nonServingCell},x}$) exceeds a first threshold value (e.g., $\text{Thresh}_{x, \text{high}}$). Means for determining (e.g., a processor) whether the priority of a frequency or RAT of the second candidate cell is lower than a priority of a frequency of a serving cell is included in the apparatus. The apparatus also includes means for determining (e.g., a
30 processor) whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the

second candidate cell. Means for choosing (e.g., a processor) the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell is included in the apparatus. The apparatus also includes means for reselecting (e.g., a processor) the mobile device onto the second candidate cell.

In a further exemplary embodiment of the apparatus above, a priority of a frequency or RAT of the first candidate cell is equal to or higher than the priority of the frequency or RAT of the serving cell.

In an additional exemplary embodiment of any one of the apparatus above, the apparatus also includes means for monitoring at least the first candidate cell and the second candidate cell. Monitoring a candidate cell may include determining a detected power level of the candidate cell. The monitoring means may be a processor or processing unit.

In a further exemplary embodiment of any one of the apparatus above, the apparatus also includes means for determining (e.g., a processor) whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell; means for determining (e.g., a processor) whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; and means for choosing (e.g., a processor) the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell. The ranking of a candidate cell may be based at least in part on a detected power level of the candidate cell.

In an additional exemplary embodiment of any one of apparatus above, the apparatus also includes means for determining whether a detected power level of the serving cell (e.g., $S_{\text{ServingCell}}$) meets a second threshold value (e.g., $\text{Thresh}_{\text{serving, low}}$). The identifying means are configured to identify candidate cells in response to a determination that the detected power level of the serving cell does not meet the second threshold value. The determining means may be a processor or processing unit.

In a further exemplary embodiment of any one of the apparatus above, the

apparatus also includes means for determining whether a detected power level of the second candidate cell (e.g., $S_{\text{nonServingCell},x}$) meets or exceeds a third threshold value (e.g., $\text{Thresh}_{x, \text{low}}$) in response to choosing the second candidate cell. The reselecting means are configured to reselect the mobile device to the second candidate cell in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value. The determining means may be a processor or processing unit.

In an additional exemplary embodiment of any one of the apparatus above, determining whether service from the first candidate cell is available includes determining whether the first candidate cell is part of a list of authorized cells for the apparatus and/or determining whether a received indicator indicates that the apparatus is not authorized to receive service from a cell other than the highest/best ranked cell, where the first candidate cell is not suitable and is the highest/best ranked cell (e.g., the *intraFrequencyReselection* is set to 'not allowed').

In a further exemplary embodiment of any one of the apparatus above, the apparatus also includes means for receiving an indication of a priority of a frequency or RAT of the first candidate cell, the priority of the frequency or RAT of the second candidate cell and the priority of the frequency or RAT of the serving cell. These priorities may be received in a single transmission or in multiple transmission. The receiving means may be a transceiver or a receiver.

In an additional exemplary embodiment of any one of the apparatus above, the first candidate cell is a closed service group cell.

In a further exemplary embodiment of any one of the apparatus above, the apparatus also includes means for receiving instructions to reselect the apparatus to a candidate cell having a highest priority of a frequency when reselecting. Determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell may be performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

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In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be

implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the exemplary embodiments of this invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as nonlimiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

It should thus be appreciated that at least some aspects of the exemplary embodiments of the inventions may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this invention may be realized in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings. However, any and all modifications will still fall within the scope of the non-limiting and exemplary embodiments of this invention.

For example, while the exemplary embodiments have been described above in the context of the EUTRAN (UTRAN-LTE) system, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other wireless communication systems such as for example (WLAN, GSM as appropriate).

It should be noted that the terms "connected," "coupled," or any variant thereof,

mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As
5 employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and/or printed electrical connections, as well as by the use of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as several non-limiting and non-exhaustive examples.

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Further, the various names used for the described parameters (e.g., IFRI, etc.) are not intended to be limiting in any respect, as these parameters may be identified by any suitable names. Further, the formulas and expressions that use these various parameters may differ from those expressly disclosed herein.

15

Furthermore, some of the features of the various non-limiting and exemplary embodiments of this invention may be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention,
20 and not in limitation thereof.

CLAIMS

What is claimed is:

1. A method comprising:

identifying candidate cells comprising at least a first candidate cell and a second candidate cell;

determining whether a detected power level of the first candidate cell exceeds a first threshold value;

determining whether a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell;

in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell, determining whether a mobile device is authorized to receive service from the first candidate cell; and

in response to a determination that the mobile device is not authorized to receive service from the first candidate cell, choosing the second candidate cell; and

reselecting the mobile device to the second candidate cell.

2. The method of claim 1, where a priority of a frequency of the first candidate cell is equal to or higher than the priority of the frequency of the serving cell.

3. The method of claim 1, further comprising monitoring at least the first candidate cell and the second candidate cell.

4. The method of claim 3, where monitoring a candidate cell comprises determining a detected power level of the candidate cell.

5. The method of claim 1, further comprising:

in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell, determining whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell;

in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell, determining whether the mobile device is authorized to receive service from the first candidate cell; and

in response to a determination that the mobile device is not authorized to receive service from the first candidate cell, choosing the second candidate cell.

6. The method of claim 5, further comprising determining a ranking of a candidate cell based at least in part on a detected power level of the candidate cell.

7. The method of claim 1, further comprising determining whether a detected power level of the serving cell meets a second threshold value, where identifying candidate cells is preformed in response to a determination that the detected power level of the serving cell does not meet the second threshold value.

8. The method of claim 1, further comprising, in response to choosing the second candidate cell, determining whether a detected power level of the second candidate cell meets or exceeds a third threshold value, where reselecting the mobile device to the second candidate cell is performed in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

9. The method of claim 1, where determining whether service from the first candidate cell is available comprises determining whether the first candidate cell is part of a list of authorized cells for the mobile device.

10. The method of claim 1, where determining whether the mobile device is authorized to receive service from the first candidate cell comprises determining whether a received indicator indicates that the mobile device is not authorized to receive service from the first candidate cell.

11. The method of claim 1, further comprising receiving an indication of the priority of a frequency of the first candidate cell, the priority of the frequency of the

second candidate cell and the priority of the frequency of the serving cell.

12. The method of claim 1, where the first candidate cell is a closed service group cell.

13. The method of any one of claims 1-12, further comprising receiving instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

14. The method of claim 13, where determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell is performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

15. An apparatus, comprising at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to perform at least the following:

- to identify candidate cells comprising at least a first candidate cell and a second candidate cell;

- to determine whether a detected power level of the first candidate cell exceeds a first threshold value;

- to determine whether a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell;

- in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell, to determine whether a mobile device is authorized to receive service from the first candidate cell; and

- in response to a determination that the mobile device is not authorized to receive service from the first candidate cell, to choose the second candidate cell; and

- to reselect the mobile device to the second candidate cell.

16. The apparatus of claim 15, where a priority of a frequency of the first candidate cell is equal to or higher than the priority of the frequency of the serving cell.

17. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to cause the apparatus to monitor at least the first candidate cell and the second candidate cell.

18. The apparatus of claim 17, where the at least one memory and the computer program code are further configured to, when monitoring a candidate cell, to determine a detected power level of the candidate cell.

19. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to cause the apparatus:

to determine whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell;

to determine whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; and

to choose the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell.

20. The apparatus of claim 19, where the at least one memory and the computer program code are further configured to cause the apparatus to determine a ranking of a candidate cell based at least in part on a detected power level of the candidate cell.

21. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to cause the apparatus to determine whether a detected power level of the serving cell meets a second threshold value; and

to identify the candidate cells in response to a determination that the detected power

level of the serving cell does not meet the second threshold value.

22. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to cause the apparatus to determine whether a detected power level of the second candidate cell meets or exceeds a third threshold value in response to choosing the second candidate cell; and

to reselect the mobile device to the second candidate cell in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

23. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to, when determining whether service from the first candidate cell is available, to determine whether the first candidate cell is part of a list of authorized cells for the mobile device.

24. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to, when determining whether the mobile device is authorized to receive service from the first candidate cell, to determine whether a received indicator indicates that the mobile device is not authorized to receive service from the first candidate cell.

25. The apparatus of claim 15, where the at least one memory and the computer program code are further configured to cause the apparatus to receive an indication of the priority of a frequency of the first candidate cell, the priority of the frequency of the second candidate cell and the priority of the frequency of the serving cell.

26. The apparatus of claim 15, where the first candidate cell is a closed service group cell.

27. The apparatus of any one of claims 15-26, where the at least one memory and the computer program code are further configured to cause the apparatus to receive instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

28. The apparatus of claim 27, where determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell is performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

29. A computer readable medium tangibly encoded with a computer program executable by a processor to perform actions comprising:

identifying candidate cells comprising at least a first candidate cell and a second candidate cell;

determining whether a detected power level of the first candidate cell exceeds a first threshold value;

determining whether a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell;

in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell, determining whether a mobile device is authorized to receive service from the first candidate cell; and

in response to a determination that the mobile device is not authorized to receive service from the first candidate cell, choosing the second candidate cell; and

reselecting the mobile device to the second candidate cell.

30. The computer readable medium of claim 29, where a priority of a frequency of the first candidate cell is equal to or higher than the priority of the frequency of the serving cell.

31. The computer readable medium of claim 29, where the actions further comprise monitoring at least the first candidate cell and the second candidate cell.

32. The computer readable medium of claim 31, where monitoring a candidate cell comprises determining a detected power level of the candidate cell.

33. The computer readable medium of claim 29, where the actions further comprise:

in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell, determining whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell;

in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell, determining whether the mobile device is authorized to receive service from the first candidate cell; and

in response to a determination that the mobile device is not authorized to receive service from the first candidate cell, choosing the second candidate cell.

34. The computer readable medium of claim 33, where the actions further comprise determining a ranking of a candidate cell based at least in part on a detected power level of the candidate cell.

35. The computer readable medium of claim 29, where the actions further comprise determining whether a detected power level of the serving cell meets a second threshold value, where identifying candidate cells is preformed in response to a determination that the detected power level of the serving cell does not meet the second threshold value.

36. The computer readable medium of claim 29, where the actions further comprise, in response to choosing the second candidate cell, determining whether a detected power level of the second candidate cell meets or exceeds a third threshold value, where reselecting the mobile device to the second candidate cell is performed in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

37. The computer readable medium of claim 29, where determining whether service from the first candidate cell is available comprises determining whether the first

candidate cell is part of a list of authorized cells for the mobile device.

38. The computer readable medium of claim 29, where determining whether the mobile device is authorized to receive service from the first candidate cell comprises determining whether a received indicator indicates that the mobile device is not authorized to receive service from the first candidate cell.

39. The computer readable medium of claim 29, where the actions further comprise receiving an indication of the priority of a frequency of the first candidate cell, the priority of the frequency of the second candidate cell and the priority of the frequency of the serving cell.

40. The computer readable medium of claim 29, where the first candidate cell is a closed service group cell.

41. The computer readable medium of any one of claims 29-40, where the actions further comprise receiving instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

42. The computer readable medium of claim 41, where determining a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell is performed in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

43. An apparatus, comprising:

means for identifying candidate cells comprising at least a first candidate cell and a second candidate cell;

means for determining whether a detected power level of the first candidate cell exceeds a first threshold value;

priority determining means for determining whether a priority of a frequency of a serving cell is higher than a priority of a frequency of the second candidate cell;

service authorization determining means for determining whether a mobile device

is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the priority of the frequency of the serving cell is higher than the priority of the frequency of the second candidate cell; and

means for choosing the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell; and

means for reselecting the mobile device to the second candidate cell.

44. The apparatus of claim 43, where a priority of a frequency of the first candidate cell is equal to or higher than the priority of the frequency of the serving cell.

45. The apparatus of claim 43, further comprising means for monitoring at least the first candidate cell and the second candidate cell.

46. The apparatus of claim 45, where the monitoring means comprises means for determining a detected power level of the candidate cell.

47. The apparatus of claim 43, further comprising:

means for determining whether a ranking of the first candidate cell is higher than a ranking of the second candidate cell in response to a determination that the priority of the frequency of the serving cell is equal to the priority of the frequency of the second candidate cell;

means for determining whether the mobile device is authorized to receive service from the first candidate cell in response to a determination that the detected power level of the first candidate cell exceeds the first threshold value and a determination that the ranking of the first candidate cell is higher than the ranking of the second candidate cell; and

means for choosing the second candidate cell in response to a determination that the mobile device is not authorized to receive service from the first candidate cell.

48. The apparatus of claim 47, further comprising means for determining a ranking of a candidate cell based at least in part on a detected power level of the candidate cell.

49. The apparatus of claim 43, further comprising means for determining whether a detected power level of the serving cell meets a second threshold value, where the identifying means is configured to perform the identifying in response to a determination that the detected power level of the serving cell does not meet the second threshold value.

50. The apparatus of claim 43, further comprising means for determining whether a detected power level of the second candidate cell meets or exceeds a third threshold value in response to choosing the second candidate cell, where the reselecting means is configured to perform the reselecting in response to a determination that the detected power level of the second candidate cell meets or exceeds the third threshold value.

51. The apparatus of claim 43, where the service authorization determining means comprises means for determining whether the first candidate cell is part of a list of authorized cells for the mobile device.

52. The apparatus of claim 43, where the service authorization determining means comprises means for determining whether a received indicator indicates that the mobile device is not authorized to receive service from the first candidate cell.

53. The apparatus of claim 43, further comprising means for receiving an indication of the priority of a frequency of the first candidate cell, the priority of the frequency of the second candidate cell and the priority of the frequency of the serving cell.

54. The apparatus of claim 43, where the first candidate cell is a closed service group cell.

55. The apparatus of any one of claims 43-54, further comprising means for receiving instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

56. The apparatus of claim 55, where the priority determining means is for determining whether the priority of the frequency of the serving cell is higher than the

priority of the frequency of the second candidate cell in response to receiving the instructions to reselect the mobile device to a candidate cell having a highest priority of a frequency when reselecting.

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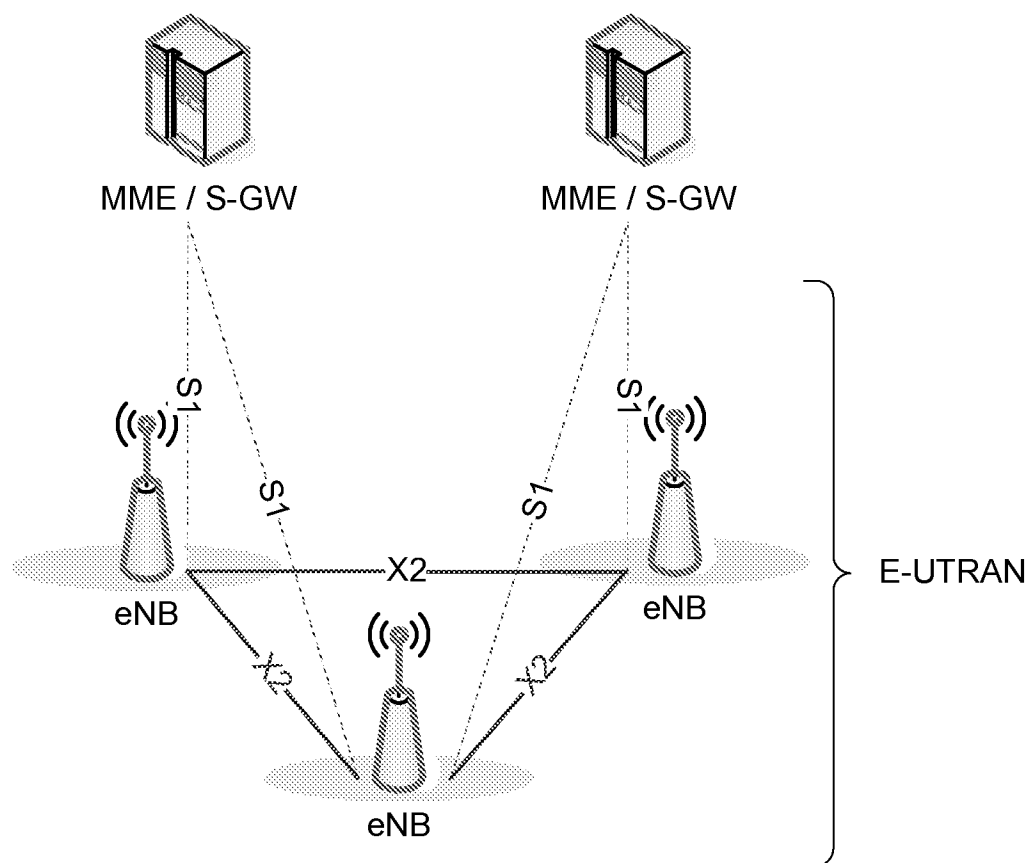


Figure 1 (Prior Art)

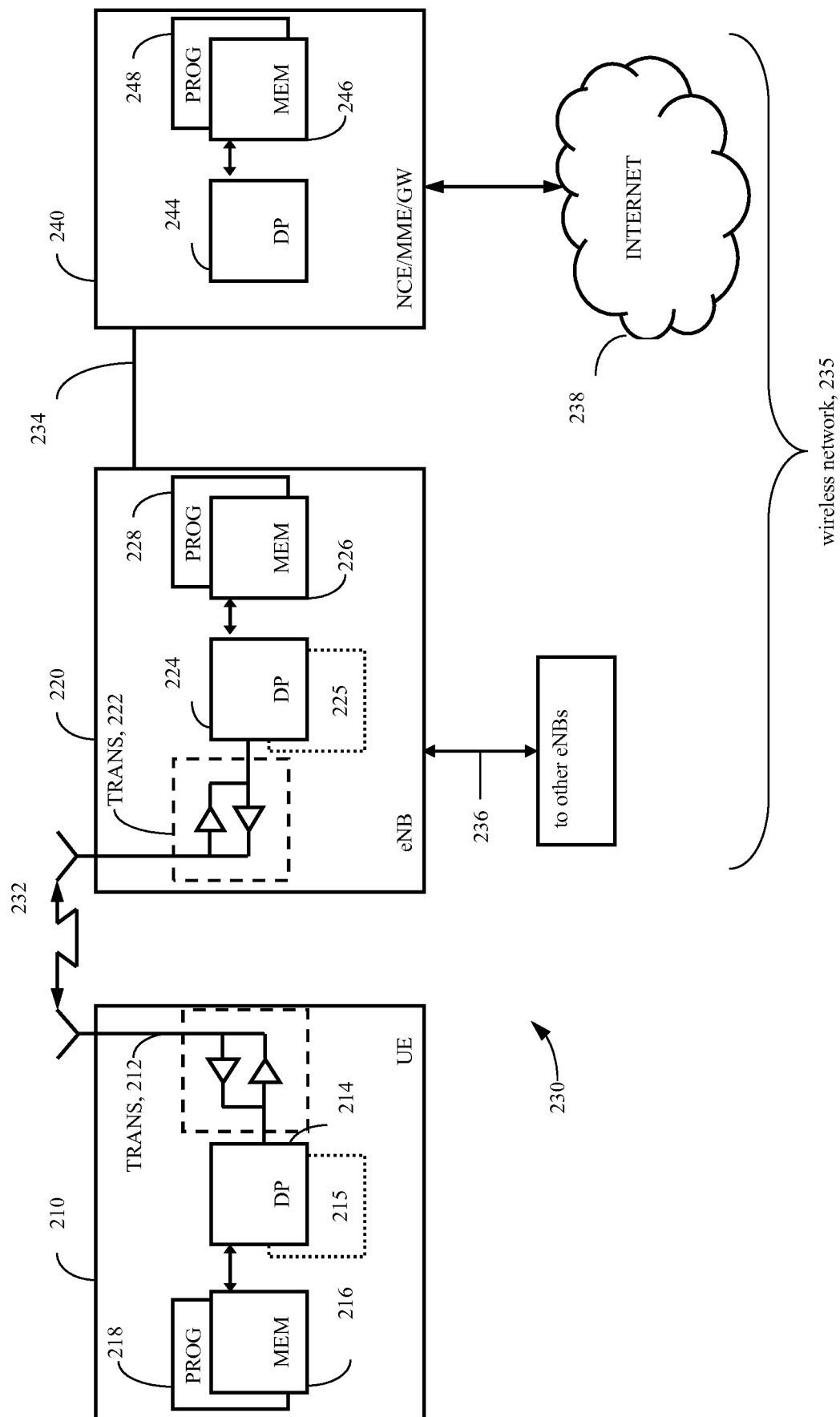


Figure 2

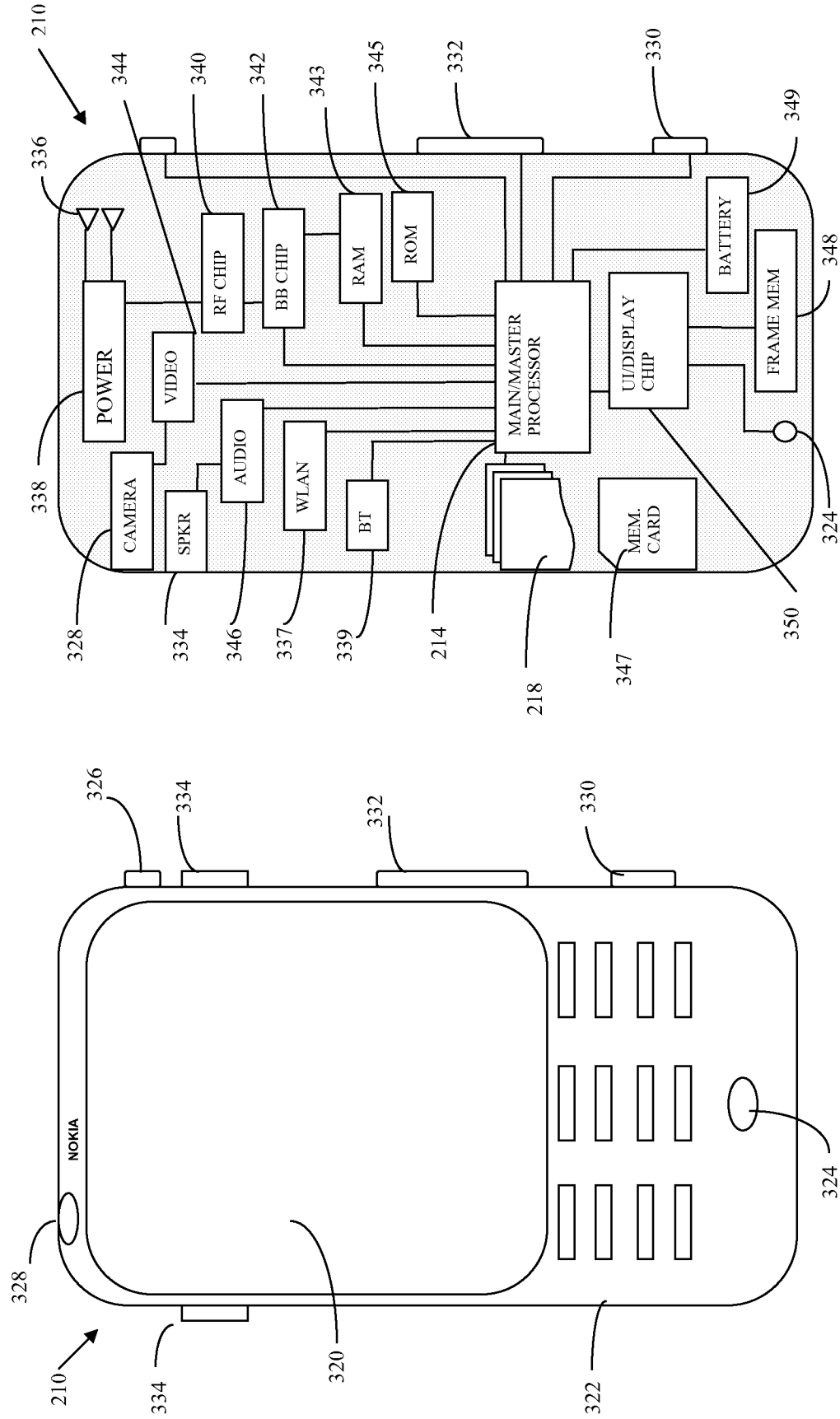


Figure 3

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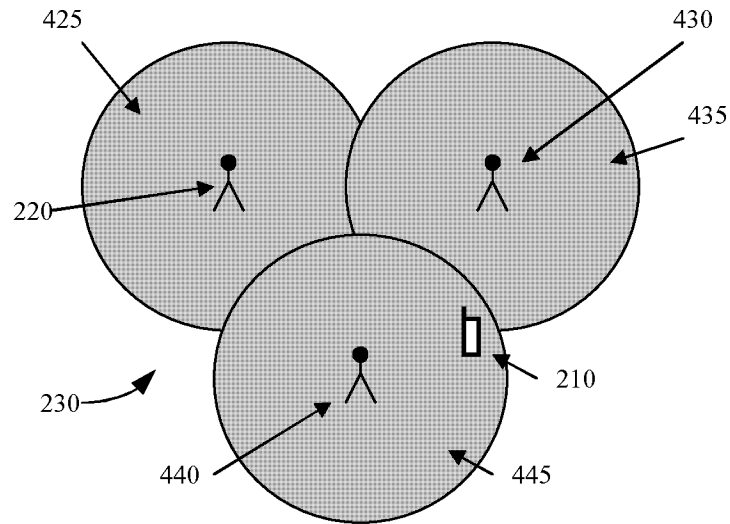


Figure 4

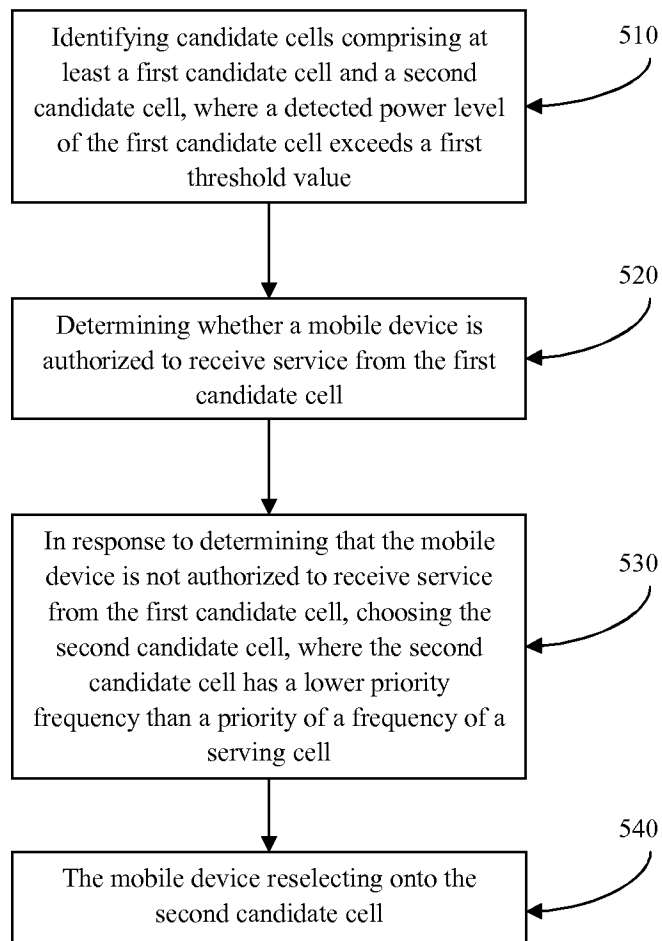


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2010/050002

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

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

EPO-Internal, WPI, Inspec, Xpi3e, Xpipcom, Xp3gpp,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

22 April 2010 (22.04.2010)

Date of mailing of the international search report

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Information on patent family members

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INTERNATIONAL SEARCH REPORT

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PCT/FI2010/050002

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

H04W 36/34 (2009.01)