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Pao et al.

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(54) **METHOD OF HANDLING CELL RESELECTION**

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H04W 28/08	(2009.01)
H04W 36/30	(2009.01)
H04W 36/00	(2009.01)
H04W 36/24	(2009.01)
H04W 48/20	(2009.01)
H04W 48/06	(2009.01)
H04W 48/12	(2009.01)

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CPC ***H04W 36/22*** (2013.01); ***H04W 28/08*** (2013.01); ***H04W 36/0088*** (2013.01); ***H04W 36/24*** (2013.01); ***H04W 36/30*** (2013.01); ***H04W 48/20*** (2013.01); *H04W 48/06* (2013.01); *H04W 48/12* (2013.01)

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CPC H04W 36/14; H04W 88/06; H04W 24/02; H04W 36/04; H04W 76/046; H04W 48/18; H04W 28/08; H04W 36/0061; H04W 36/08; H04W 36/24; H04W 72/085; H04W 36/165; H04W 72/0406; H04W 36/00

See application file for complete search history.

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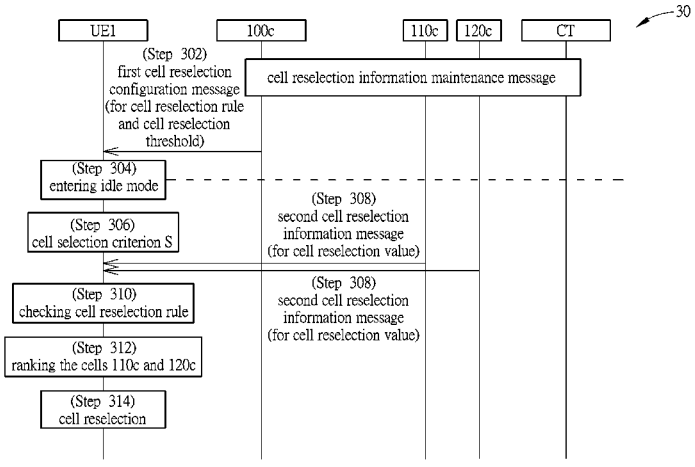
(57) **ABSTRACT**

A method of handling cell reselection includes receiving a first cell reselection configuration message including at least one cell reselection rule from a first cell of the communication system, checking whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list, and selecting one of the plurality of second cells to camp on according to the rule ranking list.

21 Claims, 11 Drawing Sheets



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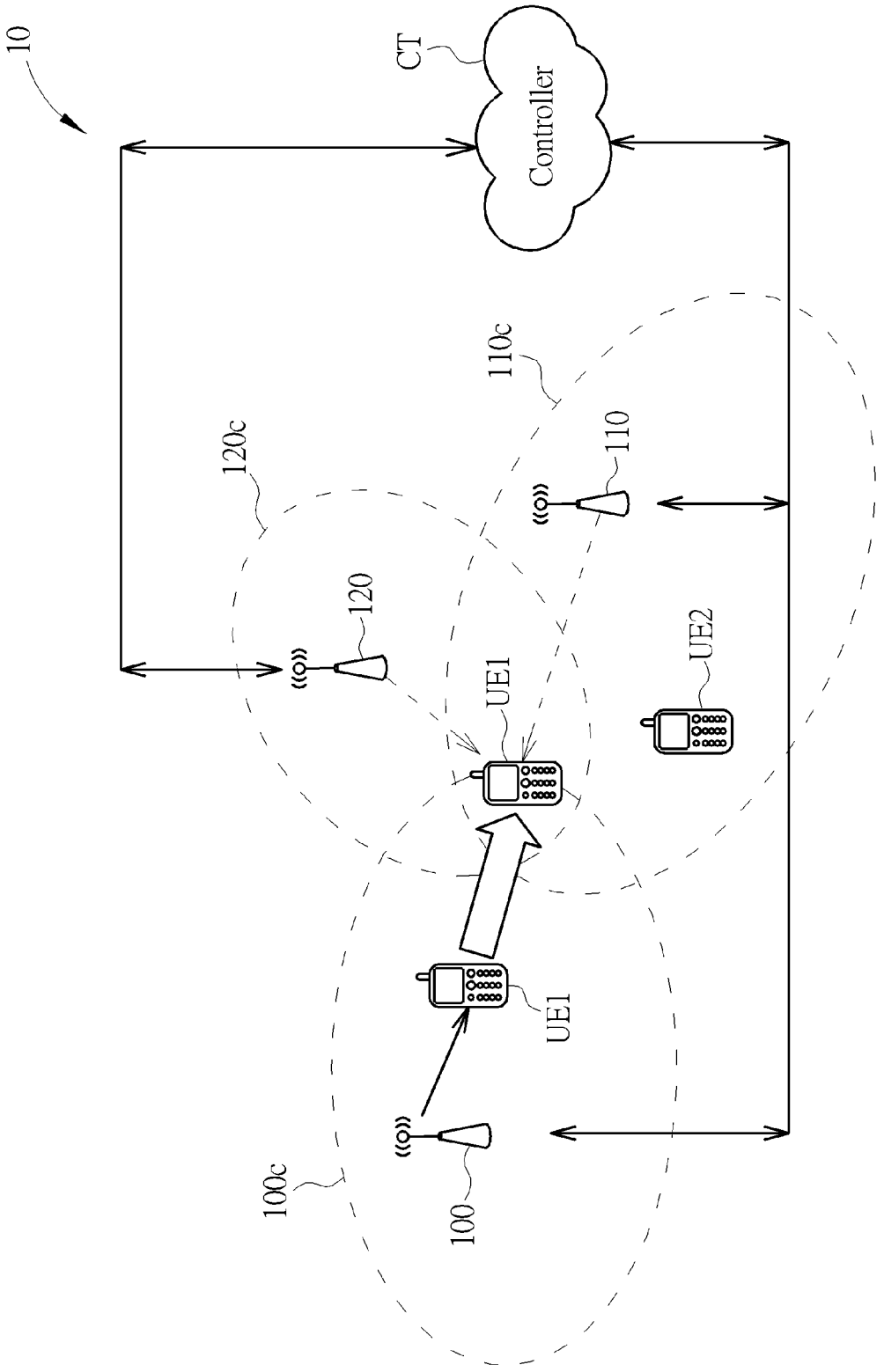

FIG. 1

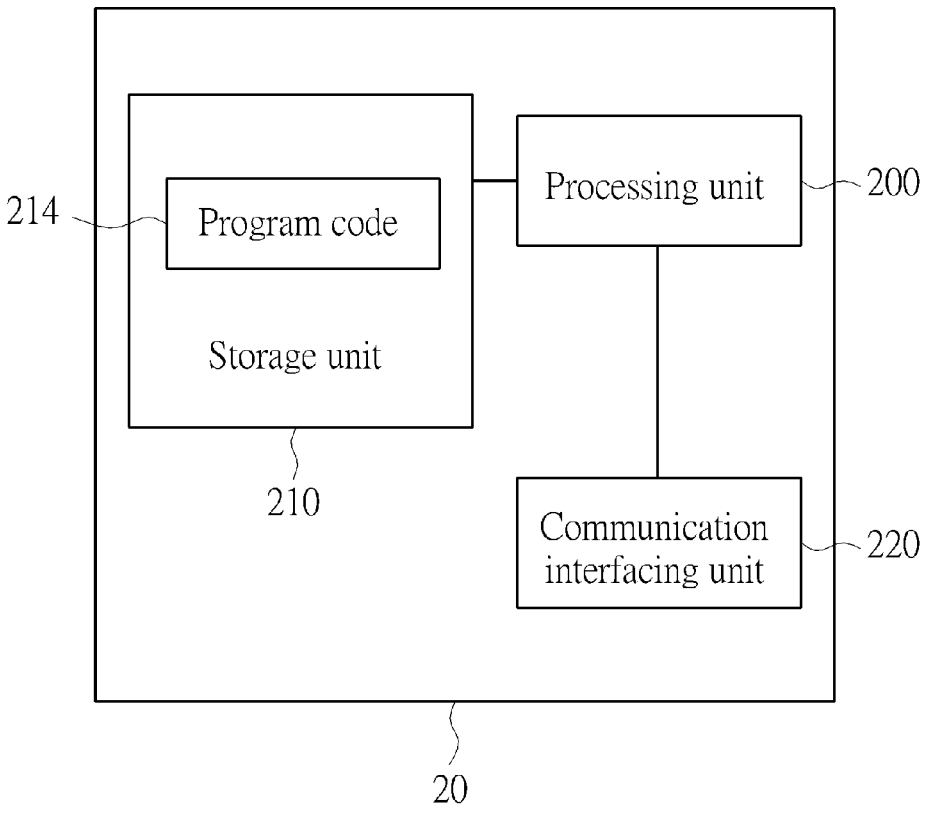
214
Program code
Storage unit
210
Processing unit
200
Communication interfacing unit
220
20

FIG. 2

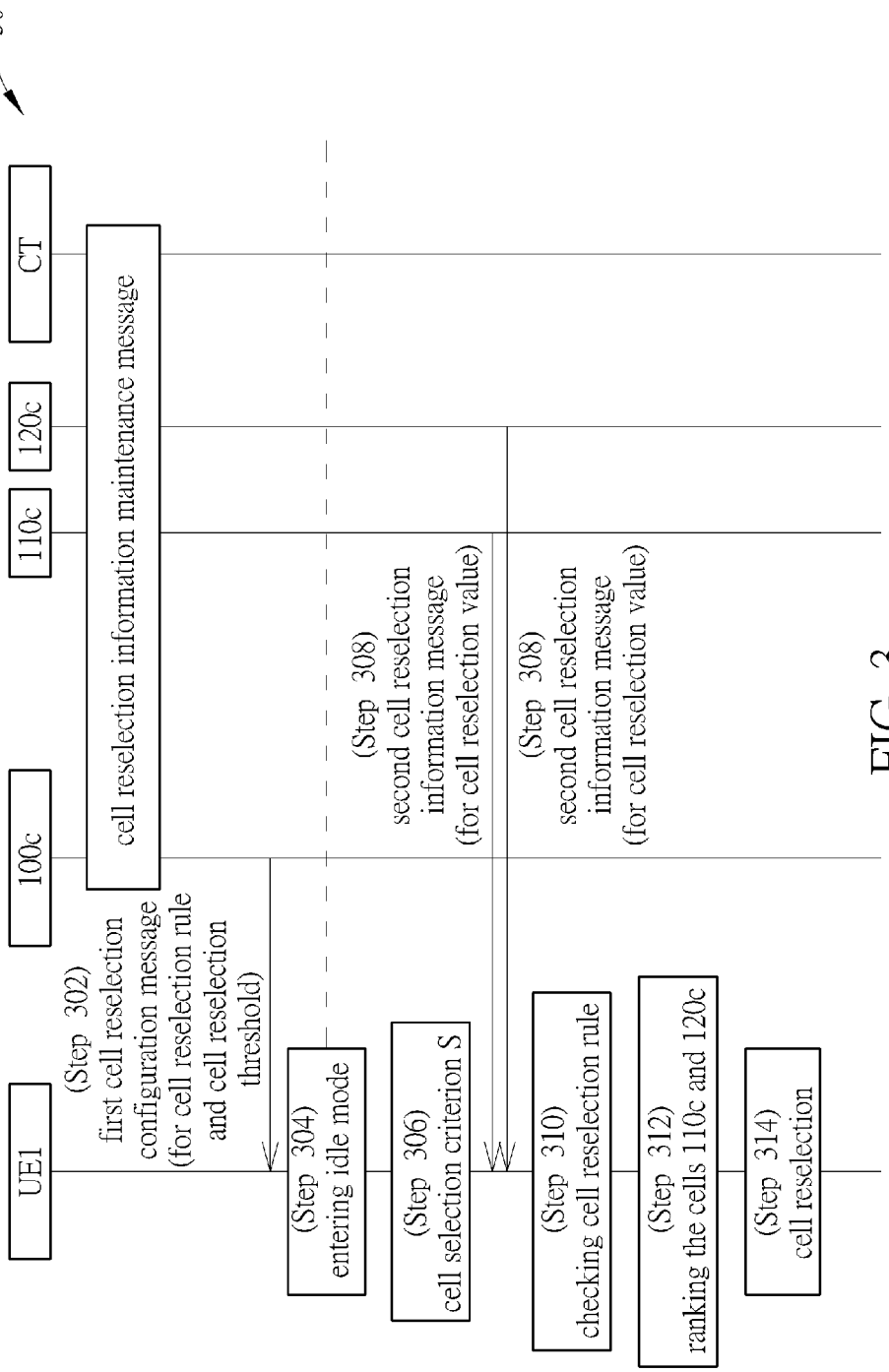
30
UE1
100c
110c
120c
CT
(Step 302)
first cell reselection configuration message (for cell reselection rule and cell reselection threshold)
cell reselection information maintenance message
(Step 304)
entering idle mode
(Step 306)
cell selection criterion S
(Step 308)
second cell reselection information message (for cell reselection value)
(Step 308)
second cell reselection information message (for cell reselection value)
(Step 310)
checking cell reselection rule
(Step 312)
ranking the cells 110c and 120c
(Step 314)
cell reselection

FIG. 3

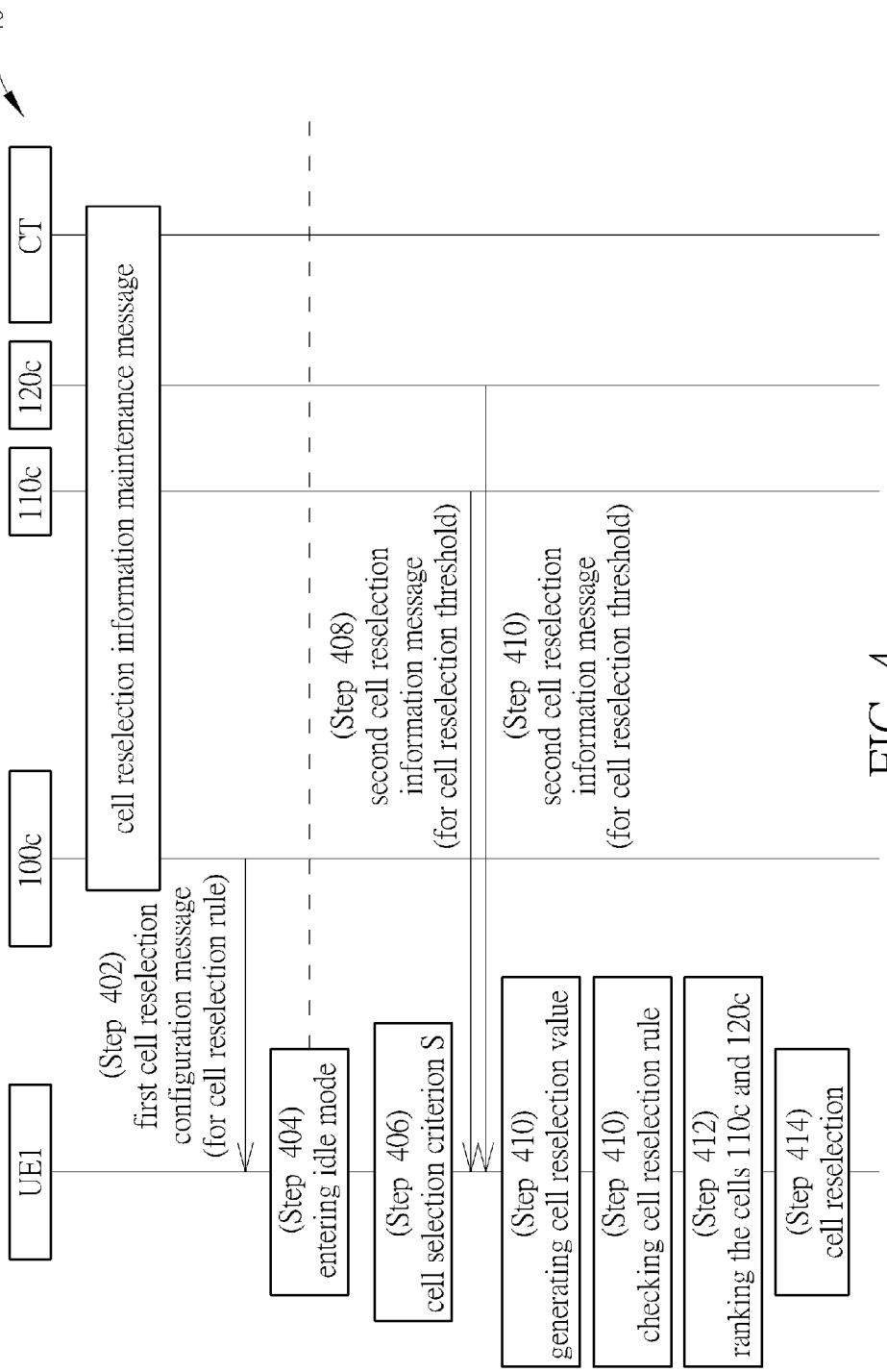
40
UE1
100c
110c
120c
CT
cell reselection information maintenance message
(Step 402)
first cell reselection
configuration message
(for cell reselection rule)
(Step 404)
entering idle mode
(Step 406)
cell selection criterion S
(Step 408)
second cell reselection
information message
(for cell reselection threshold)
(Step 410)
second cell reselection
information message
(for cell reselection threshold)
(Step 410)
generating cell reselection value
(Step 410)
checking cell reselection rule
(Step 412)
ranking the cells 110c and 120c
(Step 414)
cell reselection

FIG. 4

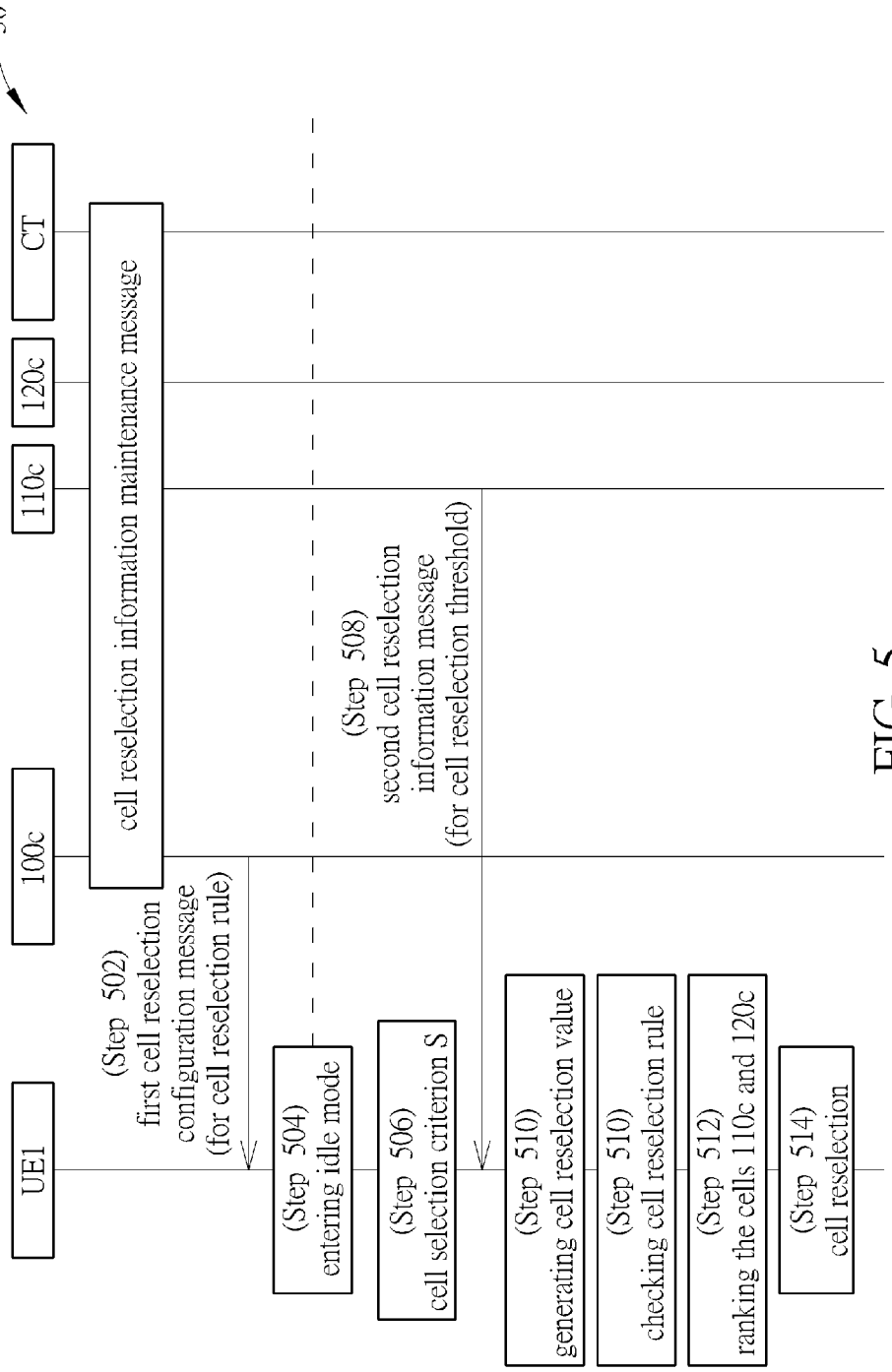
50
UE1
100c
110c
120c
CT
cell reselection information maintenance message
(Step 502)
first cell reselection
configuration message
(for cell reselection rule)
(Step 504)
entering idle mode
(Step 506)
cell selection criterion S
(Step 508)
second cell reselection
information message
(for cell reselection threshold)
(Step 510)
generating cell reselection value
(Step 510)
checking cell reselection rule
(Step 512)
ranking the cells 110c and 120c
(Step 514)
cell reselection

FIG. 5

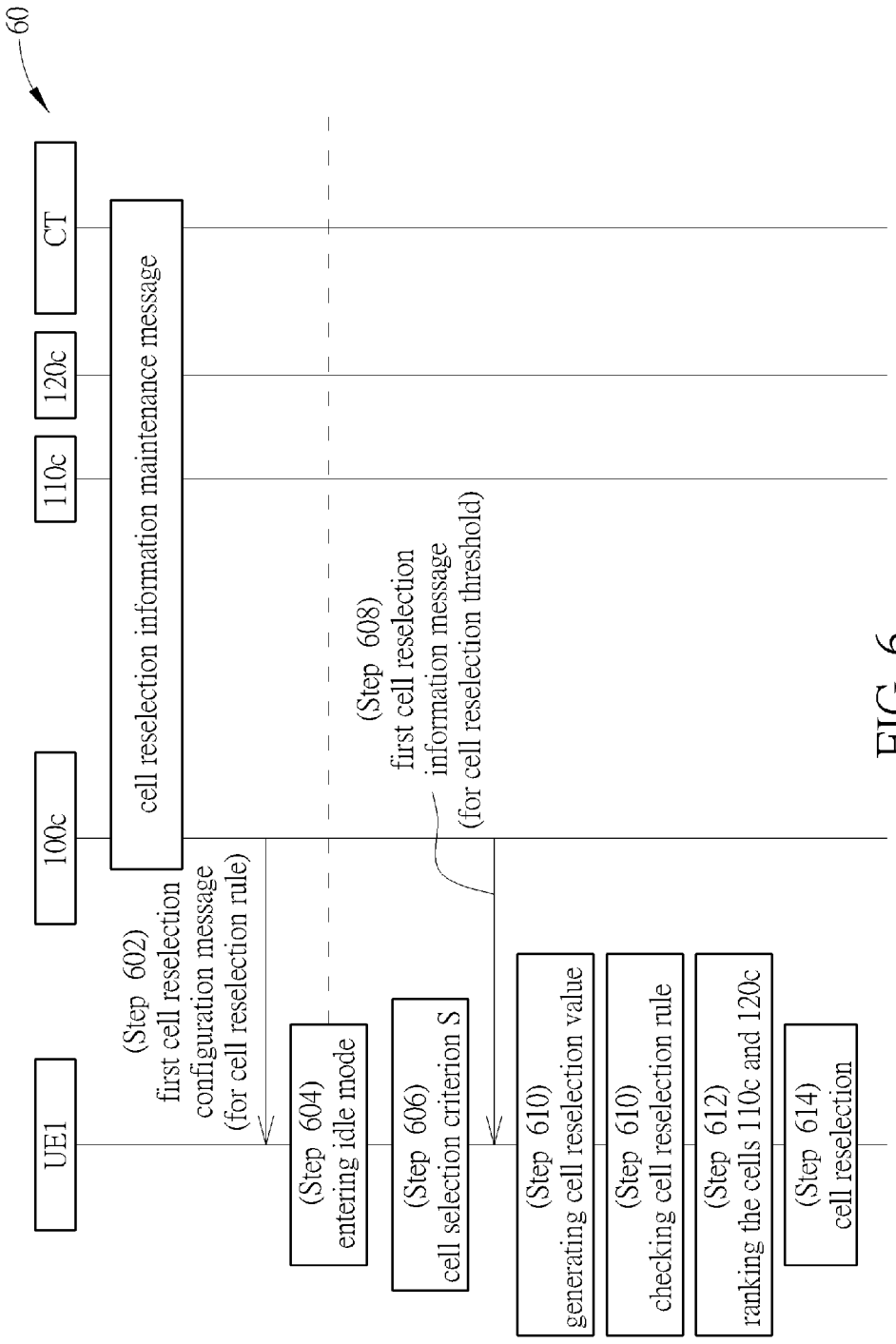
60
UE1
100c
110c
120c
CT
cell reselection information maintenance message
(Step 602)
first cell reselection
configuration message
(for cell reselection rule)
(Step 604)
entering idle mode
(Step 606)
cell selection criterion S
(Step 608)
first cell reselection
information message
(for cell reselection threshold)
(Step 610)
generating cell reselection value
(Step 610)
checking cell reselection rule
(Step 612)
ranking the cells 110c and 120c
(Step 614)
cell reselection

FIG. 6

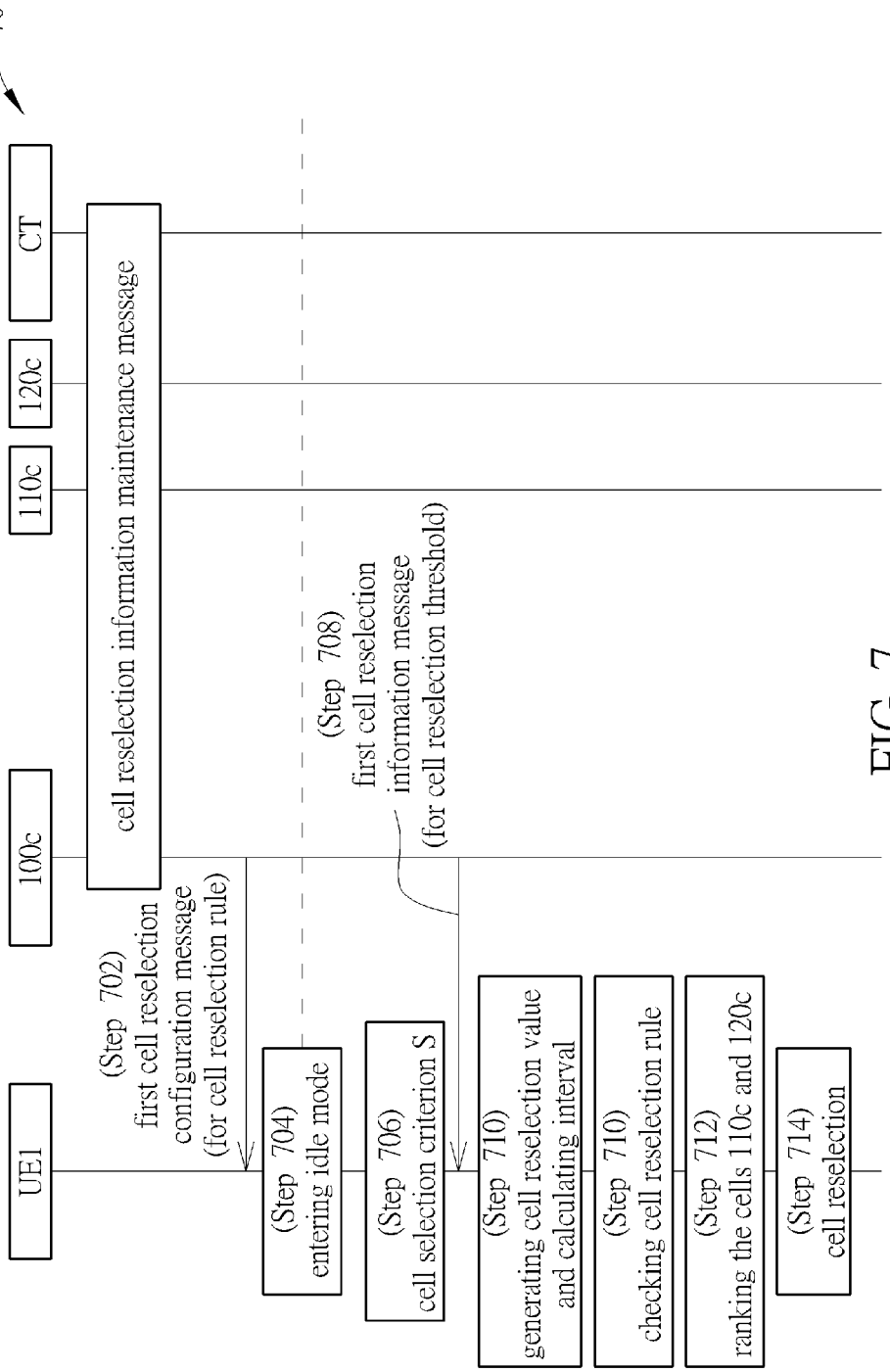
70
UE1
100c
110c
120c
CT
cell reselection information maintenance message
(Step 702)
first cell reselection
configuration message
(for cell reselection rule)
(Step 704)
entering idle mode
(Step 706)
cell selection criterion S
(Step 708)
first cell reselection
information message
(for cell reselection threshold)
(Step 710)
generating cell reselection value
and calculating interval
(Step 710)
checking cell reselection rule
(Step 712)
ranking the cells 110c and 120c
(Step 714)
cell reselection

FIG. 7

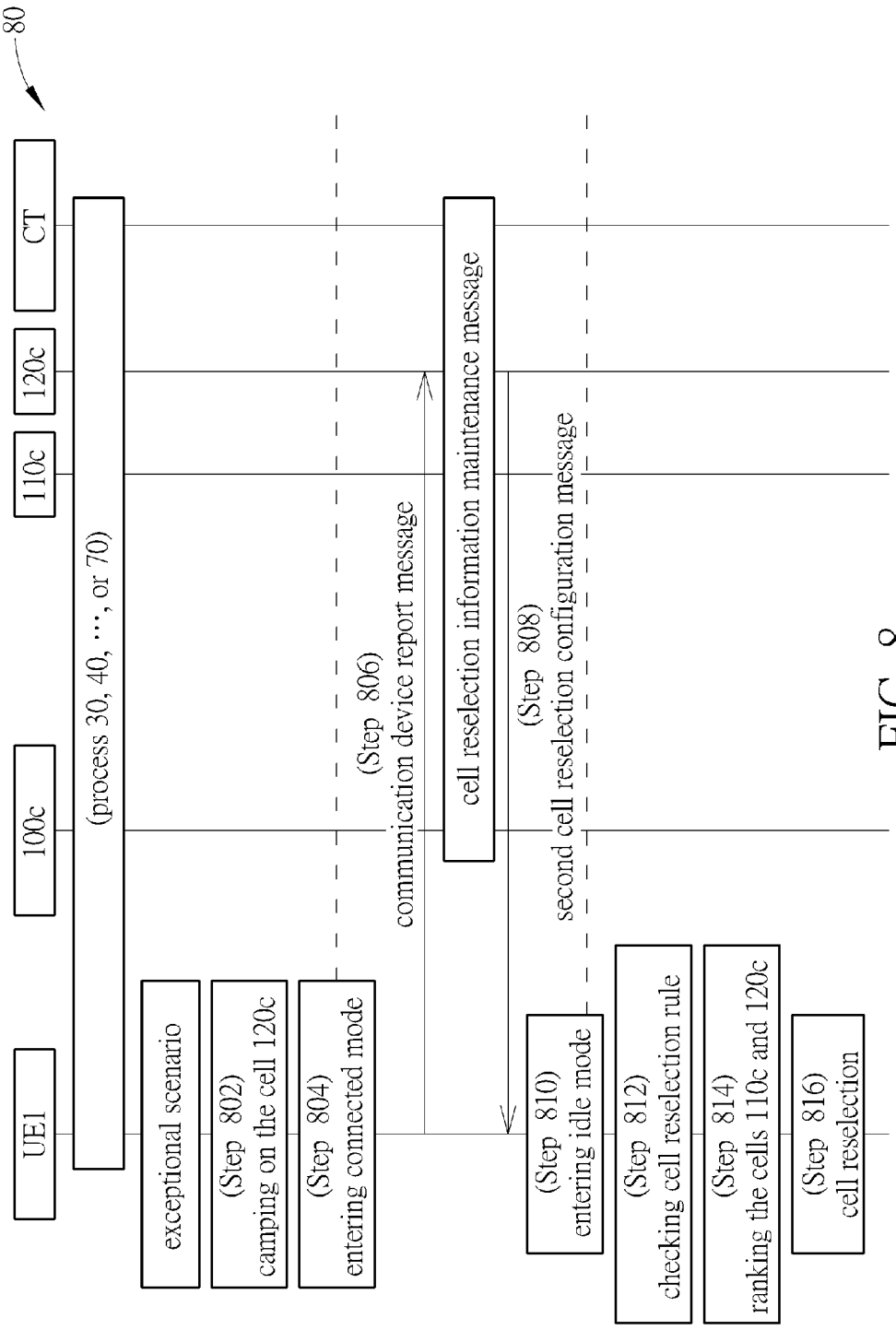
80
UE1
100c
110c
120c
CT
(process 30, 40, ···, or 70)
exceptional scenario
(Step 802)
camping on the cell 120c
(Step 804)
entering connected mode
(Step 806)
communication device report message
cell reselection information maintenance message
(Step 808)
second cell reselection configuration message
(Step 810)
entering idle mode
(Step 812)
checking cell reselection rule
(Step 814)
ranking the cells 110c and 120c
(Step 816)
cell reselection

FIG. 8

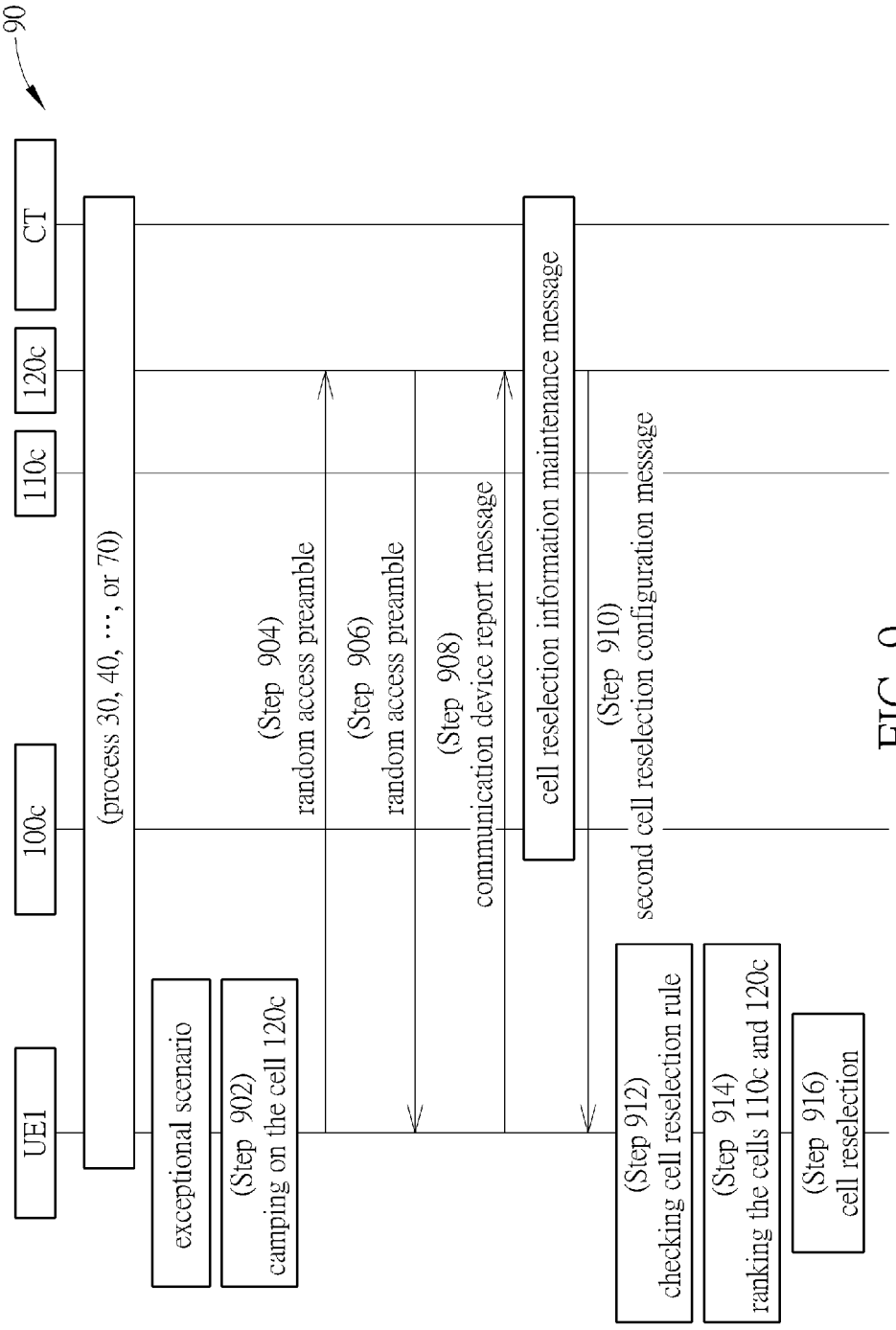
90
UE1
100c
110c
120c
CT
(process 30, 40, ···, or 70)
exceptional scenario
(Step 902)
camping on the cell 120c
(Step 904)
random access preamble
(Step 906)
random access preamble
(Step 908)
communication device report message
cell reselection information maintenance message
(Step 910)
second cell reselection configuration message
(Step 912)
checking cell reselection rule
(Step 914)
ranking the cells 110c and 120c
(Step 916)
cell reselection

FIG. 9

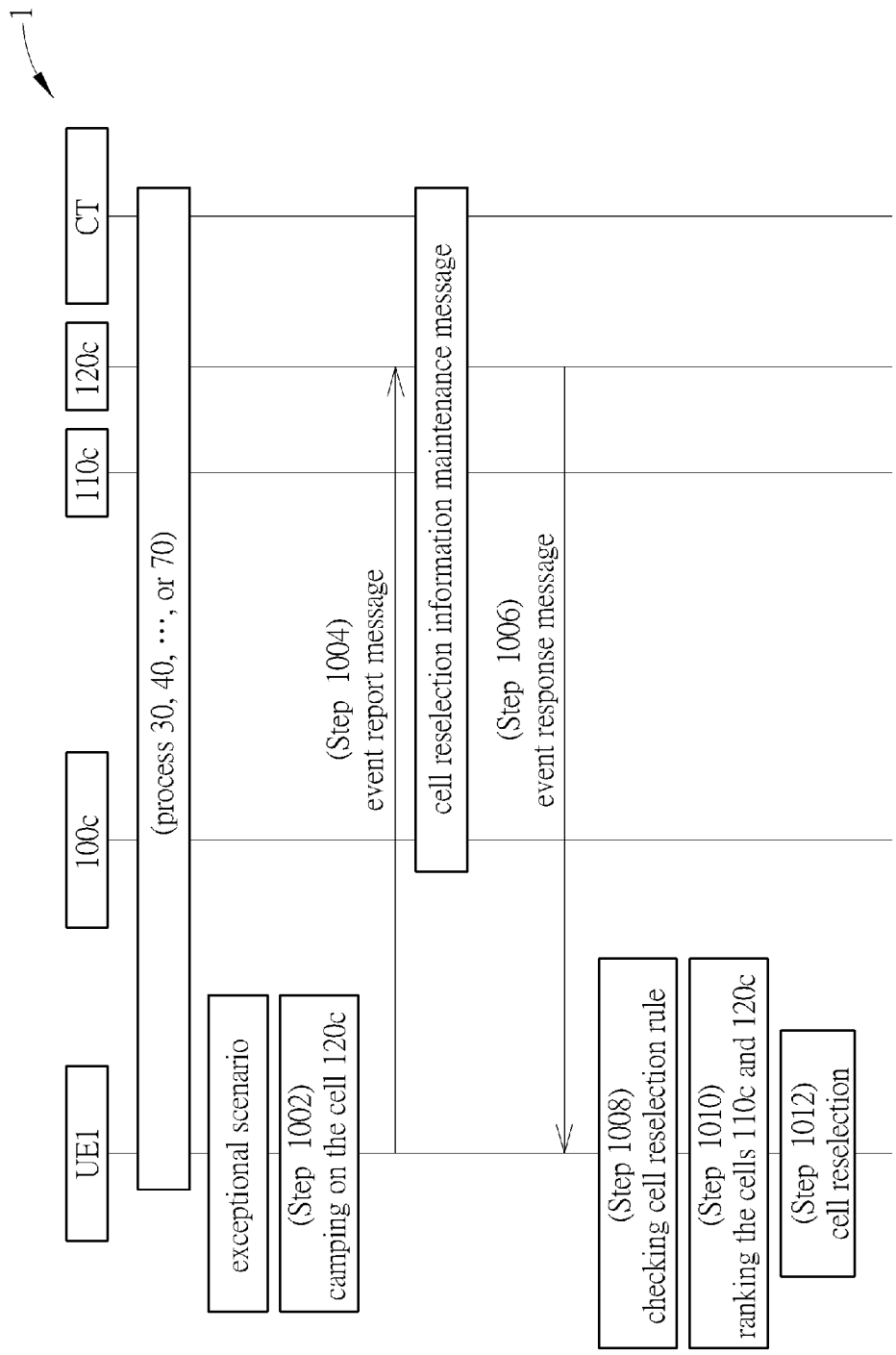
1
UE1
100c
110c
120c
CT
(process 30, 40, ···, or 70)
exceptional scenario
(Step 1002)
camping on the cell 120c
(Step 1004)
event report message
cell reselection information maintenance message
(Step 1006)
event response message
(Step 1008)
checking cell reselection rule
(Step 1010)
ranking the cells 110c and 120c
(Step 1012)
cell reselection

FIG. 10

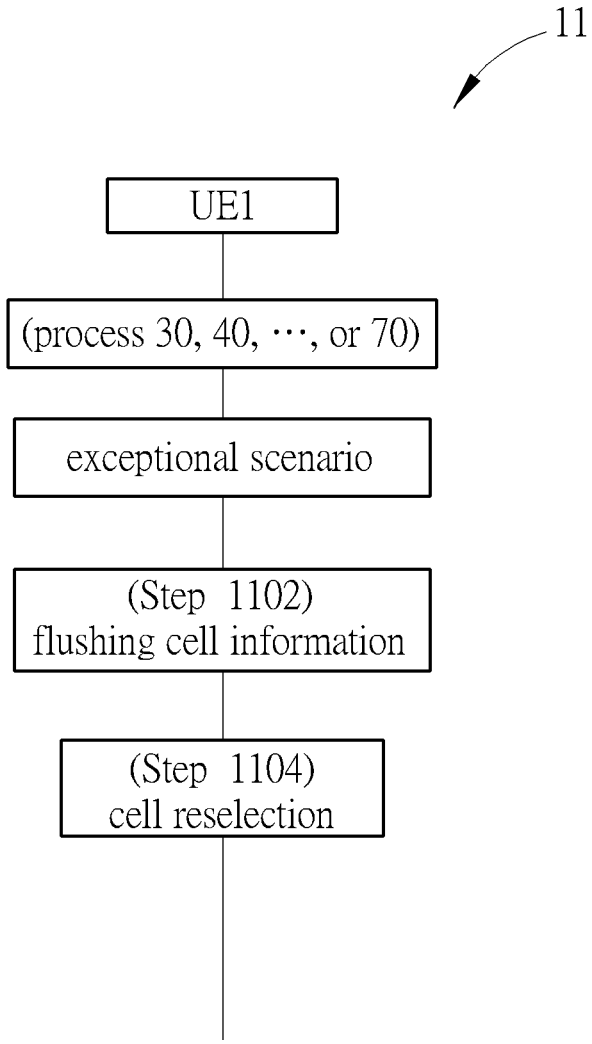
11
UE1
(process 30, 40, ···, or 70)
exceptional scenario
(Step 1102)
flushing cell information
(Step 1104)
cell reselection

FIG. 11

METHOD OF HANDLING CELL RESELECTION

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. provisional application No. 62/075,194 filed on 2014 Nov. 4, included herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is related to a method of handling cell reselection, and more particularly, to a method of handling cell reselection which ensures load balancing when communication devices in idle mode attempt to perform cell reselection.

2. Description of the Prior Art

The 3rd Generation Partnership Project (3GPP) has initiated the Long Term Evolution (LTE) program to bring novel network architecture and configuration, novel technology, and novel applications and services to provide reduced latency, improved spectral efficiency and faster user experiences with less cost.

Upon powered up or losing coverage, a communication device (i.e., a UE) of a communication system may search for suitable cells, such that the UE can receive communication services. If a suitable cell is found, the UE may registers with the cell when necessary. Furthermore, if the UE is in idle mode and not actively communicating with the cell, the UE may then camp on the cell and periodically search for better cells. When a better cell is found, the UE may select the better cell as a serving cell via a process commonly referred to as cell reselection. The searches performed in idle mode may allow the UE to camp on the best possible cell even if channel conditions change—for example, as the UE moves to a new location. In this way, the UE can reliably receive incoming paging messages and initiate or receive calls.

Basically, the UE selects a cell to camp on according to frequency priority as being in idle mode. Frequency priorities of different (inter) frequencies or inter radio access technology (inter-RAT) frequencies are determined according to CellReselectionPriority specified in 3rd Generation Partnership Project (3GPP) standard TS 36.331, which may be provided to the UE in a system information, in an RRCConnectionRelease message, or by inheriting from another RAT at inter-RAT cell (re) selection. And based on 3GPP standard TS 36.304, a frequency list or a cell list, which is associated with frequency priority, is configured at the time the UE goes to idle mode.

Therefore, existing cell reselection mechanisms may cause UEs in idle mode to concentrate on the cell with highest frequency priority, while it is beneficial if the UEs are distributed between the available frequencies in a way such that the capacity the communication system can offer is utilized in a good manner.

Obviously, there is a need for an improved method of handling cell reselection.

SUMMARY OF THE INVENTION

The present invention therefore provides a method of handling cell reselection to achieve load balancing when communication devices in idle mode attempt to perform cell reselection.

An embodiment of the present invention discloses a method of handling cell reselection, which includes receiving a first cell reselection configuration message from a first cell of the communication system, checking whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list, and selecting one of the plurality of second cells to camp on according to the rule ranking list. The first cell reselection configuration message includes at least one cell reselection rule.

Another embodiment of the present invention discloses a communication device including a storage unit and a processing unit. The processing unit is configured to execute a program code stored in the storage unit. A method of handling cell reselection compiled into the program code includes receiving a first cell reselection configuration message from a first cell of the communication system, checking whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list, and selecting one of the plurality of second cells to camp on according to the rule ranking list. The first cell reselection configuration message includes at least one cell reselection rule.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating a communication system according to an example of the present invention.

FIG. **2** is a schematic diagram illustrating a device according to an example of the present invention.

FIG. **3** to FIG. **11** are flowcharts illustrating different processes according to different embodiments of the present invention.

DETAILED DESCRIPTION

FIG. **1** is a schematic diagram illustrating a communication system **10** according to an example of the present invention. The communication system **10** is a cellular network wireless communication system, which briefly includes network nodes, communication devices UE**1** and UE**2**. It is worth noting that the network nodes and/or the communication devices UE**1** and UE**2** in FIG. **1** are simply utilized for illustrating the structure of the wireless communication system **10**. The network nodes may include base stations **100**, **110**, **120**, a controller CT, a server (not shown), and a database (not shown). The base stations **100** to **120** may serve cells **100***c*, **110***c*, and **120***c*, respectively; however, the present invention is not limited thereto and a base station may provide services within a plurality of cells, and frequencies corresponding to the plurality of cells can be different. The base stations **100** to **120** constitute radio access networks. In an embodiment, the radio access networks can be a universal terrestrial radio access network (UTRAN) in a universal mobile telecommunications system (UMTS) respectively, and the base stations **100** to **120** correspond to Node-Bs (NBs). In another example, the radio access networks can be an evolved UTRAN (E-UTRAN) in a long term evolution (LTE) system, a LTE-Advanced (LTE-A) system or an evolution of the LTE-A system respectively, and the base stations **100** to **120** correspond to evolved NBs (eNBs). In another example, the radio access

networks may be a radio access network conforming to wireless standards such as IEEE 802.11 and IEEE 802.16 respectively.

Furthermore, the controller CT, the server, and the database constitute a core network, and the core network may further include network entities such as a Mobility Management Entity (MME), a Serving Gateway (S-GW), a Packet Data Network (PDN) Gateway (P-GW), a Self-Organizing Networks (SON) server and/or a Radio Network Controller (RNC). In other words, after the network nodes receive information transmitted by the communication device UE**1** or UE**2**, the information may be processed only by the radio access networks and decisions corresponding to the information are made at the radio access networks. Alternatively, the radio access networks may forward the information to the core network, and the decisions corresponding to the information are made at the core network after the core network processes the information. Besides, the information can be processed by both the radio access networks and the core network, and the decisions are made after coordination and/or cooperation are performed by the radio access networks and the core network. The communication devices UE**1**, UE**2** can be a user equipment (UE), a machine type communication (MTC) device, a mobile phone, a laptop, a tablet computer, an electronic book or a portable computer system, respectively. Besides, the network nodes and the communication devices UE**1**, UE**2** can be regarded as a transmitter or a receiver according to transmission, for example, for an uplink (UL), the communication devices UE**1**, UE**2** are the transmitter and the network nodes are the receiver, and for a downlink (DL), the network nodes are the transmitter and the communication devices UE**1**, UE**2** are the receiver.

FIG. **2** is a schematic diagram illustrating a device **20** according to an example of the present invention. The device **20** can be the communication devices UE**1**, UE**2** or the network nodes shown in FIG. **1**, but is not limited herein. The device **20** may include a processing unit **200** such as a microprocessor or an Application Specific Integrated Circuit (ASIC), a storage unit **210** and a communication interface unit **220**. The storage unit **210** may be any data storage device that can store a program code **214**, accessed and executed by the processing unit **200**. Examples of the storage unit **210** include but are not limited to a subscriber identity module (SIM), a read-only memory (ROM), a flash memory, a random-access memory (RAM), a CD-ROM/DVD-ROM, a magnetic tape, a hard disk and an optical data storage device. The communication interface unit **220** is preferably a transceiver and is used to transmit and receive signals (for example, messages or packets) according to processing results of the processing unit **200**.

The basic condition for initiating a cell reselection is that the signal strength or signal quality from a candidate cell is better than the signal strength or signal quality from the current serving cell or cells of higher frequency priority. The signal strength or signal quality of signals received by the communication device UE**1** shown in FIG. **1** may vary due to movement of the communication device UE**1** or channel condition changes. Additionally, the communication device UE**1** may perform cell reselection when cell reselection conditions are satisfied or if necessary (e.g., when frequency priority is changed via broadcasted information, or when the communication device is paged). A process can be utilized in the communication device UE**1** to handle cell reselection. The process may be compiled into the program code **214** of the communication device UE**1** and includes the following steps:

Step S**02**: Start.

Step S**04**: Receive a first cell reselection configuration message from the cell **100***c* of the communication system **10**, wherein the first cell reselection configuration message includes at least one cell reselection rule.

Step S**06**: Check whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list.

Step S**08**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list.

Step S**10**: End.

Specifically, FIG. **3** is a flowchart illustrating a process **30** according to an embodiment of the present invention. The process **30** can be utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection. The process **30** may be compiled into the program code **214** of the communication device UE**1** and includes the following steps:

Step **300**: Start.

Step **302**: Receive a first cell reselection configuration message from the cell **100***c*, wherein the first cell reselection configuration message includes at least one cell reselection rule and at least one cell reselection threshold, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule, the at least one cell reselection threshold and at least one cell reselection value.

Step **304**: Enter idle mode.

Step **306**: Determines whether the cells **110***c* and **120***c* fulfill a cell selection criterion S when the communication device UE**1** in idle mode attempts to perform cell reselection.

Step **308**: Receive second cell reselection information messages broadcasted from the cells **110***c* and **120***c*, wherein each of the second cell reselection information messages includes the at least one cell reselection value.

Step **310**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection information messages, wherein the communication device UE**1** compares each of the at least one cell reselection value corresponding to one of the cells **110***c* and **120***c* with the at least one cell reselection threshold to determine which of the at least one cell reselection rule is satisfied.

Step **312**: Rank the cells **110***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **314**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **316**: End.

According to Step **302**, the network nodes (i.e., the base stations **100** to **120** and the controller CT) interact with each other and exchange the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value via the cell reselection information maintenance message to determine or update the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value. Specifically, the controller CT may be an Operations, Administration, and Maintenance (OAM) server to maintain and update the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value according to, for example, cell loading information from the base stations **100** to **120**, the occurrence of exceptional scenarios notified by the communication devices UE**1** and UE**2**, or network configuration (e.g., dynamic adjustment according to the distribution of the communication devices UE**1** and UE**2**). The at least one cell reselection rule includes at least

one of a loading cell reselection rule (e.g., $Value_{Loading}$<$Threshold_{Loading}$), a capability cell reselection rule (e.g., $Value_{Capability}$<$Threshold_{Capability}$), a mobility cell reselection rule (e.g., $Value_{Mobility}$<$Threshold_{Mobility}$), a subscriber class cell reselection rule (e.g., $Value_{Subscriber_Class}$<$Threshold_{Subscriber_Class}$), a signal cell reselection rule (e.g., $Value_{Signal}$<$Threshold_{Signal}$) and a constant cell reselection rule (e.g., $Value_{Constant}$<$Threshold_{Constant}$). The at least one cell reselection threshold includes at least one of a loading cell reselection threshold (e.g., $Threshold_{Loading}$), a capability cell reselection threshold (e.g., $Threshold_{Capability}$), a mobility cell reselection threshold (e.g., $Threshold_{Mobility}$), a subscriber class cell reselection threshold (e.g., $Threshold_{Subscriber_Class}$), a signal cell reselection threshold (e.g. $Threshold_{Signal}$) and a constant cell reselection threshold (e.g., $Threshold_{Constant}$). The at least one cell reselection value includes at least one of a loading cell reselection value (e.g., $Value_{Loading}$) a capability cell reselection value (e.g., $Value_{Capability}$), a mobility cell reselection value (e.g., $Value_{Mobility}$), a subscriber class cell reselection value (e.g., $Value_{Subscriber_Class}$), a signal cell reselection value (e.g., $Value_{Signal}$) and a constant cell reselection value (e.g., $Value_{Constant}$).

Specifically, $Value_{Loading}$ is related to the corresponding base station (e.g., the base stations **100** to **120**) or cell loading information, and can be presented as percentages or levels (e.g., low, medium, or high). $Value_{Loading}$ may be determined according to the number of communication devices in connected mode in the corresponding cell, radio resource utilization, backhaul rate, service (e.g., File Transfer Protocol (FTP) and Voice over IP (VoIP)), application (e.g., YouTube), or the density of communication devices in idle mode. The ratio of the number of active communication devices to the number of communication devices in idle mode may be a statistically stable value. Access load may be associated with the density of communication devices in idle mode. Therefore, the active traffic loading and the access loading may be related to the density of communication devices in idle mode. $Value_{Capability}$ is related to capability of the corresponding base station (e.g., the base stations **100** to **120**)—for example, whether higher order modulation supporting (e.g., 256 Quadrature Amplitude Modulation (QAM)), Multi-input Multi-output (MIMO) supporting, Carrier Aggregation (CA) supporting, Coordinated Multi-Point (CoMP) supporting, Dual Connectivity supporting, or specific service supporting (e.g., Multimedia Broadcast/Multicast Service (MBMS)) is provided, or whether requirements on Grade of Service (GoS) and Quality of Service (QoS) are satisfied. $Value_{Mobility}$ is related to mobility information of a communication device (e.g., the communication devices UE**1** and UE**2**), and can be presented as speed in kilometer per hour km/h or levels (e.g., low, medium, or high mobility state). $Value_{Subscriber_Class}$ is related to subscriber class of a communication device (e.g., the communication devices UE**1** and UE**2**), and can be presented as levels (e.g., Gold or Silver). $Value_{Signal}$ is related to signal strength or signal quality (e.g., RSRP or RSRQ) of the corresponding source cell (e.g., the cell **100***c*) or the corresponding target cell (e.g., the cells **110***c* and **120***c*) or an offset for measured signal strength or signal quality of the corresponding source or target cell. $Value_{Constant}$ can be presented as a number (e.g., any number between 0 and 1) or levels (e.g., level 0 to level 10), and may be generated randomly, or according to the cell loading status or communication device identifier (e.g., International Mobile Subscriber Identity (IMSI)).

For example, the base stations **100** to **120** and the controller CT determine that $Value_{Constant}$<$Threshold_{Constant}$, and that $Threshold_{Constant}$ and $Value_{Constant}$ can be any number between 0 and 1 in Step **302**. The communication device UE**1** camping on a serving cell (such as the cell **100***c*) may receive the first cell reselection configuration message from the cell **100***c*, and thus know that $Value_{Constant}$<$Threshold_{Constant}$, and that $Threshold_{Constant}$ is configured as, for example, 0.65 in Step **302**. Later, the communication device UE**1** may enter idle mode in Step **304**. The communication device UE**1** may attempt to perform cell reselection when it moves or satisfies certain cell reselection conditions or if necessary. Aiming to perform cell reselection, the communication device UE**1** determines whether its neighbor cells (i.e., the cells **110***c* and **120***c*) fulfill the cell selection criterion S, which is specified in 3GPP standard TS 36.304, in Step **306**—in other words, the communication device UE**1** may perform measurements of the signal strength (e.g., RSRP) and the signal quality (e.g., RSRQ), for example. The communication device UE**1** finds the cells **110***c* and **120***c* fulfill the cell selection criterion S, and receives the second cell reselection information messages broadcasted from the cells **110***c* and **120***c*, respectively in Step **308**. According to the second cell reselection information message broadcasted from the cell **110***c*, $Value_{Constant}$ is configured as, for example, 0.5. According to the second cell reselection information message broadcasted from the cell **120***c*, $Value_{Constant}$ is configured as, for example, 0.8. After comparing $Value_{Constant}$ corresponding to the cell **110***c* with $Threshold_{Constant}$ and $Value_{Constant}$ corresponding to the cell **120***c* with $Threshold_{Constant}$, the communication device UE**1** determines that only $Value_{Constant}$ corresponding to the cell **110***c* satisfies $Value_{Constant}$<$Threshold_{Constant}$ in Step **310**, which makes the number of the at least one cell reselection rule satisfied by $Value_{Constant}$ corresponding to the cell **110***c* equal to 1. Subsequently, the communication device UE**1** ranks the rule priority of the cell **110***c* higher than that of the cell **120***c* in the rule ranking list in Step **312** because the numbers of the at least one cell reselection rule satisfied by $Value_{Constant}$ corresponding to the cells **110***c* and **120***c* are 1 and 0, respectively. The communication device UE**1** may select the cell **110***c* to camp on according to the rule ranking list in Step **314**.

However, if $Value_{Constant}$ corresponding to the cell **120***c* is configured as 0.4 and thus satisfies $Value_{Constant}$<$Threshold_{Constant}$ in Step **310** as well, both the numbers of the at least one cell reselection rule satisfied by $Value_{Constant}$ corresponding to the cells **110***c* and **120***c* would be 1. The communication device UE**1** may select a cell with better signal quality or signal strength from the cell **110***c* or **120***c* to camp on. In another embodiment, the communication device UE**1** ranks the cells **110***c* and **120***c* according to signal strength or signal quality in order to generate a signal ranking list before checking whether the at least one cell reselection rule is satisfied. If the cell **120***c* has better signal quality or signal strength than the cell **110***c*, the communication device UE**1** then compares $Value_{Constant}$ corresponding to the cell **120***c* with $Threshold_{Constant}$. If $Value_{Constant}$ corresponding to the cell **120***c* is configured as 0.8 and does not satisfy $Value_{Constant}$<$Threshold_{Constant}$ in Step **310**, the communication device UE**1** compares $Value_{Constant}$ corresponding to the cell **110***c* with $Threshold_{Constant}$. In another embodiment, since both the cells **110***c* and **120***c* have the highest rule priority in the rule ranking list, the communication device UE**1** first selects the cells **110***c* and **120***c* as rule candidates from the cells **110***c* and **120***c*. The commu-

nication device UE**1** then ranks the rule candidates according to the frequency priorities (e.g., CellReselectionPriority) of rule candidates in order to generate a frequency ranking list. For example, the frequencies corresponding to the cell **110***c* and **120***c* (which serve as the rule candidates) differ, and hence the frequency priority of the cell **120***c* may be higher than that of the cell **110***c*. The communication device UE**1** would select the cell **120***c* to camp on according to the frequency ranking list. In another embodiment, the cells **110***c* and **120***c* serving as the rule candidates have the same (intra) frequency as the serving cell **100***c*, meaning that the frequency priorities of the cells **110***c* and **120***c* are the same and the highest in the frequency ranking list. In such a situation, the communication device UE**1** would select the cells **110***c* and **120***c* as frequency candidates, and ranks the frequency candidates according to an R criteria, which is specified in 3GPP standard TS 36.304, signal strength or signal quality in order to generate a signal ranking list. If the cell **110***c* is ranked as the best cell, the communication device UE**1** would tend to camp on the cell **110***c* according to the signal ranking list. The present invention, nevertheless, is not limited to this, and the communication device UE**1** may rank the cells **110***c* and **120***c* according to the frequency priorities before it determines whether $Value_{Constant}$ corresponding to the cell **110***c* or **120***c* satisfies the at least one cell reselection rule in Step **310**. If the frequency priority of the cells **120***c* is higher than that of the cell **110***c*, the communication device UE**1** would select the cell **120***c* to camp on without checking whether the at least one cell reselection rule is satisfied. If the rule priorities and the frequency priorities of the cells **110***c* and **120***c* are the same, the communication device UE**1** then ranks the cells **110***c* and **120***c* according to the R criteria to perform cell reselection. Additionally, when the communication device UE**1** leaves idle mode (e.g., owing to receiving an RRCConnectionSetupComplete message), it may release the at least one cell reselection rule, the at least one cell reselection value, or the at least one cell reselection threshold.

In short, the communication device UE**1** of the present invention would receive second cell reselection information messages broadcasted from the cells **110***c* and **120***c*, after the communication device UE**1** enters idle mode. Consequently, the communication device UE**1** in idle mode can apply the at least one cell reselection value updated to perform cell reselection, which maintain the communication system **10** under the balanced load condition like the one-shot redistribution mechanism specified in 3GPP TSG-RAN WG2 #91 R2-153406.

Please note that the communication system **10** in FIG. **1**, the device **20** in FIG. **2** and the process **30** in FIG. **3** are exemplary embodiments of the invention, and those skilled in the art may make alternations and modifications accordingly. For example, the cell reselection information maintenance message may be implemented by a new message distinct from the prior art, and include at least one of at least one cell reselection rule, at least one cell reselection threshold, at least one cell reselection value, a rule validity timer, a threshold validity timer, a value validity timer, a frequency list, an identity of a communication device (e.g., UE ID), a Cell ID, a default frequency, delta values of the at least one cell reselection threshold, and delta values of the at least one cell reselection value. Each of the second cell reselection information messages may include at least one of at least one cell reselection rule, at least one cell reselection threshold, at least one cell reselection value, a rule validity timer, a threshold validity timer, a value validity timer, a PLMN ID, a Cell ID, a neighboring cell list, and a Tracking Area ID. Each of the second cell reselection information messages may be implemented by a new message distinct from the prior art, a Paging message, or a SIB message. The first cell reselection configuration message may include at least one of at least one cell reselection rule, at least one cell reselection threshold, at least one cell reselection value, a rule validity timer, a threshold validity timer, a value validity timer, a frequency list, a public land mobile network (PLMN) ID, a Cell ID, a default frequency, delta values of the at least one cell reselection threshold, delta values of the at least one cell reselection value, and a neighboring cell list. The first cell reselection configuration message may be implemented by a new message distinct from the prior art, an RRCConnectionReconfiguration message, an RRCConnectionRelease message, an RRCConnectionConfiguration message, an RRCConnectionSetup message, a MeasurementControl message, a Paging message, or a System Information block (SIB) message. In this way, the content of the first cell reselection configuration message received by the communication device UE**1** can be different from that received by the communication device UE**2** if both of the first cell reselection configuration messages are implemented by RRCConnectionRelease messages, while the content of the first cell reselection configuration message received by the communication device UE**1** is identical to that received by the communication device UE**2** if both of the first cell reselection configuration messages are implemented by SIB messages. That is to say, the at least one cell reselection rule and the at least one cell reselection threshold, and the at least one cell reselection value corresponding to different communication devices (e.g., the communication devices UE**1** and UE**2**) differ.

In addition, $Value_{Capability}$ may be presented as 0 or 1 for supporting or not supporting different features. For example, when the base station **110** supports the MIMO and CA rather than the higher order modulation, $Value_{Capability}$ may be 110—namely, the first "1" is for the MIMO supporting, the second "1" is for the CA supporting, and the last "0" is for the higher order modulation supporting. If $Threshold_{Capability}$ demands **101** in order to ensure the MIMO and higher order modulation support, the capability cell reselection rule, which requires the bit string **110** of $Value_{Capability}$ to be mapping or compared with the bit string **101** of $Threshold_{Capability}$ "bit by bit", is not satisfied. In another example, it is the decimal value (i.e., 7) of the bit string **110** of $Value_{Capability}$ that is compared with the decimal value (i.e., 5) of the bit string **101** of $Threshold_{Capability}$. Since 7 is larger than 5, the capability cell reselection rule (i.e., $Value_{Capability} < Threshold_{Capability}$) is not satisfied. In such a situation, the most indispensable feature is arranged in the beginning of the bit string, and the most insignificant feature is arranged in the end of the bit string. In another example, the at least one cell reselection rule further includes a MIMO capability cell reselection rule, a CA capability cell reselection rule, and a higher order modulation capability cell reselection rule. Therefore, the binary number 1 of $Value_{Capability}$ is compared with the binary number 1 of $Value_{Capability}$ to check whether the MIMO capability cell reselection rule is satisfied; the binary number 1 of $Value_{Capability}$ is compared with the binary number 0 of $Value_{Capability}$ to check whether the CA capability cell reselection rule is satisfied; the binary number 0 of $Value_{Capability}$ is compared with the binary number 1 of $Value_{Capability}$ to check whether the higher order modulation capability cell reselection rule is satisfied.

Furthermore, when the at least one cell reselection value of the corresponding cell (e.g., one of the cells **100***c* to **120***c*)

is provided in the corresponding second cell reselection information message broadcasted from the corresponding cell (e.g., in Step **308**), the at least one cell reselection value of the corresponding cell may differ from the at least one cell reselection value of the other cells. And the at least one cell reselection value is determined according to the corresponding cell, the corresponding base station or communication devices. In another embodiment, the at least one cell reselection threshold of the corresponding cell (e.g., one of the cells **100***c* to **120***c*) instead of the at least one cell reselection value may be provided in the corresponding second cell reselection information message broadcasted from the corresponding cell. In such a situation, the at least one cell reselection threshold of the corresponding cell is defined as the at least one cell reselection value mentioned above according to the corresponding cell, the corresponding base station or communication devices, and may differ from the at least one cell reselection threshold of the corresponding cell of the other cells. It is worth noting that the process **30** is adapted for not only the communication device UE**1** but also the communication device UE**2**.

Steps utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection may also vary. For example, FIG. **4** is a flowchart illustrating a process **40** according to an embodiment of the present invention. The process **40** may be compiled into the program code **214** of the communication device UE**1** and includes the following steps:

Step **400**: Start.

Step **402**: Receive a first cell reselection configuration message from the cell **100***c*, wherein the first cell reselection configuration message includes at least one cell reselection rule, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule.

Step **404**: Enter idle mode.

Step **406**: Determine whether the cells **110***c* and **120***c* fulfill a cell selection criterion S when the communication device UE**1** in idle mode attempts to perform cell reselection.

Step **408**: Receive second cell reselection information messages broadcasted from the cells **110***c* and **120***c*, wherein each of the second cell reselection information messages includes at least one cell reselection threshold.

Step **410**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection information messages, wherein the communication device UE**1** generates at least one cell reselection value randomly, and compares each of the at least one cell reselection threshold corresponding to one of the cells **110***c* and **120***c* with the at least one cell reselection value to determine which of the at least one cell reselection rule is satisfied.

Step **412**: Rank the cells **110***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **414**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **416**: End.

The structure of the process **40** is similar to that of the process **30**—particularly, Steps **404** to **406** are identical to Steps **304** to **306**, and Steps **412** to **414** and Steps **312** to **314** are identical. However, unlike the process **30**, the base stations **100** to **120** and the controller CT merely interact with each other to determine or update the at least one cell reselection rule (for example, $Value_{Constant}$<$Threshold_{Constant}$) via the cell reselection information maintenance message in Step **402**, and hence the first cell reselection configuration message transmitted from the serving cell **100***c* merely includes the at least one cell reselection rule in Step **402**. Instead of the at least one cell reselection value, the second cell reselection information messages broadcasted from its neighbor cells **110***c* and **120***c* to the communication device UE**1** in idle mode includes the at least one cell reselection threshold (for example, $Threshold_{Constant}$) in Step **408**. According to the second cell reselection information message broadcasted from the cell **110***c*, $Threshold_{Constant}$ is configured as, for example, 0.5. According to the second cell reselection information message broadcasted from the cell **120***c*, $Threshold_{Constant}$ is configured as, for example, 0.8. The communication device UE**1** then generates the at least one cell reselection value randomly in Step **410**—for example, $Value_{Constant}$ equals 0.65. After comparing $Value_{Constant}$ with $Threshold_{Constant}$ corresponding to the cell **110***c* and $Value_{Constant}$ with $Threshold_{Constant}$ corresponding to the cell **120***c*, the communication device UE**1** determines that only $Threshold_{Constant}$ corresponding to the cell **120***c* satisfies $Value_{Constant}$<$Threshold_{Constant}$ in Step **410**. Subsequently, the communication device UE**1** may choose the cell **120***c* to perform cell reselection according to the rule ranking list in Step **414**. However, if $Value_{Constant}$ generated by the communication device UE**1** is 0.45, the communication device UE**1** may select the cell with better signal strength or signal quality from the cells **110***c* and **120***c*.

FIG. **5** is a flowchart illustrating a process **50** according to an embodiment of the present invention. The process **50**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **500**: Start.

Step **502**: Receive a first cell reselection configuration message from the cell **100***c*, wherein the first cell reselection configuration message includes at least one cell reselection rule, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule.

Step **504**: Enter idle mode.

Step **506**: Determine whether the cells **110***c* and **120***c* fulfill a cell selection criterion S when the communication device UE**1** in idle mode attempts to perform cell reselection, wherein the cells **110***c* and **120***c* are operated on the same frequency, and the signal strength or signal quality of the cell **110***c* is better than that of the cell **120***c*.

Step **508**: Receive a second cell reselection information message broadcasted from the cell **110***c* with better signal strength or signal quality, wherein the second cell reselection information message includes at least one cell reselection threshold corresponding to both the cells **110***c* and **120***c*.

Step **510**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection information messages, wherein the communication device UE**1** generates at least one cell reselection value randomly, and compares each of the at least one cell reselection threshold corresponding to one of the cells **110***c* and **120***c* with the at least one cell reselection value to determine which of the at least one cell reselection rule is satisfied.

Step **512**: Rank the cells **110***c* and **120***c* according to the number of the at least one cell reselection rule satisfied and the signal strength or signal quality of the cells **110***c* and **120***c* in order to generate a rule ranking list.

Step **514**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list, such that cell reselec-

tion (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **516**: End.

The structure of the process **50** is similar to that of the process **40**—particularly, Steps **502** to **506**, **510** and **514** are identical to Steps **402** to **406**, **410** and **414**. However, unlike the process **40**, it is assumed that the cells **110***c* and **120***c* are operated on the same frequency, and the signal strength or signal quality of the cell **110***c* is better than that of the cell **120***c*. Therefore, the communication device UE**1** receives the second cell reselection information message broadcasted merely from the cell **110***c* with better signal strength or signal quality in Step **508**, but the second cell reselection information message would include the at least one cell reselection threshold corresponding to both the neighbor cells **110***c* and **120***c*. For example, $Threshold_{Constant}$ corresponding to the cells **110***c* and **120***c* is configured as 0.5 and 0.8 respectively. If $Value_{Constant}$ generated by the communication device UE**1** randomly in Step **510** equals 0.45, the communication device UE**1** at first merely verify whether $Threshold_{Constant}$ corresponding to the cell **110***c* complies with $Value_{Constant}<Threshold_{Constant}$ because the signal strength or signal quality of the cell **110***c* is better. Since $Value_{Constant}<Threshold_{Constant}$ is satisfied, the communication device UE**1** in Step **514** would choose the cell **110***c* to perform cell reselection. However, if $Value_{Constant}$ generated by the communication device UE**1** randomly in Step **510** is larger than 0.5, the communication device UE**1** would then compares $Threshold_{Constant}$ corresponding to the cell **120***c* of lower signal strength or signal quality with $Value_{Constant}$, since $Threshold_{Constant}$ corresponding to the cell **110***c* with better signal strength or signal quality fails to comply with $Value_{Constant}<Threshold_{Constant}$. If $Threshold_{Constant}$ corresponding to the cell **120***c* does not comply with $Value_{Constant}<Threshold_{Constant}$, the communication device UE**1** would scan for cells operated on the frequency of lower frequency priority. That is to say, the communication device UE**1** selects one of the cells **110***c* and **120***c* to camp on not only according to signal strength or signal quality but also according to whether the at least one cell reselection rule is satisfied in Step **512**. However, the present invention is not limited to this, and the communication device UE**1** receives the second cell reselection information message broadcasted merely from the cell **110***c* in Step **508** because the frequency priority of the cell **110***c* is higher than that of the cell **120***c*. Furthermore, the communication device UE**1** may select one of the cells **110***c* and **120***c* to camp on according to frequency priority and according to whether the at least one cell reselection rule is satisfied in Step **512**.

FIG. **6** is a flowchart illustrating a process **60** according to an embodiment of the present invention. The process **60**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **600**: Start.

Step **602**: Receive a first cell reselection configuration message from the cell **100***c*, wherein the first cell reselection configuration message includes the at least one cell reselection rule, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule.

Step **604**: Enter idle mode.

Step **606**: Determine whether the cells **110***c* and **120***c* fulfill a cell selection criterion S when the communication device UE**1** in idle mode attempts to perform cell reselection, wherein the signal strength or signal quality of the cell **110***c* is better than that of the cell **120***c*.

Step **608**: Receive a first cell reselection information message broadcasted from the cell **100***c*, wherein the first cell reselection information message includes a neighboring cell list and at least one cell reselection threshold corresponding to both the cells **110***c* and **120***c*.

Step **610**: Check whether the at least one cell reselection rule is satisfied according to the first cell reselection information messages, wherein the communication device UE**1** generates at least one cell reselection value randomly, and compares each of the at least one cell reselection threshold corresponding to one of the cells **110***c* and **120***c* with the at least one cell reselection value to determine which of the at least one cell reselection rule is satisfied.

Step **612**: Rank the cells **110***c* and **120***c* according to the number of the at least one cell reselection rule satisfied and the signal strength or signal quality of the cells **110***c* and **120***c* in order to generate a rule ranking list.

Step **614**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **616**: End.

The structure of the process **60** is similar to that of the process **50**—particularly, Steps **602** to **606**, **612** and **614** are identical to Steps **502** to **506**, **512** and **514**. However, unlike the process **50**, the cells **110***c* and **120***c* may not be operated on the same frequency, although the signal strength or signal quality of the cell **110***c* is still assumed to be better than that of the cell **120***c*. Moreover, in Step **608**, the communication device UE**1** in idle mode receives the first cell reselection information message broadcasted from the camped cell **100***c*, which was the serving cell **100***c* before the communication device UE**1** released to idle mode in Step **604**. It is worth noting that the camped cell **100***c* may be a suitable cell. The first cell reselection information message includes the neighboring cell list, which includes for example the neighbor cells **110***c* and **120***c*, and the at least one cell reselection threshold corresponding to both the neighbor cells **110***c* and **120***c*. For example, $Threshold_{Constant}$ corresponding to the cells **110***c* and **120***c* is configured as 0.5 and 0.8 respectively. If $Value_{Constant}$ generated by the communication device UE**1** randomly in Step **610** equals 0.65, the communication device UE**1** first verify whether $Threshold_{Constant}$ corresponding to the cell **110***c* complies with $Value_{Constant}<Threshold_{Constant}$ because the signal strength or signal quality of the cell **110***c* is better. Since $Value_{Constant}<Threshold_{Constant}$ is not satisfied, the communication device UE**1** is not allowed to camp on the cell **110***c*. The communication device UE**1** would then compare $Threshold_{Constant}$ corresponding to the cell **120***c* of lower signal strength or signal quality with $Value_{Constant}$. If $Threshold_{Constant}$ corresponding to the cell **120***c* does not comply with $Value_{Constant}<Threshold_{Constant}$, the communication device UE**1** would scan for other cells, which are operated on the frequency of lower frequency priority and fulfill the cell selection criterion S. In another embodiment, the neighboring cell list and the at least one cell reselection threshold corresponding to the cells **110***c* and **120***c* is sent in the first cell reselection configuration message from the serving cell **100***c* to the communication device UE**1** in Step **602**; for this reason, the first cell reselection information message broadcasted in Step **608** may be omitted. In another embodiment, the first cell reselection information message or the first cell reselection configuration message includes at least one of the neighboring cell list, the at least one cell reselection rule corresponding to the neighbor cells **110***c* and **120***c*, the at least one cell reselection threshold correspond-

ing to the neighbor cells **110***c* and **120***c*, and the at least one cell reselection value corresponding to the neighbor cells **110***c* and **120***c*.

FIG. **7** is a flowchart illustrating a process **70** according to an embodiment of the present invention. The process **70**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **700**: Start.

Step **702**: Receive a first cell reselection configuration message from the cell **100***c*, wherein the first cell reselection configuration message includes the at least one cell reselection rule, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule.

Step **704**: Enter idle mode.

Step **706**: Determine whether the cells **110***c* and **120***c* fulfill a cell selection criterion S when the communication device UE**1** in idle mode attempts to perform cell reselection.

Step **708**: Receive a first cell reselection information message broadcasted from the cell **100***c*, wherein the first cell reselection information message includes a neighboring cell list and at least one cell reselection threshold corresponding to both the cells **110***c* and **120***c*.

Step **710**: Check whether the at least one cell reselection rule is satisfied according to the first cell reselection information messages, wherein the communication device UE**1** generates at least one cell reselection value randomly, calculates intervals corresponding to the cells **110***c* and **120***c* according to the at least one cell reselection threshold, and determines which interval the at least one cell reselection value is bounded in, wherein the communication device UE**1** compares each of the at least one cell reselection threshold corresponding to one of the cells **110***c* and **120***c* with the at least one cell reselection value to determine which of the at least one cell reselection rule is satisfied.

Step **712**: Rank the cells **110***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **714**: Select one of the cells **110***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **716**: End.

The structure of the process **70** is similar to that of the process **60**—particularly, Steps **702** to **708** and **714** are identical to Steps **602** to **608** and **614**. However, unlike the process **60**, the signal strength or signal quality of the cells **110***c* and **120***c* is not that critical. And the main difference between the processes **60** and **70** is that the communication device UE**1** would calculate intervals corresponding to the cells **110***c* and **120***c* according to the at least one cell reselection threshold and determines which interval the at least one cell reselection value is bounded in. For example, $\text{Threshold}_{Constant}$ corresponding to the cells **110***c* and **120***c* is configured as 0.2 and 0.3 respectively, and both the neighbor cells **110***c* and **120***c* fulfill a cell selection criterion S. The communication device UE**1** first normalizes $\text{Threshold}_{Constant}$ corresponding to the cells **110***c* and **120***c*. Here the normalize $\text{Threshold}_{Constant}$ corresponding to the cells **110***c* and **120***c* becomes

$$\frac{0.2}{0.2+0.3}=0.4 \text{ and } \frac{0.3}{0.2+0.3}=0.6$$

respectively, which means $\text{Threshold}_{Constant}$ can be presented as a probability. The communication device UE**1** then determines intervals corresponding to the cells **110***c* and **120***c* to be (0, 0.4] and (0.4, 1] respectively according to the normalize $\text{Threshold}_{Constant}$ in Step **710**, which means $\text{Threshold}_{Constant}$ can be presented as an interval such as "from 0 to 0.4" and "from 0.4 to 1". If $\text{Value}_{Constant}$ generated by the communication device UE**1** randomly in Step **710** is larger than 0.4, the communication device UE**1** would choose the cell **120***c* to perform cell reselection in Step **714** because $\text{Value}_{Constant}$ falls within the interval (0.4, 1]. In another embodiment, the neighboring cell list and the at least one cell reselection threshold corresponding to the cells **110***c* and **120***c* is sent in the first cell reselection configuration message from the serving cell **100***c* to the communication device UE**1** in Step **702**; for this reason, the first cell reselection information message broadcasted in Step **708** may be omitted. In another embodiment, after the communication device UE**1** generates at least one cell reselection value randomly in step **610**, the communication device UE**1** may calculate intervals corresponding to the cells **110***c* and **120***c* according to the at least one cell reselection threshold as in step **710** to determine which of the at least one cell reselection rule is satisfied.

On the other hand, the communication device UE**1** may find that no cell satisfies any of the at least one cell reselection rule in Steps **310**, **410**, **510**, **610**, or **710**—namely, neither the cell **110***c* or the cell **120***c* satisfies any of the at least one cell reselection rule. To prevent the communication device UE**1** from having no cell to camp on, the communication device UE**1** selects one of the cells **110***c* and **120***c* to camp on according to a default frequency instead of executing Steps **312** to **314**, **412** to **414**, **512** to **514**, **612** to **614**, or **712** to **714** when none of the at least one cell reselection rule is satisfied by the cell **110***c* or **120***c*. Similarly, in another embodiment, the communication device UE**1** selects one of the cells **110***c* and **120***c* to camp on according to the frequency priorities of the cells **110***c* and **120***c* when none of the at least one cell reselection rule is satisfied by the cell **110***c* or **120***c* and when the cells **110***c* and **120***c* are operated on the default frequency.

Normally, the communication device UE**1** performs cell reselection as the aforementioned processes **30** to **70**. However, the communication device UE**1** may encounter an exceptional scenario when the communication device UE**1** is not capable of performing cell reselection according to a frequency list, at least one cell reselection rule or a default frequency, when the at least one cell reselection threshold or the at least one cell reselection value received by the communication device UE**1** does not match the at least one cell reselection rule stored in the communication device UE**1**, or when a rule validity timer of the at least one cell reselection rule, a threshold validity timer of the at least one cell reselection threshold or a value validity timer of the at least one cell reselection value is expired. The rule validity timer, the threshold validity timer or the value validity timer is activated when the communication device UE**1** receives the rule validity timer, the threshold validity timer or the value validity timer, but not limited thereto. To solve this problem, FIG. **8** is a flowchart illustrating a process **80** according to an embodiment of the present invention. The process **80**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **800**: Start.

Step **802**: Select, for example, the cell **120***c* from the cells **100***c* to **120***c* to camp on according to the default frequency or the frequency list when the exceptional scenario occurs.

Step **804**: Enter connected mode.

Step **806**: Transmit a communication device report message to the cell **120***c* in order to make the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value adjusted by the network nodes, wherein the communication device report message includes cell information stored in the communication device UE**1**.

Step **808**: Receive a second cell reselection configuration message corresponding to the communication device report message from the cell **120***c* to update at least one cell reselection rule, at least one cell reselection threshold or at least one cell reselection value, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value.

Step **810**: Enter idle mode.

Step **812**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection configuration message.

Step **814**: Rank the cells **100***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **816**: Select one of the cells **100***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **818**: End.

Namely, when the exceptional scenario occurs, the communication device UE**1** selects the cell **120***c* from the cells **100***c* to **120***c* to camp on according to the default frequency or the frequency list received in the first cell reselection configuration message, the first cell reselection information message or the second cell reselection information messages in Step **802** without checking whether the at least one cell reselection rule is satisfied. The RRC connection establishment such as an establishment cause may be trigger, and the communication device UE**1** may enter connected mode in Step **804**. The communication device UE**1** then transmits the communication device report message to the cell **120***c* in Step **806**. The communication device report message includes cell information stored in the communication device UE**1** such as a blacklist or a cell ID plus frequency. The blacklist and the cell ID plus frequency may correspond to the cell that the communication device UE**1** cannot camp on because the at least one cell reselection rule are not satisfied. Furthermore, The communication device report message may also include at least one of an indicator of exceptional scenario, a UE ID, an establishment cause, at least one cell reselection rule, at least one cell reselection threshold, at least one cell reselection value, a rule validity timer, a threshold validity timer, a value validity timer, and a frequency list, and may be implemented by a new message distinct from the prior art, a MeasurementReport message, an RRCConnectionRequest message, or an RRCConnectionSetupComplete message.

After the cell **120***c* receives the communication device report message, the base stations **100** to **120** and the controller CT interact with each other to determine or update the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value via the cell reselection information maintenance message in Step **808**. For example, the base station **120** instructs the controller CT to adjust the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value. The controller CT transmits the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value to the base stations **100** and **110**. The base stations **100** and **110** then updates the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value. According to Step **808**, the cell **120***c* responds to the communication device UE**1** with the second cell reselection configuration message, such that the communication device UE**1** can update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value reassigned. The communication device UE**1** then enters idle mode, and checks whether the at least one cell reselection rule is satisfied in order to find a cell to camp on in Steps **812** to **816**. The mechanism of Steps **812** to **816** is similar to that of the Steps **310** to **314**, and the similar parts are not detailed redundantly. Additionally, the communication device UE**1** may release the blacklist such as the cell ID plus frequency when the communication device UE**1** reselects a cell successfully, when the communication device UE**1** enters connected mode, or when the rule validity timer, the threshold validity timer, or the value validity timer expires.

FIG. **9** is a flowchart illustrating a process **90** according to an embodiment of the present invention. The process **90**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **900**: Start.

Step **902**: Select, for example, the cell **120***c* from the cells **100***c* to **120***c* to camp on according to the default frequency without entering connected mode when the exceptional scenario occurs.

Step **904**: Transmit a random access preamble to the cell **120***c*.

Step **906**: Receive a random access response from the cell **120***c*.

Step **908**: Transmit a communication device report message to the cell **120***c* in order to make the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value adjusted by the network nodes, wherein the communication device report message includes cell information stored in the communication device UE**1**.

Step **910**: Receive a second cell reselection configuration message corresponding to the communication device report message from the cell **120***c* to update at least one cell reselection rule, at least one cell reselection threshold or at least one cell reselection value, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value.

Step **912**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection configuration message.

Step **914**: Rank the cells **100***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **916**: Select one of the cells **100***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **918**: End.

The structure of the process **90** is similar to that of the process **80**—particularly, Steps **908** to **910** are identical to Steps **806** to **808**, and Steps **912** to **916** and Steps **812** to **816** are identical. However, unlike the process **80**, the communication device UE**1** does not enter connected mode when camping on the cell **120***c* in Step **902**. And after the communication device UE**1** transmits the random access preamble to the cell **120***c*, it waits for the random access response in return.

FIG. **10** is a flowchart illustrating a process **1** according to an embodiment of the present invention. The process **1**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **1000**: Start.

Step **1002**: Select, for example, the cell **120***c* from the cells **100***c* to **120***c* to camp on according to the default frequency without entering connected mode when the exceptional scenario occurs.

Step **1004**: Transmit an event report message to the cell **120***c* in order to make the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value adjusted by the network nodes, wherein the event report message is configured to indicate the communication device UE**1** has no cell to camp on.

Step **1006**: Receive an event response message corresponding to the event report message from the cell **120***c* to update at least one cell reselection rule, at least one cell reselection threshold or at least one cell reselection value, wherein a cell reselection information maintenance message is transmitted between the network nodes to update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value.

Step **1008**: Check whether the at least one cell reselection rule is satisfied according to the second cell reselection configuration message.

Step **1010**: Rank the cells **100***c* and **120***c* according to the number of the at least one cell reselection rule satisfied in order to generate a rule ranking list.

Step **1012**: Select one of the cells **100***c* and **120***c* to camp on according to the rule ranking list, such that cell reselection (to the chosen cell with a highest rule priority in the rule ranking list) can be performed.

Step **1014**: End.

The structure of the process **1** is similar to that of the process **80**—particularly, Steps **1008** to **1012** and Steps **812** to **816** are identical. However, unlike the process **80**, the communication device UE**1** does not enter connected mode when camping on the cell **120***c* in Step **1002**. And the communication device UE**1** transmits the event report message to the cell **120***c* in Step **1004**. The event report message is configured to inform the cell **120***c* that the communication device UE**1** has no cell to camp on, and may include at least one of an indicator of exceptional scenario, an indicator of the communication device UE**1** camping on, a UE ID, a Cell ID, and at least one cell reselection rule. The event report message is implemented by a new message distinct from the prior art; alternatively, the event report message may be implemented by a random access preamble as Step **904** to notify the base stations **100** to **120** and the controller CT that the communication device UE**1** has camped on the cell **120***c*. In this way, the base stations **100** to **120** and the controller CT may know the distribution of communication devices (e.g., the communication devices UE**1** and UE**2**) in idle mode, and the base stations **100** to **120** and the controller CT interact with each other not only to update the at least one cell reselection rule, the at least one cell reselection threshold and the at least one cell reselection value but also to balance the distribution of communication devices in idle mode. Later, the cell **120***c* responds to the communication device UE**1** with the event response message in step **1006**, such that the communication device UE**1** can update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value reassigned. The event response message may be implemented by a new message distinct from the prior art or a random access response as Step **906**, and may include at least one of at least one cell reselection rule, at least one cell reselection threshold, at least one cell reselection value, a rule validity timer, a threshold validity timer, a value validity timer, a default frequency, delta values of the at least one cell reselection threshold, and delta values of the at least one cell reselection value.

FIG. **11** is a flowchart illustrating a process **11** according to an embodiment of the present invention. The process **11**, which is utilized in the communication device UE**1** shown in FIG. **1** to handle cell reselection, may be compiled into the program code **214** and includes the following steps:

Step **1100**: Start.

Step **1102**: Flush cell information stored in the communication device UE**1** when the exceptional scenario occurs.

Step **1104**: Perform cell reselection according to the frequency list.

Step **1106**: End.

When the exceptional scenario occurs, the communication device UE**1** may flush the cell information stored in it according to Step **1102**. The cell information stored in the communication device UE**1** may include a blacklist or a cell ID plus frequency. In an embodiment, the communication device UE**1** in step **1104** performs cell reselection according to the frequency list and the at least one cell reselection rule. In another embodiment, the communication device UE**1** in step **1104** performs cell reselection according to the frequency list but ignores the at least one cell reselection rule. Particularly, the communication device UE**1** may ignore the at least one cell reselection rule when at least one cell reselection value or at least one cell reselection threshold corresponding to the at least one cell reselection rule has not been obtained from the network nodes yet or is not applicable to the at least one cell reselection rule, causing that the at least one cell reselection rule cannot be satisfied.

In the prior art, communication devices in connected mode tend to gather at the frequency with the highest frequency priority. Even network nodes handover some of the communication devices in connected mode toward frequency with the lower frequency priority, the communication devices released to idle mode would return to the frequency with the highest frequency priority when the communication devices in idle mode reconnects. And the network nodes cannot change the frequency list or the frequency priorities stored in the communication devices in idle mode before the communication devices enter connected mode. The action of load balancing thus becomes a burden on the network nodes.

By comparison, a communication device of the present invention would receive a first cell reselection information message broadcasted from its camped cell or second cell reselection information messages broadcasted from neighbor cells after the communication device enters idle mode.

Together with a first cell reselection configuration message transmitted from the serving cell (i.e., the camped cell) of the communication device in connected mode, the communication device can determine whether at least one cell reselection rule is satisfied to choose a cell for cell reselection. Since the contents of the first cell reselection configuration message, the first cell reselection information message, and the second cell reselection information messages are frequently or regularly updated, the distribution of communication devices can be preserved, redistributed or even equalized to achieve load balancing.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A method of handling cell reselection, adapted to a communication device of a communication system, comprising:

receiving a first cell reselection configuration message from a first cell of the communication system, wherein the first cell reselection configuration message comprises at least one cell reselection rule;

checking whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list ranking a plurality of second cells; and

selecting one of the plurality of second cells of the communication system to camp on according to the rule ranking list,

wherein the step of selecting one of the plurality of second cells to camp on according to the rule ranking list comprises:

selecting a plurality of rule candidates with a highest rule priority from the plurality of second cells according to the rule ranking list;

ranking the plurality of rule candidates according to frequency priorities of the plurality of rule candidates in order to generate a frequency ranking list;

ranking a plurality of frequency candidates according to signal strength or signal quality in order to generate a signal ranking list, wherein the plurality of frequency candidates are selected from the plurality of rule candidates according to frequency priorities of the plurality of rule candidates, wherein the frequency priorities of the plurality of frequency candidates are the same and highest; and

selecting one of the plurality of second cells to camp on according to the frequency ranking list or the signal ranking list.

2. The method of claim **1**, wherein a cell reselection information maintenance message is transmitted between a plurality of network nodes to update the at least one cell reselection rule, at least one cell reselection threshold or at least one cell reselection value, wherein the plurality of network nodes comprise at least one base station corresponding to the first cell or the plurality of second cells, a server, a controller, and a database.

3. The method of claim **2**, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a first cell reselection information message broadcasted from the first cell, wherein the first cell reselection information message comprises the at least one cell reselection threshold corresponding to the plurality of second cells and a neighboring cell list corresponding to the plurality of second cells;

generating the at least one cell reselection value; and

comparing each of the at least one cell reselection threshold corresponding to one of the plurality of second cells with the at least one cell reselection value in order to determine which of the at least one cell reselection rule is satisfied,

wherein the first cell is a serving cell of the communication device.

4. The method of claim **2**, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a first cell reselection information message broadcasted from the first cell, wherein the first cell reselection information message comprises the at least one cell reselection threshold corresponding to the plurality of second cells and a neighboring cell list corresponding to the plurality of second cells;

calculating a plurality of intervals each corresponding to one of the plurality of second cells according to the at least one cell reselection threshold;

generating the at least one cell reselection value; and

determining which of the plurality of intervals the at least one cell reselection value is bounded in in order to determine which of the at least one cell reselection rule is satisfied,

wherein the first cell is a serving cell of the communication device.

5. The method of claim **2**, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a second cell reselection information message broadcasted from one of the plurality of second cells, wherein the second cell reselection information message comprises the at least one cell reselection threshold corresponding to the plurality of second cells, wherein the second cell broadcasting the second cell reselection information message has a better signal strength or signal quality or higher frequency priority;

generating the at least one cell reselection value; and

comparing each of the at least one cell reselection threshold corresponding to one of the plurality of second cells with the at least one cell reselection value in order to determine which of the at least one cell reselection rule is satisfied.

6. The method of claim **2**, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a second cell reselection information message broadcasted from one of the plurality of second cells, wherein the second cell reselection information message comprises the at least one cell reselection threshold corresponding to the plurality of second cells, wherein the second cell broadcasting the second cell reselection information message has a better signal strength or signal quality or higher frequency priority;

calculating a plurality of intervals each corresponding to one of the plurality of second cells according to the at least one cell reselection threshold;

generating the at least one cell reselection value; and

determining which of the plurality of intervals the at least one cell reselection value is bounded in in order to determine which of the at least one cell reselection rule is satisfied.

7. The method of claim 2, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a plurality of second cell reselection information messages broadcasted from the plurality of second cells, wherein the plurality of second cell reselection information messages comprises the at least one cell reselection value respectively; and

comparing each of the at least one cell reselection value corresponding to one of the plurality of second cells with the at least one cell reselection threshold in order to determine which of the at least one cell reselection rule is satisfied,

wherein the first cell reselection configuration message further comprises the at least one cell reselection threshold.

8. The method of claim 2, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

receiving a plurality of second cell reselection information messages broadcasted from the plurality of second cells, wherein the plurality of second cell reselection information messages comprises the at least one cell reselection threshold respectively; and

generating the at least one cell reselection value; and

comparing each of the at least one cell reselection threshold corresponding to one of the plurality of second cells with the at least one cell reselection value in order to determine which of the at least one cell reselection rule is satisfied.

9. The method of claim 1, wherein the at least one cell reselection rule comprises at least one of a loading cell reselection rule, a capability cell reselection rule, a mobility cell reselection rule, a subscriber class cell reselection rule, a signal cell reselection rule and a constant cell reselection rule.

10. The method of claim 2, wherein the at least one cell reselection threshold comprises at least one of a loading cell reselection threshold, a capability cell reselection threshold, a mobility cell reselection threshold, a subscriber class cell reselection threshold, a signal cell reselection threshold and a constant cell reselection threshold, wherein the at least one cell reselection value comprises at least one of a loading cell reselection value, a capability cell reselection value, a mobility cell reselection value, a subscriber class cell reselection value, a signal cell reselection value and a constant cell reselection value.

11. The method of claim 1, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

ranking the plurality of second cells according to signal strength or signal quality in order to generate a signal ranking list; and

checking whether the at least one cell reselection rule is satisfied in an order of the signal ranking list in order to generate the rule ranking list.

12. The method of claim 1, wherein the step of checking whether the at least one cell reselection rule is satisfied in order to generate the rule ranking list comprises:

ranking the plurality of second cells according to a number of the at least one cell reselection rule satisfied in order to generate the rule ranking list.

13. The method of claim 1, further comprising:

selecting one of the plurality of second cells to camp on according to a default frequency when none of the at least one cell reselection rule is satisfied, and

selecting one of the plurality of second cells to camp on according to frequency priorities of the plurality of second cells when none of the at least one cell reselection rule is satisfied and when none of the plurality of second cells is operated on the default frequency.

14. The method of claim 2, wherein the first cell reselection configuration message or a first cell reselection information message or the plurality of second cell reselection information messages comprises at least one of a default frequency, a frequency list, a rule validity timer of the at least one cell reselection rule, a threshold validity timer of the at least one cell reselection threshold and a value validity timer of the at least one cell reselection value.

15. The method of claim 14, wherein an exceptional scenario occurs when the communication device is not capable of performing cell reselection according to the frequency list, the at least one cell reselection rule or the default frequency, when the rule validity timer, the threshold validity timer or the value validity timer is expired, or when the at least one cell reselection threshold or the at least one cell reselection value received by the communication device does not match the at least one cell reselection rule stored in the communication device.

16. The method of claim 15, wherein the rule validity timer, the threshold validity timer or the value validity timer is activated when the communication device receives the rule validity timer, the threshold validity timer or the value validity timer.

17. The method of claim 15, further comprising:

selecting a fourth cell to camp on from the first cell and the plurality of second cells according to the default frequency or the frequency list when the exceptional scenario occurs;

transmitting a communication device report message or an event report message to the fourth cell in order to make the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value adjusted by the plurality of network nodes; and

receiving a second cell reselection configuration message corresponding to the communication device report message or an event response message corresponding to the event report message from the fourth cell to update the at least one cell reselection rule, the at least one cell reselection threshold or the at least one cell reselection value;

wherein the communication device report message comprises cell information stored in the communication device, wherein the cell information comprises a blacklist or a cell ID plus frequency, wherein the event report message is configured to indicate the communication device has no cell to camp on.

18. The method of claim 17, wherein the communication device transmits the event report message without entering a connected mode.

19. The method of claim 15, further comprising:

flushing cell information stored in the communication device; and

performing cell reselection according to the frequency list or the default frequency.

20. The method of claim 17, wherein the cell information stored in the communication device is released when the communication device completes cell reselection, when the communication device enters a connected mode, or when the rule validity timer, the threshold validity timer or the value validity timer is expired.

21. A communication device, comprising:

a storage unit, configured to store a program code; and

a processing unit, configured to execute the program code to perform operations comprising:

receiving a first cell reselection configuration message from a first cell of the communication system, wherein the first cell reselection configuration message comprises at least one cell reselection rule;

checking whether the at least one cell reselection rule is satisfied in order to generate a rule ranking list ranking a plurality of second cells; and

selecting one of the plurality of second cells of the communication system to camp on according to the rule ranking list,

wherein selecting one of the plurality of second cells to camp on according to the rule ranking list comprises:

selecting a plurality of rule candidates with a highest rule priority from the plurality of second cells according to the rule ranking list;

ranking the plurality of rule candidates according to frequency priorities of the plurality of rule candidates in order to generate a frequency ranking list;

ranking a plurality of frequency candidates according to signal strength or signal quality in order to generate a signal ranking list, wherein the plurality of frequency candidates are selected from the plurality of rule candidates according to frequency priorities of the plurality of rule candidates, wherein the frequency priorities of the plurality of frequency candidates are the same and highest; and

selecting one of the plurality of second cells to camp on according to the frequency ranking list or the signal ranking list.

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