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(71) Applicant: **MEDIATEK INC.** [CN/CN]; No.1, Dusing Rd. 1st, Science-Based Industrial Park, Hsin-Chu, Taiwan 300 (CN).

(72) Inventors: **LIN, Shiang-Jiun**; No.78, Ln. 30, Sec. 1, Guangfu Rd., East Dist., Hsinchu City, Taiwan 300 (CN). **ZHANG, Yuanyuan**; 1203, Unit 2, Building 13, Fuli Taoyuan, Jiancaicheng Road, Xisanqi, Haidian Disctrict, Beijing 100096 (CN). **JOHANSSON, Per Johan Mikael**; Lillsjobacken 4, 19634 Kungsangen (SE).

(74) Agent: **BEIJING SANYOU INTELLECTUAL PROPERTY AGENCY LTD.**; 16th Fl., Block A, Corporate Square, No. 35 Jinrong Street, Beijing 100033 (CN).

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(54) Title: MECHANISM OF RLF HANDLING IN SMALL CELL NETWORKS

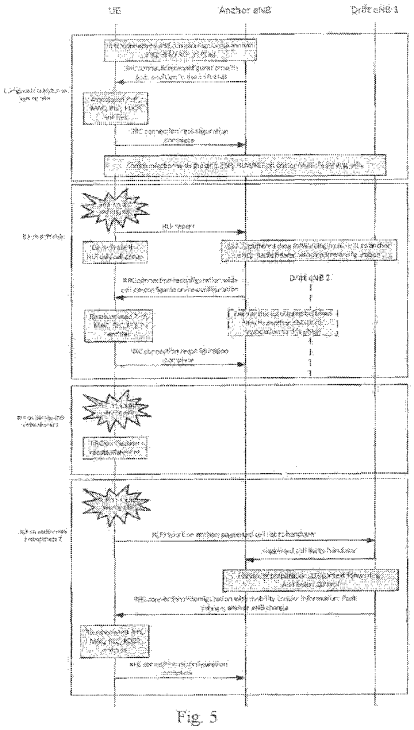

Fig. 5

(57) Abstract: A method of radio link monitoring (RLM) and radio link failure (RLF) handling over a small cell network is proposed. In a wireless network, a user equipment (UE) establishes a radio resource control (RRC) connection with a base station (eNB), which is UE anchor. The UE applies carrier aggregation for multiple component carriers (CCs) configured as multiple serving cells. The aggregated serving cells can be in the same eNB or in the other eNB, i.e., the drift eNB. The UE performs radio link monitoring over a primary serving cell (PCELL). The UE also performs radio link monitoring over a secondary serving cell (SCELL). The SCELL belongs to a cell group. When the radio link problem, i.e., RLF, happens in a serving cell, the UE and the eNB apply certain actions over the serving cell or all serving cells in the group. The RLF procedures in the anchor eNB and in the drift eNB are proposed. Both UE side and network side behaviors are included.

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MECHANISM OF RLF HANDLING IN SMALL CELL NETWORKS

TECHNICAL FIELD

[0001] The disclosed embodiments relate generally to wireless network communications, and, more particularly, to a mechanism of Radio Link failure (RLF) handling in small cell networks.

BACKGROUND

[0002] In cell networks, such as 3GPP Long-Term Evolution (LTE) networks, an evolved universal terrestrial radio access network (E-UTRAN) includes a plurality of base stations, e.g., evolved Node-Bs (eNBs) communicating with a plurality of mobile stations referred as user equipments (UEs). Radio link monitoring (RLM) is a mechanism for a UE to monitor the quality of a downlink (DL) for determining if the radio link is good enough to continue transmission. For example, the UE may monitor the DL quality based on cell-specific reference signal (CRS) to detect the downlink radio link quality for the serving cell. The UE may compare the estimated DL quality to thresholds Q_{OUT} and Q_{IN} for monitoring the downlink radio link quality of the serving cell.

[0003] In addition to RLM, the UE generally consider radio link failure (RLF) to be detected upon physical layer problems based on N310/N311/T310 mechanism, random access problem indication from MAC layer, and indication from RLC layer that the maximum number of retransmission has been reached. Once RLF is detected, the UE gathers and stores RLF information and attempts RRC connection reestablishment. If such attempt fails, the UE goes back to RRC_IDLE. The UE may indicate the availability of the RLF report to eNB and report the RLF information to eNB upon request after successful RRC connection reestablishment or RRC connection setup.

[0004] For Multicarrier system,two or more Component Carriers (CCs) are aggregated to support wider transmission bandwidth up to 100MHz. A UE with reception and/or transmission capabilities for CA can simultaneously receive and/or

transmit on multiple CCs corresponding to multiple serving cells. When carrier aggregation (CA) is configured, the UE has only one RRC connection with the network. At RRC connection establishment/reestablishment or handover, one serving cell provides the NAS mobility information. At RRC connection reestablishment or handover, one serving cell provides the security input. This cell is referred to as the primary serving cell (PCELL), and other cells are referred to as the secondary serving cells (SCELLs). Depending on UE capabilities, SCELLs can be configured to form together with the PCELL as a set of serving cells. PCELL can be changed with handover procedure (i.e. with security key change and RACH procedure). The reconfiguration, addition and removal of SCELLs can be performed by RRC. At intra-cell handover, such as intra-LTE handover,RRC can also add, remove, or reconfigure SCELLs for usage with the target PCELL. When adding a new SCELL, dedicated RRC signaling is used for sending all required system information of the SCELL i.e. while in connected mode, UEs need not acquire broadcasted system information directly from the SCELLs.

[0005] In current advanced telecommunication system, such as LTE Advanced system, radio link monitoring (RLM) and radio link failure (RLF) detection is only applied on PCELL, not on SCELLs. This is because cells are aggregated for the same eNB in some Carrier Aggregation System, i.e., intra-eNB carrier aggregation. In some of the intra-eNB CA mechanism, the PCELL and SCELL share the same scheduler which is located in an eNB. It is assumed that eNB can detect poor link quality of SCELL e.g. from Chanel Quality Indicator (CQI) reports and/or existing RRM measurement reports from PCELL.

[0006] In some adanced carrier aggregation system, besides the normal eNBs, the small eNBs with low transmission power and simplified protocol stacks/functionalities are introduced into E-UTRAN, which is so called small cell networks. The small cell architecture can be used to enhance the data throughput and to reduce the mobility signaling overhead. Instead of distributed operation, it is believed that the anchor based architecture is a promising architecture to be operated in the small cell network. The anchor should be from UE's point of view. A UE anchor is a point where the Core Network connection of the UE is terminated, that does not have to be relocated when the UE moves in a local area covered by cells of multiple base-stations.

[0007] Fig.1 is a diagram that illustrates UE anchor based system architecture 100

in a wireless communication system. As depicted in Fig.1, the UE anchor architecture of the system architecture may comprise at least part of the following principles:

- UE anchor is UE specific.
- UE anchor is housed in an eNB. This is the anchor eNB of the UE.
- UE anchor can be relocated to another eNB by handover.
- UE serving cell(s) can be controlled by an eNB that is different to the eNB housing the UE anchor. This is a drift eNB of the UE.
- When the UE is served by a drift eNB, the control of the UE and the user plane functionality is split between the anchor eNB and the drift eNB.
- Anchor – the drift concept is only applicable to UEs in connected mode.
- Handover into and out of a local area from/to other RAT or a legacy eNB shall be supported.

[0008] As illustrated in FIG. 1, since a drift eNB 103 and an anchor eNB 101may not be physically collocated, there should be transmission medium and interface in between the anchor eNB and the drift eNB. Assume X3 interface is introduced for communications between the anchor eNB and the drift eNB, such as anchor eNB 101 and the drift eNB 103 and drift eNB 104. From real deployment perspective, it can't always assume it exists the ideal backhaul connection, e.g., optical fiber, between the anchor eNB and the drift eNB. To avoid the backhaul delay and overhead due to the information exchange between the anchor eNB and the drift eNB and to improve the flexibility and efficiency of scheduling, the independent scheduler should be located in the drift eNB (assume the anchor eNB has its own scheduler originally). In that case, the protocol stack in the drift eNB should also at least include Physical layer and MAC layer. In some embodiments, the upper layer protocols, e.g., RLC and PDCP, may also locate in the drift eNB.

SUMMARY

[0009] Other embodiments and advantages are described in the detailed description below. This summary does not purport to define the invention. The invention is defined by the claims.

[0010] A method is provided, which comprises: establishing a radio resource control (RRC) connection by a user equipment (UE) with a Radio Access Network,

where the UE uses multiple component carriers (CCs) or Cells; monitoring the performance for several radio links, cells or groups of cells; and taking action when the performance of a radio link while a cell or a group of cells is low, e.g., radio link failure. In one embodiment, the UE uses the multiple component carriers (CCs) or Cells by carrier aggregation, and the component carriers or cells from a eNB are associated to a common MAC entity. In another embodiment, the serving cell on which radio link monitoring needs to be performed is configurable. The serving cell is in the status of activation and is one of the following: a reference cell that is used as pathloss reference and/or timing advance reference; the first activated serving cell in a cell group; a specific cell with configured PUCCH resource; a specific cell explicitly configured to perform RLM/RLF mechanism by the network.

[0011] In another embodiment, the cell group can be one of the following grouping methods: cell group with applying the same timing advance value; cell group referring to the same pathloss reference cell; cell group associated to a transmission point with co-located antennas; and/or cell group associated to a MAC entity.

BRIEF DESCRIPTION OF DRAWINGS

[0012] Other the accompanying drawings, where like numerals indicate like components, illustrate embodiments of the invention.

[0013] Fig.1 is a diagram that illustrates UE anchor based architecture in a wireless communication system 100.

[0014] Fig.2 is a diagram 200 that illustrates a procedure establishing a RRC connection to a radio access network in a wireless communication system in accordance with one novel aspect.

[0015] Fig.3 is a diagram 300 that configuration/usage of PHY modules in a small cell network is illustrated in accordance with one novel aspect.

[0016] Fig.4 is a diagram 400 that illustrates corresponding protocol stacks for each case in the network side and the UE side in a wireless communication system in accordance with one novel aspect.

[0017] Fig.5 is a diagram that summaries the procedure of RLF configuration, RLF reporting and RLF reaction in a wireless communication system in accordance with one novel aspect.

DETAILED DESCRIPTION

[0018] Certain terms are used throughout the description and following claims to refer to particular components. As one skilled in the art will appreciate, manufacturers may refer to a component by different names. This document does not intend to distinguish between components that differ in name but not function. In the following description and in the claims, the terms "include" and "comprise" are used in an open-ended fashion, and thus should be interpreted to mean "include, but not limited to ...". Also, the term "coupled" is intended to mean either an indirect or direct electrical connection. Accordingly, if one device is electrically connected to another device, that connection may be through a direct electrical connection, or through an indirect electrical connection via other devices and connections. Reference will now be made in detail to some embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the descriptions to refer the same or like parts.

[0019] In the current cell network system, radio link monitoring (RLM) and radio link failure (RLF) detection are only applied on PCELL, not on SCELLs. This is because in intra-eNB carrier aggregation, the PCELL and SCELL share the same scheduler which is located in an eNB. It is assumed that eNB can easily detect poor link quality of SCELL e.g. from Chanel Quality Indicator (CQI) reports and/or existing RRM measurement reports from other cells, e.g., PCELL.

[0020] In UE anchor based architecture, independent schedulers are located in the anchor eNB and the drift eNB. Since the impact of latency and overhead due to cell information exchange through the X3 interface is seriously concerned, the channel state information of each cell should be independently report to the corresponding eNB. The anchor eNB may not be in complete control of link qualities of cells in the drift eNB. The data transmissions, UE power consumption as well as UE experience will be influenced if the link failures in the drift eNB but unknown to the anchor eNB.

[0021] Fig.2 is a diagram that illustrates a procedure establishing a RRC connection to a radio access network in a wireless communication system 200 in accordance with one novel aspect. When a UE 203 establishes a radio resource control (RRC) to a radio access network, a primary cell(PCELL) will be configured to a UE, where the associated PHY, MAC, RLC and PDCP entities should be

established in the UE side, responsible for the control and data transmission/reception through the anchor eNB 201.

[0022] In the UE anchor based architecture, the cell addition/modification/release procedure in the drift eNB 202 can apply the same procedure as it in the carrier aggregation, i.e., PCELL change is through RRC connection reconfiguration with mobility control information and SCELL change is through RRC connection reconfiguration without mobility control information.

[0023] In the current UE architecture, a common MAC entity is equipped at a UE, where all serving cells configured to the UE will be associated to the common MAC entity. However, in the UE based architecture, since the channel qualities to the anchor and the drift eNBs may be uncorrelated, the independent HARQ processes to each eNB are expected. Besides, the scheduling policies of different eNBs may be independent. Thus, different PHY and MAC entities from those associated to the anchor eNB will be expected to associate with a drift eNB when a first cell in the drift eNB is configured to a UE. In other words, serving cells from a eNB will be associated to a common MAC entity and serving cells from different eNB will be associated to different MAC entity.

[0024] When a first cell in the drift eNB 202 is configured to UE 203, the corresponding PHY sublayer is initialized and one MAC entity, and/or RLC entities and PDCP entities should be established in the UE side, responsible for data transmission/reception through the drift eNB 202, where a new MAC entity should be enabled or to be set up corresponding to the serving cell. If a MAC entity is implemented by hardware, the functions of this MAC entity should be enabled and configured; if a MAC entity is implemented by software, the functions of this MAC entity should be added/configured.

[0025] As addressed in the previous section, since the independent scheduler is equipped in the drift eNB 202, the channel status report, e.g., CQI, PMI, RI, and so on, of the carriers in the drift eNB may be directly reported to the drift eNB. In that case, the anchor eNB 201 hardly knows the radio condition of the SCELLs in the drift eNB 202 for a specific UE if the drift eNB 202doesn't forward the channel quality information to the anchor eNB. Even if the drift eNB 202forwards such information to the anchor eNB 201, the anchor eNB can't respond to the deterioration of radio condition in the drift eNB 202 timely due to the backhaul latency. It is possible that the anchor eNB 201 still delivers/acquires data packets to/from the drift eNB 202

normally even the radio link on the drift eNB becomes too bad to perform reliable data transmission. The anchor eNB 201bcontinues forwarding the data uselessly until it is aware of the situation, since the data can't be scheduled by the drift eNB 202 due to the bad channel condition. From UE perspective, PDCCH monitoring, periodic CQI and SRS reporting will be performed normally on the SCELL until the SCELL is deactivated by the network, which is power wasting. RLM/RLF in at least one of the serving cells in the drift eNB can reduce the complexity of the network implementation and UE power consumption.

[0026] In the case of free multiplexing, i.e. the transmission path for each radio bearer can be selected dynamically based on the instantaneous channel and load conditions, it is possible that all the radio bears including DRBs, SRB1 and SRB2 are transmitted through the drift eNB for load balance. In this case, RLM/RLF should be done in at least one of the serving cells in the drift eNB, since the RRC connection is essentially maintained on the drift eNB.

[0027] In another case where the drift eNB is S1 connected to Serving Gateway, i.e., the data packets do not need to be forwarded from the anchor eNB, the RLM/RLF should also be done in at least one of the serving cells in the drift eNB so that the anchor eNB can do the radio bearer reconfiguration for the drift eNB if the radio link quality in the drift eNB is degraded.

[0028] Hence, considering the advantages and the usagee cases mentioned above, the configurable RLM/RLF handling is provided in this invention. In addition, RLF reporting and reaction after RLF report received by the network are proposed.

[0029] **Cell configuration in the small cell network:**

[0030] If a UE is equipped with multiple PHY modules/entities and is capable to support carrier aggregation and small cell operation, the possible configuration/usage of its PHY modules/entities in a small cell network can be illustrated in Fig.3. For example, for UE1, its multiple PHY modules are used to connect to one or multiple cells in the anchor eNB; for UE2, its PHY modules are connected to one or multiple cells in the drift eNB 302; For UE1 and UE2, since they perform intra-eNB carrier aggregation, one common MAC is configured to each of them. For UE3, its multiple PHY modules are used to one connect to anchor eNB 301 and the other connect to the drift eNB 302. Since the anchor eNB301 and the drift eNB 302 are not collocated, the independent MAC entities should be configured corresponding to different eNBs. For UE4, intra-eNB aggregation and the small cell operation are performed, where two

PHY modules are allocated to operate intra-eNB carrier aggregation, e.g., CA to the anchor eNB301, and the other PHY module is allocated for small cell operation, e.g., connection to the drift eNB 302. Intra-eNB carrier aggregation shares one MAC entity and small cell operation utilizes the other MAC entity. The corresponding protocol stacks for each case in the network side and the UE side can be illustrated in Fig.4. Fig.4 is a diagram 400 that illustrates corresponding protocol stacks for each case in the network side and the UE side in a wireless communication system in accordance with one novel aspect.

[0031] Based on the possible scenarios described in the previous section, the RLM/RLF configuration can be performed as follows.

[0032] **UE RLM on multiple cells: Configurable RLM/RLF**

[0033] According with one novel aspect, the RLM/RLF mechanism can be configured to one or more than one serving cell(s) within a cell group.

[0034] The RLM/RLF configured serving cell can be the first activated serving cell in a cell group, and the the serving cell could be one of the following cases; a serving cell configured with PUCCH resource in a cell group; a serving cell serving as timing advance reference cell and/or pathloss reference cell in a cell group; and or a specific cell explicitly configured by the network, where in the cell group can be one of following cases: cells in a timing advance group (TAG), a cell group associated to a transmission point, a cell group associated to a common MAC, and/or cells in a pathloss reference group.

[0035] Take TAG as an example,

[0036] Embodiment #1: The TAG can be discriminated by a transmission point, for example, the anchor eNB can configure serving cells in the anchor eNB form a TAG and serving cells in the drift eNB form another TAG.

[0037] Embodiment #2: When RLM/RLF is configured to the serving cells in a TAG, it can only be performed on those serving cells which are activated. The serving cell configured with RLM/RLF can't be de-activated if any other serving cell in the same group is kept activated.

[0038] According with another novel aspect, when a SCELL is activated, if the SCELL belonged group has no other cells being configured to perform RLM/RLF, the SCELL should be configured with RLM/RLF. If the SCELL is not the first cell activated in a group, the configuration of RLM/RLF on this cell can be decided by eNB. The group can be a timing advance group, a pathloss reference group, a cell

group associated to a transmission point and/or a cell group associated to a common MAC.

[0039] According with yet another novel aspect, in which serving cells the RLM/RLF needs to be performed can be configured implicitly based on the pre-defined rules or explicitly through RRC message.

[0040] Embodiment #1: The RLM/RLF can be implicitly configured and performed in a serving cell with configured PUCCH resource in a cell group.

[0041] Embodiment #2: The RLM/RLF can be implicitly configured and performed in the first activated serving cell in a cell group controlled by an eNB.

[0042] Embodiment #3: The RLM/RLF can be implicitly configured and performed in a serving cell, which can be used as reference e.g., pathloss reference, and/or timing advance reference.

[0043] Embodiment#4: The RLM/RLF can be explicitly configured and performed in a serving cell through RRC message.

[0044] Embodiment#5: Whether RLM/RLF need to be performed on the PCELL is also configurable.

[0045] According with yet another novel aspect, The values of constants and timers controlling the RLM/RLF on the serving cells, on which RLM/RLF is performed, should be configured by the network through RRC message.

[0046] Embodiment #1: The parameters for RLM/RLF constants and timers can be configured per UE, i.e. the UE applies the same values as PCELL for the constants and timers controlling the RLM/RLF on the SCELLs.

[0047] Embodiment #2: The parameters for RLM/RLF constants and timers can be configured per cell group, i.e. the network configures separate values for RLM/RLF constants and timers corresponding to the cell groups generated from the anchor eNB and the drift eNB respectively.

[0048] Embodiment #3: The parameters for RLM/RLF constants and timers can be configured per serving cell, i.e. the network configures separate values for RLM/RLF constants and timers for each serving cell, in which RLM/RLF will be performed.

[0049] According with yet another novel aspect, to support DL and UL transmissions in different eNBs, the RLM/RLF can be configured to different cells in different eNBs.

[0050] For example, if a UE's DL is through cell 1 in eNB1 and its UL is through

cell2 in eNB2, the DL RLM can be configured in cell1 in eNB1 and the UL radio link problem monitoring can be configured in cell2 in eNB2.

[0051] **Report of RLF message:**

[0052] According with one novel aspect, the channel state information of non-RLM/RLF serving cells in a cell group can be reported through any activated serving cell in the same cell group. eNB can deactivate/de-configure these poor link quality non-RLM/RLF serving cells before link failure occurs on these serving cells.

[0053] According with another novel aspect, if RLF happens in the serving cells where RLM/RLF is performed, the RLF message can be sent by the UE.

[0054] Embodiment #1: If the RLF happens in the drift eNB, the RLF report can be sent through the anchor eNB.

[0055] Embodiment #2: If the RLF happens in the drift eNB, the RLF report can be sent through other drift eNB with good link quality and UL resource. The drift eNB should pass the RLF report to the anchor eNB.

[0056] Embodiment #3: If the RLF happens in the anchor eNB, the RLC report can be sent through the drift eNB with good link quality and UL resource.

[0057] **RLF content:**

[0058] According with one novel aspect, the RLF message should indicate in which serving cell or cell group RLF occurs.

[0059] In one embodiment, if the RLF happens in the drift eNB, the RLF should indicate the corresponding cell group ID assigned to the cell group generated from the drift eNB. For example, the cell group ID can be the TAG ID.

[0060] In another embodiment, if the RLF happens in the drift eNB, the RLF should indicate the global cell identity, if available; otherwise the physical cell identity and/or carrier frequency of the SCELL where radio link failure is detected should be indicated.

[0061] According with another novel aspect UE should indicate radio link problem triggering in the RLF message. In one Embodiment, the triggering of radio link failure, i.e., DL out of sync, RACH failure, retransmission failure should be indicated, and/or other causes of RLF.

[0062] According with yet another novel aspect UE should indicate other information to network for failure problem identification and for network re-configuration/recovery from failure problem. In one Embodiment, UE can include the

latest results of available measurements in the RLF message to the network.

[0063] **Reaction to the RLF:**

[0064] **UE side behavior:**

[0065] RLF in the drift eNB:

[0066] According with one novel aspect , the RLF serving cells generated from the drift eNB can be deactivated autonomously by the UE or can be deactivated/deconfigured by the network through explicit command.

[0067] Embodiment #1: UE deactivates the serving cell autonomously upon detection of RLF. The serving cell can be the RLF cell or the cells in the same group as the RLF cell.

[0068] Embodiment #2: UE deactivates the serving cell autonomously upon transmission of the RLF report to the anchor eNB. The serving cell can be the RLF cell or the cells in the same group as the RLF cell.

[0069] Embodiment #3: UE deactivates/deconfigures the serving cell(s) upon reception of the explicit command received from the anchor eNB, e.g. RRC reconfiguration for SCELL removal.

[0070] According with another novel aspect, if a UE detects a RLF in the serving cell or cell group generated from a drift eNB, the MAC entity for the drift eNB at the UE side can be disabled/released by the UE autonomously or by the anchor eNB though explicit RRC message for radio bearer re-configuration.

[0071] Embodiment #1: After all the serving cells generated from the drift eNB are deactivated, the UE disables/releases the corresponding MAC entity.

[0072] Embodiment #2: After applying the RRC message for radio bearer reconfiguration and all the radio bearers which are originally associated to the MAC entity for the drift eNB are re-configured to the MAC entity for the anchor eNB or to other drift eNB. The UE disables/releases the corresponding MAC entity where the radio bearers are re-associated to the MAC entity to other serving eNB.

[0073] **RLF in the anchor eNB:**

[0074] In one embodiment, if a UE detect a RLF in the anchor eNB, the UE should perform cell selection and RRC connection reestablishment procedure to re-establish RRC connection to other cells.

[0075] In another embodiment, if a UE detect a RLF in the anchor eNB, UE can send an RLF indicator to a drift eNB. Besides, UE should include the latest measurement results to indicate channel quality of other serving cells or the suggested

ranking of cell qualities to the drift eNB. The drift eNB should pass the indicator to the anchor eNB so that the anchor eNB can perform PCELL change through handover procedure to other eNB.

[0076] Network side behavior:

[0077] In one embodiment, if a RLF message for the drift eNB is received by the anchor eNB, the anchor eNB should take the following actions. Note that the following actions may not need to be in order.

[0078] The anchor eNB should deconfigure the corresponding serving cell or cell group.

[0079] The anchor eNB informs to the drift eNB that RLF on the serving cells or cell group generated from the drift eNB has occurred for a specific UE, and the UE identification is also indicated.

[0080] The anchor eNB should stop DL data forwarding to the drift eNB for the UE upon reception of the RLF report from the UE.

[0081] The drift eNB should forward the data waiting for transmission/retransmission in the DL buffer to the anchor eNB. Meanwhile, the anchor eNB also requests UL data which is received from the UE and buffered in the drift eNB to be delivered to the anchor eNB through the X3 interface.

[0082] The anchor eNB should relocate the radio bearer which is associated with the MAC entity for the drift eNB experiencing RLF to other MAC entity. The relocated MAC entity can be the anchor's MAC entity or other drift eNB's MAC entity. The anchor eNB should send RRC message to the UE for radio bearer reconfiguration and SCELL reconfiguration.

[0083] Upon the RLF indication with the UE identification from the anchor eNB, the drift eNB forwards the UL data which is received from the UE and buffered to the anchor eNB through the X3 interface. The drift eNB also release the MAC entity which is responsible for data transmission to the UE.

[0084] In another embodiment, if a RLF message in the anchor cell is received by the anchor eNB, the old anchor eNB should pass the entire UE context to the new eNB; the handover procedure associated to the radio bearer reestablishment/reconfiguration should be performed.

[0085] In yet another embodiment, if a RLF message in the anchor cell is received by the anchor eNB, the anchor eNB should perform PCELL change; handover the PCELL to other eNB, e.g., handover the PCELL to a drift eNB; the drift eNB

becomes a new anchor eNB to the UE.

[0086] The procedure of RLF configuration, RLF reporting and RLF reaction is summarized in the Fig.5.

[0087] Although the present invention has been described in connection with certain specific embodiments for instructional purposes, the present invention is not limited thereto. Accordingly, various modifications, adaptations, and combinations of various features of the described embodiments can be practiced without departing from the scope of the invention as set forth in the claims.

CLAIMS

1. A method, comprising:

establishing a radio resource control (RRC) connection by a user equipment (UE) with a Radio Access Network, where the UE uses multiple component carriers (CCs) or Cells;

monitoring the performance for several radio links, cells or groups of cells; and

taking action when the performance of a radio link, a cell or a group of cells is low, e.g., radio link failure.

2. The method of Claim 1, wherein the UE uses the multiple component carriers (CCs) or Cells by carrier aggregation.

3. The method of Claim 2, wherein the component carriers or cells from a eNB are associated to a common MAC entity.

4. The method of Claim 1, wherein the serving cell on which radio link monitoring needs to be performed is configurable.

5. The method of Claim 4, wherein the serving cell is in the status of activation and is one of the following:

a reference cell that is used as pathloss reference and/or timing advance reference;

the first activated serving cell in a cell group;

a specific cell with configured PUCCH resource; and

a specific cell explicitly configured to perform RLM/RLF mechanism by the network.

6. The method of Claim 1, wherein the cell group is one of the following groups:

a cell group with applying the same timing advance value;

a cell group referring to the same pathloss reference cell;

a cell group associated to a transmission point with co-located antennas; and

and/or a cell group associated to a MAC entity.

7. The method of Claim 1, wherein the radio link monitoring involves downlink monitoring based on Q_{IN} and/or Q_{OUT} measurement.

8. The method of Claim 1, wherein the radio link failure involves downlink radio problem in terms of downlink out-of-sync;

uplink radio problem including radio link failure detection based on random access channel (RACH) failure detection and/or maximum number of radio link control (RLC) retransmissions.

9. The method of Claim 1, wherein the action involves at least one of:

the UE sending an indication of the problematic performance to the RAN;

using a still usable Cell or Radio Link, preventing spontaneous UL transmissions (PUCCH, SRS, SPS);

deactivating of the serving cell or the cell group the serving cell belongs to; and

disabling or releasing the MAC entity corresponding to the serving cell.

10. The method of Claim 9, wherein the UE sends the report of RLF message to the base station with good link quality and UL resource.

11. The method of Claim 10, wherein the report of RLF message indicates in which serving cell or cell group RLF occurs.

12. The method of Claim 11, further comprising:

indicating radio link problem triggering in the RLF message and other information for failure problem identification and re-configuration/recovery from failure problem.

13. The method of Claim 9, wherein the UE deactivates the serving cell or the cell group the serving cell belongs to upon detection of RLF, upon transmission of the report for RLF message or upon reception of the explicit command for the serving cell removal.

14. The method of Claim 9, wherein the UE disables/releases the MAC entity corresponding to the serving cell if all serving cells belong to the same cell groups are deactivated

15. The method of Claim 9, wherein the UE disables/releases the MAC entity corresponding to the serving cell upon reception the message from the network for radio bearer re-configuration.

16. The method of Claim 14, further comprising:

the UE re-associating the radio bearers originally associated to the disabled/released MAC entity to the other MAC entity.

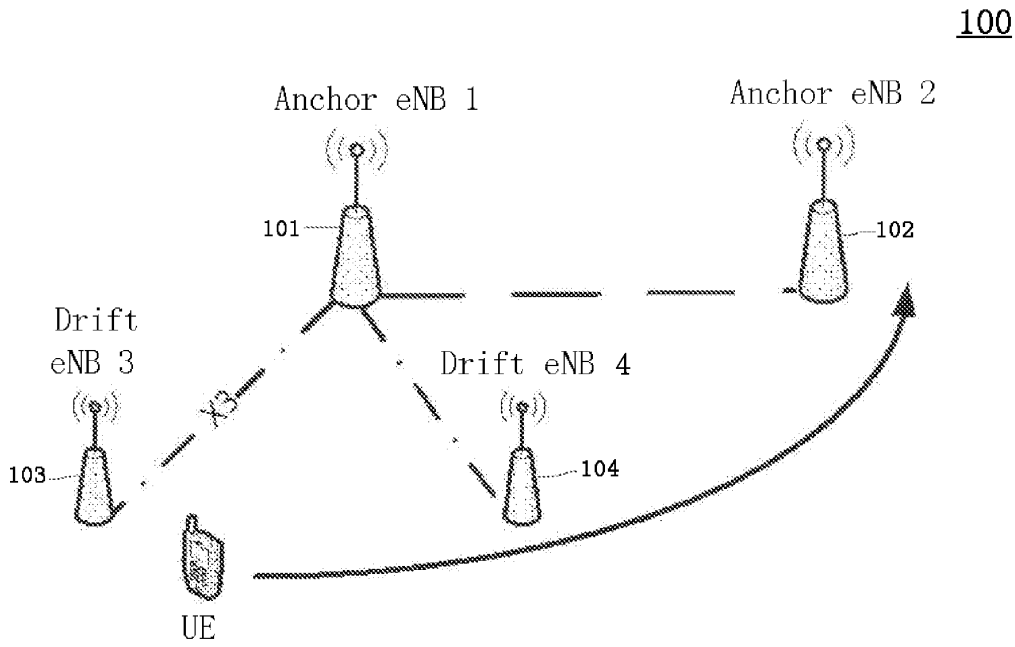
100
Anchor eNB 1
Anchor eNB 2
101
102
Drift
eNB 3
Drift eNB 4
X2
103
104
UE

Fig. 1

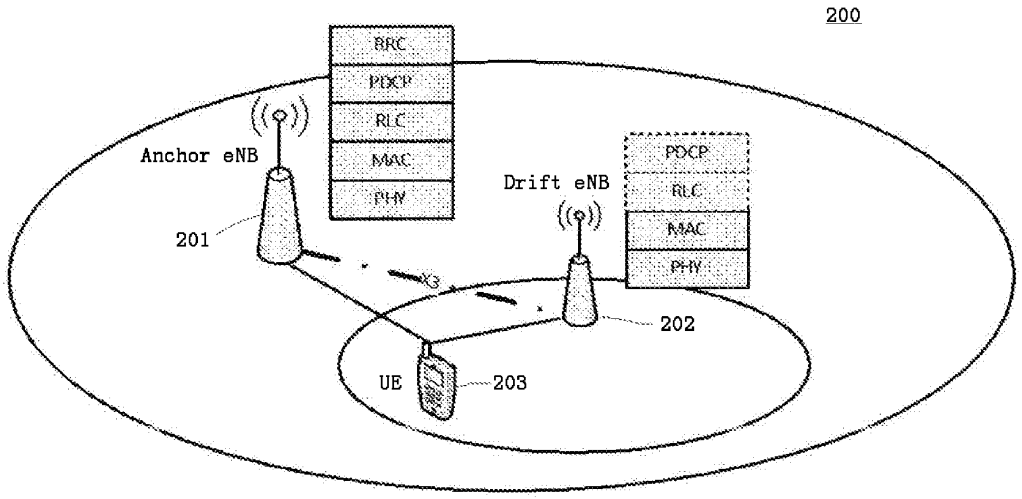
200
RRC
PDCP
RLC
MAC
PHY
Anchor eNB
201
PDCP
RLC
MAC
PHY
Drift eNB
X2
202
UE
203

Fig. 2

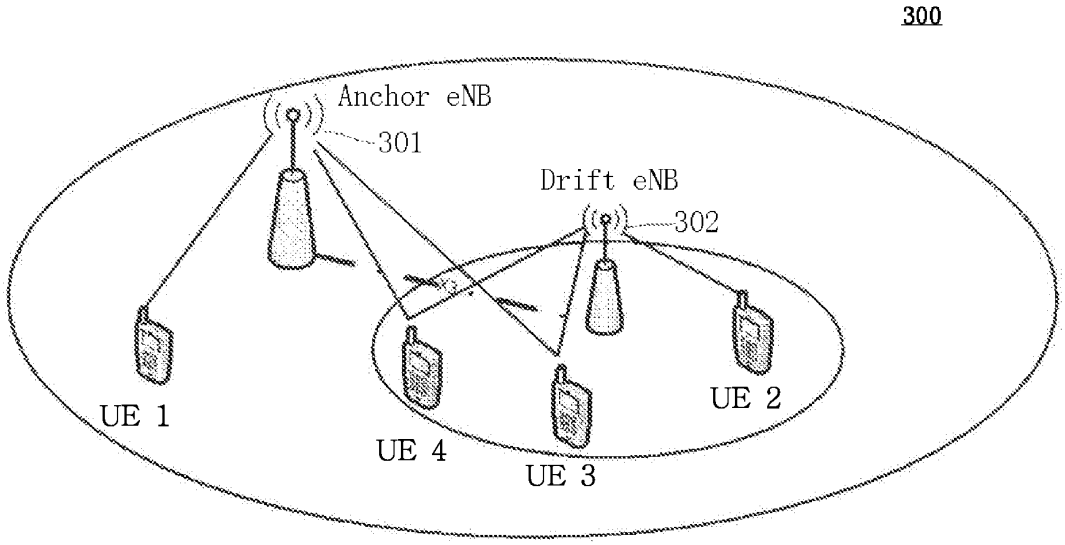

Fig. 3

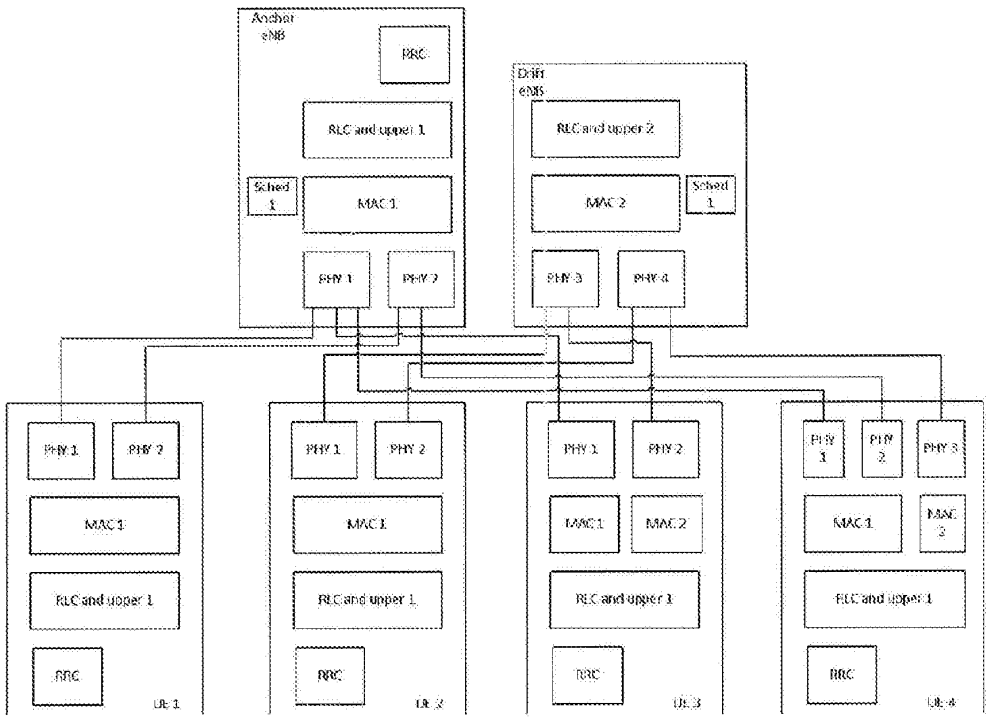
Anchor eNB
RRC
RLC and upper 1
Sched 1
MAC 1
PHY 1
PHY 2
Drift eNB
RLC and upper 2
MAC 2
Sched 1
PHY 3
PHY 4
PHY 1
PHY 2
MAC 1
RLC and upper 1
RRC
UE 1
PHY 1
PHY 2
MAC 1
RLC and upper 1
RRC
UE 2
PHY 1
PHY 2
MAC 1
MAC 2
RLC and upper 1
RRC
UE 3
PHY 1
PHY 2
PHY 3
MAC 1
MAC 2
RLC and upper 1
RRC
UE 4

Fig. 4

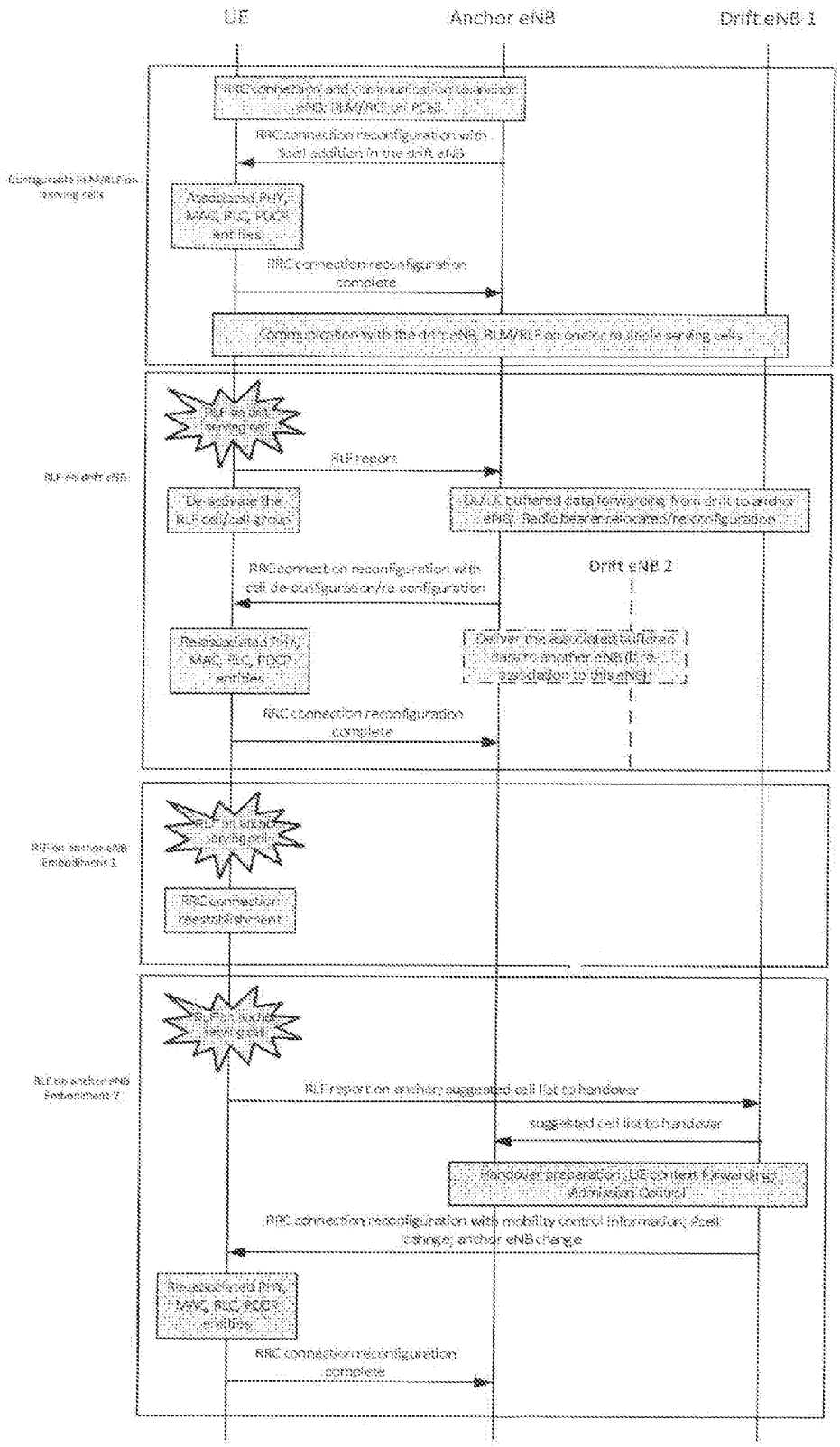
UE
Anchor eNB
Drift eNB 1
RRC connection reconfiguration with SCell addition in the drift eNB
Associated PHY, MAC, RLC, PDCP entities
RRC connection reconfiguration complete
Communication with the drift eNB, RLM/RLF on anchor PCell/its serving cells
RLF report
De-activate the RLF cell/cell group
SN/UE buffered data forwarding from drift to anchor eNB, Radio bearer relocated/reconfiguration
Drift eNB 2
RRC connection reconfiguration with cell de-configuration/re-configuration
Re-associated PHY, MAC, RLC, PDCP entities
Deliver the associated buffered data to another eNB (i.e. addition to the eNB)
RRC connection reconfiguration complete
RRC connection re-establishment
RLF report on anchor, suggested cell list to handover
suggested cell list to handover
Handover preparation, UE context forwarding, Admission Control
RRC connection reconfiguration with mobility control information, PCell change, anchor eNB change
Re-associated PHY, MAC, RLC, PDCP entities
RRC connection reconfiguration complete

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2013/070723

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/00 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W 24/-; H04W 28/-; H04L 5/-; H04W 72/-; H04W 74/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

VEN; CNABS; CNTXT; CNKI: RRC, connection, multiple w component w carriers, carrier w aggregation, CA, monitor+, radio w link W failure, MAC, performance, low

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012281548 A1 (MEDIATEK INC.) 08 Nov. 2012(08.11.2012) description, paragraphs [0001], [0026]-[0044], claims 1-8, and figures 1-12	1-8
A	the whole document	9-16
A	CN 102006655 A (ZTE CORP.) 06 Apr. 2011(06.04.2011) the whole document	1-16
A	CN 102036284 A (HUAWEI TECHNOLOGIES CO., LTD.) 27 Apr. 2011(27.04.2011) the whole document	1-16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 Oct. 2013(15.10.2013)	**31 Oct. 2013 (31.10.2013)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANG, Chunyan Telephone No. (86-10)62411298

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/070723

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US 2012281548 A1	08.11.2012	TW 201246955 A	16.11.2012
		WO 2012149898 A1	08.11.2012
		CN 102870450 A	09.01.2013
		EP 2596659 A1	29.05.2013
CN 102006655 A	06.04.2011	None	
CN 102036284 A	27.04.2011	CN 102036284 B	28.08.2013

Form PCT/ISA /210 (patent family annex) (July 2009)