



- (51) International Patent Classification:
H04W 74/08 (2009.01)
- (21) International Application Number:
PCT/CN2015/093987
- (22) International Filing Date:
6 November 2015 (06.11.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (71) Applicant: **NOKIA TECHNOLOGIES OY** [FI/FI];
Karaportti 3, 02610 Espoo (FI).
- (71) Applicant (for LC only): **NAVTEQ (SHANGHAI) TRADING CO., LTD.** [CN/CN]; Room 2930, 2933 and 2942, North Tower, Kerry Center, No.1515 Nanjing Road West, Jing'an District, Shanghai 200040 (CN).
- (72) Inventors: **ZHANG, Yanji**; Room 1507, Building 2, No.20 Shaoyaoju Road, Chaoyang District, Beijing 100029 (CN). **LI, Haitao**; Room 1004, Building 211, Wangjing East Garden, Beijing 100102 (CN). **SÉBIRE, Benoist**; 2-20-5 Kagurazaka, Shinjuku, Tokyo 162-0825 (JP). **KOSKINEN, Jussi-Pekka**; Kipinäkuja 10, 90420 Oulu (FI).
- (74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No.1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: HANDOVER FOR COVERAGE ENHANCEMENT

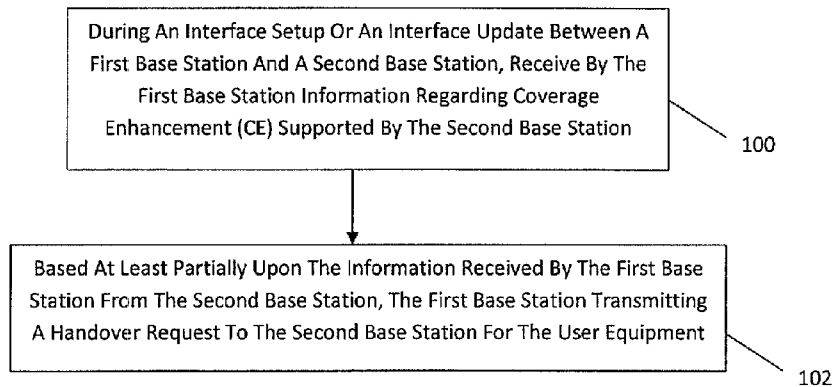


Fig 4

(57) Abstract: A method including transmitting signals from a first base station to a second base station in a network; and during an interface setup or an interface update between the first base station and the second base station, receiving by the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

WO 2017/075805 A1

HANDOVER FOR COVERAGE ENHANCEMENT

BACKGROUND

Technical Field

[0001] The exemplary and non-limiting embodiments relate generally to wireless
5 communication and, more particularly, to handover.

Brief Description of Prior Developments

[0002] Procedures for handover of a user equipment (UE) from a first base station to
a second base station are known. The Third Generation Partnership Program (3GPP) has
proposed coverage enhancement (CE) for Machine Type Communications (MTC) in LTE.
10 3GPP standards include CE levels and CE level criteria.

SUMMARY

[0003] The following summary is merely intended to be exemplary. The summary is
not intended to limit the scope of the claims.

[0004] In accordance with one aspect, an example method comprises transmitting
15 signals from a first base station to a second base station in a network; and during an interface
setup or an interface update between the first base station and the second base station,
receiving by the first base station information regarding at least one of: whether coverage
enhancement (CE) is supported by the second base station, a maximum coverage
enhancement (CE) level supported by the second base station, whether low-cost coverage
20 enhancement (CE) is supported by the second base station, and coverage enhancement (CE)
level criteria at the second base station.

[0005] In accordance with another aspect, an example embodiment is provided in an
apparatus comprising at least one processor; and at least one non-transitory memory including
computer program code, the at least one memory and the computer program code configured
25 to, with the at least one processor, cause the apparatus to: transmit signals from the apparatus
to a second base station in a network; and during an interface setup or an interface update
between the apparatus and the second base station, where the apparatus is at least part of a
first base station, receive information regarding at least one of: whether coverage

enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

5 **[0006]** In accordance with another aspect, an example embodiment is provided in a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising: transmitting signals from a first base station to a second base station in a network; and during an interface setup or an interface update between the first base station and the
10 second base station, receiving information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

15 **[0007]** In accordance with another aspect, an example method comprises transmitting signals from a second base station to a first base station in a network; and during an interface setup or an interface update between the first base station and the second base station, transmitting by the second base station to the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a
20 maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0008] In accordance with another aspect, an example embodiment is provided in an apparatus comprising at least one processor; and at least one non-transitory memory including
25 computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to: transmit signals from a second base station to a first base station in a network; and during an interface setup or an interface update between the first base station and the second base station, where the apparatus is at least part of the second base station, transmit to the first base station information regarding at least one
30 of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0009] In accordance with another aspect, an example embodiment is provided in a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising transmitting signals from a second base station to a first base station in a network; and during an interface setup or an interface update between the first base station and the second base station, transmitting to the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0010] In accordance with another aspect, an example method comprises receiving by a user equipment (UE) from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

[0011] In accordance with another aspect, an example embodiment is provided in an apparatus comprising at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to: receive from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and transmit a signal to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

[0012] In accordance with another aspect, an example embodiment is provided in a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising: receiving from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH)

resources; and transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

[0013] In accordance with another aspect, an example embodiment is provided in an apparatus comprising means for transmitting signals from a first base station to a second base station in a network; and means for receiving by the first base station, during an interface setup or an interface update between the first base station and the second base station, information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0014] In accordance with another aspect, an example embodiment is provided in an apparatus comprising means for transmitting signals from a second base station to a first base station in a network; and means for transmitting by the second base station to the first base station, during an interface setup or an interface update between the first base station and the second base station, information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0015] In accordance with another aspect, an example embodiment is provided in an apparatus comprising means for receiving by a user equipment (UE) from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and means for transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The foregoing aspects and other features are explained in the following description, taken in connection with the accompanying drawings, wherein:

[0017] Fig. 1 is a diagram illustrating an example of an overall architecture of a E-UTRAN (evolved UMTS Terrestrial Radio Access) system (an air interface of 3GPP's Long Term Evolution (LTE) upgrade path for mobile networks);

[0018] Fig. 2 is a diagram illustrating some components of the wireless system shown in Fig. 1;

[0019] Fig. 3 is a diagram illustrating an example handover procedure for a UE in a coverage enhancement mode;

[0020] Fig. 4 is a block diagram illustrating an example method;

[0021] Fig. 5 is a block diagram illustrating an example method; and

[0022] Fig. 6 is a block diagram illustrating an example method

DETAILED DESCRIPTION OF EMBODIMENTS

[0023] The following abbreviations that may be found in the specification and/or the drawing figures are defined as follows:

3GPP	Third Generation Partnership Program
AP	Access Point
ACK	Acknowledgement
ARQ	Automatic Repeat Request
CE	Coverage Enhancement
CSI	Channel State Information
CSM	Cluster Set Manager
DL	Downlink
DTX	Discontinuous Transmission
EC	Enhanced Coverage
eNB	enhanced Node B (base station according to LTE terminology)
E-UTRAN	E- Universal Terrestrial Radio Access Network

HO	Handover
LC	Low Complexity or Low Cost
LTE	Long-Term Evolution
MTC	Machine Type Communication
NACK	Negative acknowledgement
PRACH	Physical Random Access Channel
RA	Random Access
RACH	Random Access CHannel
Rel-13	3GPP Standard Release 13
RLF	Radio Link Failure
RLM	Radio Link Monitoring
RRC	Radio Resource Control
SIB	System Information Block
SINR	Signal-to-Interference and Noise Ratio
SNR	Signal-to-Noise Ratio
TDD	Time division duplex
UE	User Equipment
UL	Uplink
X2	X2 Interface

[0024] Fig. 1 shows an example of overall architecture of an E-UTRAN system. The E-UTRAN system includes eNBs, providing an E-UTRAN user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE (not shown in Fig. 1). The eNBs are interconnected with each other by means of an X2 interface.

5 The eNBs are also connected by means of a S1 interface to an EPC (Enhanced Packet Core), more specifically to a MME (Mobility Management Entity) by means of a S1 MME interface and to a Serving Gateway (S-GW) by means of a S1 interface. The S1 interface supports a many-to-many relationship between MMEs/S-GW and eNBs. One or more of the eNB may form an access point (AP) or base station.

10 [0025] Referring also to Fig. 2, a user equipment (UE) 10 is shown. In this example the UE 10 is a smartphone. However, in alternate examples the UE may be, for example, a tablet computer, a PDA, a smart watch, or any other suitable device configured for wireless communications including, for example, in a vehicle such as a car. The UE 10 is configured to be able to communicate with the base stations (BS) 13, 14, 15.

[0026] The wireless system 230 comprise a wireless network 235 adapted for communication over a wireless link 232 with an apparatus, such as the mobile communication device which may be referred to as a UE 10, via the eNB 13. The network 235 may include a network control element (NCE) 240 that may include MME/S-GW functionality, and which provides connectivity with a network, such as a telephone network and/or a data communications network (e.g., the internet 238).

[0027] The UE 10 includes a controller, such as a computer or a data processor (DP) 214, a computer-readable memory medium embodied as a memory (MEM) 216 that stores a program of computer instructions (PROG) 218, and a suitable wireless interface, such as radio frequency (RF) transceiver 212, for bidirectional wireless communications with the eNB 13 via one or more antennas.

[0028] The eNB 13 also includes a controller, such as a computer or a data processor (DP) 224, a computer-readable memory medium embodied as a memory (MEM) 226 that stores a program of computer instructions (PROG) 228, and a suitable wireless interface, such as RF transceiver 222, for communication with the UE 10 via one or more antennas. The eNB 13 is coupled via a data/control path 234 to the NCE 240. The path 234 may be implemented as an interface. The eNB 13 may also be coupled to other eNB(s) via data/control path 236 also known as the X2 interface.

[0029] The NCE 240 includes a controller, such as a computer or a data processor (DP) 244, a computer-readable memory medium embodied as a memory (MEM) 246 that stores a program of computer instructions (PROG) 248.

[0030] At least one of the PROGs 218, 228 and 248 is assumed to include program instructions that, when executed by the associated DP, enable the device to operate in accordance with exemplary embodiments of this invention, as will be discussed below in greater detail. That is, various exemplary embodiments of this invention may be implemented at least in part by computer software executable by the DP 214 of the UE 10; by the DP 224 of the eNB 13; and/or by the DP 244 of the NCE 240, or by hardware, or by a combination of software and hardware (and firmware).

[0031] For the purposes of describing various exemplary embodiments in accordance with this invention the UE 10 and the eNB 13 may also include dedicated processors, for example RRC module 215 and a corresponding RRC module 225. RRC module 215 and

RRC module 225 may be constructed so as to operate in accordance with various exemplary embodiments in accordance with this invention.

5 [0032] The computer readable MEMs 216, 226 and 246 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The DPs 214, 224 and 244 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a
10 multicore processor architecture, as non-limiting examples. The wireless interfaces (e.g., RF transceivers 212 and 222) may be of any type suitable to the local technical environment and may be implemented using any suitable communication technology such as individual transmitters, receivers, transceivers or a combination of such components.

15 [0033] Extending LTE coverage from a normal coverage mode (i.e., a non-CE mode) to a coverage enhancement (CE) mode allows LTE to be used for services such as smart metering, where the meters may be installed in basements or shielded locations, and thus may be subject to substantial penetration loss. MTC devices are sometimes referred to as low-cost or low-complexity devices because they do not require all the hardware and programming a non-MTC device may have. A low cost MTC device may suffer from coverage degradation
20 due to some restrictions, e.g. the reduced bandwidth and the single RX, etc. However, devices which use a coverage enhancement (CE) mode rather than a normal coverage mode of communication are envisioned which may be mobile and, therefore, will need a handover capability. Thus, mobility support for “Low Complexity/Enhanced Coverage” (LC/EC) UEs will be needed.

25 [0034] Low power consumption and low cost are important aspects for large-scale deployment of CE capable devices. To provide sufficient coverage of MTC devices, or MTC user equipments (UEs), special coverage enhancement (CE) considerations may be needed. These coverage enhancements may include a desired coverage enhancement level for various physical channels of communication. For example, in some instances physical uplink channels and physical downlink channels such as, for example, physical downlink control
30 channel (PDCCH), physical uplink shared channel (PUSCH), etc. may be configured to achieve a desired coverage enhancement level, or decibel (dB) gain in signal power. A required CE level can be different for different eNBs, for example depending on an eNB

transmission power or an associated cell size, as well as for different UEs, for example depending on a location of a UE or on a number of UE receiver antennas.

[0035] Features as described herein provide an improvement to exchange of information over an X2 interface for supporting a reliable handover procedure for a 3GPP
5 low-cost (low complexity) UE and a UE in a coverage enhancement mode, such as for 3GPP Rel-13 for example.

[0036] During a X2 interface setup procedure (or during a X2 interface update procedure), a source eNB and a target eNB may exchange information about their capabilities, such as, for example:

- 10
- whether coverage enhancement is supported, the supported maximum CE level and optionally the CE level criteria (i.e. the threshold(s) to decide the CE level based on the measurement result);
 - whether a low-cost type of UE is supported

[0037] Such information may be used by the source eNB to decide potential coverage
15 status in a target eNB, configure CE-specific measurement configurations and decide the CE level in the target eNB based on a measurement result from the UE. This also helps the source eNB to make handover decisions when preparing a handover towards multiple target cells with different CE conditions.

[0038] During the Handover procedure an additional flag indicating whether the UE
20 will work in a CE mode or/and the CE level of the UE may be added in a Handover Request message by the source eNB. The configuration of Random Access (RA) procedure (including CE related Physical Random Access Channel (PRACH) resources) towards the target eNB may be added by the target eNB in a Handover Request Acknowledge as part of a RRC container. PRACH resource information may include, for example, time, frequency and
25 preamble related information. As different sets of PRACH resources (e.g. time, frequency and preamble) are associated with each EC level, and also the PRACH resource for EC UEs is separated from the normal coverage UEs, that information could enable the target eNB to allocate the RA resource reflecting the practical UE coverage situation in the target eNB correctly; to ensure a successful RA procedure towards the target eNB during the handover
30 procedure. Please note that any combination of above may be considered. Alternatively, instead of signaling the CE level criteria (i.e. the threshold(s) to decide the CE level based on

the measurement result), the measurement results from the UE can be included in the Handover Request message; allowing the target eNB to decide the CE level of the UE. PRACH resources may be assigned per CE level and/or PRACH resources may be assigned per “UE type” (such as low-cost UE versus non-low-cost UE for example).

5 **[0039]** Referring also to Fig. 3, an example will be described. At Step 1, during the X2 setup or update procedure, the source eNB 13 and the target eNB 15 exchange at least one of:

- the capability whether coverage enhancement is supported
- the supported maximum CE level
- the capability whether low-cost (LC) UE is supported (by providing a separate
10 PRACH resource for LC UEs versus non-low-cost UEs)
- the CE level criteria (for example, the thresholds to decide the CE level based on measurement results).

[0040] At Step 2 the UE triggers a measurement report sent to the source eNB 13. At Step 3 the source eNB 13 makes a decision based upon the received MEASUREMENT
15 REPORT and the CE configuration of the cells of the neighbouring base stations 14, 15 exchanged during the X2 setup/update procedure. The source eNB 13 detects the UE’s CE level for the neighboring cells according to the cell specific CE level criteria. The source eNB 13 may select the suitable target eNB based on the CE level, such as:

- The cell in which the UE works in normal coverage has highest priority, and
- 20 • If the UE is to work in the CE mode rather than the normal coverage mode, the cell in which UE works with a low CE level has the highest priority.

[0041] At Step 4 when the source eNB 13 determines that the CE level for the UE in the target eNB would be better than that in the source cell, the source eNB 13 decides to prepare handover. A one bit EC indicator or the EC level indicator may be added in the
25 Handover Request. Alternatively, the source eNB 13 could provide the measurement result to the target eNB 15. The target eNB 15 may then use that measurement result to decide the UE’s CE level.

[0042] At Step 5 the target eNB may add the CE related physical random access channel (PRACH) resources in the Handover Request Acknowledge as part of the RRC

container. This may include the PRACH resource allocated for UE operating in normal coverage, and the PRACH resource associated with the UE specific EC level in the target cell. The PRACH resource may include the time/frequency allocation and dedicated preambles. Either all PRACH resource associated with all possible CE levels may be added or only the
5 PRACH resource corresponding to the estimated CE of the incoming UE might be added.

[0043] At Steps 6-10 the handover procedure in the air interface is performed. The UE accesses the target cell with the RA procedure using the assigned PRACH resources associated with its CE level in the target cell; contained in the RRC Connection Reconfiguration message. The PRACH resource may include the time/frequency allocation
10 and dedicated preambles. According to the PRACH resource, the target eNB is aware of the UE in the EC mode, and the CE level which could be applied for resource scheduling.

[0044] In the example shown in Fig. 3, step 9 (which corresponds to the target eNB 15 being aware of the UE's CE level) is shown occurring after step 8 (after the UE 10 transmitting the PRACH preamble associated with the CE level to the Target eNB 15).
15 However, if step 4 contains the measurement report, the block 20 "Decide the CE level if measurement is provided by source eNB" would imply that the target eNB 15 will be aware of the UE's CE level. So, with this alternate example, the occurrence of the target eNB 15 being aware of the UE's CE level may occur between steps 4-5 rather than between steps 8-10. Thus, the target eNB 15 being aware of the UE's CE level may occur either after step 4 or
20 after step 8; depending on the information carried in the Handover request from source eNB to target eNB.

[0045] X2 interface update:

[0046] In the X2 setup/update procedure, additional parameters may be exchanged between eNBs, such as:

- 25
- The capability whether coverage enhancement is supported
 - The supported maximum CE level
 - The capability whether low-cost UE is supported (there is separate PRACH resource for LC UEs)
 - The CE level criteria, i.e. the thresholds to decide the CE level based on the
30 measurement result.

[0047] A one bit EC indicator or the EC level indicator may be added in the Handover Request, or the measurement result may be added in the Handover Request.

[0048] Additional PRACH resources may be added in the Handover Request Acknowledge as part of the RRC container. The PRACH resource may be allocated for UE
5 operating in a normal coverage mode. The PRACH resource may be allocated for a LC UE. The PRACH resource may be associated with the UE specific EC level in the target cell. The PRACH resource may be associated with the LC UE. In addition, any combination(s) of above may be considered.

[0049] With features as described herein, the proposed solution helps to ensure a
10 reliable handover procedure for a 3GPP Rel-13 low complexity UE and a UE in coverage enhancement mode for the selection of a suitable target cell when source eNB makes the handover decision, and the correct PRACH resource utilization when the UE performs the RA towards the target eNB.

[0050] During a traditional handover procedure, the source eNB makes a decision and
15 selects a suitable target eNB based on the MEASUREMENT REPORT and the Radio Resource Management (RRM) information to handoff the UE. During the handoff procedure, the source eNB issues a HANDOVER REQUEST message to the target eNB passing necessary information to prepare the handover at the target side. After performing the Admission Control, the target eNB sends the HANDOVER REQUEST ACKNOWLEDGE to
20 the source eNB which includes a transparent container to be sent to the UE as an RRC message to perform the handover. After receiving the RRCConnectionReconfiguration message, the UE performs synchronization to target eNB and accesses the target cell via RACH. However, the conventional handover procedure does not take into consideration the new type of low-complexity UE and UE capable of EC operation in LTE; to support coverage
25 enhancement (CE) for both Rel-13 low-complexity UE and UE operating in CE compared to existing LTE networks.

[0051] Baseline connected mode mobility mechanisms may be supported for LC UEs in normal coverage and LC UEs in “shallow” enhanced coverage. Ideally, the source eNB should prioritize the cells in which the UE is able to operate in normal coverage over cells in
30 which the UE has to use enhanced coverage or to select the cells that UE works in low CE level when making the handover decision. A threshold for deciding the CE level is cell specific. With existing specification handover procedures, the source eNB has no knowledge of whether the neighboring eNB could support the coverage enhancement and the related

coverage enhancement configuration, e.g. the cell specific CE level criteria, etc. Without such information, the source eNB could not select the suitable target eNB. As a consequence, it may make a wrong decision and request a handover to a CE incapable eNB or an eNB which the UE may work in a worst coverage situation. This may cause extra signaling overhead due to the increased number of transmission repetitions and even an unsuccessful handover procedure in a worst case scenario. Furthermore, after receiving the RRCConnectionReconfiguration message, the UE performs synchronization to the target eNB and accesses the target cell via RACH. With one-to-one mapping between PRACH repetition level and PRACH resource set, the UE needs to know the correct PRACH resource associated with its CE level in the target cell to ensure a successful RA and subsequent procedures with the target eNB.

[0052] With features as described herein, the problems noted above are overcome. Information exchanged at the X2 interface setup or X2 interface update between the base stations may be used to select a proper target base station with the best CE capabilities and proper CE level for the particular “type” of UE being handed over. For example, the handover procedure may involve distinguishing handover of a low-cost UE versus a non-low-cost UE or handover of UE working in enhanced coverage versus working in normal coverage.

[0053] Referring also to Fig. 4, an example method may comprise, during an interface setup or an interface update between a first base station and a second base station, receiving by the first base station information regarding coverage enhancement (CE) supported by the second base station as indicated by block 100; and based at least partially upon the information received by the first base station from the second base station, the first base station transmitting a handover request to the second base station for the user equipment as indicated by block 102. The information may comprise at least one of:

whether coverage enhancement (CE) is supported by the second base station,
a maximum coverage enhancement (CE) level supported by the second base station,
whether low-cost coverage enhancement (CE) is supported by the second base station, and
coverage enhancement (CE) level criteria at the second base station.

[0054] Referring also to Fig. 5, an example method may comprise during an interface setup or an interface update between a first base station and a second base station,

transmitting by the second base station to the first base station information regarding coverage enhancement (CE) supported by the second base station as indicated by block 104; and based upon receipt of a handover request by the second base station from the first base station, the second base station transmitting a handover request acknowledgement comprising
5 information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources as indicated by block 106. The information regarding coverage enhancement (CE) supported by the second base station may comprise at least one of:

- whether coverage enhancement (CE) is supported by the second base station,
- a maximum coverage enhancement (CE) level supported by the second base station,
- 10 whether low-cost coverage enhancement (CE) is supported by the second base station, and
- coverage enhancement (CE) level criteria at the second base station.

[0055] Referring also to Fig. 6, an example method may comprise receiving by a user equipment (UE) from a first base station a handover command comprising information
15 regarding coverage enhancement (CE) related physical random access channel (PRACH) resources, where the information has been received by the first base station from a second base station as indicated by block 108; and transmitting, as indicated by block 110, a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel
20 (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

[0056] An example method may comprise transmitting signals from a first base station to a second base station in a network; and during an interface setup or an interface update
25 between the first base station and the second base station, receiving by the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

30 [0057] The method may further comprise, at least partially based upon the information received by the first base station from the second base station, the first base station

transmitting a handover request to the second base station. The transmitting of the handover request to the second base station may be based, at least partially, upon a measurement report received by the first base station from a user equipment (UE). The method may comprise the first base station determining, based at least partially the information received by the first base station from the second base station, whether or not to transmit the handover request to the second base station. The first base station, based at least partially upon the information received by the first base station from the second base station, may perform at least one of: configures a CE-specific measurement configuration; determines CE level criteria; and decides a CE level for the UE to use in the second base station. The first base station, based at least partially upon the information received by the first base station from the second base station, where the second base station is a neighboring base station, may compare the second base station to at least one other neighboring base station, and the first base station selects: the neighboring base station having a cell in which the UE is able to work in a normal coverage mode; or if UE has to work in a CE mode rather than in the normal coverage mode, the neighboring base station having a cell in which UE works with low CE level. Transmitting a handover request to the second base station may comprise at least one of a single bit Enhanced Coverage (EC) indicator and a Enhanced Coverage (EC) level indicator. Transmitting a handover request to the second base station may comprise transmitting a measurement report from the first base station to the second base station. The method may further comprise receiving from the second base station a handover request acknowledgement, where the handover request acknowledgement comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The method may further comprise transmitting by the first base station to a user equipment (UE) a radio resource control (RRC) connection reconfiguration message, where the RRC connection reconfiguration message comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources for the second base station.

[0058] An example apparatus may comprise at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to: transmit signals from the apparatus to a second base station in a network; and during an interface setup or an interface update between the apparatus and the second base station, where the apparatus is at least part of a first base station, receive information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether

low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0059] The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: transmit a handover request to the second base station based, at least partially, upon the information received by the apparatus from the second base station. The transmitting of the handover request to the second base station may be based, at least partially, upon a measurement report received by the apparatus from a user equipment (UE). The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: determine, based at least partially the information received by the apparatus from the second base station, whether or not to transmit the handover request to the second base station. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: perform, based at least partially upon the information received by the first base station from the second base station, at least one of: configure a CE-specific measurement configuration; determine CE level criteria; and decide a CE level for the UE to use in the second base station. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: based at least partially upon the information received by the apparatus from the second base station, where the second base station is a neighboring base station, compare the second base station to at least one other neighboring base station, and the apparatus selects: the neighboring base station having a cell in which a UE is able to work in a normal coverage mode; or if the UE has to work in a CE mode rather than in the normal coverage mode, the neighboring base station having a cell in which the UE works with low CE level. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: transmit a handover request to the second base station comprising at least one of: a single bit Enhanced Coverage (EC) indicator and a Enhanced Coverage (EC) level indicator. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: transmit a handover request to the second base station comprising transmitting a UE measurement report from the apparatus to the second base station. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: receive from the second base station a handover request acknowledgement, where the handover request acknowledgement comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: transmit by the

apparatus to a user equipment (UE) a radio resource control (RRC) connection reconfiguration message, where the RRC connection reconfiguration message comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources for the second base station.

5 **[0060]** An example embodiment may be provided in a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising: transmitting signals from a first base station to a second base station in a network; and during an interface setup or an interface update between the first base station and the second base station, receiving
10 information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0061] The operations may further comprise, based at least partially upon the
15 information received by the first base station from the second base station, the first base station transmitting a handover request to the second base station. Transmitting of the handover request to the second base station may be based, at least partially, upon a measurement report received by the first base station from a user equipment (UE). The operations may comprise the first base station determining, based at least partially the
20 information received by the first base station from the second base station, whether or not to transmit the handover request to the second base station. The operations may comprise the first base station, based at least partially upon the information received by the first base station from the second base station, performing at least one of: configures a CE-specific measurement configuration; determines CE level criteria; and decides a CE level for the UE
25 to use in the second base station. The operations may comprise the first base station, based at least partially upon the information received by the first base station from the second base station, where the second base station is a neighboring base station, comparing the second base station to at least one other neighboring base station, and the first base station selects: the neighboring base station having a cell in which the UE is able to work in a normal coverage
30 mode; or if UE has to work in a CE mode rather than in the normal coverage mode, the neighboring base station having a cell in which UE works with low CE level. Transmitting a handover request to the second base station may comprise at least one of a single bit Enhanced Coverage (EC) indicator and a Enhanced Coverage (EC) level indicator. Transmitting a handover request to the second base station may comprise transmitting a

measurement report from the first base station to the second base station. The operations may further comprise receiving from the second base station a handover request acknowledgement, where the handover request acknowledgement comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The operations may further comprise transmitting by the first base station to a user equipment (UE) a radio resource control (RRC) connection reconfiguration message, where the RRC connection reconfiguration message comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources for the second base station.

[0062] An example method may comprise transmitting signals from a second base station to a first base station in a network; and during an interface setup or an interface update between the first base station and the second base station, transmitting by the second base station to the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0063] The method may further comprise, based upon receipt of a handover request by the second base station from the first base station, the second base station transmitting a handover request acknowledgement comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The handover request may comprise at least one of a single bit EC indicator and a EC level indicator, and where the information transmitted in the handover request acknowledgement is based, at least partially, on the indicator received by the second base station. The handover request may comprise information from a measurement report received by the first base station from a user equipment (UE). The second base station may determine a CE level for the UE based upon the measurement report.

[0064] An example apparatus may comprise at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to: transmit signals from a second base station to a first base station in a network; and during an interface setup or an interface update between the first base station and the second base station, where the apparatus is at least part of the second base station, transmit to the first base station information regarding at least one of: whether coverage enhancement (CE) is

supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

5 **[0065]** The at least one memory and the computer program code may be configured to, with the at least one processor, cause the apparatus to: based upon receipt of a handover request by the second base station from the first base station, the transmit a handover request acknowledgement comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The handover request may comprise at
10 least one of a single bit EC indicator and a EC level indicator, and where the information transmitted in the handover request acknowledgement is based, at least partially, on the indicator received by the second base station. The handover request may comprise information from a measurement report received by the first base station from a user equipment (UE). The second base station may determine a CE level for the UE based upon
15 the measurement report.

[0066] An example embodiment may be provided in a non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising transmitting signals from a second base station to a first base station in a network; and during an interface setup or an
20 interface update between the first base station and the second base station, transmitting to the first base station information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the
25 second base station.

[0067] The operations may further comprise, based upon receipt of a handover request by the second base station from the first base station, the second base station transmitting a handover request acknowledgement comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources. The handover request may
30 comprise at least one of a single bit EC indicator and a EC level indicator, and where the information transmitted in the handover request acknowledgement is based, at least partially, on the indicator received by the second base station. The handover request may comprise information from a measurement report received by the first base station from a user

equipment (UE). The second base station may determine a CE level for the UE based upon the measurement report.

5 [0068] An example method may comprise receiving by a user equipment (UE) from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).
10

[0069] The information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources may comprise information regarding at least one of: whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station. Transmitting the physical random access channel (PRACH) preamble may comprise transmitting the physical random access channel (PRACH) preamble associated with a CE level supported by the second base station. The information regarding coverage enhancement (CE) physical random access channel (PRACH) resources received by the user equipment may include a resource allocation and dedicated preambles.
15
20

[0070] An example apparatus may comprise at least one processor; and at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to:
25 receive from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and transmit a signal to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).
30

[0071] Transmitting the physical random access channel (PRACH) preamble may comprise transmitting the physical random access channel (PRACH) preamble associated

with a CE level supported by the second base station. The information regarding coverage enhancement (CE) physical random access channel (PRACH) resources received by the user equipment may include a resource allocation and dedicated preambles.

[0072] An example embodiment may be provided in a non-transitory program storage
5 device readable by a machine, tangibly embodying a program of instructions executable by
the machine for performing operations, the operations comprising: receiving from a first base
station a handover command comprising information regarding coverage enhancement (CE)
related physical random access channel (PRACH) resources; and transmitting a signal by the
user equipment (UE) to the second base station, where the signal comprises a physical
10 random access channel (PRACH) preamble, where the physical random access channel
(PRACH) preamble is based, at least partially, upon the information regarding the coverage
enhancement (CE) related physical random access channel (PRACH) resources received by
the user equipment (UE).

[0073] Transmitting the physical random access channel (PRACH) preamble may
15 comprise transmitting the physical random access channel (PRACH) preamble associated
with a CE level supported by the second base station. The information regarding coverage
enhancement (CE) physical random access channel (PRACH) resources received by the user
equipment may include a resource allocation and dedicated preambles.

[0074] An example apparatus may be provided comprising means for transmitting
20 signals from a first base station to a second base station in a network; and means for receiving
by the first base station, during an interface setup or an interface update between the first base
station and the second base station, information regarding at least one of: whether coverage
enhancement (CE) is supported by the second base station, a maximum coverage
enhancement (CE) level supported by the second base station, whether low-cost coverage
25 enhancement (CE) is supported by the second base station, and coverage enhancement (CE)
level criteria at the second base station.

[0075] An example apparatus may be provided comprising means for transmitting
signals from a second base station to a first base station in a network; and means for
transmitting by the second base station to the first base station, during an interface setup or an
30 interface update between the first base station and the second base station, information
regarding at least one of: whether coverage enhancement (CE) is supported by the second
base station, a maximum coverage enhancement (CE) level supported by the second base

station, whether low-cost coverage enhancement (CE) is supported by the second base station, and coverage enhancement (CE) level criteria at the second base station.

[0076] An example apparatus may be provided comprising means for receiving by a user equipment (UE) from a first base station a handover command comprising information
5 regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and means for transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random
10 access channel (PRACH) resources received by the user equipment (UE).

[0077] Any combination of one or more computer readable medium(s) may be utilized as the memory. The computer readable medium may be a computer readable signal medium or a non-transitory computer readable storage medium. A non-transitory computer readable storage medium does not include propagating signals and may be, for example, but not
15 limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[0078] It should be understood that the foregoing description is only illustrative. Various alternatives and modifications can be devised by those skilled in the art. For example,
25 features recited in the various dependent claims could be combined with each other in any suitable combination(s). In addition, features from different embodiments described above could be selectively combined into a new embodiment. Accordingly, the description is intended to embrace all such alternatives, modifications and variances which fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method comprising:
 - transmitting signals from a first base station to a second base station in a network; and
 - 5 during an interface setup or an interface update between the first base station and the second base station, receiving by the first base station information regarding at least one of:
 - whether coverage enhancement (CE) is supported by the second base station,
 - a maximum coverage enhancement (CE) level supported by the second base
 - 10 station,
 - whether low-cost coverage enhancement (CE) is supported by the second base station, and
 - coverage enhancement (CE) level criteria at the second base station.
2. A method as in claim 1 further comprising, at least partially based upon the information
- 15 received by the first base station from the second base station, the first base station transmitting a handover request to the second base station.
3. A method as in claim 2 where the transmitting of the handover request to the second base station is based, at least partially, upon a measurement report received by the first base station from a user equipment (UE).
- 20 4. A method as in any of claims 1-3 where the method comprises the first base station determining, based at least partially upon the information received by the first base station from the second base station, whether or not to transmit the handover request to the second base station.
5. A method as in any of claims 1-4 where the first base station, based at least partially upon
- 25 the information received by the first base station from the second base station, performs at least one of:
 - configures a CE-specific measurement configuration;

determines CE level criteria; and

decides a CE level for the UE to use in the second base station.

6. A method as in any of claims 1-5 where the first base station, based at least partially upon the information received by the first base station from the second base station, where the
5 second base station is a neighboring base station, compares the second base station to at least one other neighboring base station, and the first base station selects:

the neighboring base station having a cell in which the UE is able to work in a normal coverage mode; or

10 if UE has to work in a CE mode rather than in the normal coverage mode, the neighboring base station having a cell in which UE works with low CE level.

7. A method as in any of claims 1-6 where transmitting a handover request to the second base station comprises at least one of a single bit Enhanced Coverage (EC) indicator and a Enhanced Coverage (EC) level indicator.

8. A method as in any of claims 1-7 where transmitting a handover request to the second base
15 station comprises transmitting a measurement report from the first base station to the second base station.

9. A method as in any of claims 1-7 further comprising receiving from the second base station a handover request acknowledgement, where the handover request acknowledgement comprises information regarding coverage enhancement (CE) related physical random access
20 channel (PRACH) resources.

10. A method as in any of claims 1-9 further comprising transmitting by the first base station to a user equipment (UE) a radio resource control (RRC) connection reconfiguration message, where the RRC connection reconfiguration message comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources for
25 the second base station.

11. An apparatus comprising:

at least one processor; and

at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to:

transmit signals from the apparatus to a second base station in a network; and

5 during an interface setup or an interface update between the apparatus and the second base station, where the apparatus is at least part of a first base station, receive information regarding at least one of:

whether coverage enhancement (CE) is supported by the second base station,

10 a maximum coverage enhancement (CE) level supported by the second base station,

whether low-cost coverage enhancement (CE) is supported by the second base station, and

coverage enhancement (CE) level criteria at the second base station.

15 12. An apparatus as in claim 11 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

transmit a handover request to the second base station based, at least partially, upon the information received by the apparatus from the second base station.

20 13. An apparatus as in any of claims 11-12 where the transmitting of the handover request to the second base station is based, at least partially, upon a measurement report received by the apparatus from a user equipment (UE).

14. An apparatus as in any of claims 11-13 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

25 determine, based upon at least partially the information received by the apparatus from the second base station, whether or not to transmit the handover request to the second base station.

15. An apparatus as in any of claims 11-14 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

perform, based at least partially upon the information received by the first base station from the second base station, at least one of:

configure a CE-specific measurement configuration;

determine CE level criteria; and

5 decide a CE level for the UE to use in the second base station.

16. An apparatus as in any of claims 11-15 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

based at least partially upon the information received by the apparatus from the second base station, where the second base station is a neighboring base station,
10 compare the second base station to at least one other neighboring base station, and the apparatus selects:

the neighboring base station having a cell in which a UE is able to work in a normal coverage mode; or

15 if the UE has to work in a CE mode rather than in the normal coverage mode, the neighboring base station having a cell in which the UE works with low CE level.

17. An apparatus as in any of claims 11-16 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

20 transmit a handover request to the second base station comprising at least one of: a single bit Enhanced Coverage (EC) indicator and a Enhanced Coverage (EC) level indicator.

18. An apparatus as in any of claims 11-17 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

25 transmit a handover request to the second base station comprising transmitting a UE measurement report from the apparatus to the second base station.

19. An apparatus as in any of claims 11-18 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

receive from the second base station a handover request acknowledgement, where the handover request acknowledgement comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources.

20. An apparatus as in any of claims 11-19 where the at least one memory and the computer
5 program code are configured to, with the at least one processor, cause the apparatus to:

transmit by the apparatus to a user equipment (UE) a radio resource control (RRC) connection reconfiguration message, where the RRC connection reconfiguration message comprises information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources for the second base station.

10 21. A non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising:

transmitting signals from a first base station to a second base station in a network; and

15 during an interface setup or an interface update between the first base station and the second base station, receiving information regarding at least one of:

whether coverage enhancement (CE) is supported by the second base station,

a maximum coverage enhancement (CE) level supported by the second base station,

20 whether low-cost coverage enhancement (CE) is supported by the second base station, and

coverage enhancement (CE) level criteria at the second base station.

22. A method comprising:

transmitting signals from a second base station to a first base station in a network; and

25 during an interface setup or an interface update between the first base station and the second base station, transmitting by the second base station to the first base station information regarding at least one of:

whether coverage enhancement (CE) is supported by the second base station,

a maximum coverage enhancement (CE) level supported by the second base station,

whether low-cost coverage enhancement (CE) is supported by the second base station, and

5 coverage enhancement (CE) level criteria at the second base station.

23. A method as in claim 22 further comprising:

based upon receipt of a handover request by the second base station from the first base station, the second base station transmitting a handover request acknowledgement comprising information regarding coverage enhancement (CE)
10 related physical random access channel (PRACH) resources.

24. A method as in claim 23 where the handover request comprises at least one of a single bit EC indicator and a EC level indicator, and where the information transmitted in the handover request acknowledgement is based, at least partially, on the indicator(s) received by the second base station.

15 25. A method as in any of claims 23-24 where the handover request comprises information from a measurement report received by the first base station from a user equipment (UE).

26. A method as in any of claims 22-25 where the second base station determines a CE level for the UE based upon the measurement report.

27. An apparatus comprising:

20 at least one processor; and

at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to:

25 transmit signals from a second base station to a first base station in a network;
and

during an interface setup or an interface update between the first base station and the second base station, where the apparatus is at least part of the second

base station, transmit to the first base station information regarding at least one of:

whether coverage enhancement (CE) is supported by the second base station,

5 a maximum coverage enhancement (CE) level supported by the second base station,

whether low-cost coverage enhancement (CE) is supported by the second base station, and

coverage enhancement (CE) level criteria at the second base station.

10 28. An apparatus as in claim 36 where the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus to:

based upon receipt of a handover request by the second base station from the first base station, the transmit a handover request acknowledgement comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources.

15

29. An apparatus as in claim 28 where the handover request comprises at least one of a single bit EC indicator and a EC level indicator, and where the information transmitted in the handover request acknowledgement is based, at least partially, on the indicator received by the second base station.

20 30. An apparatus as in any of claims 28-29 where the handover request comprises information from a measurement report received by the first base station from a user equipment (UE).

31. An apparatus as in any of claims 28-30 where the second base station determines a CE level for the UE based upon the measurement report.

25 32. A non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising:

transmitting signals from a second base station to a first base station in a network; and

during an interface setup or an interface update between the first base station and the second base station, transmitting to the first base station information regarding at least one of:

- 5 whether coverage enhancement (CE) is supported by the second base station,
 a maximum coverage enhancement (CE) level supported by the second base station,
 whether low-cost coverage enhancement (CE) is supported by the second base station, and
 coverage enhancement (CE) level criteria at the second base station.

10 33. A method comprising:

 receiving by a user equipment (UE) from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and

15 transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

20 34. A method as in claim 33 where the information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources comprises information regarding at least one of:

- whether coverage enhancement (CE) is supported by the second base station,
 a maximum coverage enhancement (CE) level supported by the second base station,
 whether low-cost coverage enhancement (CE) is supported by the second base station,
25 and
 coverage enhancement (CE) level criteria at the second base station.

35. A method as in any of claims 33-34 where transmitting the physical random access channel (PRACH) preamble comprises transmitting the physical random access channel (PRACH) preamble associated with a CE level supported by the second base station.

5 36. A method as in any of claims 33-35 where the information regarding coverage enhancement (CE) physical random access channel (PRACH) resources received by the user equipment includes a resource allocation and dedicated preambles.

37. An apparatus comprising:

at least one processor; and

10 at least one non-transitory memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to:

receive from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and

15 transmit a signal to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment
20 (UE).

38. An apparatus as in claim 37 where transmitting the physical random access channel (PRACH) preamble comprises transmitting the physical random access channel (PRACH) preamble associated with a CE level supported by the second base station.

25 39. An apparatus as in claim 37 where the information regarding coverage enhancement (CE) physical random access channel (PRACH) resources received by the user equipment includes a resource allocation and dedicated preambles.

40. A non-transitory program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine for performing operations, the operations comprising:

receiving from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and

5 transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment (UE).

41. An apparatus comprising:

10 means for transmitting signals from a first base station to a second base station in a network; and

means for receiving by the first base station, during an interface setup or an interface update between the first base station and the second base station, information regarding at least one of:

15 whether coverage enhancement (CE) is supported by the second base station, a maximum coverage enhancement (CE) level supported by the second base station,

whether low-cost coverage enhancement (CE) is supported by the second base station, and

20 coverage enhancement (CE) level criteria at the second base station.

42. An apparatus comprising:

means for transmitting signals from a second base station to a first base station in a network; and

25 means for transmitting by the second base station to the first base station, during an interface setup or an interface update between the first base station and the second base station, information regarding at least one of:

whether coverage enhancement (CE) is supported by the second base station,

a maximum coverage enhancement (CE) level supported by the second base station,

whether low-cost coverage enhancement (CE) is supported by the second base station, and

5 coverage enhancement (CE) level criteria at the second base station.

43. An apparatus comprising:

means for receiving by a user equipment (UE) from a first base station a handover command comprising information regarding coverage enhancement (CE) related physical random access channel (PRACH) resources; and

10 means for transmitting a signal by the user equipment (UE) to the second base station, where the signal comprises a physical random access channel (PRACH) preamble, where the physical random access channel (PRACH) preamble is based, at least partially, upon the information regarding the coverage enhancement (CE) related physical random access channel (PRACH) resources received by the user equipment
15 (UE).

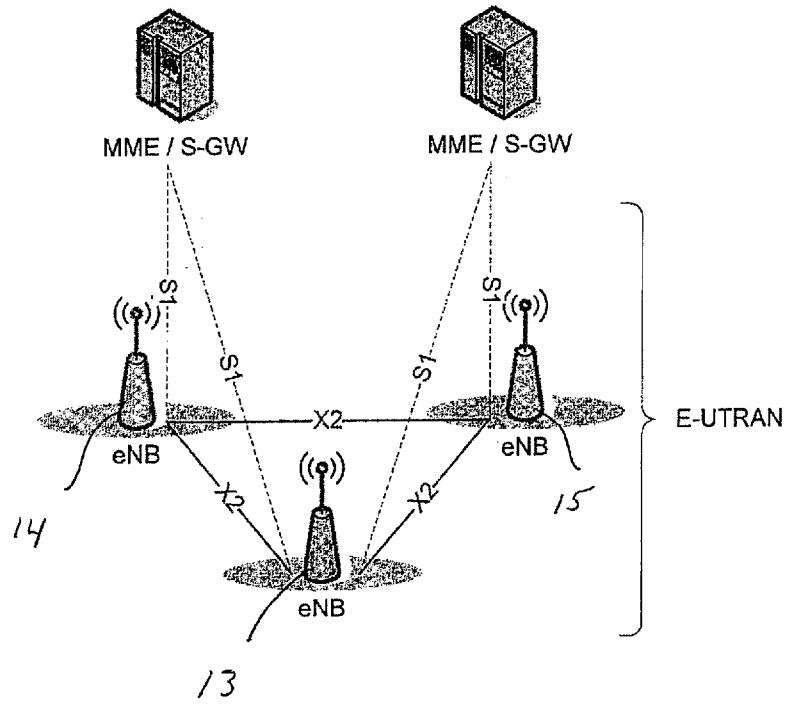


Fig 1

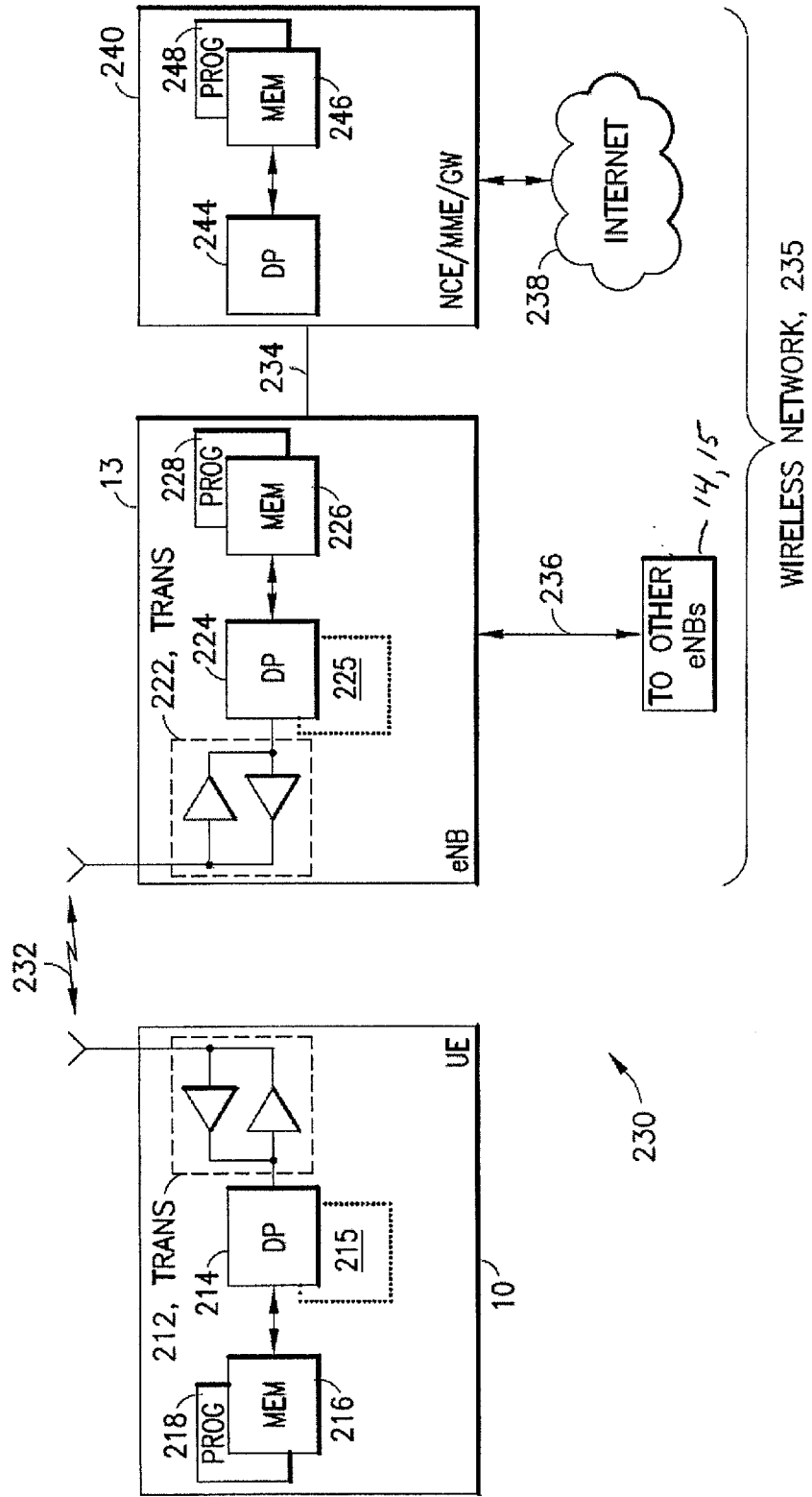


FIG. 2

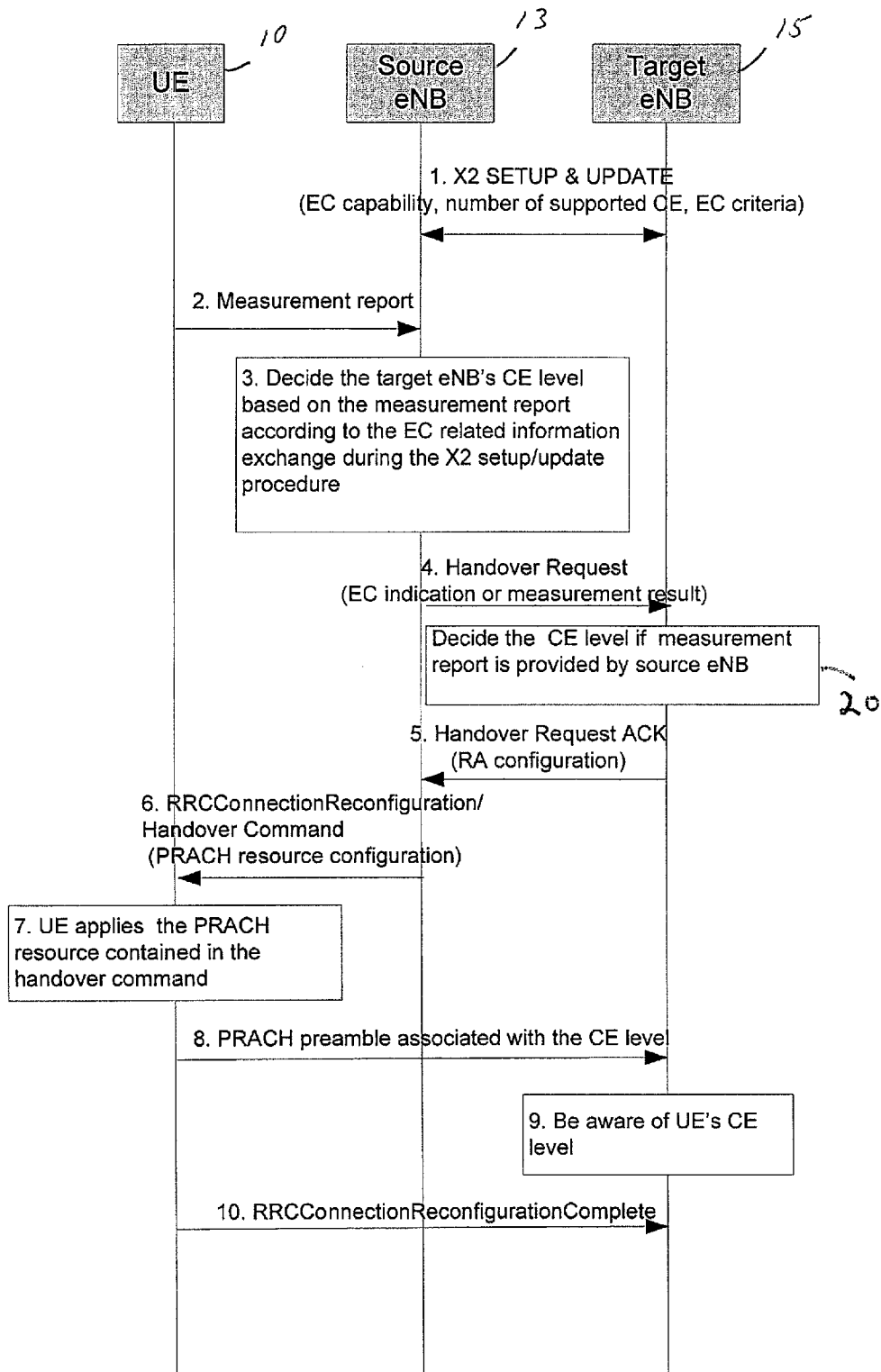


Fig 3

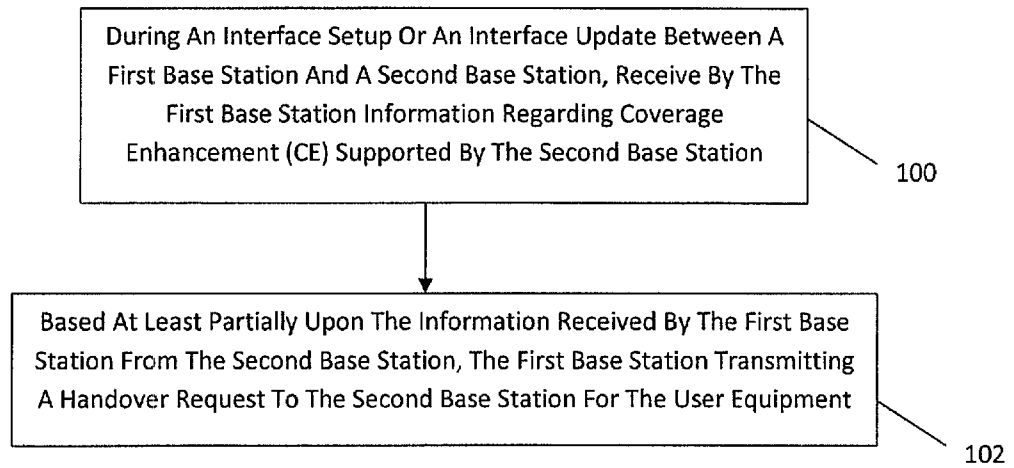


Fig 4

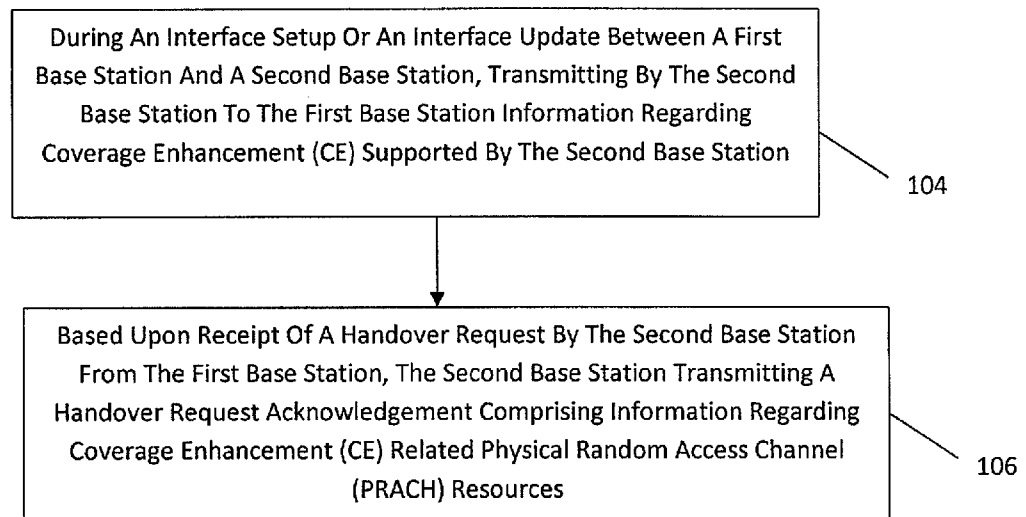


Fig 5

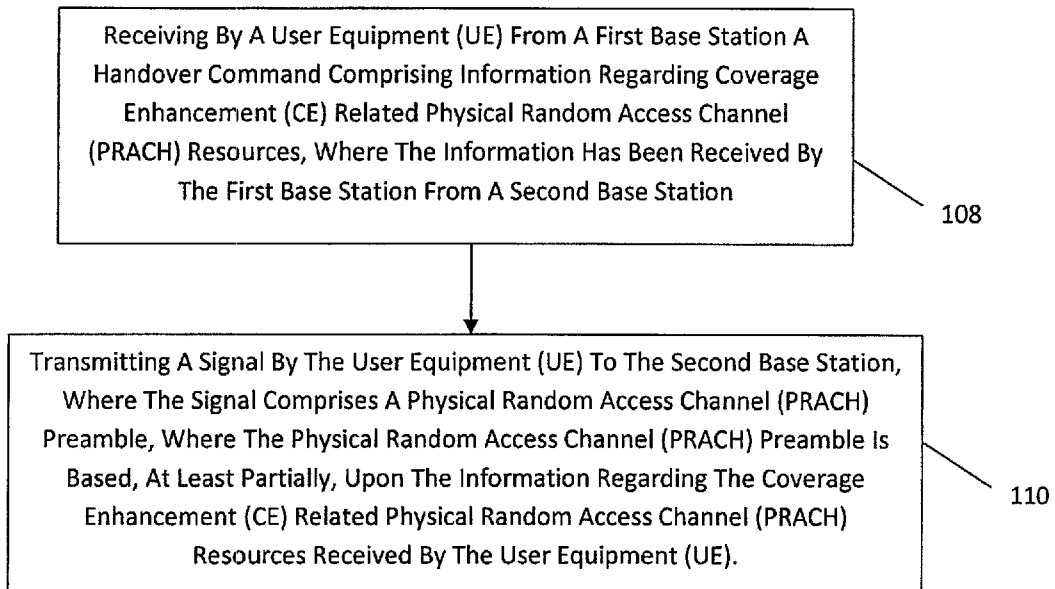


Fig 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/093987

A. CLASSIFICATION OF SUBJECT MATTER		
H04W 74/08(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; H04L		
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)		
CNABS,CNTXT,CNKI,VEN,USTXT:second base station, second UE, second node+, coverage enhancement,CE,level,interface, physical random access channel,PRACH,preamble		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 104780617 A (ZTE CORPORATION) 15 July 2015 (2015-07-15) description paragraphs [0021]-[0143]	1-43
A	CN 104184548 A (ZTE CORPORATION) 03 December 2014 (2014-12-03) the whole document	1-43
A	CN 104519591 A (ZTE CORPORATION) 15 April 2015 (2015-04-15) the whole document	1-43
A	US 2015215911 A1 (DIMOU KONSTANTINOS DET AL.) 30 July 2015 (2015-07-30) the whole document	1-43
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> 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	“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
“E”	earlier application or patent but published on or after the international filing date	“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
“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)	“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
“O”	document referring to an oral disclosure, use, exhibition or other means	“&” document member of the same patent family
“P”	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search	Date of mailing of the international search report	
14 July 2016	26 July 2016	
Name and mailing address of the ISA/CN	Authorized officer	
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China	YANG,Xiaoman	
Facsimile No. (86-10)62019451	Telephone No. (86-10)62411492	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/093987

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	104780617	A	15 July 2015	WO	2015103874	A1	16 July 2015
CN	104184548	A	03 December 2014	WO	2015157879	A1	22 October 2015
CN	104519591	A	15 April 2015	WO	2014177092	A1	06 November 2014
US	2015215911	A1	30 July 2015	None			