



(51) International Patent Classification:

H04W 76/15 (2018.01) H04W 92/20 (2009.01)
H04W 76/18 (2018.01)

(21) International Application Number:

PCT/EP2020/051393

(22) International Filing Date:

21 January 2020 (21.01.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201941003548 29 January 2019 (29.01.2019) IN

(71) Applicant: NOKIA TECHNOLOGIES OY [FI/FI];

Karakaari 7, 02610 Espoo (FI).

(72) Inventors: SELVAGANAPATHY, Srinivasan; C-002, Gopalan Atlantis, ECC Road, Whitefield, Bangalore 560066 (IN). SÄILY, Mikko; Porvoontie 380, 07150 Laukkoski (FI). KOSKINEN, Henri Markus; Huvilinnamäki 8 A 15, 02600 Espoo (FI).

(74) Agent: NOKIA EPO REPRESENTATIVES; Nokia Technologies Oy, Karakaari 7, 02610 Espoo (FI).

(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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,

(54) Title: NEW RADIO - DUAL CONNECTIVITY ENHANCEMENTS FOR LTE

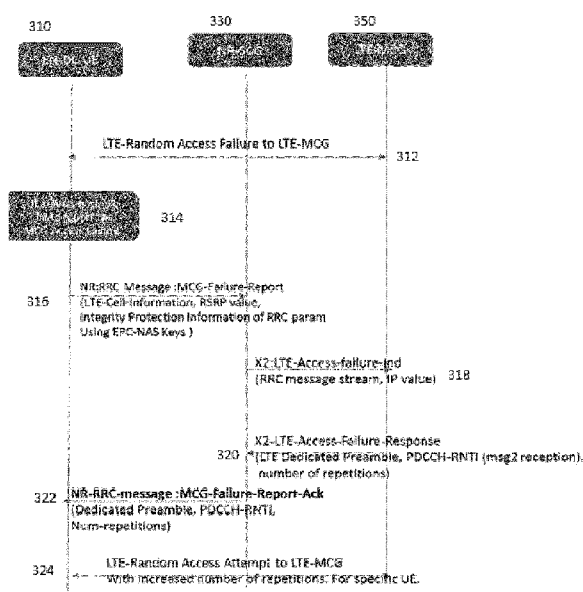


FIG. 4

(57) Abstract: In accordance with example embodiments of the invention there is at least a method performed by apparatus to determine, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and based on the determining, forward the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network. Further, in accordance with example embodiments of the invention there is at least a method performed by apparatus to determine, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network; based on the determining, detect a device associated with a new radio cell of the new radio small cell network that capable

SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

of forwarding a connectivity failure report for the new radio dual connectivity failure; and send towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

NEW RADIO - DUAL CONNECTIVITY ENHANCEMENTS FOR LTE**TECHNICAL FIELD:**

[0001] The teachings in accordance with the exemplary embodiments of this invention relate generally to multi-radio dual connectivity functionality of new radio operations and, more specifically, relate to multi-radio dual connectivity functionality of new radio operations with an evolved packet core network.

BACKGROUND:

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Certain abbreviations that may be found in the description and/or in the Figures are herewith defined as follows:

CN	core network
EN-DC	E-UTRAN new radio – dual connectivity
EPC	evolved packet core
E-UTRAN	evolved universal terrestrial radio access network
DC	dual connectivity
ECGI	E-UTRAN cell global identifier
en-gNB	E-UTRAN new radio base station
FDM	frequency division multiplex
IP	integrity protection
LCH	logical channel
LTE	long term evolution

MAC	medium access control
MCG	master cell group
NAS	non-access stratum
OFDM	orthogonal FDM
OPEX	operating expenditure
PBCH	physical Broadcast Channel
PCI	physical cell identity
PDCCH	Physical Downlink Control Channel
RACH	random access channel
RRC	radio resource control
SCG	secondary cell group
SRB	signaling radio bearer
UE	user equipment

[0004] The EN-DC Architecture as at the time of this application assumes LTE coverage to be available in all the places where the NR small cell coverage is deployed.

[0005] However, in a case where LTE coverage is not available within cells such as NR small cells in deployment scenarios like NR indoor small-cells or NR small-cells deployed in LTE coverage holes, in the standards at the time of this application at least the following issues are expected:

- If the UE starts its connection at LTE layer and establishes the dual connectivity with NR small-cell while moving into the NR coverage, the UE will experience Radio link failure for the LTE MCG and the UE will not be able to re-establish the LTE connectivity as the UE will fail to detect LTE macro-cell on entering into idle mode after the radio link failure; and
- In case if the UE capable of EN-DC switches on within the NR small cell, the UE checks for LTE cells and will not find the same. In this case the UE may enter into out of service state and keeps checking for LTE coverage through periodic check for LTE cells. For this scenario, the UE cannot make any outgoing data connections as it cannot setup the primary link (MCG) required for EN-DC.

[0006] At the time of this application these problems have not yet been discussed in detail at 3GPP for development of solutions. Still, the deployment scenario having NR cells deployed with LTE coverage remains valid in some deployments.

[0007] The example embodiments of the invention work to provide solutions to overcome at least the issues as stated above.

SUMMARY:

[0008] In an example embodiment, a method comprises determining, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and based on the determining, forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.

[0009] A further example embodiment is the method of the previous paragraph, wherein the network node is part of a new radio cell of the new radio small cell network, wherein the indication comprises a connectivity failure message associated with a failure of the user equipment to setup connectivity with the long term evolution master cell group, wherein the failure to setup the connectivity is based on a long term evolution random access channel failure associated with a radio resource control connection setup procedure, wherein there is sending towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group,

wherein there is sending towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group, wherein the at least one message comprises long term evolution radio resource control message used to control whether user equipment can access the new radio cell without LTE coverage, wherein there is sending towards the user equipment at least one broadcast message indicating that the network node supports long term evolution connection setup for the user equipment of the new radio small cell network, wherein there is receiving by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and sending, by the network node, the connection request message towards the default base station to establish the connectivity, and wherein the connection request message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the default base station.

[0010] A non-transitory computer-readable medium storing program code, the program code executed by at least one processor to perform at least the method as described in the paragraphs above.

[0011] In another example embodiment, an apparatus comprises means for determining, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and means, based on the determining, for forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.

[0012] A further example embodiment is the apparatus of the previous paragraph, wherein the network node is part of a new radio cell of the new radio small cell network, wherein the indication comprises a connectivity failure message associated with a failure

of the user equipment to setup connectivity with the long term evolution master cell group, wherein the failure to setup the connectivity is based on a long term evolution random access channel failure associated with a radio resource control connection setup procedure, wherein there is means for sending towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group, wherein there is means for sending towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group, wherein the at least one message comprises long term evolution radio resource control message used to control whether user equipment can access the new radio cell without LTE coverage, wherein there is means for sending towards the user equipment at least one broadcast message indicating that the network node supports long term evolution connection setup for the user equipment of the new radio small cell network, wherein there is means for receiving by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and sending, by the network node, the connection request message towards the default base station to establish the connectivity, and wherein the connection request message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the default base station.

[0013] In the example aspect of the invention according to the paragraphs above, wherein at least the means for determining and forwarding comprises a non-transitory computer readable medium [Memory(ies) 155 as in FIG. 2] encoded with a computer program [Computer Program Code 153 as in FIG. 2] executable by at least one processor Processor(s) 152 as in FIG. 2].

[0014] In a further exemplary embodiment, an apparatus comprises one or more processors and one or more memories including computer program code. The one or more memories and the computer program code configured, with the one or more processors, to cause the apparatus to perform at least: determining, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and based on the determining, forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.

[0015] A further example embodiment is the apparatus of the previous paragraph, wherein the network node is part of a new radio cell of the new radio small cell network, wherein the indication comprises a connectivity failure message associated with a failure of the user equipment to setup connectivity with the long term evolution master cell group, wherein the failure to setup the connectivity is based on a long term evolution random access channel failure associated with a radio resource control connection setup procedure, wherein there is sending towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group, wherein there is sending towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group, wherein the at least one message comprises long term evolution radio resource control message used to control whether user equipment can access the new radio cell without LTE coverage, wherein there is sending towards the user equipment at least one broadcast

message indicating that the network node supports long term evolution connection setup for the user equipment of the new radio small cell network, wherein there is receiving by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and sending, by the network node, the connection request message towards the default base station to establish the connectivity, and wherein the connection request message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the default base station.

[0016] In another example embodiment, a method comprises determining, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network; based on the determining, detecting a device associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and sending towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

[0017] A further example embodiment is the method of the previous paragraph, wherein the communication network comprises a long term evolution master cell group, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network, wherein the detecting comprises: determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell. The method of the previous paragraph, wherein there is based on the message, receiving via the device

associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment. The the method of the previous paragraph, wherein there is based on the information, establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity. The method of the previous paragraph, wherein there is sending, by the user equipment, towards the long term evolution master cell group of the communication network a measurement report for the long term evolution master cell group of the communication network, wherein based on the measurement report the long term evolution master cell group is reconfigured with a split signaling radio bearer associated with an activated cell of the long term evolution master cell group for the new radio dual connectivity, wherein for a case that the long term evolution cell of the communication network is controlled by a base station other than the default base station, the method comprising: a master cell group handover without a secondary cell group change to move the user equipment to the other base station.

[0018] A non-transitory computer-readable medium storing program code, the program code executed by at least one processor to perform at least the method as described in the paragraphs above.

[0019] In another example embodiment, there is an apparatus comprising means for determining, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network; means, based on the determining, for detecting a device associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and means for sending towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

[0020] A further example embodiment is the apparatus of the previous paragraph, wherein the communication network comprises a long term evolution master cell group, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network, wherein the detecting comprises: determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell. The apparatus of the previous paragraph, wherein there is means, based on the message, for receiving via the device associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity. The apparatus of the previous paragraph, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment. The apparatus of the previous paragraph, wherein there is means, based on the information, for establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity.

[0021] In another example aspect of the invention, there is an apparatus, such as a user equipment side apparatus, comprising: at least one processor; and at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least: determine, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network; based on the determining, detect a device associated with a new radio cell of the

new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and send towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

[0022] A further example embodiment is the apparatus of the previous paragraph, wherein the communication network comprises a long term evolution master cell group, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network, wherein the detecting comprises: determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell. The apparatus of the previous paragraph wherein there is: based on the message, receiving via the device associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment. The apparatus of the previous paragraph, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to: based on the information, establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity, and wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to: send, by the user equipment, towards the long term evolution master cell

group of the communication network a measurement report for the long term evolution master cell group of the communication network, wherein based on the measurement report the long term evolution master cell group is reconfigured with a split signaling radio bearer associated with an activated cell of the long term evolution master cell group for the new radio dual connectivity. The apparatus of the previous paragraph wherein for a case that the long term evolution cell of the communication network is controlled by a base station other than the default base station, the method comprising: a master cell group handover without a secondary cell group change to move the user equipment to the other base station.

[0023] A communication system comprising the apparatus in accordance with any one of the previous paragraphs.

[0024] A computer program comprising a non-transitory computer-readable medium bearing computer program code and program code for executing the method according to any of the previous paragraphs.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0025] The foregoing and other aspects of embodiments of this invention are made more evident in the following Detailed Description, when read in conjunction with the attached Drawing Figures, wherein:

[0026] FIG. 1 shows Figure 4.1.2-1: EN-DC Overall Architecture of 3GPP TS 37.340 V15.3.0 (2018-09);

[0027] FIG. 2 shows a high level block diagram of various devices used in carrying out various aspects of the invention;

[0028] FIG. 3 shows a scenario corresponding to a problem being solved by example embodiments of the invention;

[0029] FIG. 4 shows a flow of operations performed by different devices in

accordance with example embodiments of the invention; and

[0030] FIG. 5A and FIG. 5B each show a method in accordance with example embodiments of the invention which may be performed by an apparatus.

DETAILED DESCRIPTION:

[0031] In example embodiments of the invention there is proposed multi-radio dual connectivity functionality of new radio operations with an evolved packet core as a core network. Further, in accordance with example embodiments of the invention there is proposed multi-radio dual connectivity functionality with the evolved packet core as a core network, also known as E-UTRAN new radio – dual connectivity (EN-DC) multi-connectivity.

[0032] FIG. 1 shows an EN-DC architecture which can benefit from example embodiments of the invention. FIG. 1 shows an EN-DC architecture where the gNB does not have control plane connectivity to EPC. At gNB only the lower layer functions of NR will be active with higher layers of LTE/EPC functionality. The RRC control plane functions mainly resides in LTE node with some secondary support related to mobility within NR layers handled at gNB with minimum involvement from LTE-RRC. The RRC connection setup /Release and radio link failure functions are still handled at the LTE node in this architecture.

[0033] As shown in FIG. 1 E-UTRAN 1150 supports MR-DC via E-UTRA-NR Dual Connectivity (EN-DC), in which a UE is connected to one eNB that acts as a MN and one en-gNB that acts as a SN. The eNB is connected to the EPC via the S1 interface and to the en-gNB via the X2 interface. The en-gNB might also be connected to the EPC via the S1-U interface and other en-gNBs via the X2-U interface.

[0034] Example embodiments of the invention include a method in which a UE uses the SCG leg of SRB3 which was established as part of dual connectivity to communicate the radio link failure of MCG to the LTE node.

[0035] In accordance with example embodiments of the invention there are EN-DC enhancements for NR deployment without LTE coverage to provide at least one solution for situations where the UE does not find LTE coverage within NR cell in NSA deployment. In accordance with example embodiments of the invention the NR node can support forwarding of an LTE RRC message via NR air-interface to setup EN-DC connection with inactive LTE MCG.

[0036] Further, in accordance with example embodiments of the invention there is provided methods and mechanisms to report the LTE-Access failure to NR node, which can report such failure to Neighbouring LTE node. Example embodiments of the invention also provide methods and mechanisms to enable the UE to retry LTE access through dedicated preamble with increased reliability for the signaling procedure only specific to the UE. It is noted that knowledge such mechanism is not known at the time of this application.

[0037] Before describing the example embodiments of the invention in further detail, reference is made to FIG. 2 for illustrating a simplified block diagram of various electronic devices that are suitable for use in practicing the example embodiments of this invention. FIG. 2 shows a block diagram of one possible and non-limiting exemplary system in which the example embodiments of the invention may be practiced. In FIG. 2, a user equipment (UE) 110 may be in wireless communication with a wireless network 100. A UE is a wireless, typically mobile device that can access a wireless network. The UE 110 includes one or more processors 120, one or more memories 125, and one or more transceivers 130 interconnected through one or more buses 127. Each of the one or more transceivers 130 includes a receiver Rx, 132 and a transmitter Tx 133. The one or more buses 127 may be address, data, or control buses, and may include any interconnection mechanism, such as a series of lines on a motherboard or integrated circuit, fiber optics or other optical communication equipment, and the like. The one or more transceivers 130 are connected to one or more antennas 128. The one or more transceivers 130 have multi-connectivity configurations and communicate over the wireless network 100 or any other network. The one or more memories 125 include computer program code 123 executed by the one or more processors 120. The one or more processors 120 may be implemented also as an integrated circuit or through other hardware such as a

programmable gate array. For instance, the one or more memories 125 and the computer program code 123 may be configured, with the one or more processors 120, to cause the user equipment 110 to perform one or more of the operations as described herein. The UE 110 can communicate with SCG 170 and/or the gNB 180 via a wireless link 111.

[0038] The SCG 170 is a device (e.g., NR/5G Node B) of a secondary cell group (SCG) such as a secondary node base station (e.g., for NR or LTE long term evolution) that communicates with devices such as gNB 180 and UE 110 of FIG. 2. In accordance with example embodiments of the invention the SCG 170 can communicate signaling to provide access to wireless devices such as the UE 110 to the wireless network 100, such as via the gNB 180. The SCG 170 includes one or more processors 152, one or more memories 155, one or more network interfaces (N/W I/F(s)) 161, and one or more transceivers 160 interconnected through one or more buses 157. Each of the one or more transceivers 160 includes a receiver Rx 162 and a transmitter Tx 163. The one or more transceivers 160 are connected to one or more antennas 158. The one or more memories 155 include computer program code 153 executed by the one or more processors 152. The one or more processors 152 may be implemented also as an integrated circuit or through other hardware such as a programmable gate array. The one or more memories 155 and the computer program code 153 are configured to cause, with the one or more processors 152, the SCG 170 to perform one or more of the operations as described herein. The one or more network interfaces 161 and 191 and the one or more transceivers 160 that have multi-connectivity configurations and communicate over the wireless network 100 or any other network. Such communication can be between the SCG 170, the gNB 180, and the UE 110 via the links 176 and 111. In addition, two or more SCG 170 may communicate with another gNB or eNB using, e.g., links 176. The links 176 may be wired or wireless or both and may implement, e.g., an X2 interface. Further the links 176 may be through other network devices such as, but not limited to an NCE/MME/SGW device such as the NCE/MME/SGW 190 of FIG. 2.

[0039] The gNB 180 (NR/5G Node B or possibly an evolved NB) is a base station such as a master node base station (e.g., for NR or LTE long term evolution) that communicates with devices such as the SCG 170 and/or UE 110 and/or the wireless network 100. The gNB 180 can provide access of the UE 110 to the wireless

communication Network 100. The gNB 180 includes one or more processors 182, one or more memories 195, one or more network interfaces (N/W I/F(s)) 191, and one or more transceivers 190 interconnected through one or more buses 187. Each of the one or more transceivers 190 includes a receiver Rx 192 and a transmitter Tx 183. The one or more transceivers 190 are connected to one or more antennas 185. The one or more transceivers 190 have multi-connectivity configurations and communicate over the wireless network 100 or any other network. The one or more memories 195 include computer program code 193 executed by the one or more processors 182. The one or more processors 182 may be implemented also as an integrated circuit or through other hardware such as a programmable gate array. The one or more memories 155 and the computer program code 153 are configured to cause, with the one or more processors 182, the gNB 180 to perform one or more of the operations as described herein. The one or more network interfaces 181 communicate over a network such as via the links 176. Two or more SCG 170 or gNB 180 may communicate with another gNB and/or eNB or any other device using, e.g., links 176. The links 176 maybe wired or wireless or both and may implement, e.g., an X2 interface. Further, as stated above the links 176 may be through other network devices such as, but not limited to an NCE/MME/SGW device such as the NCE/MME/SGW 190 of FIG. 2.

[0040] The one or more buses 157 and 187 may be address, data, or control buses, and may include any interconnection mechanism, such as a series of lines on a motherboard or integrated circuit, fiber optics or other optical communication equipment, wireless channels, and the like. For example, the one or more transceivers 160 and/or 190 may be implemented as a remote radio head (RRH) 203 and/or 205, with the other elements of the SCG 170 being physically in a different location from the RRH, and the one or more buses 157 could be implemented in part as fiber optic cable to connect the other elements of the SCG 170 to a RRH.

[0041] It is noted that description herein indicates that “cells” perform functions, but it should be clear that the device that forms the cell can perform the functions. The cell makes up part of a base station or gNB. That is, there can be multiple cells per base station or gNB.

[0042] The wireless network 100 may include a network control element (NCE) 190 that may include MME (Mobility Management Entity)/SGW (Serving Gateway) functionality, and which provides connectivity with a further network, such as a telephone network and/or a data communications network (e.g., the Internet). The SCG 170 is coupled via a link 131 to the NCE 190. The gNB 180 is coupled via a link 200 to the NCE 190. Further, the gNB 180 is coupled via links 176 to the SCG 170. The links 131, 176, and/or 200 may be implemented as, e.g., an S1 interface.

[0043] The NCE 190 includes one or more processors 175, one or more memories 171, and one or more network interfaces (N/W I/F(s)) 197, interconnected through one or more buses coupled with the link 185. The one or more memories 171 include computer program code 173. The one or more memories 171 and the computer program code 173 are configured to, with the one or more processors 175, cause the NCE 190 to perform one or more operations which may be needed to support the operations in accordance with the example embodiments of the invention.

[0044] The wireless network 100 may implement network virtualization, which is the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity, a virtual network. Network virtualization involves platform virtualization, often combined with resource virtualization. Network virtualization is categorized as either external, combining many networks, or parts of networks, into a virtual unit, or internal, providing network-like functionality to software containers on a single system. Note that the virtualized entities that result from the network virtualization are still implemented, at some level, using hardware such as processors 152, 182, or 175 and memories 155, 195, and 171, and also such virtualized entities create technical effects.

[0045] The computer readable memories 125, 155, 171, and 195 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 computer readable memories 125, 155, 171, and 195 may be means for performing storage functions. The processors 125, 155, 171,

and 195 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 multi-core processor architecture, as non-limiting examples. The processors 120, 152, 175, and 182 may be means for performing functions, such as controlling the UE 110, SCG 170, gNB 180, and other functions as described herein.

[0046] FIG. 3 shows a scenario that corresponds to problems being solved in accordance with the example embodiments. As shown in FIG. 3 there is an LTE-MCG Coverage area 210 and an NR SCG Coverage area 220. The LTE-MCG Coverage area 210 can relate to a long term master evolution master cell group, and the NR SCG Coverage area 220 can relate to a new radio small cell network as discussed herein.

[0047] To address one main issue related to providing the radio coverage for EN-DC capable UE which is within NR coverage without LTE coverage at least some following changes as underlined below are proposed to the existing EN-DC operations:

- The gNB selects one of its X2 connected LTE eNB as default-ENB for serving the NR UE which does not have actual LTE MCG to establish the radio link. gNB uses this X2 link for relaying the LTE RRC messages to the default-ENB;
- gNB broadcasts its support for routing the LTE-RRC message for setting up the EN-DC connectivity without LTE MCG;
- gNB also optionally broadcasts range of RACH preambles dedicated for the EN-DC UE to send the LTE RRC message. In this case, the gNB forwards any Msg3 received from the RACH procedure on this preamble without processing the same to default ENB;
- EN-DC capable UE, if not detect LTE cells in idle mode, the UE checks for NR cells which supports the LTE-RRC connection setup via the NR air-interface.
 - In one embodiment, the UE sends the LTE-RRC message with unique

LCH-ID which can be used by the gNB to identify that the message needs to be routed to LTE node;

- The default LTE ENB establish RRC connection with split SRB containing only active SCG and sends the LTE-RRC connection setup via X2. The X2 tunnels for split part of SRB3 is also setup as part of this X2 transaction;
- On successful RRC connection establishment, the EPC NAS messages are sent via the split SRB3 with further DRBs redirected to gNB. This step is similar to any EN-DC setup procedure;
- UE continue to measure for LTE cell. If LTE cell is detected, it sends the measurement report via NR node and optionally triggers random access procedure towards the LTE cell for faster setup of MCG. For this purpose, the NR node may include the RACH configurations of potential LTE neighbor-cells as part of LTE RRC connection setup via NR;
- Based on LTE measurements, LTE ENB activate the MCG and reconfigure the split SRB with active MCG part. The UE can further send SRB message through both MCG and SCG directly if the RACH procedure was already completed through early connection setup;
- In case if the LTE cell belongs to different ENB than the default ENB, default ENB initiates inter MCG handover without SCG change to move the UE to the actual ENB handling the target-LTE cell.

[0048] In addition, example embodiments of the invention as described herein can also work to perform:

- Use of an NR-routed LTE-RRC connection setup can be subscribed feature at EPC. Only UE with valid subscription for such feature are allowed to access the NR cell to send LTE RRC connection setup;

- Assist of the right selection of default node, the UE may send the last seen LTE cells when it establish the RRC connection via NR node. This information which is additionally conveyed during RRC connection setup can help to setup the RRC connection via suitable ENB so that later switching of ENB can be avoided when the UE detects MCG:
 - In case if the UE is triggering the connection setup within short time after release of the EN-DC connection within the same NR cell , the LTE MCG which was part of earlier EN-DC also can be included as additional information in the MAC header for gNB to route the LTE message to the right node;
- Support for faster setup of EN-DC connection after release of EN-DC within the same NR-cell when the UE was in good coverage, The LTE node may send RRC connection suspend on release of the EN-DC connection with resume Identifier:
 - On selecting the same NR cell for resuming the connection, UE sends NR-RRC-Connection-Resume message with the resume identifier to identify the LTE ENB and UE context within the same,
 - LTE ENB reconfigures the UE with EN-DC connection with inactive LTE leg for split SRB.

[0049] Regarding the operation above where the LTE ENB reconfigures the UE with EN-DC connection with inactive LTE leg for split SRB, it may be known in LTE where UE can resume the UE context in RRC-INACTIVE state in LTE. In accordance with example embodiments of the invention this procedure can be considered as dependent method as one-way for the UE to resume the EN-DC connection via NR-cell without LTE coverage.

[0050] When an EN-DC capable UE fails in its random access procedure towards the LTE macro-cells such as when attempted within NR coverage, at least the operations

in accordance with example embodiments of the invention as below are proposed in the further signalling procedure between UE and ENB as disclosed herein.

[0051] For a case where a UE access attempt to LTE macro-cell fails due to no reception of Msg2 on contention resolution, for example, there is in accordance with example embodiments of the invention LTE-Access-failure reporting to NR, and UE Specific Extended Coverage for EN-DC RRC connection setup after failure reporting. These are described below in more detail.

[0052] LTE-Access-failure reporting to NR:

- UE checks presence of NR cell on the NR layer to send the LTE-Access-failure report to NR cell;
- On the best NR cell, UE sends new NR-RRC message “RRC-MCG-Access-Failure-Report” which also contains Integrity protection of the message. The UE generates the Integrity protection information on the generated RRC-Message content based on EPC NAS security keys. The UE will also include the LTE-PCI/ECGI information where the access attempt failed;
- NR cell forwards the failure report to any of the neighbor LTE eNB controlling the LTE cell on which the access attempt was failed;
- eNB verifies the integrity protection with new S1 signaling with EPC. Here eNB passes the message content and Integrity Protection (IP) information; and
- Once the IP is verified, the eNB may internally decide to increase the LTE coverage to the area where NR cell is deployed.

[0053] UE Specific Extended Coverage for EN-DC RRC connection setup after failure reporting:

- If the ENB supports increasing the number of repetitions for specific preamble and the PDCCH sent using specific RNTI,
 - ENB indicates new dedicated preamble and additional information on number of repetitions for preambles and also for reception of PDCCH in response to the MCG-Failure-Report message from UE,
 - The response message contains dedicated preamble and C-RNTI and also the number of repetitions to be used in the new random access,
 - On reception of the response message for MCG-Failure-Report, UE trigger LTE RRC Connection Request message transmission using the dedicated preamble and the number of repetitions provided to UE;
- With the above mechanism, the EN-DC connection setup is successfully completed through UE specific increase of number of repetitions instead of increasing the coverage of the complete LTE cell on failure reporting.

[0054] The message sequence for UE reporting LTE Access failure via NR cell and subsequent coverage extension for LTE random access procedure to successfully setup the EN-DC connection.

[0055] The message sequence for LTE-RACH failure followed by network informing dedicated resource for UE to increase the reliability of next LTE RACH access through dedicated resources with increased number of repetitions.

[0056] FIG. 4 shows a flow of operations performed by different devices in accordance with example embodiments of the invention. As shown in FIG. 4 there is an EN-DC UE 310, such as the UE 110 as in FIG. 2; an NR-SCG 330, such as the SCG 170 as in FIG. 2; and an LTE-MCG 350, such as the gNB 180 as in FIG. 2. As shown in FIG. 4 there is at step 312 an LTE-Random Access Failure has occurred between the EN-DC UE 310 and the LTE-MCG 350. At step 314 it is shown that the EN-DC UE 310 selects a best NR cell to report the MCG-Access Failure. In this regard the NR-SCG 330

comprises the best NR cell. At step 316 of FIG. 4 the EN-DC UE 310 sends an NR :RRC Message:MCG-Failure-Report towards the NR-SCG 330. As shown in FIG. 4 this message can comprise at least LTE-Cell-Information, RSRP value, Integrity Protection Information of RRC parameters using EPC-NAS keys for security. As shown in step 318 of FIG. 4 the NR-SCG 330 forwards this LTE-failure-Indication towards the LTE-MCG 350. This information can be forwarded over an X2 interface and can include an RRC message stream and an IP value for integrity protection. In step 320 of FIG. 4 the LTE-MCG 350 responds to the NR-SCG 330 with an LTE-Access-Failure-Response. This response of step 320 of FIG. 4 can be forwarded to the NR-SCG 330 over an X2 interface and can include an LTE Dedicated Preamble, PDDCH-RNTI (msg2 reception), and an increased number of repetitions for a connection request from the EN-DC UE 310. As shown in step 32 of FIG. 4 the NR-SCG 350 relays information including an NR-RRC-message : MCG-Failure-Report-Ack towards the EN-DC UE 310. This information as in step 322 of FIG. 4 can also include a Dedicated Preamble, PDCCH-RNTI, and the increased number of repetitions specific to the EN-DC UE 310. Then in response the EN-DC UE 310 is able to communicate with the LTE-MCG 350 of FIG. 4 an LTE-Random Access Attempt to the LTE-MCG 350 using the information received, such as using the increased number of repetitions.

[0057] Figure 5A illustrates operations which may be performed by a network device such as, but not limited to, a network node as in FIG.2 or an SCG 170. As shown in step 510 of FIG. 5A there is determining, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network. Then as shown in step 520 of FIG. 5A there is based on the determining, forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.

[0058] In accordance with the example embodiments as described in the paragraph above, wherein the network node is part of a new radio cell of the new radio small cell network.

[0059] In accordance with the example embodiments as described in the paragraphs above, wherein the indication comprises a connectivity failure message associated with a failure of the user equipment to setup connectivity with the long term evolution master cell group.

[0060] In accordance with the example embodiments as described in the paragraphs above, wherein the failure to setup the connectivity is based on a long term evolution random access channel failure associated with a radio resource control connection setup procedure.

[0061] In accordance with the example embodiments as described in the paragraphs above, there is sending towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment.

[0062] In accordance with the example embodiments as described in the paragraphs above, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

[0063] In accordance with the example embodiments as described in the paragraphs above, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group.

[0064] In accordance with the example embodiments as described in the paragraphs above, there is sending towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group.

[0065] In accordance with the example embodiments as described in the paragraphs above, wherein the at least one message comprises long term evolution radio resource control message used to control whether user equipment can access the new radio cell without LTE coverage.

[0066] In accordance with the example embodiments as described in the paragraphs above, there is sending towards the user equipment at least one broadcast message indicating that the network node supports long term evolution connection setup for the user equipment of the new radio small cell network.

[0067] In accordance with the example embodiments as described in the paragraphs above, there is receiving by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and sending, by the network node, the connection request message towards the default base station to establish the connectivity.

[0068] In accordance with the example embodiments as described in the paragraphs above, wherein the connection request message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the default base station.

[0069] A non-transitory computer-readable medium (Memory(ies) 155 as in FIG. 2) storing program code (Computer Program Code 153 as in FIG. 2), the program code executed by at least one processor (Processors 152 as in FIG. 2) to perform the operations as at least described in the paragraphs above.

[0070] In accordance with an example embodiment of the invention as described above there is an apparatus comprising: means for determining, based on an indication (remote radio head (RRH) 203, one or more antennas 158, Memory(ies) 155; Computer Program Code 153; and Processor(s) 152 as in FIG. 2), by a network node (SCG 170 as in FIG. 2) received by a network node (SCG 170 as in FIG. 2) of a communication network (Network 100 as in FIG. 2), that a user equipment (UE 110 as in FIG. 2)

associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; then there is means, based on the determining (remote radio head (RRH) 203, one or more antennas 158, Memory(ies) 155; Computer Program Code 153; and Processor(s) 152 as in FIG. 2), for forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment (UE 110 as in FIG 2) of the new radio small cell network.

[0071] In the example aspect of the invention according to the paragraphs above, wherein at least the means for determining and forwarding comprises a non-transitory computer readable medium [Memory(ies) 155 as in FIG. 2] encoded with a computer program [Computer Program Code 153 as in FIG. 2] executable by at least one processor Processor(s) 152 as in FIG. 2].

[0072] Figure 5B illustrates operations which may be performed by a network device such as, but not limited to, a user equipment as in FIG.2 or an UE 110. As shown in step 550 of FIG. 5B there is determining, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network. As shown in step 560 of FIG. 5B there is, based on the determining, detecting a device associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure. Then as shown in step 570 of FIG. 5B there is sending towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

[0073] In accordance with the example embodiments as described in the paragraph above, wherein the communication network comprises a long term evolution master cell group.

[0074] In accordance with the example embodiments as described in the paragraphs above, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution

master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network.

[0075] In accordance with the example embodiments as described in the paragraphs above, wherein the detecting comprises: determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network.

[0076] In accordance with the example embodiments as described in the paragraphs above, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed.

[0077] In accordance with the example embodiments as described in the paragraphs above, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell.

[0078] In accordance with the example embodiments as described in the paragraphs above, there is, based on the message, receiving via the device associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity.

[0079] In accordance with the example embodiments as described in the paragraphs above, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

[0080] In accordance with the example embodiments as described in the paragraphs above, there is based on the information, establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity.

[0081] In accordance with the example embodiments as described in the paragraphs above, there is sending, by the user equipment, towards the long term evolution master cell group of the communication network a measurement report for the long term evolution master cell group of the communication network, wherein based on the measurement report the long term evolution master cell group is reconfigured with a split signaling radio bearer associated with an activated cell of the long term evolution master cell group for the new radio dual connectivity.

[0082] In accordance with the example embodiments as described in the paragraphs above, wherein for a case that the long term evolution cell of the communication network is controlled by a base station other than the default base station, the method comprising: a master cell group handover without a secondary cell group change to move the user equipment to the other base station.

[0083] In the example aspect of the invention according to the paragraphs above, wherein at least the means for configuring and applying comprises a non-transitory computer readable medium [Memory(ies) 125 as in FIG. 2] encoded with a computer program [Computer Program Code 123 as in FIG. 2] executable by at least one processor Processor(s) 120 as in FIG. 2].

[0084] In accordance with an example embodiment of the invention as described above there is an apparatus comprising: means for determining (one or more transceivers 130 connected to one or more antennas 128, Memory(ies) 125; Computer Program Code 123; and Processor(s) 120 as in FIG. 2), by a user equipment (UE 110 as in FIG. 2) of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network (Network 100 as in FIG. 2); means, based on the determining, for detecting (one or more transceivers 130 connected to one or more antennas 128, Memory(ies) 125; Computer Program Code 123; and Processor(s) 120 as in FIG. 2) a device (SCG 170 as in FIG. 2) associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and then there is means for sending (one or more transceivers 130 connected to one or more antennas 128, Memory(ies) 125; Computer

Program Code 123; and Processor(s) 120 as in FIG. 2) towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

[0085] In the example aspect of the invention according to the paragraphs above, wherein at least the means for determining, detecting, and sending comprises a non-transitory computer readable medium [Memory(ies) 125 as in FIG. 2] encoded with a computer program [Computer Program Code 123 as in FIG. 2] executable by at least one processor Processor(s) 120 as in FIG. 2].

[0086] It is noted that the following are the changes may be required in existing specifications/implementations at the time of this application for realization of some example embodiments of the invention:

- X2 Interface changes required for LTE node to indicate that it supports the LTE-RRC connection setup via NR-SCG leg. X2 Interface changes also required to exchange the LTE RRC messages to the LTE node,
 - If the split SRB is setup, further signalling messages goes via X2-UP as transparent SRB PDCP contents to NR gNB;
- System information messages required to indicate the NR cell supporting forwarding of LTE messages via LTE node;
- MME to UE communication to indicate whether UE is authorised to use the NR routed RRC connection setup in EN-DC network;
- New LCH-ID reserved at gNB for forwarding the LTE RRC messages. New MAC control element to carry the assistance information to route the LTE RRC message.

[0087] Key aspects in accordance with example embodiments of the invention

include:

- gNB supports reception and forwarding of the Msg3 received for LTE RRC connection setup to anchor LTE node to setup the EN-DC connection with inactive MCG part until the UE obtain the MCG later due to mobility;
- NR cell broadcasts new parameter indicating that it supports forwarding of LTE RRC connection setup procedure related signaling to LTE node;
- Higher layer signaling /subscription can also be used to control whether UE can access the NR cell without LTE coverage;
- EN-DC UE selecting NR cell which is capable of forwarding the LTE RRC message when it does not find LTE cell for setting up LTE RRC connection to start the data transmission;
- UE and ENB preserving the MCG configurations after entering into idle mode also for faster setup of EN-DC via NR, if the UE needs to setup RRC connection via NR without LTE coverage;
- Reporting by EN-DC capable UE its random access failure event to NR cell using NR RRC message. This message is secured using EPC NAS keys to allow IP of the message through EPC;
- Providing by LTE eNB dedicated preamble / PDCCH related information along with increased number of repetitions for the UE which reported failure; and
- Attempting at UE a Random access procedure with LTE node as per assistance information the UE received earlier via NR cell for the last random access failure.

[0088] In general, the various embodiments of the mobile station [UE 110 as in FIG. 2 and/or EN-DC UE 310 as in FIG. 4] can include, but are not limited to, cellular

telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

[0089] The embodiments of this invention may be implemented by computer software executable by a data processor of the mobile station [UE 110 as in FIG. 2 and/or EN-DC UE 310 as in FIG. 4], such as the processor [Processor(s)] 120, 152, and/or 182 as in FIG. 2], or by hardware, or by a combination of software and hardware. Further in this regard it should be noted that the various blocks of the logic flow diagram of at least FIG. 4, FIG. 5, FIG. 6, and FIG. 7 may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. It is noted that any of these devices may have multiple processors (e.g. RF, baseband, imaging, user interface) which operate in a slave relation to a master processor. The teachings may be implemented in any single one or combination of those multiple processors.

[0090] The memory [or memories] 125, 155, and/or 195 as shown in FIG. 2 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, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors [Processor(s)] 120, 152, and/or 182 as in FIG. 2] 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 multi-core processor architecture, as non-limiting examples.

[0091] In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in

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

[0092] Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

[0093] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. All of the embodiments described in this Detailed Description are exemplary embodiments provided to enable persons skilled in the art to make or use the invention and not to limit the scope of the invention which is defined by the claims.

[0094] The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the best method and apparatus presently contemplated by the inventors for carrying out the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

[0095] It should be noted that the terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection

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

[0096] Furthermore, some of the features of the preferred embodiments of this invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles of the invention, and not in limitation thereof.

CLAIMS

What is claimed is:

1. A method, comprising:
determining, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and
based on the determining, forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.
2. The method of claim 1, wherein the network node is part of a new radio cell of the new radio small cell network.
3. The method of claim 2, wherein the indication comprises a connectivity failure message associated with a failure of the user equipment to setup connectivity with the long term evolution master cell group.
4. The method of claim 3, wherein the failure to setup the connectivity is based on a long term evolution random access channel failure associated with a radio resource control connection setup procedure.
5. The method of claim 3, comprising sending towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment.
6. The method of claim 5, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel

preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

7. The method of claim 2, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group.

8. The method of claim 7, comprising sending towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group.

9. The method of claim 8, wherein the at least one message comprises long term evolution radio resource control message used to control whether user equipment can access the new radio cell without LTE coverage.

10. The method of claim 7, comprising sending towards the user equipment at least one broadcast message indicating that the network node supports long term evolution connection setup for the user equipment of the new radio small cell network.

11. The method according to any one of claims 6 or 8, comprising:
receiving by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and
sending, by the network node, the connection request message towards the default base station to establish the connectivity.

12. The method of claim 11, wherein the connection request message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the default base station.

13. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

determine, based on an indication received by a network node of a communication network, that a user equipment associated with the new radio small cell is to establish connectivity with a long term evolution master cell group of the communication network; and

based on the determining, forwarding the message toward a default base station associated with the long term evolution master cell group to establish the connectivity with the long term evolution master cell group for the user equipment of the new radio small cell network.

14. The apparatus of claim 13, wherein the network node is part of a new radio cell of the new radio small cell network.

15. The apparatus of claim 14, wherein the indication comprises a connectivity failure message associated with a failure of the user equipment to setup connectivity with the long term evolution master cell group.

16. The apparatus of claim 15, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to:

send towards the user equipment at least one message, wherein the at least one message comprises a range of random access channel preambles dedicated for a connection request message from the user equipment.

17. The apparatus of claim 16, wherein the at least one message comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

18. The apparatus of claim 14, wherein the indication comprises a long term evolution radio resource control message to setup connectivity for the user equipment with the long term evolution master cell group.

19. The apparatus of claim 18, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to:

send towards the user equipment at least one message, wherein the at least one message comprises routing parameters for a connection request message from the user equipment to enable reception by the communication network of the connection request message from the user equipment without operations of the master cell group.

20. The apparatus according to any one of claims 16 or 19, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to:

receive by the network node the connection request message from the user equipment using one of the provided routing parameters or the random access channel preamble of the range of random access channel preambles; and

send, by the network node, the connection request message towards the default base station to establish the connectivity.

21. A method, comprising:

determining, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network;

based on the determining, detecting a device associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and

sending towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

22. The method of claim 21, wherein the communication network comprises a long term evolution master cell group.
23. The method of claim 22, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network.
24. The method of claim 23, wherein the detecting comprises:
determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network.
25. The method of claim 23, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed.
26. The method of claim 23, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell.
27. The method of claim 25, comprising:
based on the message, receiving via the device associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity.
28. The method of claim 27, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

29. The method of claim 28, comprising:
based on the information, establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity.
30. The method of claim 29, comprising:
sending, by the user equipment, towards the long term evolution master cell group of the communication network a measurement report for the long term evolution master cell group of the communication network, wherein based on the measurement report the long term evolution master cell group is reconfigured with a split signaling radio bearer associated with an activated cell of the long term evolution master cell group for the new radio dual connectivity
31. The method of claim 29, wherein for a case that the long term evolution cell of the communication network is controlled by a base station other than the default base station, the method comprising: a master cell group handover without a secondary cell group change to move the user equipment to the other base station.
32. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:
determine, by a user equipment of a new radio small cell network, a new radio dual connectivity failure of the user equipment to a cell of the communication network;
based on the determining, detect a device associated with a new radio cell of the new radio small cell network that capable of forwarding a connectivity failure report for the new radio dual connectivity failure; and

send towards the device associated with the new radio cell a message comprising the connectivity failure report for forwarding towards the cell of the communication network for enabling the new radio dual connectivity.

33. The apparatus of claim 32, wherein the communication network comprises a long term evolution master cell group.

34. The apparatus of claim 33, wherein the new radio dual connectivity failure is based on a failure of the user equipment of the new radio small cell network to access the long term evolution master cell group to communicate a connection request message with a default base station of the long term evolution master cell group of the communication network.

35. The apparatus of claim 34, wherein the detecting comprises:
determining, by the user equipment, a presence of the new radio cell on a new radio layer to send the message comprising the connectivity failure report for forwarding towards the cell of the communication network.

36. The apparatus of claim 34, wherein the message comprises long term evolution physical cell identity and E-UTRAN cell global identifier information associated with where the access attempt failed.

37. The apparatus of claim 34, wherein the message comprises generated evolved packet core non-access stratum keys for integrity protection verification of the connection request message by the device associated with the new radio cell.

38. The apparatus of claim 36, comprising:
based on the message, receiving via the device associated with the new radio cell from a network node associated with the long term evolution master cell group, information comprising a range of random access channel preambles dedicated for the connection request message from the user equipment forward by the device associated with the new radio cell for the new radio dual connectivity.

39. The apparatus of claim 38, wherein information comprises an increased number of repetitions allowed over at least one random access channel preamble of the range of random access channel preambles dedicated for the connection request message from the user equipment.

40. The apparatus of claim 33, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to:

based on the information, establishing a connection with the cell of the long term evolution master cell group for the new radio dual connectivity.

41. The apparatus of claim 40, wherein the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to:

send, by the user equipment, towards the long term evolution master cell group of the communication network a measurement report for the long term evolution master cell group of the communication network, wherein based on the measurement report the long term evolution master cell group is reconfigured with a split signaling radio bearer associated with an activated cell of the long term evolution master cell group for the new radio dual connectivity

42. The apparatus of claim 40, wherein for a case that the long term evolution cell of the communication network is controlled by a base station other than the default base station, the method comprising: a master cell group handover without a secondary cell group change to move the user equipment to the other base station.

43. A computer program comprising computer program code for executing the method according to any of the claims 1-12 or 21-31.

44. A non-transitory computer-readable medium storing program code, the program code executed by at least one processor to perform at least the method according to any of the claims 1-12 or 21-31.

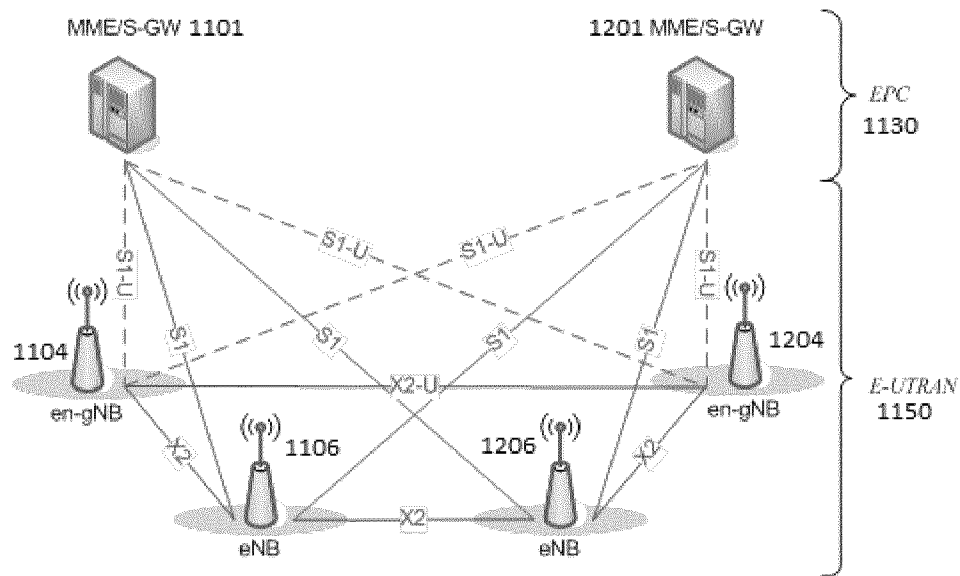


FIG. 1

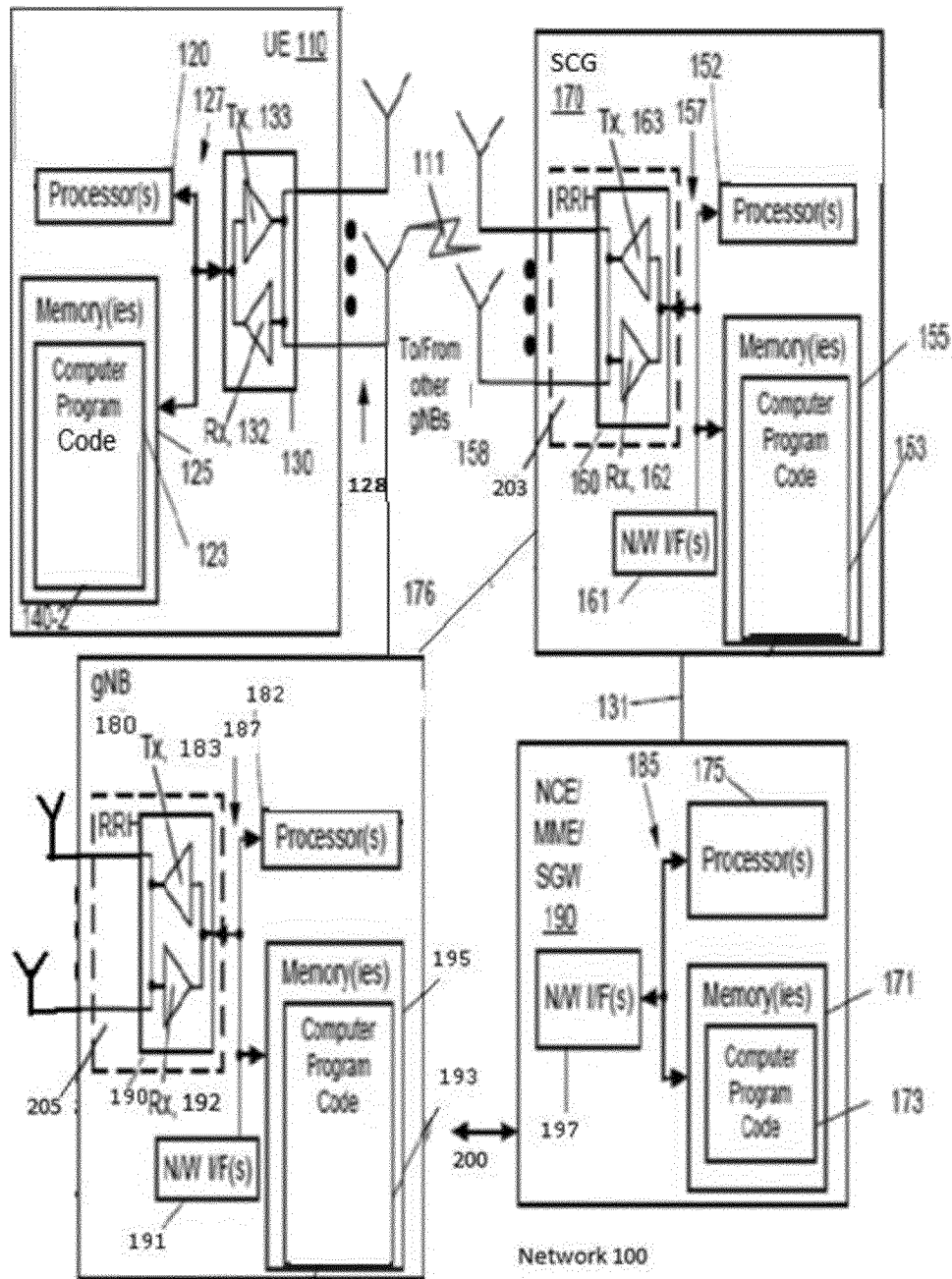


FIG. 2

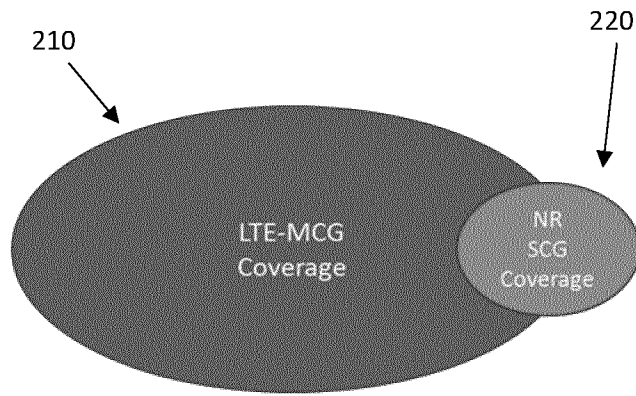


FIG. 3

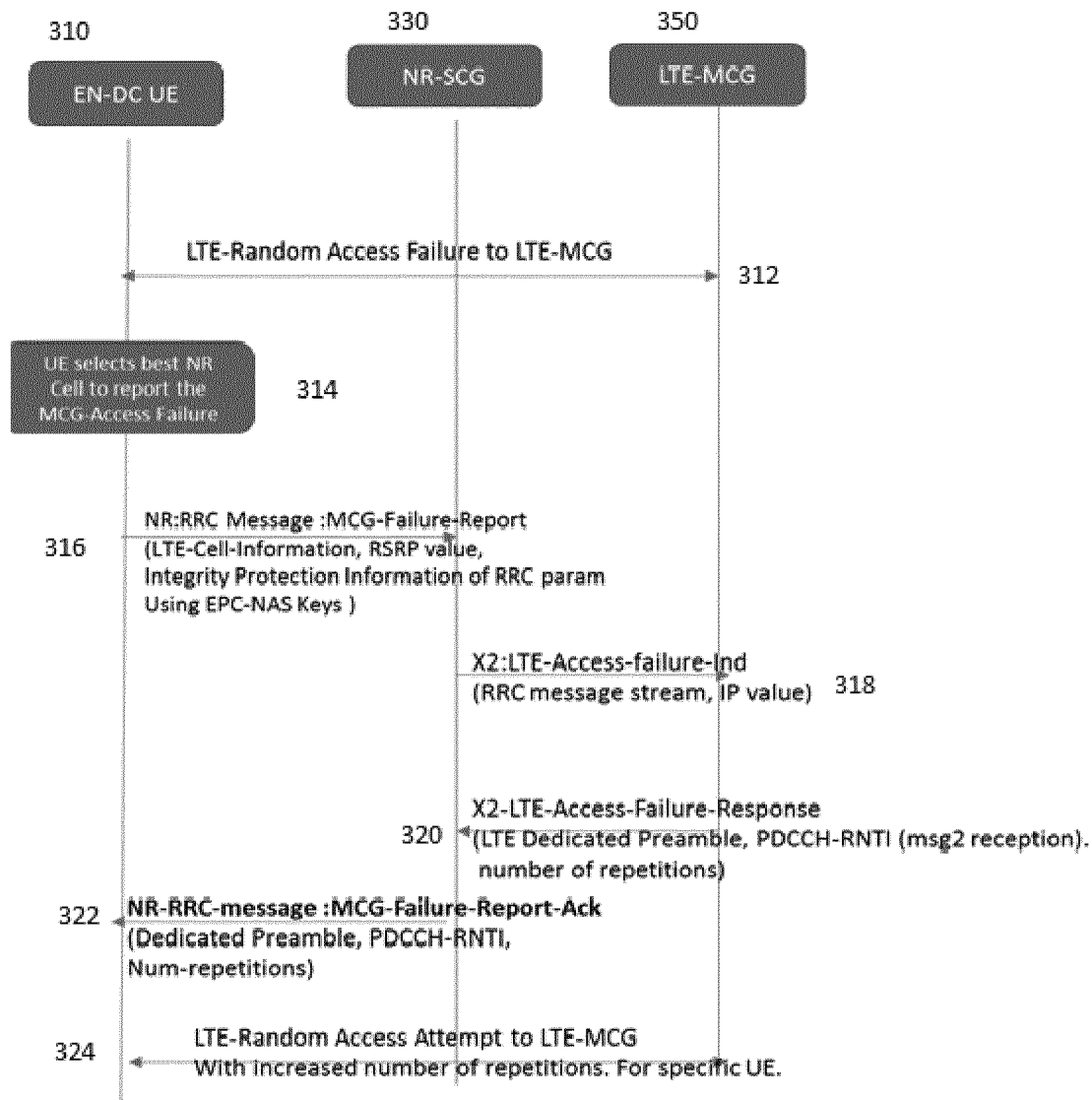


FIG. 4

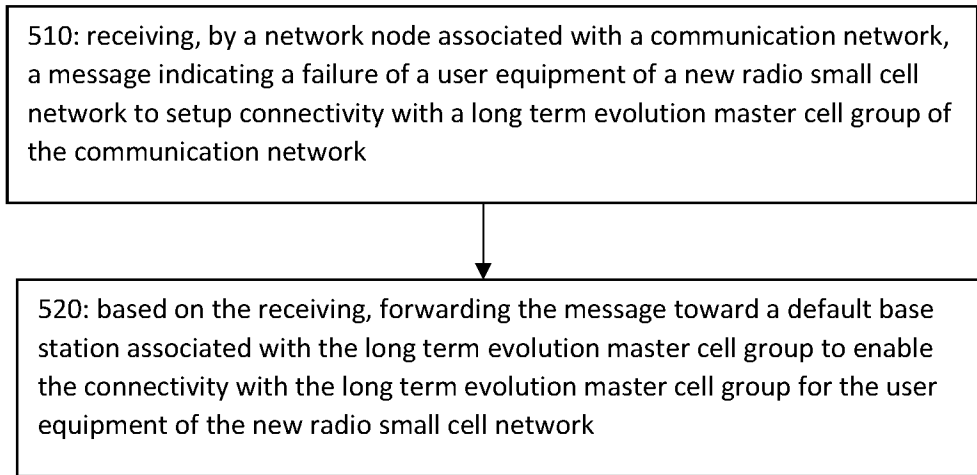


FIG. 5A

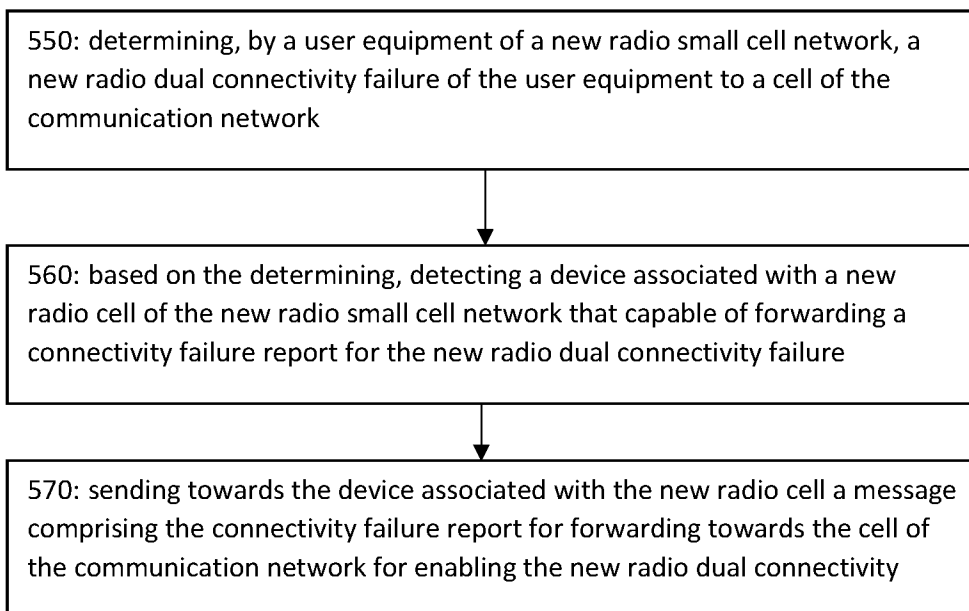


FIG. 5B

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/051393

A. CLASSIFICATION OF SUBJECT MATTER INV. H04W76/15 H04W76/18 H04W92/20 ADD.		
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		
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) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018/128572 A1 (ERICSSON TELEFON AB L M [SE]) 12 July 2018 (2018-07-12) page 3, lines 16-21 page 4, line 5 - page 6, line 17 page 7, lines 12-23 page 7, line 33 - page 11, line 21 page 15, line 29 - page 16, line 21 figures 3,4,8A -----	1-44
X	WO 2018/028969 A1 (SONY CORP [JP]; SONY EUROPE LTD [GB]) 15 February 2018 (2018-02-15) page 16, line 18 - page 19, line 31 figure 14 ----- -/--	1-44
☒ 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 9 June 2020		Date of mailing of the international search report 16/06/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Espuela, Vicente

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/051393

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/208488 A1 (HWANG JUNE [KR] ET AL) 20 July 2017 (2017-07-20) paragraph [0011] - paragraph [0014] paragraph [0046] - paragraph [0052] paragraph [0053] - paragraph [0058] paragraph [0060] - paragraph [0061] paragraph [0064] - paragraph [0087] paragraph [0110] - paragraph [0115] paragraph [0175] - paragraph [0225] figures 1,2A,2B,6,12-14B -----	1-44
X	US 2016/219475 A1 (KIM JAE HEUNG [KR]) 28 July 2016 (2016-07-28) paragraph [0010] - paragraph [0013] paragraph [0020] - paragraph [0021] paragraph [0099] - paragraph [0108] paragraph [0120] - paragraph [0125] paragraph [0140] - paragraph [0141] paragraph [0193] - paragraph [0209] figures 2,4 -----	1-44

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/051393

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018128572 A1	12-07-2018	CN 110169192 A EP 3566539 A1 US 2019289510 A1 WO 2018128572 A1	23-08-2019 13-11-2019 19-09-2019 12-07-2018
WO 2018028969 A1	15-02-2018	EP 3497967 A1 US 2019182689 A1 WO 2018028969 A1	19-06-2019 13-06-2019 15-02-2018
US 2017208488 A1	20-07-2017	KR 20170087054 A US 2017208488 A1 WO 2017126919 A1	27-07-2017 20-07-2017 27-07-2017
US 2016219475 A1	28-07-2016	CN 105519167 A CN 109510697 A CN 110830227 A KR 20150005458 A US 2016219475 A1 US 2017164419 A1 US 2018279403 A1 WO 2015002466 A2	20-04-2016 22-03-2019 21-02-2020 14-01-2015 28-07-2016 08-06-2017 27-09-2018 08-01-2015