



(51) International Patent Classification:
H04W 8/00 (2009.01)

(21) International Application Number:
PCT/US2016/065180

(22) International Filing Date:
06 December 2016 (06.12.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/328,413 27 April 2016 (27.04.2016) US

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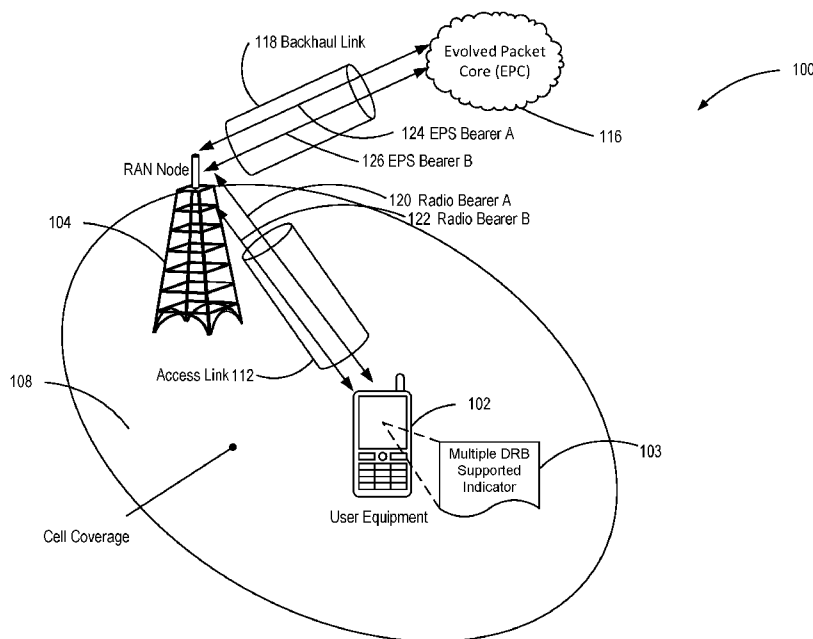
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, 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, 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,

(54) Title: SYSTEMS, METHODS AND DEVICES FOR INDICATING SUPPORT OF MORE THAN ONE DATA RADIO BEARER FOR CELLULAR INTERNET OF THINGS DEVICES

FIG. 1



(57) Abstract: A cellular internet of things (CIoT) device can indicate support (or lack thereof) for more than one data radio bearer (DRB). For example, in at least some long term evolution (LTE) embodiments, a maximum number of bearers is fixed to a known value. In a narrowband internet of things (NB-IoT), it can be defined as an optional capability feature that user equipments (UEs) have different maximum supported numbers of bearers. In some embodiments, mechanisms to exchange the UE bearer capability information can be used to communicate with the network to ensure that the network only establishes up to the maximum supported number of bearers.



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:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*

SYSTEMS, METHODS AND DEVICES FOR INDICATING SUPPORT OF MORE THAN ONE DATA RADIO BEARER FOR CELLULAR INTERNET OF THINGS DEVICES

Related Application

[0001] This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 62/328,413 filed April 27, 2016, which is hereby incorporated by reference herein in its entirety.

Technical Field

[0002] The present disclosure relates to cellular devices and more specifically to indicating support of more than one data radio bearer for cellular internet of things devices.

Background

[0003] Wireless mobile communication technology uses various standards and protocols to transmit data between a base station and a wireless mobile device. Wireless communication system standards and protocols can include the 3rd Generation Partnership Project (3GPP) long term evolution (LTE); the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard, which is commonly known to industry groups as worldwide interoperability for microwave access (WiMAX); and the IEEE 802.11 standard for wireless local area networks (WLAN), which is commonly known to industry groups as Wi-Fi. In 3GPP radio access networks (RANs) in LTE systems, the base station can include a RAN Node such as a Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node B (also commonly denoted as evolved Node B, enhanced Node B, eNodeB, or eNB) and/or Radio Network Controller (RNC) in an E-UTRAN, which communicate with a wireless communication device, known as user equipment (UE).

[0004] RANs use a radio access technology (RAT) to communicate between the RAN Node and UE. RANs can include global system for mobile communications (GSM), enhanced data rates for GSM evolution (EDGE) RAN (GERAN), Universal Terrestrial Radio Access Network (UTRAN), and/or E-UTRAN, which provide access to communication services through a core network. Each of the RANs operates according to a specific 3GPP RAT. For example, the GERAN implements GSM and/or EDGE RAT, the UTRAN implements

universal mobile telecommunication system (UMTS) RAT or other 3GPP RAT, and the E-UTRAN implements LTE RAT.

[0005] A core network can be connected to the UE through the RAN Node. The core network can include a serving gateway (SGW), a packet data network (PDN) gateway (PGW), an access network detection and selection function (ANDSF) server, an enhanced packet data gateway (ePDG) and/or a mobility management entity (MME).

Brief Description of the Drawings

[0006] FIG. 1 is a schematic diagram of a communication system for providing wireless communication services to a UE or other mobile wireless device consistent with embodiments disclosed herein.

[0007] FIG. 2 is a process diagram illustrating a UE requested bearer resource modification consistent with embodiments disclosed herein.

[0008] FIG. 3 is a process diagram of a dedicated bearer activation procedure consistent with embodiments disclosed herein.

[0009] FIG. 4 is code illustrating a UE-Capability-NB information element consistent with embodiments disclosed herein.

[0010] FIG. 5 is another table illustrating an example of a bit listing 500 for a UE network capability information element consistent with embodiments disclosed herein.

[0011] FIG. 6 is a flow chart illustrating a method for indicating support for more than one data radio bearer for a NB-IoT cellular device.

[0012] FIG. 7 is a data flow diagram illustrating data flow between a UE and Serving Gateway/ Packet Data Network (PDN) Gateway (S/P-GW) in dual connectivity configuration consistent with embodiments disclosed herein.

[0013] FIG. 8 is a block diagram illustrating electronic device circuitry that may be radio access network (RAN) node circuitry (such as an eNB circuitry), UE circuitry, network node circuitry, or some other type of circuitry consistent with embodiments disclosed herein.

[0014] FIG. 9 is a block diagram illustrating example components of a user equipment (UE) or mobile station (MS) device consistent with embodiments disclosed herein.

Detailed Description

[0015] A detailed description of systems and methods consistent with embodiments of the present disclosure is provided below. While several embodiments are described, it should be understood that the disclosure is not limited to any one embodiment, but instead encompasses numerous alternatives, modifications, and equivalents. In addition, while numerous specific details are set forth in the following description in order to provide a thorough understanding

of the embodiments disclosed herein, some embodiments can be practiced without some or all of these details. Moreover, for the purpose of clarity, certain technical material that is known in the related art has not been described in detail in order to avoid unnecessarily obscuring the disclosure.

[0016] Techniques, apparatus and methods are disclosed that enable a cellular internet of things (CIoT) device to indicate support (or lack thereof) for more than one data radio bearer (DRB). For example, in at least some LTE embodiments, a maximum number of bearers is fixed to a known value and there is no signaling to convey this information to the network, and the network's mechanisms are not defined, assuming always that each UE might support a different number of bearers. In NB-IoT, it can be defined as an optional capability feature that UEs have different maximum supported number of bearers. In some embodiments, mechanisms to exchange the UE bearer capability information can be used to communicate with the network to handle and/or ensure that the network only establishes up to the maximum supported number of bearers.

[0017] This mechanism can be related to 3GPP radio interface architecture and protocols, UE-Core Network-L3 radio protocols, core network side of the IoT reference point, system-wide architecture, and devices operated in long term evolution (LTE), UMTS, GERAN, fourth generation (4G) and fifth generation (5G) RATs. This mechanism can be applicable for UEs (such as phones or smartphones) where, for example, the systems can support normal access or can tolerate long delays in terms of reachability. The mechanism can be applicable, for example, for Cellular Internet of Things (CIoT), Machine-Type Communications (MTC), narrowband IoT (NB-IoT) or non-NB-IoT (i.e., wide band UEs that operate within the whole system bandwidth (BW), e.g., WB-E-UTRAN) devices. Therefore this mechanism can be applicable to any UE category, although for simplicity this disclosure focuses on MTC related UE categories, such as a Rel-13 category M1 UE or a Rel-13 NB-IoT UE.

[0018] In LTE, according to 3GPP TS 36.331, section 11, UEs of categories 1 - 5 support 8 data radio bearers (DRBs). Defining a UE that supports less than 8 bearers and associated signaling of the maximum number of DRBs supported would enable less capable UEs. A motivation can be to reduce a size for the associated UE hardware and/or memories and a corresponding UE cost. This reduced DRB capability can also increase network resources available, because without more information, a network currently assumes that UEs can establish up to 8 DRBs. In the network side, there can be a one-to-one mapping of these DRBs to the end-to-end evolved packet system (EPS) bearers.

[0019] This mechanism introduces optional Multiple DRB UE capability for UEs supporting Rel-13 CIoT UP solution (i.e., transfer of user data via DRB and UE AS context caching). Multiple DRB UE capabilities can be signaled with a solution for 2 DRBs. A NB-IoT UE supporting user plane optimization can optionally support more than 1 DRB. A higher capable NB-IoT UE can support 2 DRBs.

[0020] This signaling to the network can help limit creation of new DRBs beyond what is supported by the UE. In some cases, a UE can limit sending a request to establish new bearers. However there are cases where limiting DRB creation by the UE is not possible and the decision needs to be driven by the network, as the UE might not have all the required information.

[0021] In a first example, if the UE requests the establishment of a new additional PDN connection, in principle the decision whether to send a new PDN connection request or not, the request can be controlled by the UE. According to the Rel-12 version of TS 24.301, section 6.5.1.4A, “[i]f the maximum number of active EPS bearer contexts is reached at the UE (see subclause 6.5.0) and the upper layers of the UE request connectivity to a PDN the UE shall not send a PDN CONNECTIVITY REQUEST message unless an active EPS bearer is deactivated.” However, from Rel-13 onwards, the UE does not know if the new PDN connection requested by the UE requires the usage of a new bearer or not. For example, a PDN connection pinned to the Control plane (e.g., a Service Capability Exposure Function (SCEF) connection) would not require the usage of a new RAN bearer (i.e., DRB), as the data is sent over a signaling radio bearer (SRB) (i.e., data is encapsulated over non-access stratum (NAS)). This kind of information might not be known by the UE in advance, because a network node (e.g., the MME) is making this decision during the PDN connection establishment (e.g., based on the APN requested by the UE and subscription information provided by the HSS, or other criteria).

[0022] In a second example, if the UE sends a request for dedicated resources, e.g., for IP connectivity (even for non-guaranteed bit rate (GBR)), then it is up to the core network (CN) nodes to decide whether a new EPS bearer will be created or whether an existing one will be modified. E.g., this might be a decision taken by the MME, the Packet Data Network Gateway (P-GW) or the Policy and Charging Rules Function (PCRF).

[0023] The activation of a dedicated EPS bearer can also be initiated by the CN, e.g., triggered by an application server (AS) or by some information sent by the UE on the application level. In addition, it is useful for the network to know in advance whether the UE is able to support the DRB for the additional dedicated EPS bearer. If not, then the first CN

node which has the information about the maximum number of DRBs supported by the UE available (e.g., the MME or the P-GW), could terminate the activation of a dedicated EPS bearer, thus avoiding unnecessary signaling between the network and the UE.

[0024] New mechanisms can be used to exchange the UE bearer capability information with the network and to actually handle and/or ensure that the UE only establishes up to the maximum supported number of DRBs that can be used.

[0025] These mechanisms can be applicable for various systems (e.g., UE and network side systems) that are designed to operate in full system bandwidth (BW), reduced bandwidth (BR) or narrowband (NB). The UE or network can operate within the full BW, BR or NB, such as 20MHz, 10MHz, 1.4MHz, 200kHz or 180kHz bandwidth. These mechanisms can be applicable for LTE systems, NB-IoT systems or 5G UE and/or network systems.

[0026] The descriptions herein use exemplary network messages, but it should be recognized that the scope of the disclosure is not limited to these specific messages. Other network messages can carry this information. The described mechanisms use as exemplary certain RRC messages, S1 Application Protocol (S1-AP) messages or a Non-Access Stratum Protocol Data Unit (NAS PDU) or containers. For new elements or messages, exemplary names are used for simplicity, but naming conventions should not restrict the scope of embodiments disclosed herein.

[0027] Use of the term “bearers” should not be limited to data radio bearers (DRBs), even if given as examples in the embodiments. In the disclosed embodiments, DRBs are given as examples, but the embodiments can also be extended to the concept of EPS bearers or EPS bearer contexts. In addition, the embodiments can also be extended to also include other kind of bearers, such as the signal radio bearers (SRB). Alternatively, a similar kind of capability or signaling mechanism can be defined to enable a separate control of each of these different kinds of bearers.

[0028] The embodiments focus on signaling to convey the information to the eNodeB or MME, however, it should be recognized that a similar mechanism can also be extended to other CN nodes (such as S-GW, P-GW, PCRF, etc.), understanding that other messages can be involved depending on the impacted interface.

[0029] New mechanisms are defined to exchange the UE bearer capability information with the network and to actually handle and/or ensure that the UE only establishes up to the maximum supported number of bearers.

[0030] The UE bearer capability information (sometimes referred to as bearer-support) is a single option or multiple options that the UE can support. This bearer-support information

indicates the maximum number of data radio bearers that a UE can support. This information can be conveyed to the network in different ways, including UE radio access capability information, a new indication IE defined in the UE context but outside of the UE radio capabilities (the bearer-support indication is sent to the CN node or the UE sends the bearer-support indication to eNB in random access channel (RACH) or radio resource control (RRC) message) or new information stored in UE subscription data in a home subscriber server (HSS), home location register (HLR), or authentication authorization and accounting (AAA) server.

[0031] In a first embodiment, the bearer-support information is present in a new IE within the UE radio access capability information (see 3GPP TS 36.331). The UE radio access capabilities are retrieved by the eNB during a connection and stored in the MME when the UE is idle. The MME provides it to the eNB when the UE transitions from idle to connected mode; alternatively this information is also kept stored in the eNB if the UE is suspended.

[0032] The UE radio capabilities are stored in a transparent manner within the UE context in the MME, which means that the MME might not interpret the capability information. However, it is possible for the MME to interpret this information in order to determine a maximum number of data radio bearers supported by the UE.

[0033] In another embodiment, a new indication IE is defined in the UE context but outside of the UE radio capabilities. The bearer-support information can be within a new IE that is indicated to the network in different ways. In an embodiment, this new IE is created outside of the UE radio access capability structure which is stored transparently within the UE context in the MME. The MME would be able to get this information without having to check the UE radio access capability structure.

[0034] In a first embodiment, the bearer-support indication is sent to the CN node (e.g., MME) via, e.g., a NAS message. As this information is not expected to change dynamically, this information might be defined within the NAS Attach Request or NAS tracking area update (TAU)/routing area update (RAU) Request. For example, it would be possible to add a new parameter to the UE network capability IE (see, e.g., 3GPP TS 24.301, section 9.9.3.34) which is provided to the network during the attach and TAU/RAU procedure. However if it is expected to be information that might change dynamically, this information can be included in other information elements, e.g., in a Service Request, a Control Plane Service Request message, etc. For example, it can be possible to add a new parameter to the device properties IE (see 3GPP TS 24.301, section 9.9.2.0A). The NAS message is forwarded by the eNB to the MME, but not interpreted by the eNB.

[0035] In a second embodiment, the UE sends the bearer-support indication to eNB in a RACH or RRC message (e.g., RRC Connection Request, RRC Connection Setup Complete, RRC Connection Reconfiguration, UE Capability Information, etc.). This option includes the possibility that the bearer-support indication is included as part of the UE radio access capabilities provided to the eNB. The eNB can then indicate the bearer-support indication to the MME by adding the new indication IE in an S1-AP message. This S1-AP message can be a legacy S1-AP message (e.g., S1-AP initial UE message) or a new S1-AP message can be defined to carry this bearer-support indication in other cases.

[0036] Alternatively, this new bearer-support indication can be determined based on other information that allows the network to distinguish or characterize the UEs for a certain maximum number of bearers. This can be for UEs belonging to a certain group, a certain UE category or certain UE class, or certain UE service category classes. New information can be stored in UE subscription data in a home subscriber server (HSS), a home location register (HLR), or an authentication authorization and accounting (AAA) server.

[0037] In some embodiments, this information is downloaded to MME from these entities as part of an Insert Subscription Data During Attach/TAU procedure. This support information is also sent by MME to another MME during inter MME relocation/handover. If the information is statically configured in the HSS/HLR/AAA, this approach ties the subscription and the device capabilities together which can have some implications. For example, if the USIM was placed into a UE of a different UE capabilities then the network which is getting the bearer-support indication from the subscription data can continue to treat this UE based on the bearer-support subscription indication regardless of its UE capabilities. However, with the introduction of embedded UICCs (eUICCs) for machine-type communication devices, it is possible that this form of “USIM roaming” (“plastic card roaming”) might become less relevant.

[0038] It can also be possible to use the International Mobile Equipment Identity (IMEI or IMEISV) of the UE provided by the MME to the HSS/HLR during the attach procedure in the Update Location Request to perform a mapping to a bearer-support indication. This indication is then downloaded to the MME (and any subsequent MME) in the Update Location Ack.

[0039] A mechanism can be provided to ensure that the UE does not exceed the maximum bearers supported. In a first embodiment, for a given UE, the maximum number indicated by the bearer-support can be used by the CN node (e.g., MME) or eNB when having to establish a new PDN connection or reconfiguring an existing one based on a new request. This can

involve the CN node or eNB rejecting a request from another node to establish a bearer taking into account the maximum number of data radio bearers supported by the UE. For example, if the node receives a Bearer Establishment Request for a UE from another node and this node realizes all of the DRBs that the UE is capable of supporting are already established, it can reject the Bearer Establishment Request. Another example could be where the node looks at the quality of service (QoS) requirements for the bearer establishment and may reject it even if the maximum number of DRBs that the UE is capable of is not established. This can be based on the priority of the Bearer Request to allow a spare DRB to be kept for higher priority. In yet another example, the node may preempt an existing DRB of the UE to allow the establishment of a higher priority DRB when all the DRBs the UE is capable of supporting were already established.

[0040] In a second embodiment and in addition or alternatively to the first embodiment, the UE can also use this information when deciding whether to request or accept the establishment of a new bearer.

[0041] In a third embodiment, the bearer-support indication can also be used by the MME during PDN connection establishment, when deciding whether to pin the PDN connection to the Control plane or not. According to 3GPP TS 23.401, when the PDN connection is established to a service capability exposure function (SCEF), there is no choice for the MME (i.e., the PDN connection will be pinned to the Control plane and a DRB is not established); but for a PDN connection to a P-GW the MME could still decide to pin the PDN connection or not (e.g., based on the APN requested by the UE). Pinning the PDN connection would allow the UE to have more additional PDN connections active simultaneously.

[0042] FIG. 1 is a schematic diagram of a communication system 100 for providing wireless communication services to a UE 102 or other mobile wireless device. The system 100 includes a plurality of RANs including RAN Node 104 through which the UE 102 may access IP services or other data services within cell coverage 108 of the RAN Node 104, such as voice services or the Internet. Specifically, the system 100 may include a global system for mobile communications (GSM) enhanced data rates for GSM evolution (EDGE) RAN (GERAN), a UTRAN, and/or an E-UTRAN, which provide access to communication services through a core network 116 (e.g., an EPC). Each of the RANs operates according to a specific 3GPP RAT. For example, the GERAN implements GSM and/or EDGE RAT, the UTRAN implements universal mobile telecommunication system (UMTS) RAT or other 3GPP RAT, and the E-UTRAN implements LTE RAT.

[0043] Each of the RANs includes one or more base stations or other infrastructure for wirelessly communicating with the UE 102 and providing access to communication services. For example, the E-UTRAN includes one or more eNBs, such as RAN Node 104, which are configured to wirelessly communicate with the UE 102.

[0044] The core network 116 may include a serving gateway (SGW), a packet data network (PDN) gateway (PGW), an ANDSF server, and an enhanced packet data gateway ePDG. The PGW may be connected to the WAG via the ePDG using the S2b interface (for the case of untrusted access) and to the TWAG and ASN-GW using the S2a interface (for the case of trusted access). One of skill in the art will recognize that numerous other components and functions may be included or implemented in the core network 116.

[0045] UE 102 communicates with the EPC 116 through an access link 112 to the RAN Node 104 using a RAT, which then uses a backhaul link 118 to provide the UE communication to the EPC 116. How many DRBs 120, 122 are supported by UE 102 can be indicated by Multiple DRB supported indicator 103. In the embodiment shown, the UE 102 supports multiple DRBs 120, 122 and using the two DRBs 120, 122 to communicate with the RAN Node 104 over access link 112. The DRBs 120, 122 have a one-to-one correspondence with EPS bearers 124, 126 in communication with the EPC 116 over backhaul link 118.

[0046] FIG. 2 shows a UE requested bearer resource modification. A UE 202 sends a request bearer resource modification message 216 through the link with the eNodeB 204 to the MME 206. The MME 206 sends a bearer resource command 217 to the S-GW 210. The S-GW 210 sends a bearer resource command 218 to the PDN-GW 212. The PDN-GW 212 and PCRF 214 perform a first part of a policy and charging enforcement function (PCEF) initiated internet protocol connectivity access network (IP-CAN) session modification 220.

Depending on whether the UE can support another bearer as indicated by the bearer-support indicator, the system 200 can perform 222 dedicated bearer activation, a bearer modification procedure or a dedicated bearer deactivation procedure. The PDN-GW 212 can then communicate the second part of a PCEF initiated IP-CAN session modification 224 to the PCRF 214.

[0047] In a fourth embodiment and as a further possible use case, the MME 206, the P-GW or the PCRF can use the bearer-support indication together with the number of already allocated DRBs when processing a request from the UE for dedicated bearer resources for a PDN connection for which one or more DRBs have already been allocated. Generally, depending on the QoS requested for the new dedicated bearer resources and on the QoS of the already established EPS bearers, the network can decide to allocate a new EPS bearer or

to modify an existing one. If the UE has already reached the maximum number of supported DRBs, then the network should – if possible – modify an existing EPS bearer (e.g., by modifying the QoS Class Identifier (QCI) of the bearer and adding the packet filter(s) for the new packet flow to the corresponding traffic flow template (TFT)).

[0048] To this purpose, the MME 206 could signal with the GTP message bearer resource command to the Serving-GW (S-GW) 210, P-GW and PCRF either: (1) both the maximum number of DRBs supported by the UE and the number of already allocated DRBs; or (2) only an indication whether establishment of another DRB is not possible (i.e., whether the number of already allocated DRBs is equal to the maximum number of DRBs supported by the UE).

[0049] In principle the second option can be sufficient, because a UE can have PDN connections to multiple P-GWs or SCEFs (or both), and it is not intended to inform P-GW 1 when the UE deactivates an EPS bearer related to a PDN connection towards, e.g., P-GW 2. This means the indication might be valid for the specific bearer resource allocation and is not supposed to be stored by the P-GW 1 for later use.

[0050] FIG. 3 shows a dedicated bearer activation procedure 300. In the embodiment shown, the PCRF communicates an IP-CAN session modification 320 to the PDN-GW 310. Then PDN-GW sends a create bearer request 322 to the serving GW 308. The serving GW 308 sends a create bearer request 324 to the MME 306. The MME 306 sends a bearer setup request/session management request 326 to the eNodeB 304. The eNodeB 304 sends a RRC Connection Reconfiguration 328 to UE 302. The UE 302 sends a RRC connection reconfiguration complete message 330 to eNodeB 304. The eNodeB 304 sends a bearer setup response 322 to MME 306. The UE 302 sends a direct transfer 334 to eNodeB 304. The eNodeB 304 sends a session management response 336 to MME 306. The MME 306 sends a create bearer response 338 to serving GW 308. Serving GW 308 sends a create bearer response 340 to PDN GW 310. PDN GW 310 sends an IP-CAN session modification 342 to PCRF 312.

[0051] For example, if the PCRF 312 of P-GW initiates the activation of a dedicated EPS bearer, the MME 306 can, after operation 3 (i.e., upon receipt of a create bearer request from the S-GW), check whether the number of already allocated DRBs is equal to the maximum number of DRBs supported by the UE. If yes, then the MME 306 could immediately reject the request, thus avoiding the unnecessary signaling shown in operations 4 to 9 (324 to 336) in FIG. 3. It would also be possible that dependent on the reject cause received in the Create Bearer Response message (e.g., “maximum number of EPS bearers reached”), the PCRF 312

or the P-GW terminates the bearer activation and initiates a modification of an existing EPS bearer instead.

[0052] As an alternative solution, instead of rejecting the request from the S-GW 308 after operation 3, the MME 306 could proceed with the signaling procedure as shown in FIG. 3. It is then left to the UE to decide upon receipt of the RRC Connection Reconfiguration message in operation 5 whether to reject the request (not shown in the figure); or whether to accept the request temporarily (operation 6) and afterwards deactivate one of the existing EPS bearers using a DRB by means of a UE requested bearer resource modification (see FIG. 2). The deactivated EPS bearer can belong to another PDN connection which is no longer needed or which has a lower priority compared to the PDN connection for which the new EPS bearer was created.

[0053] “Max Bearer-Support” support can also be used as a UE configuration. In some scenarios the operator may want to restrict the maximum number of data radio bearers a UE could establish even though the device itself is capable of establishing multiple bearers (for example to reduce the number of applications requiring DRB on the device, or to reduce the UE's ability of causing congestion in the network). In such scenarios the operator may configure the device, for example using SIM-OTA or OMA-DM, to a certain “Max Bearer-Support” value.

[0054] FIG. 4 shows a UE-Capability-NB information element 400. The MultipleDRB-r13 field is part of a UE-Capability NB-r13 information element 400. This field defines whether the UE supports multiple DRBs. In some embodiments, this field is applicable if the UE supports User plane CIoT EPS Optimization and a UE-Category-NB. In the embodiment, if a UE of this release supports multiple DRBs, the UE supports at least two simultaneous DRBs. In an alternative embodiment, the MultipleDRB-r13 field is encoded as an integer value defining the maximum number of DRBs the UE can support.

[0055] FIG. 5 shows an example of a bit listing 500 for a UE network capability information element. In some embodiments, a purpose of the UE network capability information element is to provide the network with information concerning aspects of the UE related to EPS or interworking with GPRS. The contents might affect the manner in which the network handles the operation of the UE. The UE network capability information indicates general UE characteristics and it shall therefore, except for fields explicitly indicated, be independent of the frequency band of the channel it is sent on.

[0056] The UE network capability information element can be coded as shown in FIG. 5. The UE network capability is a type 4 information element with a minimum length of 4 octets and a maximum length of 15 octets.

[0057] In the embodiment, Multiple DRB support (multipleDRB which is octet 9, bit 1) indicates the capability to support multiple user plane radio bearers in NB-S1 mode. A bit set to 0 indicates that Multiple DRB is not supported. A bit set to 1 indicates Multiple DRB is supported. Other bits in octet 10 to 15 are spare and can be coded as zero, if the respective octet is included in the information element. In an alternative embodiment, the multipleDRB field is encoded as an integer value in 2 or more bits defining the maximum number of DRBs the UE can support.

[0058] FIG. 6 shows a method for indicating support for more than one data radio bearer for a NB-IoT cellular device. This can be performed by systems shown in FIGs. 1, 7, 8 or 9, including a UE, baseband circuitry, and RF circuitry, among others. In block 602, a narrowband internet of things (NB-IoT) cellular device determines that a set of radio access capability parameters including a value indicating support for more than one data radio bearer are to be signaled to a network. In block 604, the NB-IoT cellular device generates a message to the network including the value indicating support for more than one data radio bearer with the radio access capability parameters. Block 602 can be performed as a part of an attach procedure or tracking update procedure or as part of otherwise providing an information element.

[0059] In some embodiments, it can operate the other way around. For example, the UE is configured by the operator to a new value (as described above), the UE determines that the value of the Support Indicator has changed and therefore it needs to signal the new value to the network. To this purpose it initiates a tracking area update (TAU) procedure.

[0060] In other embodiments, an attach procedure initiation is performed. If the UE supports user plane CIoT EPS optimization and multiple user plane radio bearers in NB-S1 mode, then the UE shall set the Multiple DRB support bit to "Multiple DRB supported" in the UE network capability IE of the ATTACH REQUEST message.

[0061] In some embodiments, normal and periodic tracking area updating procedure initiation can be performed. If the UE supports user plane CIoT EPS optimization and multiple user plane radio bearers in NB-S1 mode, then the UE shall set the Multiple DRB support bit to "Multiple DRB supported" in the UE network capability IE of the TRACKING AREA UPDATE REQUEST message.

[0062] In some embodiments, the following UE radio access capability parameters are applicable in NB-IoT: The UE radio access capability parameters can be included. The following subclauses define the UE radio access capability parameters and minimum capabilities for multimedia broadcast multicast service (MBMS) capable UE. Only parameters for which there is the possibility for UEs to signal different values are considered as UE radio access capability parameters. Therefore, mandatory features without capability parameters that are the same for all UEs are not listed here. Also capabilities which are optional or conditionally mandatory for UEs to implement but do not have UE radio access capability parameter are listed in this specification.

[0063] In some embodiments, E-UTRAN needs to respect the signalled UE radio access capability parameters when configuring the UE and when scheduling the UE. In regard to mobility, NB-IoT is a separate RAT from E-UTRAN.

[0064] In an embodiment and for optional features, the UE radio access capability parameter indicates whether the feature has been implemented and successfully tested. For mandatory features with the UE radio access capability parameter, the parameter indicates whether the feature has been successfully tested.

[0065] The IE UE-Capability-NB can be used to convey the NB-IoT UE radio access capability parameters. The IE UE-Capability-NB is transferred in NB-IoT. The UE-Capability-NB information element can include: multipleDRB-r13 which is ENUMERATED {supported} and OPTIONAL.

[0066] Radio Resource Control protocol can be specified for the radio interface between UE and E-UTRAN as well as for the radio interface between RN and E-UTRAN.

[0067] A scope of the description can include: the radio related information transported in a transparent container between source eNB and target eNB upon inter eNB handover; and the radio related information transported in a transparent container between a source or target eNB and another system upon inter RAT handover.

[0068] Control plane CIoT EPS optimization can enable support of efficient transport of user data (IP, non-IP or SMS) over the control plane via the MME without triggering data radio bearer establishment.

[0069] The RRC protocol can include the following main functions: Establishment/modification/release of RBs carrying user data (DRBs); and NB-IoT RRC multiplicity and type constraint values.

[0070] Multiplicity and type constraint definitions can include a field in an information element called maxDRB-NB-r13 which is an INTEGER ::= 2 and defines a maximum number of DRBs for NB-IoT.

[0071] A UE Capability Information-NB message is used to transfer of UE radio access capabilities requested by the E-UTRAN. This transfer can include a Signaling radio bearer: SRB1 or SRB1bis, a RLC-SAP: AM, a Logical channel: DCCH and/or Direction: UE to E UTRAN.

[0072] In an embodiment, the IE UE-Capability-NB is used to convey the NB-IoT UE Radio Access Capability Parameters. The IE UE-Capability-NB is transferred in NB-IoT only. It can include a multipleDRB field that defines whether the UE supports multiple DRBs.

[0073] FIG. 7 is a data flow diagram illustrating data flow between a UE and Serving Gateway/ Packet Data Network (PDN) Gateway (S/P-GW) in dual connectivity configuration consistent with embodiments disclosed herein. While this example uses two radio links, one towards Master eNB (MeNB) and one towards Secondary eNB (SeNB), it should be recognized that a single link can be used. Application specific packets 722, 724 and 726 are generated from applications 702, 704 and 706 on UE 708. A first traffic flow template (TFT) including one or more packet filters 736 routes packets 722, 724 to a first wireless interface for transmission to MeNB 710 based on application specific attributes or bearer. A second TFT including one or more packet filters 736 routes packets 726 to a second wireless interface for transmission to SeNB 711. In some embodiments, one of the TFTs may be missing, and any packet which does not match the filter criteria of any of the packet filters of the other TFT(s) is routed to the wireless interface not associated with a TFT (default wireless interface). MeNB 710 and SeNB 711 transmit the packets 722, 724 and 726 to S/P-GW 712. S/P-GW 712 transmits traffic flows 762, 764 and 766 to service 714 that includes application 1 (716), application 2 (718) and application 3 (720).

[0074] For example, as the packet filters 736 reside above PDCP layers 728 and 738, traffic flow aggregates can be formed by means of the TFTs (a first TFT that includes packet filters matching packets 722 and 724 and a second TFT that includes packet filters matching packets 726). Packets 722 and 724 flow through PDCP layer 728 (becoming associated with a radio bearer) through RLC layer 730 (becoming associated with a logical channel (DTCH)) through MAC layer 732 (becoming associated with a transport channel (ULSCH)) and through the PHY layer 734 (becoming associated with a physical channel (PUSCH)) to be transmitted to MeNB 710. Packets 726 flow through a second protocol stack through PDCP layer 738 (becoming associated with a radio bearer) through RLC layer 740 (becoming

associated with a logical channel (DTCH)) through MAC layer 742 (becoming associated with a transport channel (ULSCH)) and through the PHY layer 744 (becoming associated with a physical channel (PUSCH)) to be transmitted to SeNB 711.

[0075] The packets 722, 724 and 726 are received by MeNB 710 and SeNB 711 and sent to S/P-GW 712, which can provide the packets to service 714 that includes application 1 (716), application 2 (718) and application 3 (720). A transmission from UE 708 to SeNB 711 based on packets 726 is routed through PHY layer 754 to MAC layer 756 to RLC layer 758 to PDCP layer 760 and then through an EPS bearer to S/P-GW 712 which routes packets 726 to application 720 (becoming traffic flow 762). A transmission from UE 708 to MeNB 710 based on packets 722 and 724 is routed through PHY layer 746 to MAC layer 748 to RLC layer 750 to PDCP layer 752 and then through an EPS bearer to S/P-GW 712 which routes packets 722 and 724 to applications 716 and 718 (becoming traffic flows 766 and 764).

[0076] For example, UE is running a GPS voice directions application. Current positioning information is reported by application 1 (702 on UE 708 and 716 on service 714). Voice directions are handled by application 2 (704 on UE 708 and 718 on service 714). A background map cache is provided by application 3 (706 on UE 708 and 720 on service 714). Positioning information (packets 724) and voice directions (packets 724) can be timing and reliability sensitive (as routes may need to be recalculated). However, a background map cache (packets 726) can be quickly loaded and stored for later use, allowing for high current data rates, but more unreliable connections if small updates are needed. MeNB 746 can determine that application 3 (706 on UE 708 and 720 on service 714) can make use of SeNB 711 and enables SeNB 711 for use (such as a request to turn on and/or accept connections from UE 708). MeNB 710 can then configure the radio bearer (738 on UE 708 and 760 on network side) to be used with the second TFT including packet filters 736 (on both UE 708 and EPC, such as S/P-GW 712) to filter packets based on application based criteria (such as IP address, application of origin, etc.). Positioning information (packets 724) and voice directions (packets 722) are routed over a more robust (but potentially slower) link to MeNB 710 by packet filter 736. Background map cache (packets 726) are routed over a less robust (but potentially faster) link from SeNB 711 to UE 708 by packet filters in the S/P-GW 712.

[0077] In one embodiment, the sequence of events is: 1) The UE requests additional bearer resources (see, e.g., FIG. 2). 2) The network then activates a dedicated EPS bearer (with associated TFT). At this point the first EPS bearer (default bearer) and the new, dedicated bearer are both between UE and (M)eNB. The UE uses the TFT(s) to map the uplink packets to one of the two EPS bearers and such to one of the two DRBs and P-GW uses the TFT(s) to

map the downlink packets to one of the 2 EPS bearers. 3) (M)eNB decides to switch to a dual connectivity configuration. At this point the first EPS bearer (default bearer) is between UE and MeNB, and the dedicated bearer is between UE and SeNB. The UE still uses the TFT(s) to map the uplink packets to one of the two EPS bearers and P-GW still uses the TFT(s) to map the downlink packets to one of the two EPS bearers.

[0078] In some embodiments, the WLAN technology can be used instead of an SeNB.

[0079] FIG. 8 is a block diagram illustrating electronic device circuitry 800 that may be radio access node (RAN) node circuitry (such as an eNB circuitry), UE circuitry, network node circuitry, or some other type of circuitry in accordance with various embodiments. In embodiments, the electronic device circuitry 800 may be, or may be incorporated into or otherwise a part of, a RAN Node (e.g., an eNB), a UE, a mobile station (MS), a BTS, a network node, or some other type of electronic device. In embodiments, the electronic device circuitry 800 may include radio transmit circuitry 810 and receive circuitry 812 coupled to control circuitry 814 (e.g., baseband processor(s), etc.). In embodiments, the transmit circuitry 810 and/or receive circuitry 812 may be elements or modules of transceiver circuitry, as shown. In some embodiments, some or all of the control circuitry 815 can be in a device separate or external from the transmit circuitry 810 and the receive circuitry 812 (baseband processors shared by multiple antenna devices, as in cloud-RAN (C-RAN) implementations, for example).

[0080] The electronic device circuitry 810 may be coupled with one or more plurality of antenna elements 816 of one or more antennas. The electronic device circuitry 800 and/or the components of the electronic device circuitry 800 may be configured to perform operations similar to those described elsewhere in this disclosure.

[0081] In embodiments where the electronic device circuitry 800 is or is incorporated into or otherwise part of a UE, the transmit circuitry 810 can transmit an information element and/or a bearer resource modification request as shown in FIG. 2. The receive circuitry 812 can receive a RRC connection reconfiguration message as shown in FIG. 3.

[0082] In embodiments where the electronic device circuitry 800 is an eNB, BTS and/or a network node, or is incorporated into or is otherwise part of an eNB, BTS and/or a network node, the transmit circuitry 810 can transmit a RRC connection reconfiguration message as shown in FIG. 3. The receive circuitry 812 can receive a RRC connection reconfiguration complete message or direct transfer message as shown in FIG. 3. In an embodiment, a bearer setup request is received from the MME via a fixed line and not via a radio interface.

[0083] In certain embodiments, the electronic device circuitry 800 shown in FIG. 8 is operable to perform one or more methods, such as the methods shown in FIG. 6.

[0084] As used herein, the term “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[0085] Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. FIG. 9 is a block diagram illustrating, for one embodiment, example components of a user equipment (UE) or mobile station (MS) device 900. In some embodiments, the UE device 900 may include application circuitry 902, baseband circuitry 904, Radio Frequency (RF) circuitry 906, front-end module (FEM) circuitry 908, and one or more antennas 910, coupled together at least as shown in FIG. 9.

[0086] The application circuitry 902 may include one or more application processors. By way of non-limiting example, the application circuitry 902 may include one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processor(s) may be operably coupled and/or include memory/storage, and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

[0087] By way of non-limiting example, the baseband circuitry 904 may include one or more single-core or multi-core processors. The baseband circuitry 904 may include one or more baseband processors and/or control logic. The baseband circuitry 904 may be configured to process baseband signals received from a receive signal path of the RF circuitry 906. The baseband 904 may also be configured to generate baseband signals for a transmit signal path of the RF circuitry 906. The baseband processing circuitry 904 may interface with the application circuitry 902 for generation and processing of the baseband signals, and for controlling operations of the RF circuitry 906.

[0088] By way of non-limiting example, the baseband circuitry 904 may include at least one of a second generation (2G) baseband processor 904A, a third generation (3G) baseband processor 904B, a fourth generation (4G) baseband processor 904C, other baseband

processor(s) 904D for other existing generations, and generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 904 (e.g., at least one of baseband processors 904A-904D) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 906. By way of non-limiting example, the radio control functions may include signal modulation/demodulation, encoding/decoding, radio frequency shifting, other functions, and combinations thereof. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 904 may be programmed to perform Fast-Fourier Transform (FFT), precoding, constellation mapping/demapping functions, other functions, and combinations thereof. In some embodiments, encoding/decoding circuitry of the baseband circuitry 904 may be programmed to perform convolutions, tail-biting convolutions, turbo, Viterbi, Low Density Parity Check (LDPC) encoder/decoder functions, other functions, and combinations thereof. Embodiments of modulation/demodulation and encoder/decoder functions are not limited to these examples, and may include other suitable functions.

[0089] In some embodiments, the baseband circuitry 904 may include elements of a protocol stack. By way of non-limiting example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 904E of the baseband circuitry 904 may be programmed to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry 904 may include one or more audio digital signal processor(s) (DSP) 904F. The audio DSP(s) 904F may include elements for compression/decompression and echo cancellation. The audio DSP(s) 904F may also include other suitable processing elements.

[0090] The baseband circuitry 904 may further include memory/storage 904G. The memory/storage 904G may include data and/or instructions for operations performed by the processors of the baseband circuitry 904 stored thereon. In some embodiments, the memory/storage 904G may include any combination of suitable volatile memory and/or non-volatile memory. The memory/storage 904G may also include any combination of various levels of memory/storage including, but not limited to, read-only memory (ROM) having embedded software instructions (e.g., firmware), random access memory (e.g., dynamic random access memory (DRAM)), cache, buffers, etc. In some embodiments, the

memory/storage 904G may be shared among the various processors or dedicated to particular processors.

[0091] Components of the baseband circuitry 904 may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 904 and the application circuitry 902 may be implemented together, such as, for example, on a system on a chip (SOC).

[0092] In some embodiments, the baseband circuitry 904 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 904 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 904 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0093] The RF circuitry 906 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 906 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. The RF circuitry 906 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 908, and provide baseband signals to the baseband circuitry 904. The RF circuitry 906 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 904, and provide RF output signals to the FEM circuitry 908 for transmission.

[0094] In some embodiments, the RF circuitry 906 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 906 may include mixer circuitry 906A, amplifier circuitry 906B, and filter circuitry 906C. The transmit signal path of the RF circuitry 906 may include filter circuitry 906C and mixer circuitry 906A. The RF circuitry 906 may further include synthesizer circuitry 906D configured to synthesize a frequency for use by the mixer circuitry 906A of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 906A of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 908 based on the synthesized frequency provided by synthesizer circuitry 906D. The amplifier circuitry 906B may be configured to amplify the down-converted signals.

[0095] The filter circuitry 906C may include a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband signals. Output baseband signals may be provided to the baseband circuitry 904 for further processing. In some embodiments, the output baseband signals may include zero-frequency baseband signals, although this is not a requirement. In some embodiments, the mixer circuitry 906A of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[0096] In some embodiments, the mixer circuitry 906A of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 906D to generate RF output signals for the FEM circuitry 908. The baseband signals may be provided by the baseband circuitry 904 and may be filtered by filter circuitry 906C. The filter circuitry 906C may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect. In some embodiments, the mixer circuitry 906A of the receive signal path and the mixer circuitry 906A of the transmit signal path may include two or more mixers, and may be arranged for quadrature downconversion and/or upconversion, respectively. In some embodiments, the mixer circuitry 906A of the receive signal path and the mixer circuitry 906A of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 906A of the receive signal path and the mixer circuitry 906A may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 906A of the receive signal path and the mixer circuitry 906A of the transmit signal path may be configured for super-heterodyne operation.

[0097] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In such embodiments, the RF circuitry 906 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry, and the baseband circuitry 904 may include a digital baseband interface to communicate with the RF circuitry 906.

[0098] In some dual-mode embodiments, separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[0099] In some embodiments, the synthesizer circuitry 906D may include one or more of a fractional-N synthesizer and a fractional $N/N+1$ synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 906D may include a delta-sigma synthesizer, a frequency multiplier, a synthesizer comprising a phase-locked loop with a frequency divider, other synthesizers and combinations thereof.

[00100] The synthesizer circuitry 906D may be configured to synthesize an output frequency for use by the mixer circuitry 906A of the RF circuitry 906 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 906D may be a fractional $N/N+1$ synthesizer.

[0100] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 904 or the applications processor 902 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 902.

[0101] The synthesizer circuitry 906D of the RF circuitry 906 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may include a dual modulus divider (DMD), and the phase accumulator may include a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In such embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL may provide negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0102] In some embodiments, the synthesizer circuitry 906D may be configured to generate a carrier frequency as the output frequency. In some embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency, etc.) and used in conjunction with a quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO

frequency (fLO). In some embodiments, the RF circuitry 906 may include an IQ/polar converter.

[0103] The FEM circuitry 908 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 910, amplify the received signals, and provide the amplified versions of the received signals to the RF circuitry 906 for further processing. The FEM circuitry 908 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 906 for transmission by at least one of the one or more antennas 910.

[0104] In some embodiments, the FEM circuitry 908 may include a TX/RX switch configured to switch between a transmit mode and a receive mode operation. The FEM circuitry 908 may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry 908 may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 906). The transmit signal path of the FEM circuitry 908 may include a power amplifier (PA) configured to amplify input RF signals (e.g., provided by RF circuitry 906), and one or more filters configured to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 910).

[0105] In some embodiments, the MS device 900 may include additional elements such as, for example, memory/storage, a display, a camera, one of more sensors, an input/output (I/O) interface, other elements, and combinations thereof.

[0106] In some embodiments, the MS device 900 may be configured to perform one or more processes, techniques, and/or methods as described herein, or portions thereof.

[0107] As used herein, the term “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

Examples

[0108] The following examples pertain to further embodiments.

[0109] Example 1 is an apparatus of a narrowband user equipment (UE). The apparatus includes storage designed to store a set of radio access capability parameters for the narrowband UE including an indicator of support for more than one data radio bearer. The apparatus includes one or more baseband processors designed to determine that the set of radio access capability parameters are to be signaled to a network, and encode a message for the network including the indicator of support for more than one data radio bearer with the set of radio access capability parameters.

[0110] Example 2 is the apparatus of Example 1, where to determine that the set of radio access capability parameters are to be signaled to a network further includes to initiate an attach procedure that discloses the set of radio access capability parameters.

[0111] Example 3 is the apparatus of Example 1, where to determine that the set of radio access capability parameters are to be signaled to a network further includes to initiate a tracking area updating procedure.

[0112] Example 4 is the apparatus of Example 1, where the message is a radio resource control message.

[0113] Example 5 is the apparatus of Example 4, where the indicator is part of a UE Capability Information-NB information element.

[0114] Example 6 is the apparatus of Example 1, where the UE is designed to communicate with the network using a narrowband internet of things (NB-IoT) radio access technology.

[0115] Example 7 is the apparatus of Example 1, where the UE is designed to communicate with the network that includes an evolved UMTS Terrestrial Radio Access Network (E-UTRAN).

[0116] Example 8 is the apparatus of Example 1, where the network includes at least one of an enhanced Node B (eNB) or mobility management entity (MME).

[0117] Example 9 is the apparatus of Example 1, where the message is an Evolved Packet System (EPS) Mobility Management (MM) message.

[0118] Example 10 is the apparatus of Example 9, where the indicator is part of a UE network capability information element.

[0119] Example 11 is an apparatus of an evolved universal mobile telecommunications system (UMTS) Terrestrial Radio Access Network (E-UTRAN) entity. The apparatus includes storage designed to store a variety of sets of radio access capability parameters for one or more cellular internet of things (CIoT) user equipments (UEs), a set of radio access capability parameters including an indicator of support for more than one data radio bearer.

The apparatus includes one or more processing units designed to process a variety of sets of radio access capability parameters from a set of CIoT UEs including indicators of support for more than one data radio bearer, and process a first request to establish an additional evolved packet system (EPS) bearer for a first CIoT UE from the set of CIoT UEs. The apparatus also includes one or more processing units designed to, in response to the first request, determine that the first CIoT UE supports more than one data radio bearer based at least in part on a first indicator of support for more than one data radio bearer, and based at least in part on the first indicator of support for more than one data radio bearer indicating a support for more than one data radio bearer, design the additional radio bearer for use with the first CIoT UE.

[0120] Example 12 is the apparatus of Example 11, where the one or more processing units are further designed to process a second request to establish an additional EPS bearer for a second CIoT UE from the set of CIoT UEs. The processing units are further designed to process in response to the second request; determine that the second CIoT UE supports one data radio bearer based at least in part on a second indicator of support for more than one data radio bearer, and based at least in part on the second indicator of support for more than one data radio bearer indicating a lack of support for more than one data radio bearer, reuse an existing radio bearer for the CIoT UE, create an additional packet data network (PDN) connection without a data radio bearer, or reject the second request.

[0121] Example 13 is the apparatus of Example 12, where to reuse an existing radio bearer further includes to use an existing radio bearer.

[0122] Example 14 is the apparatus of Example 12, where to reuse an existing radio bearer further includes to release an existing radio bearer and create a new radio bearer.

[0123] Example 15 is the apparatus of Example 11, where the E-UTRAN entity is an enhanced Node B (eNB).

[0124] Example 16 is the apparatus of Example 11, where the E-UTRAN entity is a mobility management entity (MME).

[0125] Example 17 is the apparatus of Example 11, where to process the set of radio access capability parameters from a CIoT UE including the first indicator of support for more than one data radio bearer further includes to process a message from an attach procedure that discloses the set of radio access capability parameters.

[0126] Example 18 is the apparatus of Example 11, where to process the set of radio access capability parameters from a CIoT UE including the first indicator of support for more

than one data radio bearer further includes to process a message from a tracking area updating procedure.

[0127] Example 19 is the apparatus of Example 11, where to process the set of radio access capability parameters from a CIoT UE including the first indicator of support for more than one data radio bearer further includes to process a EPS mobility management (MM) message that includes the first indicator of support for more than one data radio bearer.

[0128] Example 20 is the apparatus of Example 19, where the indicator is part of a UE network capability information element.

[0129] Example 21 is the apparatus of Example 11, where E-UTRAN communication with the CIoT UE uses a narrowband internet of things (NB-IoT) radio access technology.

[0130] Example 22 is the apparatus of Example 11, where to process the set of radio access capability parameters from a CIoT UE including the first indicator of support for more than one data radio bearer further includes to process a radio resource control message that includes the first indicator of support for more than one data radio bearer.

[0131] Example 23 is the apparatus of Example 22, where the indicator is part of a UECapabilityInformation-NB information element.

[0132] Example 24 is a computer program product. The computer program product includes a computer-readable storage medium that stores instructions for execution by one or more processors to perform operations of a narrowband internet of things (NB-IoT) cellular device, the operations, when executed by the one or more processors to determine that a set of radio access capability parameters including a value indicating support for more than one data radio bearer are to be signaled to a network, and generate a message to the network including the value indicating support for more than one data radio bearer with the set of radio access capability parameters.

[0133] Example 25 is the computer program product of Example 24, where to determine that the set of radio access capability parameters are to be signaled to a network further includes to initiate an attach procedure that discloses the set of radio access capability parameters.

[0134] Example 26 is the computer program product of Example 24, where to determine that the set of radio access capability parameters are to be signaled to a network further includes to initiate a tracking area updating procedure.

[0135] Example 27 is the computer program product of Example 24, where to generate the message further includes to generate an evolved packet system (EPS) mobility management (MM) message with the indicator.

[0136] Example 28 is the computer program product of Example 27, where to generate the message further includes to include the indicator as part of a UE network capability information element.

[0137] Example 29 is the computer program product of Example 24, where the instructions, when executed by the one or more processors, are further designed to transmit the message using a narrowband internet of things (NB-IoT) radio access technology.

[0138] Example 30 is the computer program product of Example 24, where to generate the message further includes to generate the message as a radio resource control message.

[0139] Example 31 is the computer program product of Example 30, where to generate the message as the radio resource control message further includes to include the value as part of a UECapabilityInformation-NB information element.

[0140] Example 32 is the computer program product of Example 24, where the value indicates a maximum number of data radio bearers supported by the NB-IoT cellular device.

[0141] Embodiments and implementations of the systems and methods described herein may include various operations, which may be embodied in machine-executable instructions to be executed by a computer system. A computer system may include one or more general-purpose or special-purpose computers (or other electronic devices). The computer system may include hardware components that include specific logic for performing the operations or may include a combination of hardware, software, and/or firmware.

[0142] Computer systems and the computers in a computer system may be connected via a network. Suitable networks for configuration and/or use as described herein include one or more local area networks, wide area networks, metropolitan area networks, and/or Internet or IP networks, such as the World Wide Web, a private Internet, a secure Internet, a value-added network, a virtual private network, an extranet, an intranet, or even stand-alone machines which communicate with other machines by physical transport of media. In particular, a suitable network may be formed from parts or entirety of two or more other networks, including networks using disparate hardware and network communication technologies.

[0143] One suitable network includes a server and one or more clients; other suitable networks may contain other combinations of servers, clients, and/or peer-to-peer nodes, and a given computer system may function both as a client and as a server. Each network includes at least two computers or computer systems, such as the server and/or clients. A computer system may include a workstation, laptop computer, disconnectable mobile computer, server, mainframe, cluster, so-called "network computer" or "thin client," tablet, smart phone,

personal digital assistant or other hand-held computing device, “smart” consumer electronics device or appliance, medical device, or a combination thereof.

[0144] Suitable networks may include communications or networking software, such as the software available from Novell®, Microsoft®, and other vendors, and may operate using TCP/IP, SPX, IPX, and other protocols over twisted pair, coaxial, or optical fiber cables, telephone lines, radio waves, satellites, microwave relays, modulated AC power lines, physical media transfer, and/or other data transmission “wires” known to those of skill in the art. The network may encompass smaller networks and/or be connectable to other networks through a gateway or similar mechanism.

[0145] Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, magnetic or optical cards, solid-state memory devices, a nontransitory computer-readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and nonvolatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and nonvolatile memory and/or storage elements may be a RAM, an EPROM, a flash drive, an optical drive, a magnetic hard drive, or other medium for storing electronic data. The eNB (or other base station) and UE (or other mobile station) may also include a transceiver component, a counter component, a processing component, and/or a clock component or timer component. One or more programs that may implement or utilize the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high-level procedural or an object-oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[0146] Each computer system includes one or more processors and/or memory; computer systems may also include various input devices and/or output devices. The processor may include a general purpose device, such as an Intel®, AMD®, or other “off-the-shelf” microprocessor. The processor may include a special purpose processing device, such as ASIC, SoC, SiP, FPGA, PAL, PLA, FPLA, PLD, or other customized or programmable

device. The memory may include static RAM, dynamic RAM, flash memory, one or more flip-flops, ROM, CD-ROM, DVD, disk, tape, or magnetic, optical, or other computer storage medium. The input device(s) may include a keyboard, mouse, touch screen, light pen, tablet, microphone, sensor, or other hardware with accompanying firmware and/or software. The output device(s) may include a monitor or other display, printer, speech or text synthesizer, switch, signal line, or other hardware with accompanying firmware and/or software.

[0147] It should be understood that many of the functional units described in this specification may be implemented as one or more components, which is a term used to more particularly emphasize their implementation independence. For example, a component may be implemented as a hardware circuit comprising custom very large scale integration (VLSI) circuits or gate arrays, or off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A component may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices, or the like.

[0148] Components may also be implemented in software for execution by various types of processors. An identified component of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, a procedure, or a function. Nevertheless, the executables of an identified component need not be physically located together, but may comprise disparate instructions stored in different locations that, when joined logically together, comprise the component and achieve the stated purpose for the component.

[0149] Indeed, a component of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within components, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The components may be passive or active, including agents operable to perform desired functions.

[0150] Several aspects of the embodiments described will be illustrated as software modules or components. As used herein, a software module or component may include any type of computer instruction or computer-executable code located within a memory device. A software module may, for instance, include one or more physical or logical blocks of

computer instructions, which may be organized as a routine, program, object, component, data structure, etc., that perform one or more tasks or implement particular data types. It is appreciated that a software module may be implemented in hardware and/or firmware instead of or in addition to software. One or more of the functional modules described herein may be separated into sub-modules and/or combined into a single or smaller number of modules.

[0151] In certain embodiments, a particular software module may include disparate instructions stored in different locations of a memory device, different memory devices, or different computers, which together implement the described functionality of the module. Indeed, a module may include a single instruction or many instructions, and may be distributed over several different code segments, among different programs, and across several memory devices. Some embodiments may be practiced in a distributed computing environment where tasks are performed by a remote processing device linked through a communications network. In a distributed computing environment, software modules may be located in local and/or remote memory storage devices. In addition, data being tied or rendered together in a database record may be resident in the same memory device, or across several memory devices, and may be linked together in fields of a record in a database across a network.

[0152] Reference throughout this specification to “an example” means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present invention. Thus, appearances of the phrase “in an example” in various places throughout this specification are not necessarily all referring to the same embodiment.

[0153] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on its presentation in a common group without indications to the contrary. In addition, various embodiments and examples of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0154] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description,

numerous specific details are provided, such as examples of materials, frequencies, sizes, lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention may be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0155] It should be recognized that the systems described herein include descriptions of specific embodiments. These embodiments can be combined into single systems, partially combined into other systems, split into multiple systems or divided or combined in other ways. In addition, it is contemplated that parameters/attributes/aspects/etc. of one embodiment can be used in another embodiment. The parameters/attributes/aspects /etc. are merely described in one or more embodiments for clarity, and it is recognized that the parameters/attributes/aspects /etc. can be combined with or substituted for parameters/attributes/etc. of another embodiment unless specifically disclaimed herein.

[0156] Although the foregoing has been described in some detail for purposes of clarity, it will be apparent that certain changes and modifications may be made without departing from the principles thereof. It should be noted that there are many alternative ways of implementing both the processes and apparatuses described herein. Accordingly, the present embodiments are to be considered illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

[0157] Those having skill in the art will appreciate that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

Claims:

1. An apparatus of a narrowband user equipment (UE), comprising:
storage configured to store a set of radio access capability parameters for the narrowband UE including an indicator of support for more than one data radio bearer;
one or more baseband processors configured to:
 - determine that the set of radio access capability parameters are to be signaled to a network; and
 - encode a message for the network including the indicator of support for more than one data radio bearer with the set of radio access capability parameters.
2. The apparatus of claim 1, wherein to determine that the set of radio access capability parameters are to be signaled to the network further comprises to initiate an attach procedure that discloses the set of radio access capability parameters.
3. The apparatus of claim 1, wherein to determine that the set of radio access capability parameters are to be signaled to the network further comprises to initiate a tracking area updating procedure.
4. The apparatus of claim 1, wherein the message is a radio resource control message.
5. The apparatus of claim 4, wherein the indicator is part of a UECapabilityInformation-NB information element.
6. The apparatus of claim 1, wherein the UE is configured to communicate with the network using a narrowband internet of things (NB-IoT) radio access technology.
7. The apparatus of claim 1, wherein the UE is configured to communicate with the network that comprises an evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
8. The apparatus of claim 1, wherein the network comprises at least one of an enhanced Node B (eNB) or mobility management entity (MME).
9. The apparatus of claim 1, wherein the message is an Evolved Packet System (EPS) Mobility Management (MM) message.

10. The apparatus of claim 9, wherein the indicator is part of a UE network capability information element.

11. An apparatus of an evolved universal mobile telecommunications system (UMTS) Terrestrial Radio Access Network (E-UTRAN) entity, comprising:

storage configured to store a plurality of sets of radio access capability parameters for one or more cellular internet of things (CIoT) user equipments (UEs), a set of radio access capability parameters including an indicator of support for more than one data radio bearer;

one or more processing units configured to:

process the plurality of sets of radio access capability parameters from a set of CIoT UEs including indicators of support for more than one data radio bearer;

process a first request to establish an additional evolved packet system (EPS) bearer for a first CIoT UE from the set of CIoT UEs; and

in response to the first request:

determine that the first CIoT UE supports more than one data radio bearer based at least in part on a first indicator of support for more than one data radio bearer; and

based at least in part on the first indicator of support for more than one data radio bearer indicating a support for more than one data radio bearer, configure the additional EPS bearer for use with the first CIoT UE.

12. The apparatus of claim 11, wherein the one or more processing units are further configured to:

process a second request to establish a second additional EPS bearer for a second CIoT UE from the set of CIoT UEs;

in response to the second request:

determine that the second CIoT UE supports one data radio bearer based at least in part on a second indicator of support for more than one data radio bearer; and

based at least in part on the second indicator of support for more than one data radio bearer indicating a lack of support for more than one data radio bearer, reuse an existing radio bearer for the second CIoT UE, create an additional packet data network (PDN) connection without a data radio bearer, or reject the second request.

13. The apparatus of claim 12, wherein to reuse the existing radio bearer further comprises to use the existing radio bearer.

14. The apparatus of claim 12, wherein to reuse the existing radio bearer further comprises to release the existing radio bearer and create a new radio bearer.

15. The apparatus of claim 11, wherein the E-UTRAN entity is an enhanced Node B (eNB).

16. The apparatus of claim 11, wherein the E-UTRAN entity is a mobility management entity (MME).

17. The apparatus of claim 11, wherein to process the set of radio access capability parameters from the first CIoT UE including the indicator of support for more than one data radio bearer further comprises to process a message from an attach procedure that discloses the set of radio access capability parameters.

18. The apparatus of claim 11, wherein to process the set of radio access capability parameters from the first CIoT UE including the indicator of support for more than one data radio bearer further comprises to process a message from a tracking area updating procedure.

19. The apparatus of claim 11, wherein to process the set of radio access capability parameters from the first CIoT UE including the first indicator of support for more than one data radio bearer further comprises to process a EPS mobility management (MM) message that includes the indicator of support for more than one data radio bearer.

20. The apparatus of claim 19, wherein the first indicator is part of a UE network capability information element.

21. The apparatus of claim 11, wherein E-UTRAN communication with the first CIoT UE uses a narrowband internet of things (NB-IoT) radio access technology.

22. The apparatus of claim 11, wherein to process the set of radio access capability parameters from the first CIoT UE including the indicator of support for more than one data

radio bearer further comprises to process a radio resource control message that includes the indicator of support for more than one data radio bearer.

23. The apparatus of claim 22, wherein the first indicator is part of a UE Capability Information-NB information element.

24. A computer program product comprising a computer-readable storage medium that stores instructions for execution by one or more processors to perform operations of a narrowband internet of things (NB-IoT) cellular device, the operations, when executed by the one or more processors to:

determine that a set of radio access capability parameters including a value indicating support for more than one data radio bearer are to be signaled to a network; and

generate a message to the network including the value indicating support for more than one data radio bearer with the set of radio access capability parameters.

25. The computer program product of claim 24, wherein the instructions, when executed by the one or more processors, are further configured to transmit the message using a narrowband internet of things (NB-IoT) radio access technology.

26. The computer program product of claim 24, wherein to generate the message further comprises to generate the message as a radio resource control message.

27. The computer program product of claim 26, wherein to generate the message as the radio resource control message further comprises to include the value as part of a UE Capability Information-NB information element.

28. The computer program product of claim 24, wherein the value indicates a maximum number of data radio bearers supported by the NB-IoT cellular device.

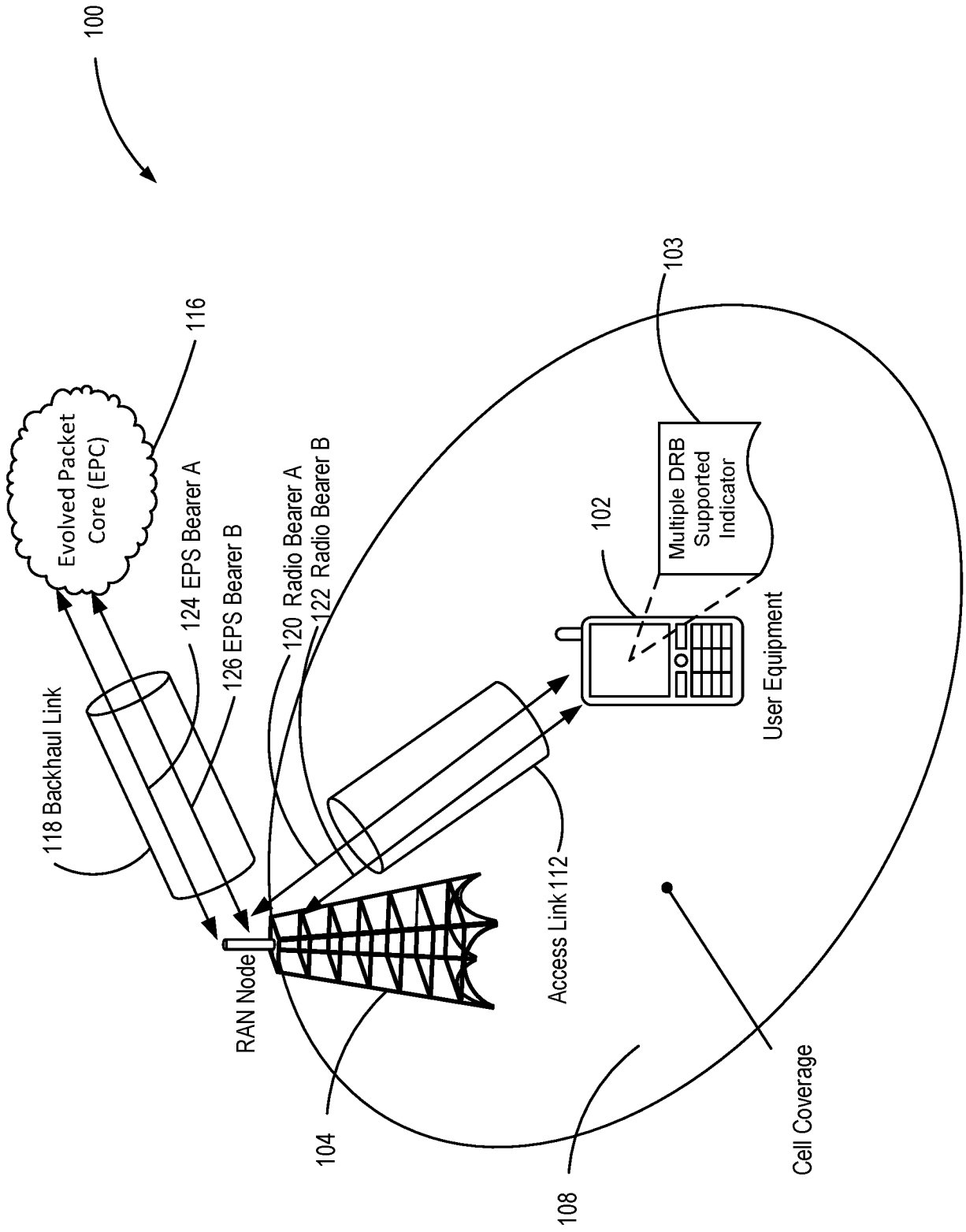


FIG. 1

200

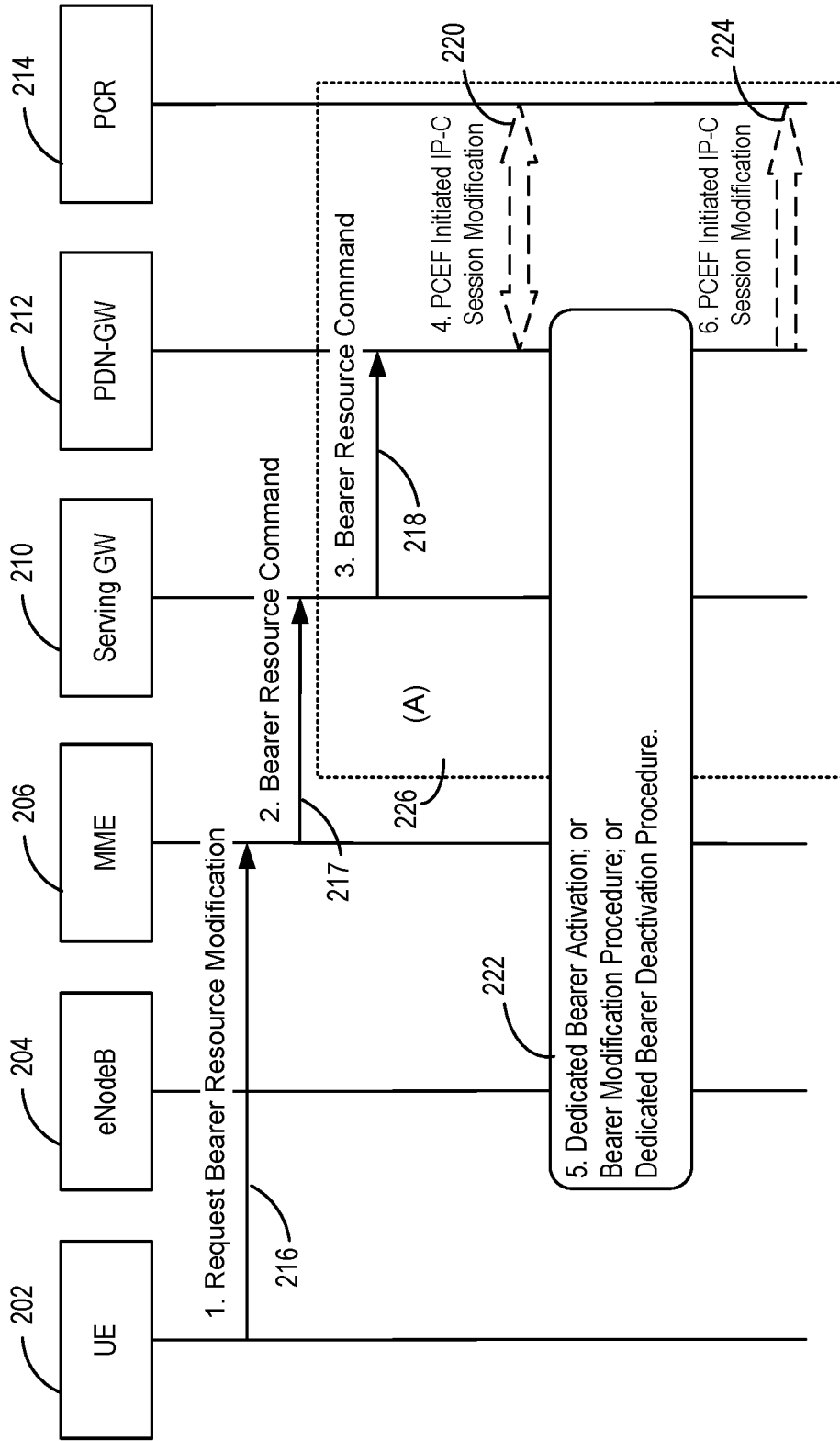


FIG. 2

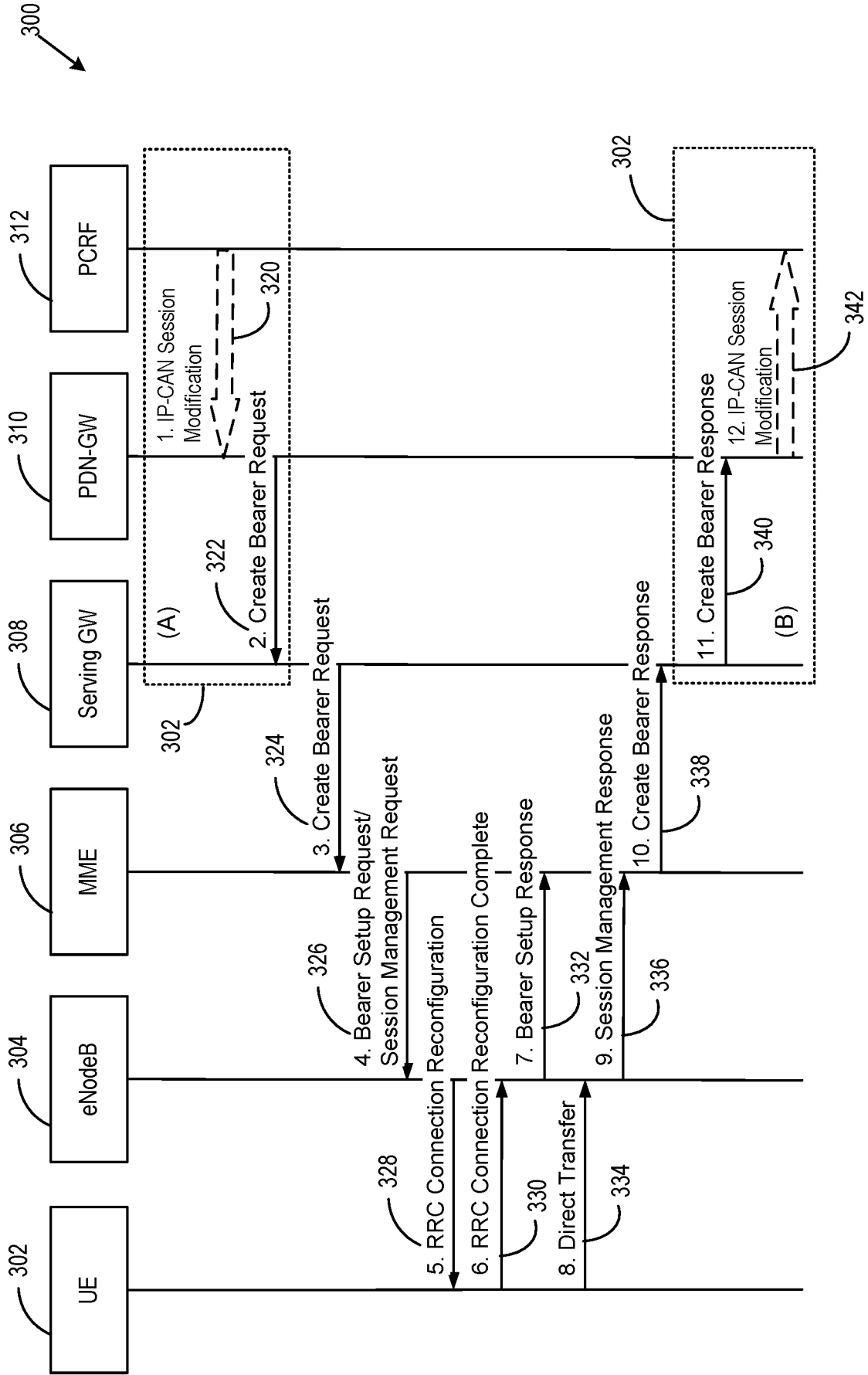


FIG. 3

400

```

UE-Capability-NB-r13 ::= SEQUENCE {
    accessStratumRelease-r13    AccessStratumRelease-NB-r13,
    ue-Category-NB-r13         ENUMERATED {nb1} OPTIONAL,
    multipleDRB-r13           ENUMERATED {supported} OPTIONAL,
    pdcp-Parameters-r13       PDCP-Parameters-NB-r13    OPTIONAL,
    phyLayerParameters-r13    PhyLayerParameters-NB-r13  OPTIONAL,
    rf-Parameters-r13        RF-Parameters-NB-r13,
    nonCriticalExtension      SEQUENCE {} OPTIONAL
}
    
```

4/9

UE-Capability-NB information element

FIG. 4

500

UE network capability IEI								1	octet 1
Length of UE network capability contents								2	octet 2
8	7	6	5	4	3	2	1	octet 3	
EEA0	128- EEA1	128- EEA2	128- EEA3	EEA4	EEA5	EEA6	EEA7	octet 4	
EIA0	128- EIA1	128- EIA2	128- EIA3	EIA4	EIA5	EIA6	EIA7	octet 5*	
UEA0	UEA1	UEA2	UEA3	UEA4	UEA5	UEA6	UEA7	octet 6*	
UCS2	UIA1	UIA2	UIA3	UIA4	UIA5	UIA6	UIA7	octet 7*	
ProSe- dd	ProSe ASH	H.245- ERw/o PDN	ACC- CSFB	LPP	LCS	1xSR VCC	NF	octet 8*	
ePCO	HC- CP Clot	CP Clot	S1-U data	UP Clot	CP Clot	ProSe- relay	ProSe- dc	octet 9*	
0	0	0	0	0	0	0	multiple DRB	octet 10*	
Spare	Spare	Spare	Spare	Spare	Spare	Spare	0	-15*	
0	0	0	0	0	0	0	0		
Spare									

FIG. 5

600

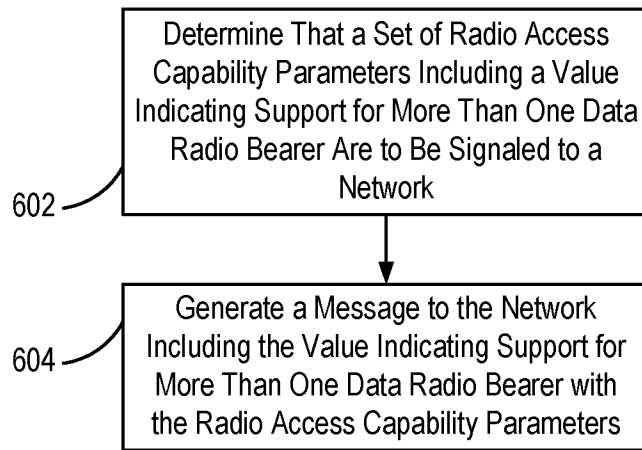


FIG. 6

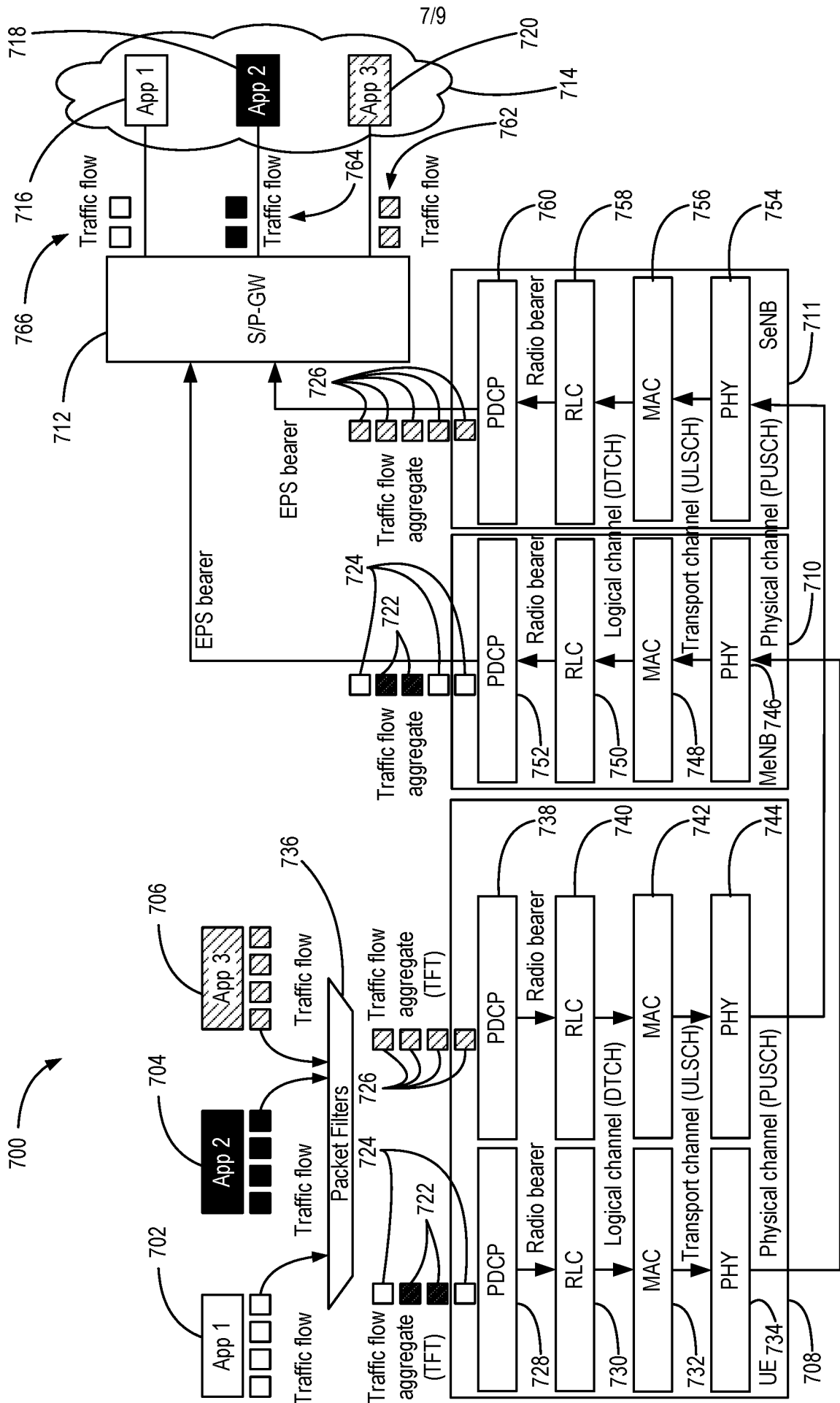


FIG. 7

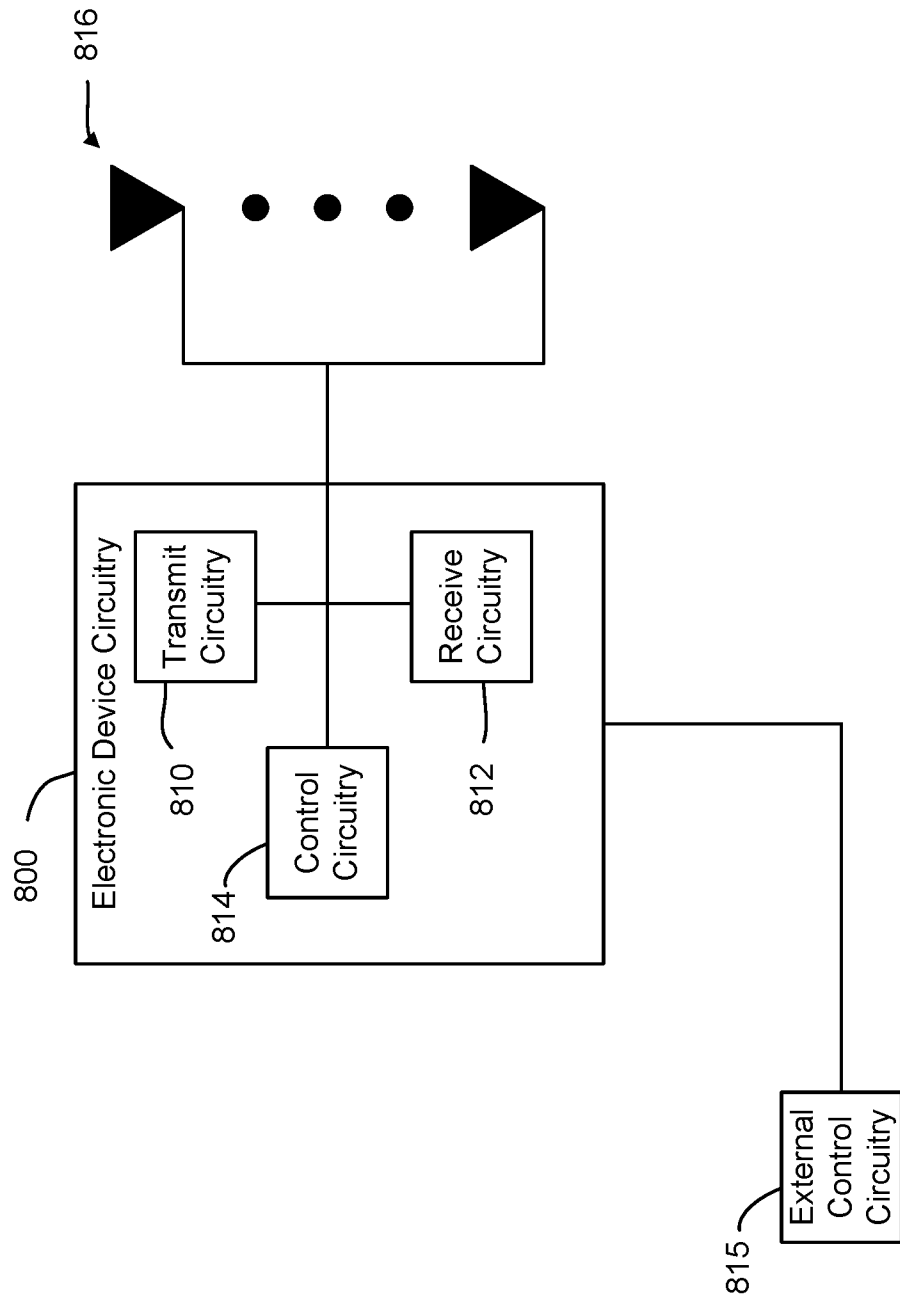


FIG. 8

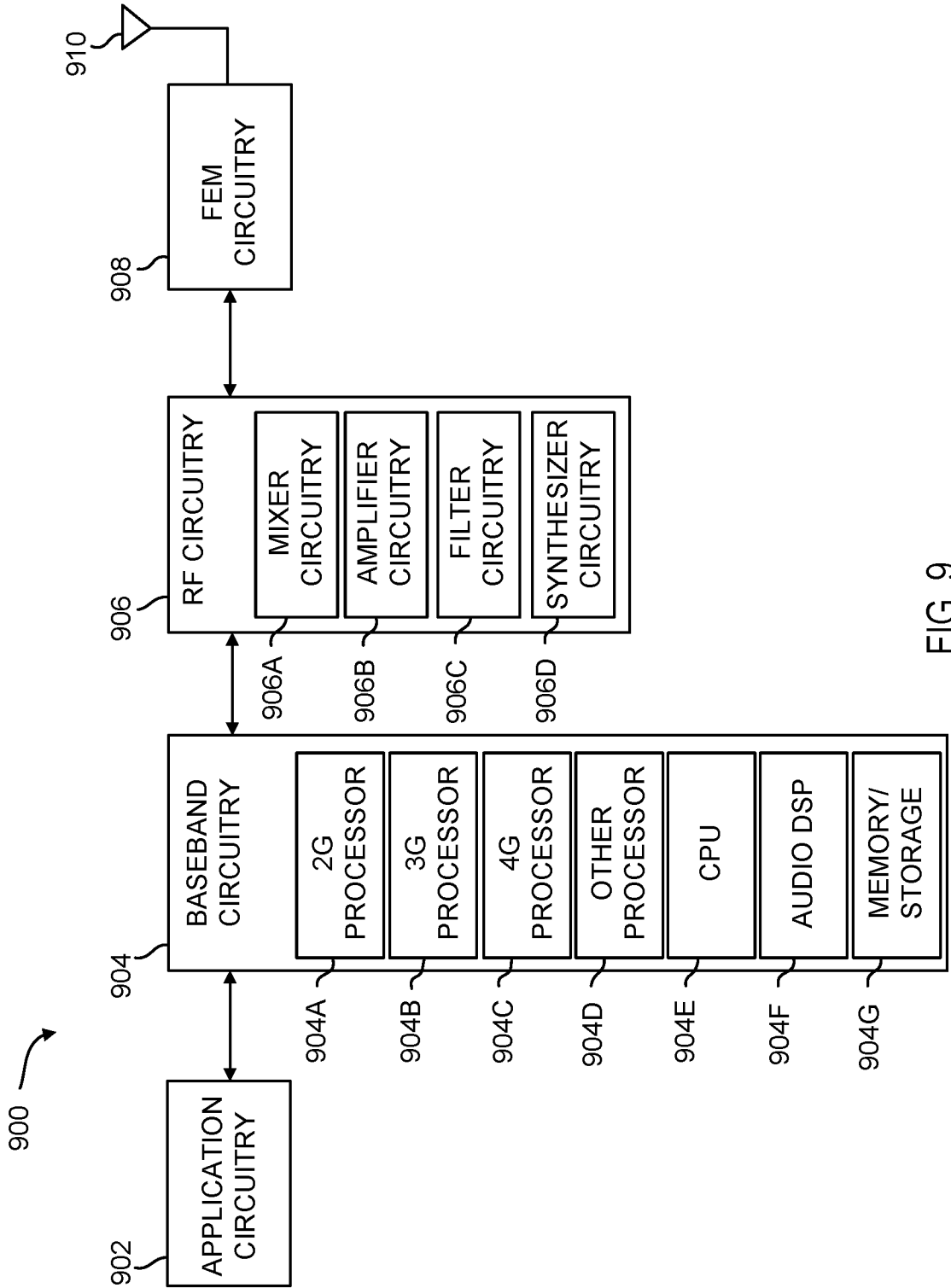


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/065180

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W8/00
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/075679 A1 (TENNY NATHAN EDWARD [US] ET AL) 25 March 2010 (2010-03-25)	1
Y	abstract paragraphs [0007], [0008], [0009], [0010], [0011], [0049], [0050], [0055], [0056], [0057], [0058] claims 1,7 ----- -/--	2-28

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

7 February 2017

Date of mailing of the international search report

17/02/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Bertini, Stefano

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/065180

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	<p>QUALCOMM INCORPORATED ET AL: "Simultaneous support for CP and UP optimisation", 3GPP DRAFT; S2-162056-23 401 CR CIOT SIMULTANEOUS SUPPORT CP AND UP-R9, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; ; vol. SA WG2, no. Sophia Antipolis, France; 20160411 - 20160415 16 April 2016 (2016-04-16), XP051091986, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_sa/WG2_Arch/TSGS2_114_Sophia_Antipolis/Docs/ [retrieved on 2016-04-16] paragraphs [4.10], [5.3.2.1], [5.10.2]</p>	2-28
A	<p>US 2014/204736 A1 (BAKKER JAN HENDRICK LUCAS [US] ET AL) 24 July 2014 (2014-07-24) abstract paragraphs [0059] - [0070]</p>	1-28
A	<p>WO 2015/136122 A1 (NEC EUROPE LTD [DE]) 17 September 2015 (2015-09-17) abstract page 13, line 15 - page 15, line 24</p>	1-28

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/065180

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		WO 2014111510 A1	24-07-2014

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		EP 3117682 A1	18-01-2017
		WO 2015136122 A1	17-09-2015
