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(54) **Title:** PAGING ASSISTANCE INDICATION

(57) **Abstract:** Apparatuses, methods, and systems are disclosed for paging assistance indication. One method (600) includes receiving (602) a first radio resource configuration release message from a network unit. The method (600) includes transmitting (604) a paging assistance required message to the network unit indicating that paging assistance is required. The method (600) may include transmitting user equipment assistance information to the network unit.

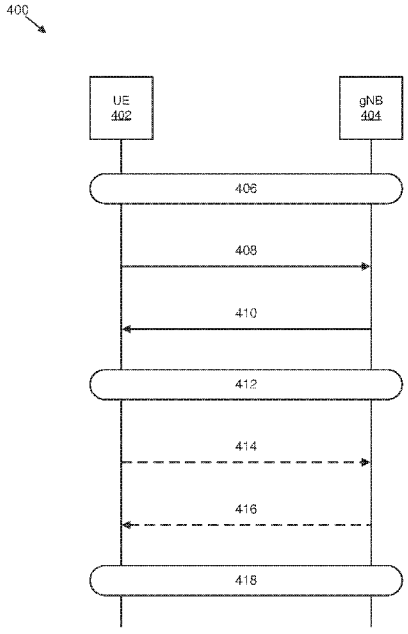

FIG. 4

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PAGING ASSISTANCE INDICATION

FIELD

[0001] The subject matter disclosed herein relates generally to wireless communications and more particularly relates to paging assistance indication.

BACKGROUND

[0002] The following abbreviations are herewith defined, at least some of which are referred to within the following description: Third Generation Partnership Project ("3GPP"), 5G QoS Indicator ("5QI"), Acknowledge Mode ("AM"), Aperiodic ("AP"), Backhaul ("BH"), Broadcast Multicast ("BM"), Buffer Occupancy ("BO"), Base Station ("BS"), Buffer Status Report ("BSR"), Bandwidth ("BW"), Bandwidth Part ("BWP"), Carrier Aggregation ("CA"), Component Carrier ("CC"), Code Division Multiplexing ("CDM"), Control Element ("CE"), Commercial Mobile Alert System ("CMAS"), Coordinated Multipoint ("CoMP"), Categories of Requirements ("CoR"), Control Resource Set ("CORESET"), Cyclic Prefix ("CP"), Cyclic Prefix OFDM ("CP-OFDM"), CSI-RS Resource Indicator ("CRI"), Cell RNTI ("C-RNTI"), Channel State Information ("CSI"), CSI IM ("CSI-IM"), CSI RS ("CSI-RS"), Channel Quality Indicator ("CQI"), Central Unit ("CU"), Codeword ("CW"), Downlink Assignment Index ("DAI"), Downlink Control Information ("DCI"), Downlink ("DL"), Discrete Fourier Transform Spread OFDM ("DFT-s-OFDM"), Demodulation Reference Signal ("DMRS" or "DM-RS"), Data Radio Bearer ("DRB"), Discontinuous Reception ("DRX"), Dedicated Short-Range Communications ("DSRC"), Distributed Unit ("DU"), Enhanced Mobile Broadband ("eMBB"), Evolved Node B ("eNB"), Enhanced Subscriber Identification Module ("eSIM"), Earthquake and Tsunami Warning System ("ETWS"), Enhanced ("E"), Frequency Division Duplex ("FDD"), Frequency Division Multiplexing ("FDM"), Frequency Division Multiple Access ("FDMA"), Frequency Range ("FR"), 450 MHz – 6000 MHz ("FR1"), 24250 MHz – 52600 MHz ("FR2"), Hybrid Automatic Repeat Request ("HARQ"), High-Definition Multimedia Interface ("HDMI"), Integrated Access Backhaul ("IAB"), Identity or Identifier or Identification ("ID"), Information Element ("IE"), Interference Measurement ("IM"), International Mobile Subscriber Identity ("IMSI"), Internet-of-Things ("IoT"), Internet Protocol ("IP"), Joint Transmission ("JT"), Level 1 ("L1"), L1 RSRP ("L1-RSRP"), L1 SINR ("L1-SINR"), Logical Channel ("LCH"), Logical Channel Group ("LCG"), Logical Channel ID ("LCID"), Logical Channel Prioritization ("LCP"), Layer Indicator ("LI"), Long Term Evolution ("LTE"), Levels of Automation ("LoA"), Medium Access Control ("MAC"), Modulation Coding Scheme ("MCS"), Multi DCI ("M-DCI"), Mobile Equipment ("ME"), Master Information Block ("MIB"), Multiple Input Multiple Output

("MIMO"), Mobile-Termination ("MT"), Machine Type Communication ("MTC"), Multi PDSCH ("Multi-PDSCH"), Multi TRP ("M-TRP"), Multi-User ("MU"), Multi-User MIMO ("MU-MIMO"), Minimum Mean Square Error ("MMSE"), Multi-USIM ("MUSIM"), Negative-Acknowledgment ("NACK") or ("NAK"), Next Generation ("NG"), Next Generation Node B ("gNB"), New Radio ("NR"), Non-Zero Power ("NZP"), NZP CSI-RS ("NZP-CSI-RS"), Orthogonal Frequency Division Multiplexing ("OFDM"), Peak-to-Average Power Ratio ("PAPR"), Physical Broadcast Channel ("PBCH"), Physical Downlink Control Channel ("PDCCH"), Physical Downlink Shared Channel ("PDSCH"), PDSCH Configuration ("PDSCH-Config"), Policy Control Function ("PCF"), Packet Data Convergence Protocol ("PDCP"), Packet Data Network ("PDN"), Protocol Data Unit ("PDU"), Paging Frame ("PF"), Public Land Mobile Network ("PLMN"), Precoding Matrix Indicator ("PMI"), Paging Occasion ("PO"), ProSe Per Packet Priority ("PPPP"), ProSe Per Packet Reliability ("PPPR"), Physical Resource Block ("PRB"), Packet Switched ("PS"), Physical Sidelink Control Channel ("PSCCH"), Physical Sidelink Shared Channel ("PSSCH"), Phase Tracking RS ("PTRS" or "PT-RS"), Physical Uplink Control Channel ("PUCCH"), Physical Uplink Shared Channel ("PUSCH"), Quasi Co-Located ("QCL"), Quality of Service ("QoS"), Random Access Channel ("RACH"), Radio Access Network ("RAN"), Radio Access Technology ("RAT"), Resource Element ("RE"), Radio Frequency ("RF"), Rank Indicator ("RI"), Radio Link Control ("RLC"), Radio Link Failure ("RLF"), Radio Network Temporary Identifier ("RNTI"), Resource Pool ("RP"), Radio Resource Control ("RRC"), Remote Radio Head ("RRH"), Reference Signal ("RS"), Reference Signal Received Power ("RSRP"), Reference Signal Received Quality ("RSRQ"), Redundancy Version ("RV"), Receive ("RX"), Single Carrier Frequency Domain Spread Spectrum ("SC-FDSS"), Secondary Cell ("SCell"), Spatial Channel Model ("SCM"), Sub Carrier Spacing ("SCS"), Single DCI ("S-DCI"), Spatial Division Multiplexing ("SDM"), Service Data Unit ("SDU"), System Frame Number ("SFN"), System Information ("SI"), Subscriber Identity Module ("SIM"), Signal-to-Interference Ratio ("SINR"), Sidelink ("SL"), Sequence Number ("SN"), Semi Persistent ("SP"), Scheduling Request ("SR"), SRS Resource Indicator ("SRI"), Sounding Reference Signal ("SRS"), Synchronization Signal ("SS"), SS/PBCH Block ("SSB"), Transport Block ("TB"), Transmission Configuration Indication ("TCI"), Time Division Duplex ("TDD"), Time Division Multiplexing ("TDM"), Temporary Mobile Subscriber Identity ("TMSI"), Transmitted Precoding Matrix Indicator ("TPMI"), Transmission Reception Point ("TRP"), Technical Standard ("TS"), Transmit ("TX"), User Entity/Equipment (Mobile Terminal) ("UE"), Universal Integrated Circuit Card ("UICC"), Uplink ("UL"), Unacknowledged Mode ("UM"), Universal Mobile Telecommunications System ("UMTS"), LTE Radio Interface ("Uu

interface"), User Plane ("UP"), Ultra Reliable Low Latency Communication ("URLLC"), Universal Subscriber Identity Module ("USIM"), Universal Terrestrial Radio Access Network ("UTRAN"), Vehicle to Everything ("V2X"), Voice Over IP ("VoIP"), Visited Public Land Mobile Network ("VPLMN"), Vehicle RNTI ("V-RNTI"), Worldwide Interoperability for Microwave Access ("WiMAX"), Zero Forcing ("ZF"), Zero Power ("ZP"), and ZP CSI-RS ("ZP-CSI-RS"). As used herein, "HARQ-ACK" may represent collectively the Positive Acknowledge ("ACK") and the Negative Acknowledge ("NAK"). ACK means that a TB is correctly received while NAK means a TB is erroneously received.

[0003] In certain wireless communications networks, paging collisions may occur.

BRIEF SUMMARY

[0004] Methods for paging assistance indication are disclosed. Apparatuses and systems also perform the functions of the methods. One embodiment of a method includes receiving a first radio resource configuration release message from a network unit. In some embodiments, the method includes transmitting a paging assistance required message to the network unit indicating that paging assistance is required.

[0005] An apparatus for paging assistance indication, in one embodiment, includes a receiver that receives a first radio resource configuration release message from a network unit. In certain embodiments, the apparatus includes a transmitter that transmits a paging assistance required message to the network unit indicating that paging assistance is required.

[0006] A method for paging assistance indication includes receiving, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment. In various embodiments, the method includes transmitting a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information. In certain embodiments, the method includes receiving a paging assistance required message from the user equipment indicating that paging assistance is required.

[0007] An apparatus for paging assistance indication, in one embodiment, includes a receiver that receives, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment. In some embodiments, the apparatus includes a transmitter that transmits a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information; wherein the receiver receives a paging assistance required message from the user equipment indicating that paging assistance is required.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A more particular description of the embodiments briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only some embodiments and are not therefore to be considered to be limiting of scope, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

[0009] Figure 1 is a schematic block diagram illustrating one embodiment of a wireless communication system for paging assistance indication;

[0010] Figure 2 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for paging assistance indication;

[0011] Figure 3 is a schematic block diagram illustrating one embodiment of an apparatus that may be used for paging assistance indication;

[0012] Figure 4 is a block diagram illustrating one embodiment of communications between a UE and a gNB;

[0013] Figure 5 is a block diagram illustrating another embodiment of communications between a UE and a gNB;

[0014] Figure 6 is a schematic flowchart diagram illustrating one embodiment of a method for paging assistance indication; and

[0015] Figure 7 is a schematic flowchart diagram illustrating another embodiment of a method for paging assistance indication.

DETAILED DESCRIPTION

[0016] As will be appreciated by one skilled in the art, aspects of the embodiments may be embodied as a system, apparatus, method, or program product. Accordingly, embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, embodiments may take the form of a program product embodied in one or more computer readable storage devices storing machine readable code, computer readable code, and/or program code, referred hereafter as code. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

[0017] Certain of the functional units described in this specification may be labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very-large-

scale integration ("VLSI") circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

[0018] Modules may also be implemented in code and/or software for execution by various types of processors. An identified module of code may, for instance, include one or more physical or logical blocks of executable code which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose for the module.

[0019] Indeed, a module of 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 modules, 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 computer readable storage devices. Where a module or portions of a module are implemented in software, the software portions are stored on one or more computer readable storage devices.

[0020] Any combination of one or more computer readable medium may be utilized. The computer readable medium may be a computer readable storage medium. The computer readable storage medium may be a storage device storing the code. The storage device may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

[0021] More specific examples (a non-exhaustive list) of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM" or Flash memory), a portable compact disc read-only memory ("CD-ROM"), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0022] Code for carrying out operations for embodiments may be any number of lines and may be written in any combination of one or more programming languages including an object oriented programming language such as Python, Ruby, Java, Smalltalk, C++, or the like, and conventional procedural programming languages, such as the "C" programming language, or the like, and/or machine languages such as assembly languages. The code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network ("LAN") or a wide area network ("WAN"), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0023] Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean "one or more but not all embodiments" unless expressly specified otherwise. The terms "including," "comprising," "having," and variations thereof mean "including but not limited to," unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an," and "the" also refer to "one or more" unless expressly specified otherwise.

[0024] Furthermore, the described features, structures, or characteristics of the embodiments may be combined in any suitable manner. In the following description, numerous specific details are provided, such as examples of programming, software modules, user selections, network transactions, database queries, database structures, hardware modules, hardware circuits, hardware chips, etc., to provide a thorough understanding of embodiments. One skilled in the relevant art will recognize, however, that embodiments may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of an embodiment.

[0025] Aspects of the embodiments are described below with reference to schematic flowchart diagrams and/or schematic block diagrams of methods, apparatuses, systems, and program products according to embodiments. It will be understood that each block of the schematic flowchart diagrams and/or schematic block diagrams, and combinations of blocks in

the schematic flowchart diagrams and/or schematic block diagrams, can be implemented by code. The code may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0026] The code may also be stored in a storage device that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the storage device produce an article of manufacture including instructions which implement the function/act specified in the schematic flowchart diagrams and/or schematic block diagrams block or blocks.

[0027] The code may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the code which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0028] The schematic flowchart diagrams and/or schematic block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of apparatuses, systems, methods and program products according to various embodiments. In this regard, each block in the schematic flowchart diagrams and/or schematic block diagrams may represent a module, segment, or portion of code, which includes one or more executable instructions of the code for implementing the specified logical function(s).

[0029] It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more blocks, or portions thereof, of the illustrated Figures.

[0030] Although various arrow types and line types may be employed in the flowchart and/or block diagrams, they are understood not to limit the scope of the corresponding embodiments. Indeed, some arrows or other connectors may be used to indicate only the logical flow of the depicted embodiment. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of the depicted embodiment. It will

also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and code.

[0031] The description of elements in each figure may refer to elements of proceeding figures. Like numbers refer to like elements in all figures, including alternate embodiments of like elements.

[0032] Figure 1 depicts an embodiment of a wireless communication system 100 for paging assistance indication. In one embodiment, the wireless communication system 100 includes remote units 102 and network units 104. Even though a specific number of remote units 102 and network units 104 are depicted in Figure 1, one of skill in the art will recognize that any number of remote units 102 and network units 104 may be included in the wireless communication system 100.

[0033] In one embodiment, the remote units 102 may include computing devices, such as desktop computers, laptop computers, personal digital assistants ("PDAs"), tablet computers, smart phones, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, modems), IoT devices, or the like. In some embodiments, the remote units 102 include wearable devices, such as smart watches, fitness bands, optical head-mounted displays, or the like. Moreover, the remote units 102 may be referred to as subscriber units, mobiles, mobile stations, users, terminals, mobile terminals, fixed terminals, subscriber stations, UE, user terminals, a device, or by other terminology used in the art. The remote units 102 may communicate directly with one or more of the network units 104 via UL communication signals and/or the remote units 102 may communicate directly with other remote units 102 via sidelink communication.

[0034] The network units 104 may be distributed over a geographic region. In certain embodiments, a network unit 104 may also be referred to as an access point, an access terminal, a base, a base station, a Node-B, an eNB, a gNB, a Home Node-B, a RAN, a relay node, a device, a network device, an IAB node, a donor IAB node, or by any other terminology used in the art. The network units 104 are generally part of a radio access network that includes one or more controllers communicably coupled to one or more corresponding network units 104. The radio access network is generally communicably coupled to one or more core networks, which may be coupled to other networks, like the Internet and public switched telephone networks, among

other networks. These and other elements of radio access and core networks are not illustrated but are well known generally by those having ordinary skill in the art.

[0035] In one implementation, the wireless communication system 100 is compliant with the 5G or NG (Next Generation) standard of the 3GPP protocol, wherein the network unit 104 transmits using NG RAN technology. More generally, however, the wireless communication system 100 may implement some other open or proprietary communication protocol, for example, WiMAX, among other protocols. The present disclosure is not intended to be limited to the implementation of any particular wireless communication system architecture or protocol.

[0036] The network units 104 may serve a number of remote units 102 within a serving area, for example, a cell or a cell sector via a wireless communication link. The network units 104 transmit DL communication signals to serve the remote units 102 in the time, frequency, and/or spatial domain.

[0037] In various embodiments, a remote unit 102 may receive a first radio resource configuration release message from a network unit. In certain embodiments, the remote unit 102 may transmit a paging assistance required message to the network unit indicating that paging assistance is required. Accordingly, a remote unit 102 may be used for paging assistance indication.

[0038] In some embodiments, a network unit 104 may receive, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment. In certain embodiments, the network unit 104 may transmit a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information. In various embodiments, the network unit 104 may receive a paging assistance required message from the user equipment indicating that paging assistance is required. Accordingly, a network unit 104 may be used for paging assistance indication.

[0039] Figure 2 depicts one embodiment of an apparatus 200 that may be used for paging assistance indication. The apparatus 200 includes one embodiment of the remote unit 102. Furthermore, the remote unit 102 may include a processor 202, a memory 204, an input device 206, a display 208, a transmitter 210, and a receiver 212. In some embodiments, the input device 206 and the display 208 are combined into a single device, such as a touchscreen. In certain embodiments, the remote unit 102 may not include any input device 206 and/or display 208. In various embodiments, the remote unit 102 may include one or more of the processor 202, the memory 204, the transmitter 210, and the receiver 212, and may not include the input device 206 and/or the display 208.

[0040] The processor 202, in one embodiment, may include any known controller capable of executing computer-readable instructions and/or capable of performing logical operations. For example, the processor 202 may be a microcontroller, a microprocessor, a central processing unit ("CPU"), a graphics processing unit ("GPU"), an auxiliary processing unit, a field programmable gate array ("FPGA"), or similar programmable controller. In some embodiments, the processor 202 executes instructions stored in the memory 204 to perform the methods and routines described herein. The processor 202 is communicatively coupled to the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212.

[0041] The memory 204, in one embodiment, is a computer readable storage medium. In some embodiments, the memory 204 includes volatile computer storage media. For example, the memory 204 may include a RAM, including dynamic RAM ("DRAM"), synchronous dynamic RAM ("SDRAM"), and/or static RAM ("SRAM"). In some embodiments, the memory 204 includes non-volatile computer storage media. For example, the memory 204 may include a hard disk drive, a flash memory, or any other suitable non-volatile computer storage device. In some embodiments, the memory 204 includes both volatile and non-volatile computer storage media. In some embodiments, the memory 204 also stores program code and related data, such as an operating system or other controller algorithms operating on the remote unit 102.

[0042] The input device 206, in one embodiment, may include any known computer input device including a touch panel, a button, a keyboard, a stylus, a microphone, or the like. In some embodiments, the input device 206 may be integrated with the display 208, for example, as a touchscreen or similar touch-sensitive display. In some embodiments, the input device 206 includes a touchscreen such that text may be input using a virtual keyboard displayed on the touchscreen and/or by handwriting on the touchscreen. In some embodiments, the input device 206 includes two or more different devices, such as a keyboard and a touch panel.

[0043] The display 208, in one embodiment, may include any known electronically controllable display or display device. The display 208 may be designed to output visual, audible, and/or haptic signals. In some embodiments, the display 208 includes an electronic display capable of outputting visual data to a user. For example, the display 208 may include, but is not limited to, an LCD display, an LED display, an OLED display, a projector, or similar display device capable of outputting images, text, or the like to a user. As another, non-limiting, example, the display 208 may include a wearable display such as a smart watch, smart glasses, a heads-up display, or the like. Further, the display 208 may be a component of a smart phone, a personal digital assistant, a television, a table computer, a notebook (laptop) computer, a personal computer, a vehicle dashboard, or the like.

[0044] In certain embodiments, the display 208 includes one or more speakers for producing sound. For example, the display 208 may produce an audible alert or notification (e.g., a beep or chime). In some embodiments, the display 208 includes one or more haptic devices for producing vibrations, motion, or other haptic feedback. In some embodiments, all or portions of the display 208 may be integrated with the input device 206. For example, the input device 206 and display 208 may form a touchscreen or similar touch-sensitive display. In other embodiments, the display 208 may be located near the input device 206.

[0045] In various embodiments, the transmitter 210 may receive a first radio resource configuration release message from a network unit (e.g., network unit 104). In some embodiments, the transmitter 210 may transmit a paging assistance required message to the network unit indicating that paging assistance is required.

[0046] Although only one transmitter 210 and one receiver 212 are illustrated, the remote unit 102 may have any suitable number of transmitters 210 and receivers 212. The transmitter 210 and the receiver 212 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 210 and the receiver 212 may be part of a transceiver.

[0047] Figure 3 depicts one embodiment of an apparatus 300 that may be used for paging assistance indication. The apparatus 300 includes one embodiment of the network unit 104. Furthermore, the network unit 104 may include a processor 302, a memory 304, an input device 306, a display 308, a transmitter 310, and a receiver 312. As may be appreciated, the processor 302, the memory 304, the input device 306, the display 308, the transmitter 310, and the receiver 312 may be substantially similar to the processor 202, the memory 204, the input device 206, the display 208, the transmitter 210, and the receiver 212 of the remote unit 102, respectively.

[0048] In some embodiments, the receiver 312 may receive user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment (e.g., remote unit 102). In various embodiments, the transmitter 310 may transmit a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information. In certain embodiments, the receiver 312 may receive a paging assistance required message from the user equipment indicating that paging assistance is required.

[0049] Although only one transmitter 310 and one receiver 312 are illustrated, the network unit 104 may have any suitable number of transmitters 310 and receivers 312. The transmitter 310 and the receiver 312 may be any suitable type of transmitters and receivers. In one embodiment, the transmitter 310 and the receiver 312 may be part of a transceiver.

[0050] In various embodiments, there may be support for MUSIM devices. In some embodiments, a MUSIM device is a device that supports more than one USIM in the same ME.

[0051] In certain embodiments, a MUSIM device may wish to receive paging for two or more USIMs. In various embodiments, time occasions for which a USMI expects paging messages may be calculated. For example, a UE may use DRX in an RRC_IDLE state and an RRC_INACTIVE state to reduce power consumption. The UE may monitor one PO per DRX cycle. A PO may be a set of PDCCH monitoring occasions and may include multiple time slots (e.g., subframes or OFDM symbols) in which paging DCI may be sent. One PF may be one radio frame and may contain one or more POs or a starting point of a PO.

[0052] In some embodiments, a PF and PO for paging may be determined by the following: a SFN for the PF may be determined by the following: (SFN + PF_offset) mod T = (T div N)*(UE_ID mod N), and an Index (i_s) indicating an index of the PO may be determined by: i_s = floor (UE_ID/N) mod Ns.

[0053] The following parameters may be used for the calculation of PF and i_s: 1) T: DRX cycle of the UE (T may be determined by a shortest of UE specific DRX values if configured by RRC and/or upper layers, and a default DRX value may be broadcast in system information. If a UE specific DRX is not configured by RRC or by upper layers, the default value may be applied); 2) N: number of total paging frames in T; 3) Ns: number of paging occasions for a PF; 4) PF_offset: offset used for PF determination; and 5) UE_ID: 5G-S-TMSI mod 1024.

[0054] In various embodiments, a UE_ID used for a calculation of PF, PO, and/or corresponding PDCCH monitoring occasions (herein combinedly referred to as a paging opportunity) may be the same for two USIMs because the UE_ID are Modulo values (mode 1024), or the operations 'div', 'mod' or '/' may result in that some of the paging opportunities (e.g., PF + PO) corresponding to the two USIMs overlap. The collision of paging opportunities may depend on whether the two USIMs are camped on the same cell (or different cell with the same or different parameters values affecting the PF and/or PO calculations like Ns, nAndPagingFrameOffset, nrofPDCCH-MonitoringOccasionPerSSB-InPO, and the length of a default DRX cycle which may be signaled in SIB1). If a UE has a single RX chain, it may not be able to receive paging for two USIMs (e.g., at least in inter-frequency scenarios but also in some intra-frequency scenarios) if the paging opportunities collide (or even partially overlap) in time.

[0055] In various embodiments, it may be unclear how an RRC Inactive UE may receive paging for multiple USIMs if paging opportunities collide. In certain embodiments, a paging

procedure may be mostly common for both RRC Idle and RRC Inactive UEs, except that for RRC Inactive UEs, a network may provide a ran-PagingCycle while suspending the UE to the RRC Inactive state using an RRCRelease message. In some embodiments, as Paging for RRC Inactive UE is initiated in a RAN, a possible collision of multiple USIMs may occur.

[0056] In various embodiments, a gNB may page UEs if system information is being updated. In such embodiments, as Paging for an RRC Inactive UE is initiated in RAN, a possible collision of multiple USIMs may occur.

[0057] It should be noted that certain embodiments described herein refer to 2 USIM UEs, but the embodiments also apply to UEs with more than 2 USIMs.

[0058] In certain embodiments, a 1st USIM in a UE supporting more than one USIM is active and has a serving cell (e.g., camped in an RRC Idle state or an RRC Connected state). In such embodiments, if a second USIM becomes active (e.g., a protocol stack of the 2nd USIM is activated), the UE (e.g., second USIM, "USIM-2") may initiate a NAS registration procedure. If there would be a collision if the UE with respect to both USIMs is in an RRC Idle state, the UE may seek assistance from a network if the collision can't be solved by the UE itself. If one of the USIMs (e.g., UE) moves to an RRC Connected state and later, at some point in time is then moved to an RRC Inactive state (e.g., using an RRCRelease message), the UE may start experiencing paging collision issues because of the RAN-pagingCycle signaled in the RRCRelease suspending the UE to the RRC Inactive state.

[0059] In a first embodiment, a UE may (e.g., before initiating transition to an RRC Inactive state) let a network know of an impending collision based on paging parameters of a cell (e.g., including a RAN-pagingCycle signaled in an RRCRelease message). In such an embodiment, the network may support providing assistance for paging collision avoidance and/or may expect the UE to respond with a message saying that the UE foresees a paging collision, if the UE has previously indicated that it is a MUSIM device (e.g., this information may have been included in a RRC message - such as in UEAssistanceInformation). One implementation of the first embodiment is illustrated in Figure 4.

[0060] Figure 4 is a block diagram illustrating one embodiment of communications 400 between a UE 402 and a gNB 404. As may be appreciated each of the communications 400 illustrated may include one or more messages.

[0061] As illustrated in Figure 4, initially the UE 402 may be in 406 an RRC Connected state.

[0062] In a first communication 408 transmitted from the UE 402 to the gNB 404, the UE 402 indicates to the gNB 404 that it has more than one USIM active. The first communication

408 may include UEAssistanceInformation which may include information such as MUSIM device = True.

[0063] In a second communication 410 transmitted from the gNB 404 to the UE 402, the gNB 404 may transmit an RRC release message (e.g., including suspendConfig – with a RAN-PagingCycle) to the UE 402. The gNB 404 may expect the UE 402 to request paging assistance if the UE 402 is sent a RAN-pagingCycle signaled in the RRC release message, if a paging collision is foreseen in the UE 402.

[0064] Accordingly, the gNB 404 (e.g., network) and the UE 402 employ 412 a Wait_for_Paging Assistance sub-state (e.g., this may be initiated using a Wait_for_Paging assistance message) which runs until a certain time (e.g., according to a timer_PA).

[0065] In certain embodiments, the UE 402, upon receiving the RRC release message, may immediately calculate paging opportunities for a current cell and any other neighboring cells (e.g., the best 'x' cells based on RSRP) because the UE 402 can't be sure which cell may be selected (e.g., enter an RRC_INACTIVE state and perform cell selection) while transitioning to an RRC Inactive state.

[0066] In a third (e.g., optional) communication 414 transmitted from the UE 402 to the gNB 404, if a paging collision is foreseen, the UE 402 may send a paging assistance required message to the gNB 404. The paging assistance required message may include one or more of the following: 1) cell IDs of cells the UE 402 may select (which create foreseen paging collisions due to their pcch-Config); 2) corresponding pcch-Config or part of it; and/or 3) some candidate RAN-pagingCycles which alleviate the paging collision problem. However, if there would be no paging collision or if the UE 402 does not intend to request any assistance (e.g., if it can solve the problem itself on another USIM, etc.), the UE 402 may not send the paging assistance required message to the gNB 404. Therefore, after a timer expires (e.g., timer_PA), the gNB 404 may assume that the UE 402 has transitioned to the RRC Inactive state.

[0067] In a fourth (e.g., optional) communication 416 transmitted from the gNB 404 to the UE 402, if the paging assistance required message was transmitted in the third communication 414, the gNB 404 may send an RRC release message (e.g., including suspendConfig – with a RAN-PagingCycle) to the UE 402. After receiving the optional fourth communication 416, the UE 402 may transition 418 to the RRC Inactive state.

[0068] Figure 5 is a block diagram illustrating another embodiment of communications 500 between a UE 502 and a gNB 504. As may be appreciated each of the communications 500 illustrated may include one or more messages.

[0069] As illustrated in Figure 5, initially the UE 502 may be in 506 an RRC Connected state. In certain embodiments, while in the RRC Connected state, the UE 502 may request and/or determine RAN service gaps. The RAN service gaps may facilitate the UE 502 determining paging opportunities. For example, POs of one or more USIMs may be determined using the RAN service gaps.

[0070] In a first communication 508 transmitted from the UE 502 to the gNB 504, the UE 502 while in an RRC Connected state and before getting an RRC release message, may inform the gNB 504 of paging opportunities of other USIMs within UE assistance information (e.g., UEAssistanceInformation). This may be done with respect to timelines of a current cell and the UE 504 may indicate which paging opportunities of other USIMs fall in which radio frames. Accordingly, the UE 504 may provide examples of radio frames (e.g., RF#100, RF#200, RF#300, etc.) or may provide a starting RF# (or PF Offset) in a SFN cycle and may provide periodicities of paging opportunities. In various embodiments, a BITMAP may be used (e.g., e.g. a 32 bit BITMAP for a paging cycle of rf32, a 64 bit BITMAP for a paging cycle of rf64, and so forth). Thus, the UE 504 may be able to convey where the POs of other USIMs are with respect to a current cell's timeline.

[0071] In a second communication 510 transmitted from the gNB 504 to the UE 502, the gNB 504, (e.g., network) upon receiving the first communication 508, may transmits an RRC release message (e.g., including suspendConfig – with a RAN-PagingCycle) to the UE 502. Furthermore, the gNB 504 may use and signal a RAN-pagingCycle that creates paging opportunities at time locations not colliding with the POs of other USIMs. The UE 502 may then transition 512 to the RRC Inactive state.

[0072] In a second embodiment, a UE may, after initiating transition to an RRC Inactive state, let a network know that there is an impending collision based on paging parameters of a cell. In such an embodiment, this may happen due to one of the following conditions: 1) there may be paging collisions happening due to a RAN-PagingCycle signaled in an RRC release message, and, if so, the UE transitions to the RRC Inactive state but resumes connection immediately to inform a RAN about a paging collision and optionally provides assistance as described in the first embodiment and receives a resolution (e.g., a new RAN-PagingCycle); and/or 2) if a collision becomes apparent later due to activation of another USIM, change of a UE ID (e.g., GUTI, 5G-TMSI), reconfiguration of any involved pcch-Config, and so forth, then the UE initiates to resume an RRC connection immediately to inform the RAN about the paging collision and optionally provides assistance as described in the first embodiment and receives a resolution (e.g., a new RAN-PagingCycle).

[0073] In various embodiments, a ResumeCause may be used to indicate to a network that a UE is resuming only and/or mainly to seek assistance to avoid paging collisions. In such embodiments, a gNB, based on the ResumeCause, may control access of the UE accordingly (e.g., including hastening to provide a resolution in any of procedure message like RRCResume, RRCSetup, RRCRelease, RRCRelease with Suspend Config., RRCReject, and so forth). In some embodiments, a RRCResumeRequest may be triggered by NAS or by AS. In certain embodiments, there is only one cause 'rna-Update' used for an AS triggered RRCResumeRequest. In various embodiments, there may be an AS based trigger and a cause for AS-triggered RRCResumeRequest as shown in Table 1. In Table 1, the ResumeCause IE may be used to indicate a resome cause in an RRCResumeRequest and/or an RRCResumeRequest1.

Table 1: ResumeCause Information Element

```
-- ASN1START
-- TAG-RESUMECAUSE-START

ResumeCause ::=             ENUMERATED {emergency, highPriorityAccess, mt-Access, mo-
Signalling, mo-Data, mo-VoiceCall, mo-VideoCall, mo-SMS, rna-Update, mps-PriorityAccess,
mcs-PriorityAccess, ran-pagingcollision, spare2, spare3, spare4, spare5 }
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[0074] In various embodiments, a RAN-PagingCycle may be configured by a gNB and transmitted to a UE. In other embodiments, there may be other solutions that shift POs to different locations.

[0075] In a third embodiment, a UE may seek assistance for avoiding a paging collision for other USIMs (e.g., not for a USIM corresponding to which the UE transitions to an RRC Inactive state).

[0076] A fourth embodiment deals with a change of system information. In such an embodiment, UEs in an RRC_IDLE state or in an RRC_INACTIVE state may monitor for a SI change indication in its own paging occasion every DRX cycle. If the UE's own paging occasion collides with a PO of another USIM, the UE may monitor for a SI change indication in any paging occasion at least once per modification period or in every DRX cycle. The fourth embodiment may also be applied for ETWS or CMAS capable UEs in the RRC_IDLE state or in the RRC_INACTIVE state (e.g., such a UE may monitor for a SI change indication in any paging occasion at least once per modification period or in every DRX cycle).

[0077] Figure 6 is a schematic flow chart diagram illustrating one embodiment of a method 600 for paging assistance indication. In some embodiments, the method 600 is performed by an apparatus, such as the remote unit 102. In certain embodiments, the method

600 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0078] The method 600 may include receiving 602 a first radio resource configuration release message from a network unit (e.g., the network unit 104). In certain embodiments, the method 600 includes transmitting 604 a paging assistance required message to the network unit indicating that paging assistance is required.

[0079] In certain embodiments, the paging assistance required message is transmitted before receiving the first radio resource configuration release message. In various embodiments, the method 600 comprises transmitting user equipment assistance information to the network unit, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at the user equipment. In some embodiments, the user equipment assistance information comprises the paging assistance required message. In various embodiments, the paging assistance require message is transmitted after receiving the first radio resource configuration release message.

[0080] In one embodiment, the method 600 further comprises entering into a radio resource control inactive state after receiving the first radio resource configuration release message, wherein the first radio resource configuration release message comprises a first radio access network paging cycle. In certain embodiments, the method 600 further comprises determining whether a paging collision is determined after entering into the radio resource control inactive state. In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected.

[0081] In various embodiments, a new resume cause indicator is used during resuming a radio resource control connection or in the paging assistance required message, and the paging assistance required message is sent during resuming the radio resource control connection or after resuming the radio resource control connection. In one embodiment, the method 600 further comprises receiving a second radio resource configuration release message after transmitting the paging assistance required message, wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used. Examples of another radio access network paging technique will be used can be some kind of offset to one or more of the paging parameters, paging frame, paging occasion, UE_ID, or any other RAN technique. In certain embodiments, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

[0082] In some embodiments, the paging assistance required message comprises the corresponding paging control channel configuration. In various embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision. In one embodiment, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

[0083] In certain embodiments, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof. In some embodiments, the first radio resource configuration release message comprises a radio access network paging cycle. In various embodiments, the network unit transmits the first radio resource configuration release message to the user equipment, and the network unit enters a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

[0084] In one embodiment, the waiting time period comprises a predetermined time period. In certain embodiments, the method 600 further comprises determining whether a paging collision is expected after receiving the first radio resource configuration release message. In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected. In various embodiments, the paging assistance required message is not transmitted in response to determining that the paging collision is not expected.

[0085] Figure 7 is a schematic flow chart diagram illustrating one embodiment of a method 700 for paging assistance indication. In some embodiments, the method 700 is performed by an apparatus, such as the network unit 104. In certain embodiments, the method 700 may be performed by a processor executing program code, for example, a microcontroller, a microprocessor, a CPU, a GPU, an auxiliary processing unit, a FPGA, or the like.

[0086] The method 700 may include receiving 702 user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment (e.g., the remote unit 102). In some embodiments, the method 700 includes transmitting 704 a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information. In certain embodiments, the method 700 includes receiving 706 a paging assistance required message from the user equipment indicating that paging assistance is required.

[0087] In various embodiments, receiving the user equipment assistance information comprises receiving the user equipment assistance information from the user equipment. In

some embodiments, receiving the user equipment assistance information comprises receiving the user equipment assistance information from an access and mobility management function.

[0088] In certain embodiments, the paging assistance required message is received before transmitting the first radio resource configuration release message. In some embodiments, the user equipment assistance information comprises the paging assistance required message. In various embodiments, the paging assistance require message is received after transmitting the first radio resource configuration release message.

[0089] In one embodiment, the first radio resource configuration release message comprises a first radio access network paging cycle. In certain embodiments, the paging assistance required message is received in response to the user equipment determining that a paging collision is expected. In some embodiments, the method 700 further comprises transmitting a second radio resource configuration release message after receiving the paging assistance required message, wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

[0090] In various embodiments, the paging assistance required message comprises a new resume cause indicator. In one embodiment, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration. In certain embodiments, the paging assistance required message comprises the corresponding paging control channel configuration.

[0091] In some embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision. In various embodiments, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment. In one embodiment, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

[0092] In certain embodiments, the first radio resource configuration release message comprises a radio access network paging cycle. In some embodiments, the method 700 further comprises entering a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message. In various embodiments, the waiting time period comprises a predetermined time period.

[0093] In one embodiment, a method comprises: receiving a first radio resource configuration release message from a network unit; and transmitting a paging assistance required message to the network unit indicating that paging assistance is required.

[0094] In certain embodiments, the paging assistance required message is transmitted before receiving the first radio resource configuration release message.

[0095] The various embodiments, the method comprises transmitting user equipment assistance information to the network unit, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at the user equipment.

[0096] In some embodiments, the user equipment assistance information comprises the paging assistance required message.

[0097] In various embodiments, the paging assistance require message is transmitted after receiving the first radio resource configuration release message.

[0098] In one embodiment, the method further comprises entering into a radio resource control inactive state after receiving the first radio resource configuration release message, wherein the first radio resource configuration release message comprises a first radio access network paging cycle.

[0099] In certain embodiments, the method further comprises determining whether a paging collision is determined after entering into the radio resource control inactive state.

[0100] In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected.

[0101] In various embodiments, a new resume cause indicator is used during resuming a radio resource control connection or in the paging assistance required message, and the paging assistance required message is sent during resuming the radio resource control connection or after resuming the radio resource control connection.

[0102] In one embodiment, the method further comprises receiving a second radio resource configuration release message after transmitting the paging assistance required message, wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

[0103] In certain embodiments, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

[0104] In some embodiments, the paging assistance required message comprises the corresponding paging control channel configuration.

[0105] In various embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

[0106] In one embodiment, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

[0107] In certain embodiments, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

[0108] In some embodiments, the first radio resource configuration release message comprises a radio access network paging cycle.

[0109] In various embodiments, the network unit transmits the first radio resource configuration release message to the user equipment, and the network unit enters a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

[0110] In one embodiment, the waiting time period comprises a predetermined time period.

[0111] In certain embodiments, the method further comprises determining whether a paging collision is expected after receiving the first radio resource configuration release message.

[0112] In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected.

[0113] In various embodiments, the paging assistance required message is not transmitted in response to determining that the paging collision is not expected.

[0114] In one embodiment, an apparatus comprises: a receiver that receives a first radio resource configuration release message from a network unit; and a transmitter that transmits a paging assistance required message to the network unit indicating that paging assistance is required.

[0115] In various embodiments, the transmitter transmits user equipment assistance information to the network unit, and the user equipment assistance information indicates that there is more than one universal subscriber identity module active at the user equipment.

[0116] In certain embodiments, the paging assistance required message is transmitted before receiving the first radio resource configuration release message.

[0117] In some embodiments, the user equipment assistance information comprises the paging assistance required message.

[0118] In various embodiments, the paging assistance require message is transmitted after receiving the first radio resource configuration release message.

[0119] In one embodiment, the apparatus further comprises a processor, wherein the processor causes the apparatus to enter into a radio resource control inactive state after receiving the first radio resource configuration release message, and the first radio resource configuration release message comprises a first radio access network paging cycle.

[0120] In certain embodiments, the processor determines whether a paging collision is determined after entering into the radio resource control inactive state.

[0121] In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected.

[0122] In various embodiments, a new resume cause indicator is used during resuming a radio resource control connection or in the paging assistance required message, and the paging assistance required message is sent during resuming the radio resource control connection or after resuming the radio resource control connection.

[0123] In one embodiment, the receiver receives a second radio resource configuration release message after transmitting the paging assistance required message, and the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

[0124] In certain embodiments, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

[0125] In some embodiments, the paging assistance required message comprises the corresponding paging control channel configuration.

[0126] In various embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

[0127] In one embodiment, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

[0128] In certain embodiments, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

[0129] In some embodiments, the first radio resource configuration release message comprises a radio access network paging cycle.

[0130] In various embodiments, the network unit transmits the first radio resource configuration release message to the user equipment, and the network unit enters a waiting time

period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

[0131] In one embodiment, the waiting time period comprises a predetermined time period.

[0132] In certain embodiments, the apparatus further comprises a processor, wherein the processor determines whether a paging collision is expected after receiving the first radio resource configuration release message.

[0133] In some embodiments, the paging assistance required message is transmitted in response to determining that the paging collision is expected.

[0134] In various embodiments, the paging assistance required message is not transmitted in response to determining that the paging collision is not expected.

[0135] In one embodiment, a method comprises: receiving, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment; transmitting a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information; and receiving a paging assistance required message from the user equipment indicating that paging assistance is required.

[0136] In various embodiments, receiving the user equipment assistance information comprises receiving the user equipment assistance information from the user equipment.

[0137] In some embodiments, receiving the user equipment assistance information comprises receiving the user equipment assistance information from an access and mobility management function.

[0138] In certain embodiments, the paging assistance required message is received before transmitting the first radio resource configuration release message.

[0139] In some embodiments, the user equipment assistance information comprises the paging assistance required message.

[0140] In various embodiments, the paging assistance require message is received after transmitting the first radio resource configuration release message.

[0141] In one embodiment, the first radio resource configuration release message comprises a first radio access network paging cycle.

[0142] In certain embodiments, the paging assistance required message is received in response to the user equipment determining that a paging collision is expected.

[0143] In some embodiments, the method further comprises transmitting a second radio resource configuration release message after receiving the paging assistance required message,

wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

[0144] In various embodiments, the paging assistance required message comprises a new resume cause indicator.

[0145] In one embodiment, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

[0146] In certain embodiments, the paging assistance required message comprises the corresponding paging control channel configuration.

[0147] In some embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

[0148] In various embodiments, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

[0149] In one embodiment, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

[0150] In certain embodiments, the first radio resource configuration release message comprises a radio access network paging cycle.

[0151] In some embodiments, the method further comprises entering a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

[0152] In various embodiments, the waiting time period comprises a predetermined time period.

[0153] In one embodiment, an apparatus comprises: a receiver that receives, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment; and a transmitter that transmits a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information; wherein the receiver receives a paging assistance required message from the user equipment indicating that paging assistance is required.

[0154] In various embodiments, the receiver receives the user equipment assistance information by receiving the user equipment assistance information from the user equipment.

[0155] In some embodiments, the receiver receives the user equipment assistance information by receiving the user equipment assistance information from an access and mobility management function.

[0156] In certain embodiments, the paging assistance required message is received before transmitting the first radio resource configuration release message.

[0157] In some embodiments, the user equipment assistance information comprises the paging assistance required message.

[0158] In various embodiments, the paging assistance require message is received after transmitting the first radio resource configuration release message.

[0159] In one embodiment, the first radio resource configuration release message comprises a first radio access network paging cycle.

[0160] In certain embodiments, the paging assistance required message is received in response to the user equipment determining that a paging collision is expected.

[0161] In some embodiments, the transmitter transmits a second radio resource configuration release message after receiving the paging assistance required message, and the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

[0162] In various embodiments, the paging assistance required message comprises a new resume cause indicator.

[0163] In one embodiment, the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

[0164] In certain embodiments, the paging assistance required message comprises the corresponding paging control channel configuration.

[0165] In some embodiments, the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

[0166] In various embodiments, the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

[0167] In one embodiment, the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

[0168] In certain embodiments, the first radio resource configuration release message comprises a radio access network paging cycle.

[0169] In some embodiments, the apparatus further comprises a processor, wherein the processor causes the apparatus to enter a waiting time period after the transmitter transmits the first radio resource configuration release message to wait for the paging assistance required message.

[0170] In various embodiments, the waiting time period comprises a predetermined time period.

[0171] Embodiments may be practiced in other specific forms. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

1. A method comprising:

receiving a first radio resource configuration release message from a network unit; and

transmitting a paging assistance required message to the network unit indicating that paging assistance is required.

2. The method of claim 1, further comprising transmitting user equipment assistance information to the network unit, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at the user equipment.

3. The method of claim 2, wherein the user equipment assistance information comprises the paging assistance required message.

4. The method of claim 1, wherein the paging assistance require message is transmitted after receiving the first radio resource configuration release message.

5. The method of claim 4, further comprising entering into a radio resource control inactive state after receiving the first radio resource configuration release message, wherein the first radio resource configuration release message comprises a first radio access network paging cycle.

6. The method of claim 5, further comprising determining whether a paging collision is determined after entering into the radio resource control inactive state.

7. The method of claim 6, wherein the paging assistance required message is transmitted in response to determining that the paging collision is expected.

8. The method of claim 7, wherein a new resume cause indicator is used during resuming a radio resource control connection or in the paging assistance required message, and the paging assistance required message is sent during resuming the radio resource control connection or after resuming the radio resource control connection.

9. The method of claim 7, further comprising receiving a second radio resource configuration release message after transmitting the paging assistance required message, wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

10. The method of claim 1, wherein the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

11. The method of claim 10, wherein the paging assistance required message comprises the corresponding paging control channel configuration.

12. The method of claim 1, wherein the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

13. The method of claim 1, wherein the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

14. The method of claim 1, wherein the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

15. The method of claim 1, wherein the first radio resource configuration release message comprises a radio access network paging cycle.

16. The method of claim 1, wherein the network unit transmits the first radio resource configuration release message to the user equipment, and the network unit enters a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

17. The method of claim 16, wherein the waiting time period comprises a predetermined time period.

18. The method of claim 1, further comprising determining whether a paging collision is expected after receiving the first radio resource configuration release message.

19. The method of claim 18, wherein the paging assistance required message is transmitted in response to determining that the paging collision is expected.

20. The method of claim 18, wherein the paging assistance required message is not transmitted in response to determining that the paging collision is not expected.

21. An apparatus comprising:

a receiver that receives a first radio resource configuration release message from a network unit; and

a transmitter that transmits a paging assistance required message to the network unit indicating that paging assistance is required.

22. The apparatus of claim 21, wherein the transmitter transmits user equipment assistance information to the network unit, and the user equipment assistance information indicates that there is more than one universal subscriber identity module active at the user equipment.

23. The apparatus of claim 22, wherein the user equipment assistance information comprises the paging assistance required message.

24. The apparatus of claim 21, wherein the paging assistance require message is transmitted after receiving the first radio resource configuration release message.

25. The apparatus of claim 24, further comprising a processor, wherein the processor causes the apparatus to enter into a radio resource control inactive state after receiving the first radio resource configuration release message, and the first radio resource configuration release message comprises a first radio access network paging cycle.

26. The apparatus of claim 25, wherein the processor determines whether a paging collision is determined after entering into the radio resource control inactive state.

27. The apparatus of claim 26, wherein the paging assistance required message is transmitted in response to determining that the paging collision is expected.

28. The apparatus of claim 27, wherein a new resume cause indicator is used during resuming a radio resource control connection or in the paging assistance required message, and the paging assistance required message is sent during resuming the radio resource control connection or after resuming the radio resource control connection.

29. The apparatus of claim 27, wherein the receiver receives a second radio resource configuration release message after transmitting the paging assistance required message, and the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

30. The apparatus of claim 21, wherein the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

31. The apparatus of claim 30, wherein the paging assistance required message comprises the corresponding paging control channel configuration.

32. The apparatus of claim 21, wherein the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

33. The apparatus of claim 21, wherein the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

34. The apparatus of claim 21, wherein the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

35. The apparatus of claim 21, wherein the first radio resource configuration release message comprises a radio access network paging cycle.

36. The apparatus of claim 21, wherein the network unit transmits the first radio resource configuration release message to the user equipment, and the network unit enters a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

37. The apparatus of claim 36, wherein the waiting time period comprises a predetermined time period.

38. The apparatus of claim 21, further comprising a processor, wherein the processor determines whether a paging collision is expected after receiving the first radio resource configuration release message.

39. The apparatus of claim 38, wherein the paging assistance required message is transmitted in response to determining that the paging collision is expected.

40. The apparatus of claim 38, wherein the paging assistance required message is not transmitted in response to determining that the paging collision is not expected.

41. A method comprising:

receiving, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment;

transmitting a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information; and

receiving a paging assistance required message from the user equipment indicating that paging assistance is required.

42. The method of claim 41, wherein receiving the user equipment assistance information comprises receiving the user equipment assistance information from the user equipment.

43. The method of claim 41, wherein receiving the user equipment assistance information comprises receiving the user equipment assistance information from an access and mobility management function.

44. The method of claim 41, wherein the user equipment assistance information comprises the paging assistance required message.

45. The method of claim 41, wherein the paging assistance require message is received after transmitting the first radio resource configuration release message.

46. The method of claim 45, wherein the first radio resource configuration release message comprises a first radio access network paging cycle.

47. The method of claim 46, wherein the paging assistance required message is received in response to the user equipment determining that a paging collision is expected.

48. The method of claim 47, further comprising transmitting a second radio resource configuration release message after receiving the paging assistance required message, wherein the second radio resource configuration release message comprises a second radio access network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

49. The method of claim 41, wherein the paging assistance required message comprises a new resume cause indicator.

50. The method of claim 41, wherein the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

51. The method of claim 50, wherein the paging assistance required message comprises the corresponding paging control channel configuration.

52. The method of claim 41, wherein the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

53. The method of claim 41, wherein the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

54. The method of claim 41, wherein the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

55. The method of claim 41, wherein the first radio resource configuration release message comprises a radio access network paging cycle.

56. The method of claim 41, further comprising entering a waiting time period after transmitting the first radio resource configuration release message to wait for the paging assistance required message.

57. The method of claim 56, wherein the waiting time period comprises a predetermined time period.

58. An apparatus comprising:

a receiver that receives, at a network unit, user equipment assistance information, wherein the user equipment assistance information indicates that there is more than one universal subscriber identity module active at a user equipment; and

a transmitter that transmits a first radio resource configuration release message to the user equipment after receiving the user equipment assistance information;

wherein the receiver receives a paging assistance required message from the user equipment indicating that paging assistance is required.

59. The apparatus of claim 58, wherein the receiver receives the user equipment assistance information by receiving the user equipment assistance information from the user equipment.

60. The apparatus of claim 58, wherein the receiver receives the user equipment assistance information by receiving the user equipment assistance information from an access and mobility management function.

61. The apparatus of claim 58, wherein the user equipment assistance information comprises the paging assistance required message.

62. The apparatus of claim 58, wherein the paging assistance require message is received after transmitting the first radio resource configuration release message.

63. The apparatus of claim 62, wherein the first radio resource configuration release message comprises a first radio access network paging cycle.

64. The apparatus of claim 63, wherein the paging assistance required message is received in response to the user equipment determining that a paging collision is expected.

65. The apparatus of claim 64, wherein the transmitter transmits a second radio resource configuration release message after receiving the paging assistance required message, and the second radio resource configuration release message comprises a second radio access

network paging cycle different from the first radio access network paging cycle or an indication indicating that another radio access network paging technique is to be used.

66. The apparatus of claim 58, wherein the paging assistance required message comprises a new resume cause indicator.

67. The apparatus of claim 58, wherein the paging assistance required message comprises a cell identifier of a cell expected to create paging collisions due to a corresponding paging control channel configuration.

68. The apparatus of claim 67, wherein the paging assistance required message comprises the corresponding paging control channel configuration.

69. The apparatus of claim 58, wherein the paging assistance required message comprises at least one radio access network paging cycle for inhibiting a paging collision.

70. The apparatus of claim 58, wherein the paging assistance required message comprises paging opportunities of active universal subscriber identity modules of the user equipment.

71. The apparatus of claim 58, wherein the paging assistance required message comprises paging parameters, a recommended discontinuous reception cycle, or a combination thereof.

72. The apparatus of claim 58, wherein the first radio resource configuration release message comprises a radio access network paging cycle.

73. The apparatus of claim 58, further comprising a processor, wherein the processor causes the apparatus to enter a waiting time period after the transmitter transmits the first radio resource configuration release message to wait for the paging assistance required message.

74. The apparatus of claim 73, wherein the waiting time period comprises a predetermined time period.

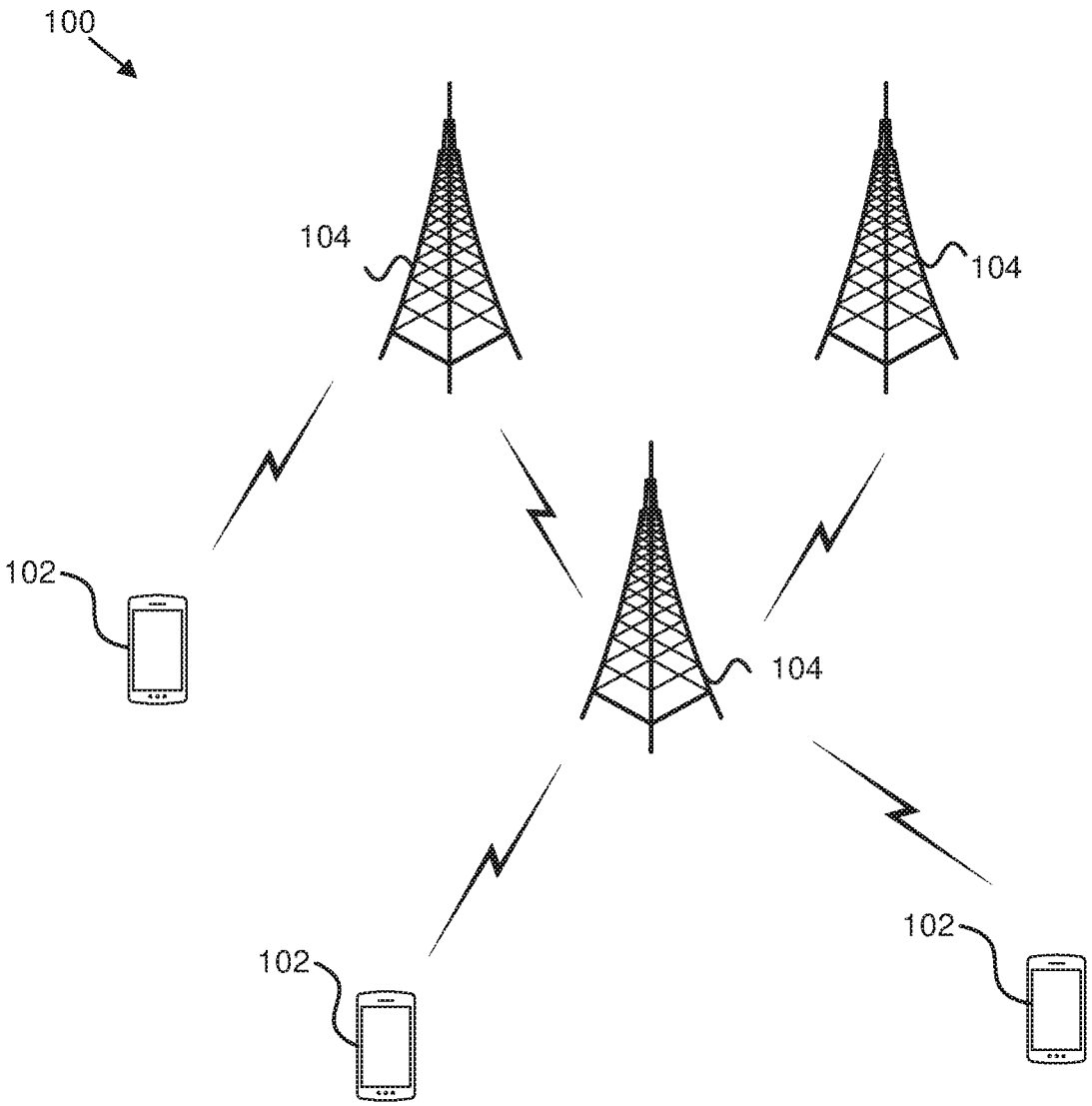

FIG. 1

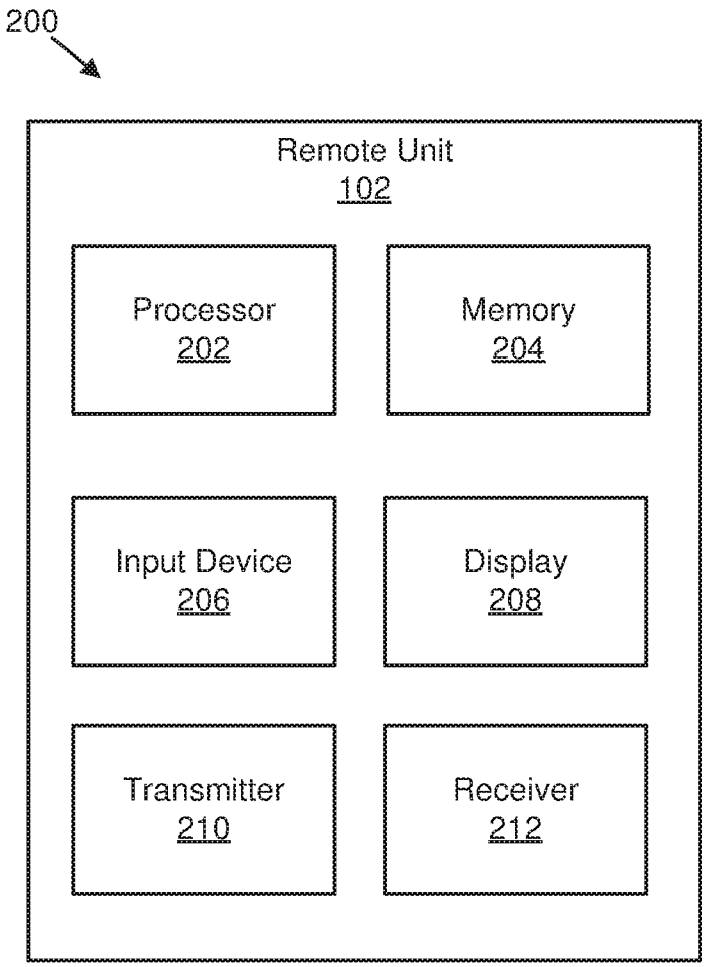
200
Remote Unit
102
Processor
202
Memory
204
Input Device
206
Display
208
Transmitter
210
Receiver
212

FIG. 2

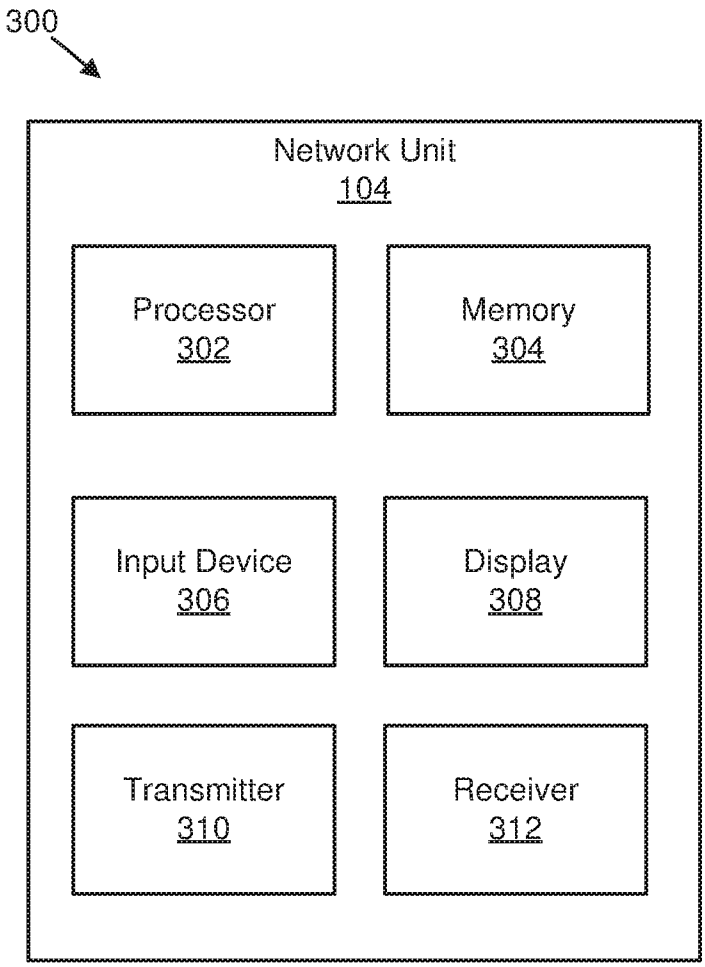
300
Network Unit
104
Processor
302
Memory
304
Input Device
306
Display
308
Transmitter
310
Receiver
312

FIG. 3

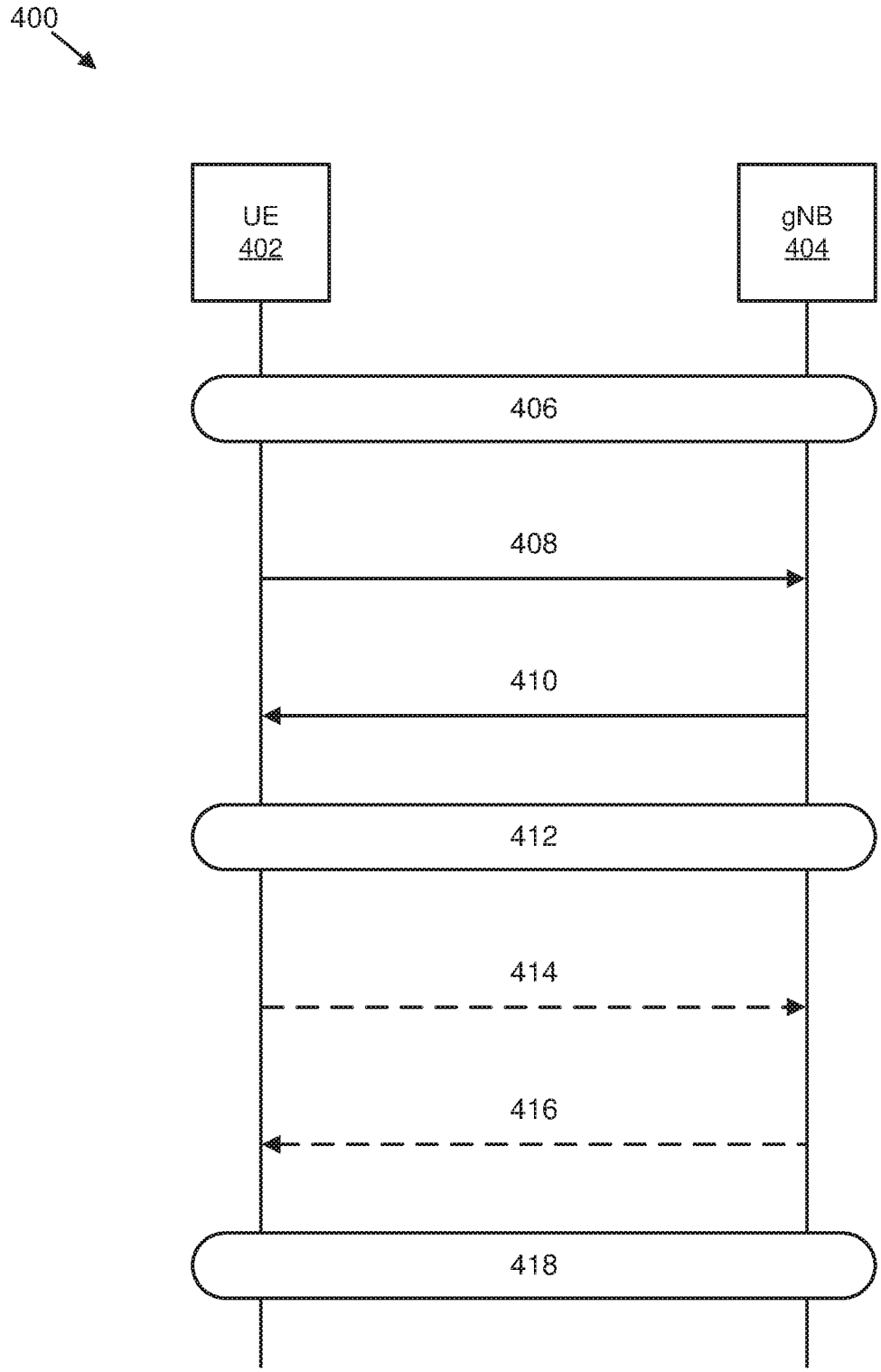

FIG. 4

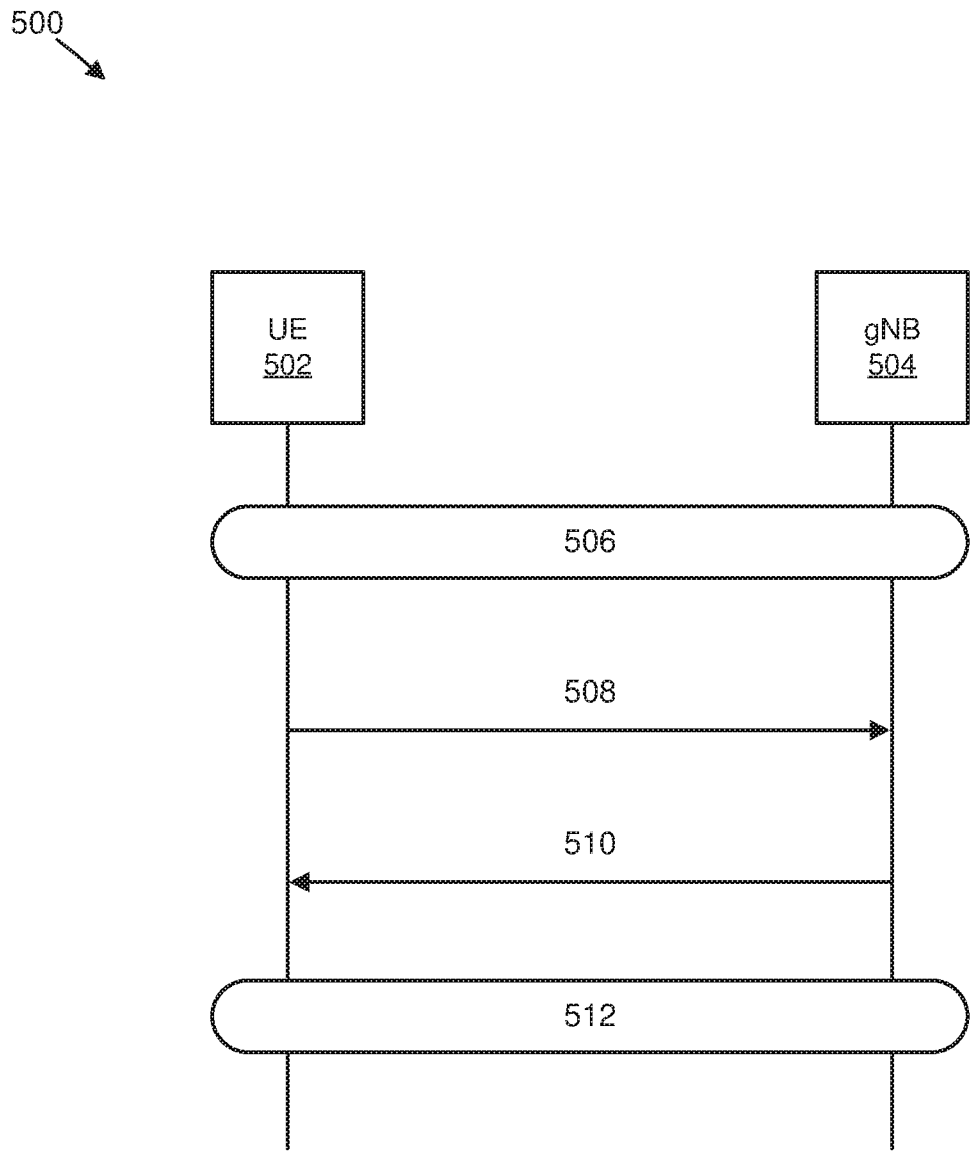

FIG. 5

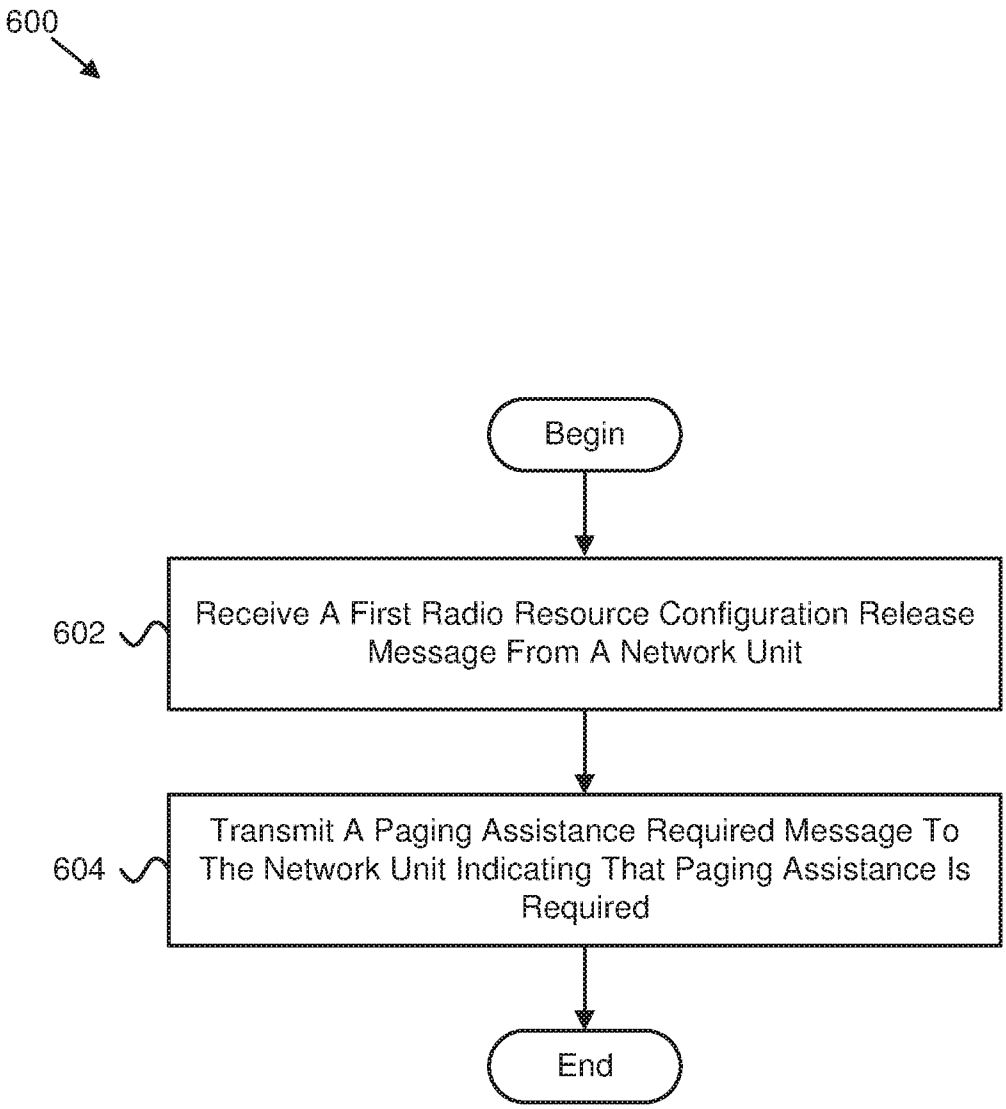
600
Begin
602
Receive A First Radio Resource Configuration Release Message From A Network Unit
604
Transmit A Paging Assistance Required Message To The Network Unit Indicating That Paging Assistance Is Required
End

FIG. 6

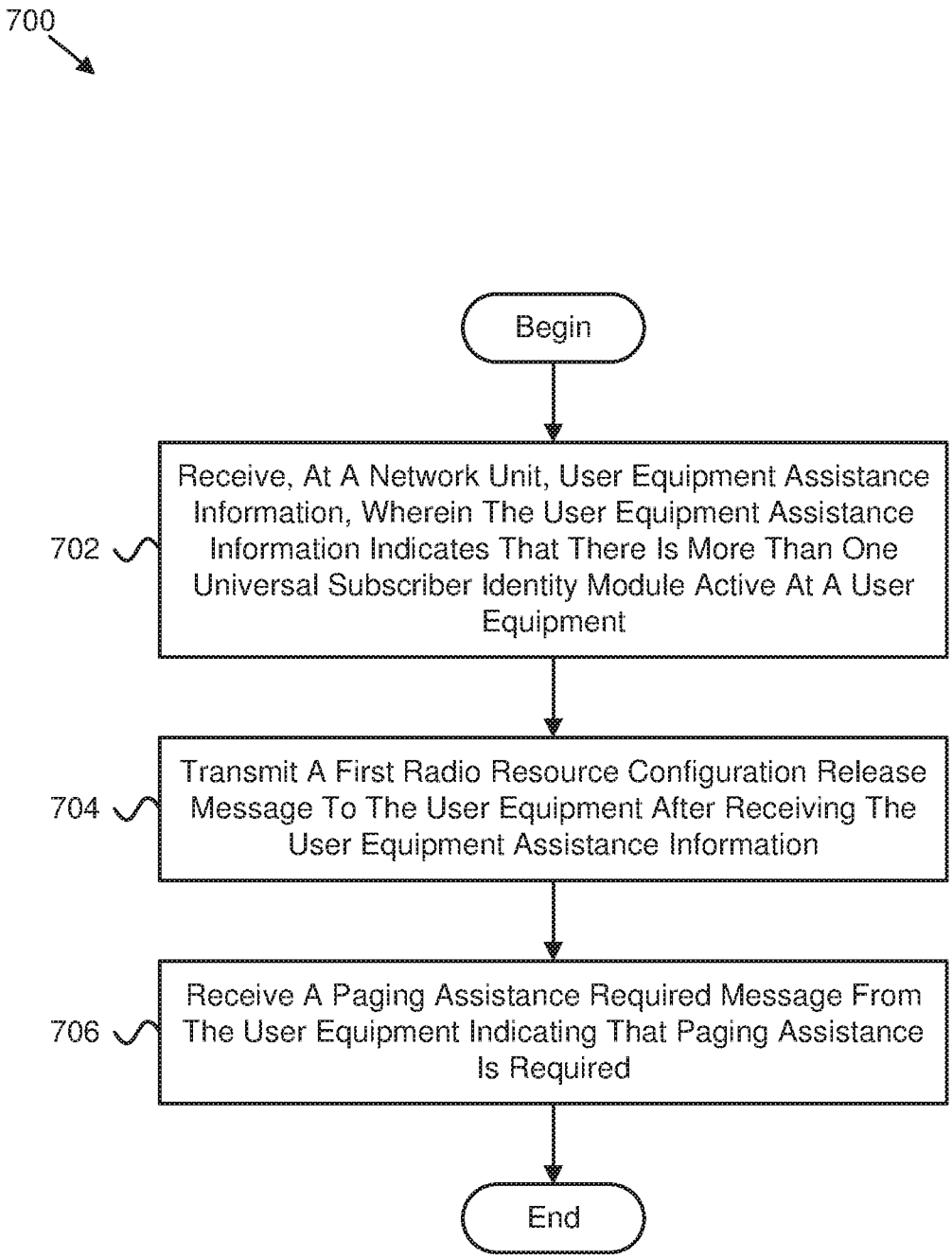
700
Begin
Receive, At A Network Unit, User Equipment Assistance Information, Wherein The User Equipment Assistance Information Indicates That There Is More Than One Universal Subscriber Identity Module Active At A User Equipment
702
Transmit A First Radio Resource Configuration Release Message To The User Equipment After Receiving The User Equipment Assistance Information
704
Receive A Paging Assistance Required Message From The User Equipment Indicating That Paging Assistance Is Required
706
End

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/101035

A. CLASSIFICATION OF SUBJECT MATTER

H04W 8/18(2009.01)i; H04W 68/02(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

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)

CNPAT;CNKI;WPI;EPODOC;3GPP: assistance, information, universal subscriber identity module, USIM, active, radio resource configuration, RRC, release, message, paging, require, indicate, cycle, collision, conflict, opportunity, occasion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	3RD GENERATION PARTNERSHIP PROJECT. "Technical Specification Group Services and System Aspects, Study on system enablers for devices having multiple Universal Subscriber Identity Modules (USIM) (Release 17)" *3GPP TR 23.761 V0.4.0 (2020-06),* 30 June 2020 (2020-06-30), section 6.17	1-74
Y	CN 111294789 A (SPREADTRUM COMMUNICATIONS SHANGHAI INC.) 16 June 2020 (2020-06-16) description, paragraphs [0054]-[0101]	1-74
A	US 2015163827 A1 (BROADCOM CORPORATION) 11 June 2015 (2015-06-11) the whole document	1-74
A	US 2018368099 A1 (QUALCOMM INCORPORATED) 20 December 2018 (2018-12-20) the whole document	1-74

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 March 2021	**09 April 2021**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **YU, Xiaoxi** Telephone No. **86-(10)-53961578**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/101035

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 111294789 A	16 June 2020	None	
US 2015163827 A1	11 June 2015	None	
US 2018368099 A1	20 December 2018	WO 2018231352 A1	20 December 2018