

(43) International Publication Date
26 June 2014 (26.06.2014)(51) International Patent Classification:
H04W 72/04 (2009.01)(21) International Application Number:
PCT/CA2013/051002(22) International Filing Date:
20 December 2013 (20.12.2013)

(25) Filing Language: English

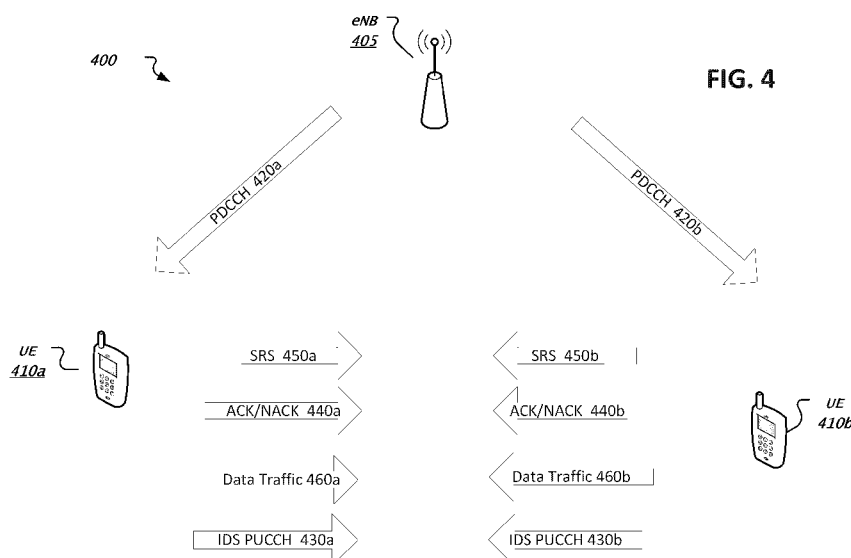
(26) Publication Language: English

(30) Priority Data:
13/724,723 21 December 2012 (21.12.2012) US(71) Applicant: **BLACKBERRY LIMITED** [CA/CA]; 2200
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enue, 5th Floor, Toronto, Ontario M5H 3E5 (CA).(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: USER-EQUIPMENT-MANAGED DIRECT DEVICE TO DEVICE COMMUNICATIONS



(57) Abstract: Systems, methods, and apparatuses of a wireless communications network involve receiving configuration information for the first UE (UE1 configuration information) for an inter-device session (IDS) between the first UE and a second UE, the UE configuration information including a radio network identifier. A control message configured with the radio network identifier and a radio resource identifier may be received. Data can be transmitted directly from the first UE to the second UE during the IDS using the identified radio resource. A feedback signal can be received directly from the second UE in response to at least one IDS transmission

USER-EQUIPMENT-MANAGED DIRECT DEVICE TO DEVICE COMMUNICATIONS

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CLAIM OF PRIORITY

[0001] This application claims priority to U.S. Patent Application No. 13/724,723 filed on December 21, 2012, the entire contents of which are hereby incorporated by reference.

FIELD

10 [0002] This disclosure relates to direct device-to-device (DD2D) communications in a mobile communications network.

BACKGROUND

[0003] Communication networks include wired and wireless networks. Example wired networks include the Public Switched Telephone Network (PSTN) and
15 Ethernet local area networks. Example wireless networks include licensed cellular networks as well as unlicensed wireless networks that connect to wired networks. Calls and other communications may be connected across wired and wireless networks.

[0004] In wireless cellular networks, mobile devices generally communicate
20 with each other by transmitting and receiving data traffic through base stations or other similar network nodes, even when the mobile devices are in close proximity. Direct communications between mobile devices in a licensed band without network control can cause interference to other mobile devices operating in the network.

[0005] With the proliferation of devices equipped with a cellular modem,
25 direct device-to-device communication offers itself as a potential feature that may significantly enhance the performance of wireless communications technology.

[0006] Furthermore proximity-based applications and services represent a recent and enormous social-technological trend. The introduction of a direct communication capability would allow the wireless communications industry to
30 promote this important trend. Additionally, there is also interest in the ability to offload the network in some cases via direct device-to-device communication.

DESCRIPTION OF DRAWINGS

[0007] FIG. 1 is a schematic block diagram of an example mobile communication system.

[0008] FIG. 2 is a schematic illustrating an example network node.

5 [0009] FIG. 3 is a schematic illustrating an example user equipment device.

[0010] FIG. 4 is a schematic illustrating an example of signaling and traffic for an inter-device session (IDS), where a first user equipment (UE) receives signaling feedback directly from a second UE.

[0011] FIG. 5 is a message sequence diagram illustrating an example signal
10 flow and traffic for an inter-device session.

[0012] FIG. 6 is a message sequence diagram illustrating an example network operation for an inter-device session.

[0013] FIG. 7 is a flow chart illustrating an example process of IDS communications performed by a network node.

15 [0014] FIG. 8 is a flow chart illustrating an example process of IDS communications performed by a user equipment.

[0015] FIG. 9 is a graphical diagram showing the sub-band allocation of IDS resources for an inter-device session physical uplink control channel.

[0016] Like reference symbols in the various drawings indicate like elements.

20 DETAILED DESCRIPTION

[0017] Certain aspects of the disclosure are directed to systems, methods, and apparatuses for providing an inter-device session where the devices can communicate directly, and where the network and the network operator maintain an acceptable level of control over the device-to-device communication. In the present application, the
25 term “directly” is used to indicate communications between devices and/or communications between a device and a network element without intervening devices. For example, a first UE can transmit data and feedback signaling directly to a second

UE without having to transmit the data and feedback signaling to a network element. In the interest of consistency, certain examples in this disclosure may be described in relation to Long Term Evolution (LTE) technology. However, similar device-to-device communications aspects described in this disclosure may also be applied to
5 other wireless communications technologies.

[0018] In this disclosure, direct device-to-device communications may be referenced as an inter-device session (IDS). An inter-device session (IDS) may include configuration to allow communication between two or more UEs. For a given IDS resource allocation, one UE in the session may be transmitting in an allotted
10 resource, and other UEs in the session are expected to be receiving in that allotted resource. It should be understood that the IDS resource may be allocated in resources that may previously be considered “uplink” or “downlink” resources. A first UE may transmit over the IDS resource and one or more other UEs will receive the transmission over the IDS resource. Therefore, in some implementations, the IDS
15 resource may be allocated from either “uplink” or “downlink” portions of the resource pool, where the IDS resource is used for inter-device communications.

[0019] The term inter-device session is meant to encompass scenarios where two or more devices transmit and/or receive data directly with one another via a radio channel shared by the two or more devices. As such, the term inter-device session
20 may also be referred to as a multi-device session, plural-device session, Direct Device-to-Device(s) (DD2D), LTE Direct, or other representative terms.

[0020] In a first example embodiment, an eNB in an LTE system can allocate resources to one user equipment (UE) for direct communication with another UE. It is possible for the UEs to conduct a UE-to-UE data session without continuous eNB
25 involvement. In particular, the transmitting UE may receive the ACK/NACK response sent by the receiving UE(s). In this scheme, data traffic and feedback signalling may be transmitted directly between the UEs. It should be understood that while data and feedback signalling may be transferred from one UE to another UE in an inter-device session (IDS), a network node of a wireless communications network may still be
30 utilized to control certain aspects of the IDS. For example, a Physical Uplink Control Channel (PUCCH), and other control channels may be used to transmit control

information related to an IDS to the eNB from each UE as needed. Additionally, in some embodiments, the UEs may also listen to the other UE's PUCCH, Sounding Reference Signals (SRS) or other reference signal transmissions. Further, control information such as resource allocation, Modulation and Coding Scheme (MCS) for traffic, and power control commands related to an IDS may be transmitted to the UE(s) from the eNB.

[0021] After session initiation, each of the UEs may be assigned a semi-persistent scheduling (SPS) or inter-device persistent (IDPS) assignment for transmission (described in more detail below). Due to this assignment, the reoccurring resources for UE-to-UE transmissions are known to the other UEs so no further allocations need to be signalled by the eNB. The UEs may be given the location and configuration of the other UE's IDS-PUCCH and instructed by the eNB to read the ACK/NACK response of the other UE to the UE-to-UE packet transmission. By reading this information, further allocations and ACK/NACK responses from the eNB are not required and the UEs may transfer data autonomously. The behavior of the UE is indicated in Table 1.

Table 1. UL HARQ Operation for UE-UE SPS Autonomous Mode

HARQ feedback seen by the UE	UE behaviour (next SPS opportunity)
ACK	New transmission
NACK	Non-adaptive retransmission

[0022] In this application, a name with the prefix "IDS" (Inter-Device Session) refers to an entity, resource, or other concept related to the direct UE-to-UE(s) (Device-to-Device(s) (or D2D)) connection (e.g., IDS-PUCCH, IDS-PUSCH, IDS-RNTI) while a name without the "IDS" prefix refers to an entity related to standard UE-to-eNB connections (e.g., PUCCH, physical uplink shared channel (PUSCH), physical downlink shared channel (PDSCH), radio network temporary identifier (RNTI), physical downlink control channel (PDCCH)).

[0023] The terms UE1 and UE2 are used here for simplicity and clarity, and are not meant to convey a particular order of the process, a particular actor, or limit the number of devices involved.

[0024] Each inter-device session is identified by an inter-device session radio network identifier (RNI) that is assigned by the network node (e.g., eNB) of the wireless communications network. One example of a radio network identifier used in accordance with this disclosure is an IDS radio network temporary identifier (IDS-RNTI). PDCCH/ enhanced physical downlink control channel (ePDCCH) messages related to an IDS may be configured with the IDS-RNTI. Therefore, a UE must attempt to decode PDCCH/ePDCCH messages using the IDS-RNTI(s) assigned to its session(s). This may be done in addition to decoding messages addressed to other RNTIs associated with the UE. The term “configured with” can include, among other things, configured by, corresponding to, addressed to, directed to, scrambled with, encoded with, portion encoded with (e.g., cyclic redundancy check (CRC) scrambled with the radio network identifier (RNI), such that the control message can be determined to be addressed to a UE that knows the RNI), referencing, etc.

[0025] IDS resource allocations signalled in the PDCCH/ePDCCH and configured with the IDS-RNTI may indicate grants for direct UE-to-UE transmissions. IDS resource allocations may be signalled in control messages sent from the eNB to one or more UEs participating in the inter-device session. In one embodiment, control messages are sent to all the UEs participating in the inter-device session, such that the UEs are all made aware of the IDS resource allocations being granted for the inter-device session. In an embodiment where the IDS-RNTI refers to a session with two or more UEs, the IDS resource allocation configured with the IDS-RNTI may also be configured with a UE session ID associated with one of the UEs in the IDS (for example, the grant of the IDS resource allocation may include the UE session ID of the UE that should transmit using the IDS resource).

[0026] In an alternate embodiment, there may be more than one IDS Radio Network Temporary Identifier (RNTI) assigned for an inter-device session. For example, a first IDS-RNTI is assigned to indicate transmission from a first UE to a second UE, while a second IDS-RNTI may be assigned to indicate transmissions from the second UE to the first UE. In this alternate embodiment, each IDS-RNTI may be assigned for a particular transmission direction, or more specifically, to a particular UE that may act as a transmitter in the inter-device session. In this alternate embodiment, the network node (e.g., eNB) may maintain a group context that includes a first UE's

unique IDS-RNTI, and the other UEs that are configured to receive transmission from the first UE.

[0027] Advantages of using the IDS-RNTI as described in this disclosure may be numerous. For example, the network node (e.g., eNB) can use the IDS-RNTI to control allocation for each transmission thereby ensuring that UE-UE communications do not interfere with neighbouring UEs. Meanwhile sharing the IDS-RNTI with UEs participating in the inter-device session may reduce channel utilization since one Physical Downlink Control Channel (PDCCH) transmission is used to signal allocations for both the transmitter and receiver.

[0028] FIG. 1 is a schematic block diagram of an example mobile communication system 100. The mobile communication system 100 shown in FIG. 1 may include one or more network nodes (e.g., 112a and 112b). It will be understood that the network node may take several forms in a mobile communication system, such as (but not limited to) an evolved Node B (eNB), a base station, a Node B, a wireless access point, a radio network controller, a base transceiver station, a layer two relay node, a layer three relay node, a femto cell, home evolved Node B (HeNB), a home Node B (HNB), a base station controller, or other network node that includes radio resource control. In the long term evolution (LTE) example of FIG. 1, the network nodes are shown as evolved Node Bs (eNBs) 112a and 112b. The example mobile communication system 100 of FIG. 1 may include one or more radio access networks 110, core networks (CNs) 120, and external networks 130. In certain implementations, the radio access networks 110 may be evolved- UMTS terrestrial radio access networks (E-UTRAN). In addition, in certain instances, core networks 120 may be evolved packet cores (EPCs). Further, there may be one or more mobile electronic devices 102a, 102b operating within the mobile communication system 100. In some implementations, 2G/3G systems 140, e.g., Global System for Mobile communication (GSM), Interim Standard 95 (IS-95), Universal Mobile Telecommunications System (UMTS) and CDMA2000 (Code Division Multiple Access) may also be integrated into the mobile communication system 100.

[0029] In the example LTE system shown in FIG. 1, the radio access network 110 includes eNB 112a and eNB 112b. Cell 114a is the service area of eNB 112a, and

Cell 114b is the service area of eNB 112b. In this example, UEs 102a and 102b operate in Cell 114a and are served by eNB 112a. The UEs 102a and 102b may be any electronic device used by an end-user to communicate, for example, within the mobile communication system 100. The UEs 102a and 102b may transmit voice data, video data, user data, application data, multimedia data, text, web content and/or any other content.

[0030] The UE 102a or 102b may be referred to as mobile electronic device, user device, mobile station, subscriber station, portable electronic device, mobile communications device, wireless modem, or wireless terminal. Examples of a UE (e.g., UE 102a or 102b) may include a cellular phone, personal data assistant (PDA), smart phone, laptop, tablet personal computer (PC), pager, portable computer, portable gaming device, wearable electronic device, or other mobile communications device having components for communicating voice or data via a mobile communication network.

[0031] Other examples of a UE include, but are not limited to, a television, a remote controller, a set-top box, a computer monitor, a computer (including a tablet, a desktop computer, a handheld or laptop computer, a netbook computer), a microwave, a refrigerator, a stereo system, a cassette recorder or player, a DVD player or recorder, a CD player or recorder, a VCR, an MP3 player, a radio, a camcorder, a camera, a digital camera, a portable memory chip, a washer, a dryer, a washer/dryer, a copier, a facsimile machine, a scanner, a multi-functional peripheral device, a wristwatch, a clock, and a game device, etc. The UE 102a or 102b may include a device and a removable memory module, such as a Universal Integrated Circuit Card (UICC) that includes a Subscriber Identity Module (SIM) application, a Universal Subscriber Identity Module (USIM) application, or a Removable User Identity Module (R-UIM) application. Alternatively, the UE 102a or 102b may include the device without such a module. The term “UE” can also refer to any hardware or software component that can terminate a communication session for a user. In addition, the terms “user equipment,” “UE,” “user equipment device,” “user agent,” “UA,” “user device,” and “mobile device” can be used synonymously herein.

[0032] A radio access network is part of a mobile communication system which implements a radio access technology, such as UMTS, CDMA2000 and 3GPP LTE. For example, the radio access network (RAN) 110 included in an LTE telecommunications system is called an EUTRAN. The EUTRAN can be located
5 between the UEs and core network 120 (e.g., an evolved packet core, EPC). The EUTRAN includes at least one eNB. The eNB can be a radio base station that may control all or at least some radio related functions in a fixed part of the system. The at least one eNB can provide radio interface within their coverage area or a cell for the UEs to communicate. The eNBs may be distributed throughout the cellular network to
10 provide a wide area of coverage. The eNBs directly communicate with one or more UEs, other eNBs, and the core network.

[0033] This disclosure describes several ways that an inter-device session may be initiated. For example, a UE could initiate an inter-device session responsive to a user action, the presence of data at the device intended for a potentially nearby device,
15 detection of signals from a proximate device, or an in-device application exchanging location information with other devices. Alternatively, the network could create an inter-device session at its discretion, based on one or more of the following factors: UE location, network traffic, operator policies, user subscription and UE capabilities.

[0034] Once it is determined that attempting an IDS connection between two
20 or more UEs is appropriate, the eNB sends IDS configuration information to the UEs to enable the inter-device session. IDS configuration information for each UE may include the IDS-RNTI and a UE session ID used to identify the UE within this IDS as well as the SRS and IDS PUCCH channel assigned to the UE. The IDS configuration information may also be used to facilitate various aspects such as timing and Channel
25 Quality Indicator (CQI) feedback.

[0035] Furthermore, if the UE is transmitting and/or receiving in multiple inter-device sessions, the eNB may assign multiple IDS-RNTIs to the UE. The eNB may maintain an IDS group context for each inter-device session in the eNB coverage area. The IDS group context may include the IDS-RNTI for each UE in the inter-
30 device session, a UE session ID (if configured) for the UE, and identifiers of other UEs that may be part of the inter-device session.

[0036] A transmitting UE may align its IDS-transmit-timing with a transmission resource subframe as directed by the network node timing. The UE may adjust its IDS transmission timing according to a timing advance command from the network node. For example, a first UE (UE1) may be sent a timing advance command
5 from the eNB to adjust UE1's timing for transmitting IDS transmissions using an IDS. A second UE (UE2) may receive the IDS transmissions according to a timing reference detected from UE1. For example, UE1 may be configured with SRS or other reference signal (RS), which UE2 can receive from UE1 to determine receive window timing for IDS transmissions. In this example, the eNB must provide UE2 with
10 information on location/configuration of UE1 RS/SRS. It should be noted that the RS/SRS configuration may be specific for the IDS or may be the same RS/SRS configuration used by UE1 for communication with the eNB.

[0037] As described previously, an IDS resource may use UL radio resources or DL radio resources. For time division duplex (TDD) implementations, the IDS
15 resource allocation may include assignment of particular subframes. For frequency division duplex (FDD) implementations, the IDS resource allocation may include assignment of particular sub-band frequencies. In other implementations, the IDS resource allocation may include assignment of particular component carriers.

[0038] For example, in some embodiments, a UE may not be able to transmit
20 and receive UE-UE (IDS) and UE-eNB transmissions at the same time. Considering an example where UL radio resources are used for the IDS resource allocations, the eNB may allocate the IDS resource such that a UE receives IDS transmissions in an UL subframe that is different from another UL subframe that the UE uses for other uplink transmissions to the eNB. In other words, the eNB may not schedule a UE as
25 the receiving UE in an IDS assignment in a subframe where the UE is scheduled to send a PUCCH, IDS-PUCCH, SRS, or UL-SCH transmission. In addition, the eNB may assign PUCCH and IDS-PUCCH transmission to occur in different UL subframes for UEs on the same inter-device session in order to allow for UEs in the session to receive and/or measure the other UEs PUCCH/IDS-PUCCH for the purposes of CQI
30 and/or timing. Just as UL subframes and UL radio resources may be scheduled to avoid overlap with other UL operations of a UE, there may be implementations where DL radio resources are used for IDS resource allocations, and scheduling is carefully

done to avoid overlap with other DL operations of a UE. In some FDD embodiments, a UE may be able to receive both IDS-PUSCH transmissions and PDSCH transmissions in the same subframe on different carriers. In other embodiments, a UE may only be able to receive either an IDS-PUSCH transmission or a PDSCH transmission, but not both, within a given subframe. The capabilities of the UE are
5 signaled to the eNB during radio resource control (RRC) connection configuration.

[0039] The eNBs 112a and 112b may be the end point of the radio protocols towards the UEs 102a, 102b and may relay signals between the radio connection and the connectivity towards the core network 120. In certain implementations, the EPC
10 may be the main component of a core network 120. The core network 120 may include a backbone network, which may be a central part of the mobile communication system 100. The core network 120 may include other components, such as (but not limited to) a mobility management entity (MME), a serving gateway (SGW), and/or a packet data network gateway (PGW). The MME may be the main control element in
15 the core network 120 responsible for the functionalities comprising the control plane functions related to subscriber and session management. The SGW can serve as a local mobility anchor, such that the packets are routed through this point for intra radio access network 110 (e.g., intra-EUTRAN) mobility and mobility with other legacy 2G/3G systems 140. The SGW functions may include the user plane tunnel management
20 and switching. The PGW may provide connectivity to the services domain comprising external networks 130, such as the IP networks. The UEs 102a, 102b, radio access network 110 (e.g., EUTRAN), and core network 120 (e.g., EPC) are sometimes referred to together as the evolved packet system (EPS).

[0040] Though described in terms of FIG. 1, the present disclosure is not
25 limited to such an LTE environment.

[0041] FIG. 2 is a schematic illustrating an example network node 200. The example network node 200 includes a processing module 202, a wired communication subsystem 204, and a wireless communication subsystem 206. The processing module 202 can include one or more processing components (alternatively referred to as
30 “processors” or “central processing units” (CPUs)) operable to execute instructions associated with managing inter-device communications. The processing module 202

can also include other auxiliary components, such as random access memory (RAM), read only memory (ROM), secondary storage (for example, a hard disk drive or flash memory). The processing module 202 can execute certain instructions and commands to provide wireless or wired communication, using the wired communication subsystem 204 or a wireless communication subsystem 206. A skilled artisan will readily appreciate that various other components can also be included in the example network node 200.

[0042] The network node may establish an inter-device session by sending IDS configuration information (e.g., RRC connection reconfiguration) to each UE that will be part of the inter-device session. For example, the IDS configuration information may be sent in a configuration message (e.g., an RRC message) to each UE in the inter-device session. It should be understood that the IDS configuration information may not be identical for each UE in the IDS, but the IDS configuration information sent to each UE includes the configuration needed for the UE to participate in the IDS. The IDS configuration information may include an IDS-RNTI used to configure other IDS-related control messages sent to the UE. For example, the network node sends a control message to indicate an allocation of IDS resources (e.g., IDS-PUSCH/PDSCH) for at least the transmitting UE in the inter-device session using a PDCCH Downlink Control Information (DCI) configured with the IDS- RNTI. In addition, in some implementations, other control messages may be sent using a PDCCH DCI configured with the IDS-RNTI.

[0043] The network node may manage the power level of the IDS transmissions based on the level of the signal from the transmitting UE received by the receiving UE. The receiving UE may indicate the received signal level to the network node, such that the network node may send a command to the transmitting UE to adjust the power level for subsequent IDS transmissions. For purpose of adjusting the power levels, the network node may configure a special transmit power control RNTI for the IDS for a given UE, including a Transmit Power Control (TPC)-IDS-RNTI (to identify transmit power commands for the IDS transmissions by the UE) in the IDS configuration information. In some embodiments, the power level may be increased until an upper limit is reached. When the power level is beyond a limiting threshold

for a UE, the network node may determine that the inter-device session is no longer appropriate and cause the inter-device session to terminate.

[0044] In some variants of this embodiment, power control commands may be specific for either IDS-PDSCH communications in normally DL radio resources or
5 IDS-PUSCH communications in normally UL radio resources for a given UE. In this variant, the network node may configure special transmit power control RNTIs for the IDS for a given UE, including an IDS-TPC-PUSCH-RNTI (to identify transmit power commands for the IDS-PUSCH) and/or IDS-TPC-PDSCH-RNTI (to identify transmit power commands for the IDS-PDSCH) in the IDS configuration information. Once
10 configured, the network node may use special transmit power control RNTIs to signal separate commands to adjust power for IDS communications for a UE in UL radio resources separately from those in DL radio resources.

[0045] In some further variants of the embodiment, the network node may configure special transmit power control RNTIs for the IDS for a given UE, including
15 an IDS-TPC-SCH-RNTI (to identify transmit power commands for IDS user data transmissions) and/or IDS-TPC-CCH-RNTI (to identify transmit power commands for IDS control data transmissions) in the IDS configuration information. Once configured, the network node may use special transmit power control RNTIs to signal separate commands to adjust power for IDS communications for a UE separately from
20 the power levels used for UL (UE-eNB) communications.

[0046] In some embodiments where the receiving UE determines the received signal level of the IDS transmission from an SRS, or other reference signal from the transmitting UE, the transmitting UE may also be instructed to adjust the power level for the reference signal in subsequent transmissions.

25 [0047] In some embodiments, the initial transmit power level for IDS transmissions is the same as for UE to eNB UL transmissions. In other embodiments, the initial transmit power level is communicated to a UE by the eNB during IDS configuration.

[0048] Additionally, to gain more accurate timing for the synchronization of
30 the receive window, the eNB may provide a UE with information on the location and

configuration of the other UE's PUCCH and/or SRS (if available) or other reference signal (if available).

[0049] FIG. 3 is a schematic illustrating an example UE apparatus. The example UE 300 includes a processing unit 302, a computer readable storage medium 304 (for example, ROM or flash memory), a wireless communication subsystem 306, an interface 308, and an I/O interface 310. The wireless communication subsystem 306 may be configured to provide wireless communications for data information or control information provided by the processing unit 302. The wireless communication subsystem 306 can include, for example, one or more antennas, a receiver, a transmitter, a local oscillator, a mixer, and a digital signal processing (DSP) unit. In some embodiments, the wireless communication subsystem 306 can support multiple input multiple output (MIMO) transmissions.

[0050] The interface 308 can include, for example, one or more of a screen or touch screen (for example, a liquid crystal display (LCD), a light emitting display (LED), an organic light emitting display (OLED), a microelectromechanical system (MEMS) display), a keyboard or keypad, a trackball, a speaker, and a microphone. The I/O interface 310 can include, for example, a universal serial bus (USB) interface. A skilled artisan will readily appreciate that various other components can also be included in the example UE device 300. The interface 308 may be a hardware interface that permits/facilitates communication between two devices.

[0051] A UE may indicate to a network node that the UE has data to send to another UE. For example, the UE may transmit an explicit radio link protocol indication requesting an inter-device session with another UE. Alternatively, the UE may simply send data destined to a network address associated with the other UE. In the typical embodiment, the network node will determine whether or not to attempt establishment of an inter-device session. In one embodiment, the network node may configure a reference signal in inter-device session setup commands to a transmitting UE and a receiving UE. The reference signal is transmitted by the transmitting UE and received by the receiving UE to determine whether the two UEs are in-range to directly communicate. The reference signal may also be used to determine receive timing window and channel state information (CSI). A receiving UE may send a

feedback message to the network node to indicate CSI based upon the received reference signal. Alternatively, the receiving UE may send CSI based upon detection of PUCCH RS or SRS transmissions from the transmitting UE. In this alternative, the network node provides the location and/or configuration of PUCCH RS or SRS of the transmitting UE to the receiving UE so that the receiving UE can detect these transmissions. In some variants of this alternative, the network node may provide a C-RNTI, IDS-RNTI, or other RNTI of the transmitting UE to the receiving UE so that the receiving UE is configured to detect the PUCCH transmissions. From feedback about channel state information, the network node may determine to establish the inter-device session. The feedback may also be used by the network node to determine appropriate IDS resource allocations.

[0052] In some embodiments, the transmitting UE may send an IDS transmission with the same subframe timing as other UL transmissions intended for the eNB. In some embodiments, the UEs in an inter-device session may be closer to each other than they are to the eNB. In some of these cases, the receiving UE may initially use its UL transmission timing to estimate the receiving window timing of UE-to-UE transmissions. Finer adjustments to the receive window may be made from reception of one or more of IDS-PUSCH transmissions, PUCCH transmissions, IDS-PUCCH transmissions (if available), and SRS transmissions or other reference signals (if available) from the transmitting UE.

[0053] In implementations where IDS resources are allocated from DL radio resources, the UEs may send their IDS transmissions at a time offset relative to UL timing as specified by the eNB. In some embodiments, the receiving UE may require a signal from the transmitting UE in order to estimate appropriate timing of the receive window for IDS transmissions prior to the initial reception of IDS-PDSCH transmission. In this case, the receiving UE may use one or more of the SRS or other reference signals or PUCCH or IDS-PUCCH from the transmitting UE.

[0054] FIG. 4 is a schematic diagram illustrating an example environment 400 showing signaling and traffic for an inter-device session, where user equipment (UE) 410a and 410b communicate signaling feedback to one another (e.g., eNB). In FIG. 4, data traffic 460a and 460b may be transmitted directly between the UEs; the control

elements PDCCH (420a and 420b) are transmitted to the UEs from the eNB while IDS related ACK/NACK (440a and 440b) and SRS (450a and 450b) are transmitted to one UE from the other UE. The eNB may transmit an IDS-PUCCH of UE1 410a to UE2 410b. The UEs may be given the location and configuration of the other UE's IDS-PUCCH and instructed by the eNB to read the ACK/NACK response of the other UE to the UE-to-UE packet transmission. The UEs use this information to transfer data directly to one another without further allocations and ACK/NACK responses from the eNB. This allows the UEs to transfer data autonomously to one another. The control elements are described below:

10 [0055] PDCCH (420a and 420b): Physical Downlink Control CHannel. A downlink control channel used to support efficient data transmission in LTE. A PDCCH carries a message known as Downlink Control Information (DCI), which may include IDS transmission resource assignments and other control information for a specific UE within an inter-device session or for all UEs within a session. During the inter-device session, a PDCCH message configured via IDS-RNTI may be used to allocate IDS resources to a UE within the session designated as the transmitter within that subframe. The subsequent IDS transmissions may occur over regular PUSCH/PDSCH resources designated by the DCI. HARQ operation, power control and timing adjustments may be included in the DCI by the eNB for the inter-device session. Further, certain transmission multiplexing and session procedures may be used to properly schedule various transmission reception windows for the UEs, as well as minimization of assigned resources during inactivity. In certain implementations, for an IDS allocation, one control message (e.g., PDCCH) may be sent from the eNB that is received and decoded by both transmitting and receiving UEs.

25 [0056] PUCCH (430a and 440b): Physical Uplink Control CHannel. The LTE uplink physical channel carrying uplink control information including Channel Quality Indicators (CQI), Hybrid Automatic Repeat reQuest (HARQ) ACKnowledgment/Negative ACKnowledgment (ACK/NACK) and uplink scheduling requests. In some embodiments, in addition to its normal PUCCH, a UE is configured with an IDS-PUCCH for each inter-device session in which the UE participates.

[0057] As described in more detail below, the UE2 may send feedback related to the IDS channel and IDS transmissions directly to UE1. This feedback could include CQI/CSI, ACK/NACK, scheduling request or other uplink control information. In some cases, one or more of these information elements can be sent in the same message such as an as IDS-PUCCH. In other cases, the IDS-PUCCH resources for feedback may be derived from related parameters of the IDS transmission and/or assignment for the purpose of at least NACK/ACK. In some of these implementations, UE1 is configured to receive at least the ACK/NACK feedback from UE2, while the eNB may also receive some or all of the feedback from UE2. The feedback to the eNB and UE1 may be separate messages, or the same message received by both. In some case, the eNB may ignore the ACK/NACK information as UE1 is making the decision on the HARQ process based on the ACK/NACK information it receives.

[0058] FIG. 5 is a message sequence diagram 500 illustrating example signal flow and traffic for an inter-device session. A first UE, referred to as UE1, may indicate to a network node that UE1 has data to send to a second UE, referred to as UE2 (502). This indication can be a radio link protocol indication or a scheduling request; however, it is the network that can choose whether or not to attempt a UE-to-UE session. The indication can also be a data packet destined for the network address assigned to UE2. It is understood that UE1 may want to send data to a single UE, UE2, or may want to send data to multiple UEs, such as in a multicast or broadcast session. Generally, the indication sent by UE1 and received by the network node indicates that UE1 wants to send data to at least UE2, and possibly other UEs. Other indications are also contemplated. For example, UE1 may not have a preference as to whether UE1 communicates in an inter-device session, or UE1 may specifically request an inter-device session. The network node may decide, based on network conditions, location of the UEs, operator policies, etc., whether or not the inter-device session is possible. If the network node determines that an inter-device session is possible, the eNB then sends information to start the session to each UE (504). For example, the eNB may send IDS-configuration information to the UEs. Such IDS-configuration information can include the reference signals to be transmitted and received to determine the proximity of the UEs and a radio network identifier for the

IDS, which may be referred to as an IDS radio network temporary identifier (IDS-RNTI).

[0059] This disclosure describes multiple ways that an IDS-RNTI may be used in an inter-device session. A first example embodiment described herein includes an
5 IDS-RNTI that may be referred to as a “session IDS-RNTI.” A session IDS-RNTI is used when the same IDS-RNTI is shared by all UEs participating in the inter-device session. All UEs in the inter-device session may be able to detect and decode the same control messages transmitted in the PDCCH from the eNB. If the eNB uses a session IDS-RNTI, the eNB may also configure each UE in the IDS with a session UE-
10 identifier (UE-ID) unique to each UE within the inter-device session. The UE-ID allows the eNB to identify each UE within the session and allows the UEs to identify each other as part of the inter-device session communications. In such a scenario, the control message may also include the UE-ID to indicate a particular UE associated with the control message. For example, if a UE receives a control message configured
15 with the IDS-RNTI, the UE can check for the UE-ID to determine if the instruction indicates the UE’s UE-ID or if the instruction indicates another UE’s UE-ID.

[0060] A second example embodiment described herein includes IDS-RNTIs that may be referred to as “unidirectional IDS-RNTI” for each UE. For the unidirectional case, additional configuration information may be transmitted to the
20 UEs. A unidirectional IDS-RNTI is used to indicate commands, messages, and/or feedback that are related to transmissions in one direction - from a first UE to a second UE, but not vice versa. Typically, but not necessarily, there will be two or more unidirectional IDS-RNTIs assigned for an inter-device session. For example, a first IDS-RNTI may be assigned to indicate transmissions from UE1, while a second IDS-
25 RNTI may be assigned to indicate transmissions from UE2. The eNB may send control messages in the PDCCH configured with the unidirectional first IDS-RNTI to indicate transmission from UE1. All UEs in the inter-device session may be able to detect and decode the same control messages transmitted in the PDCCH from the eNB. The eNB may send other control messages in the PDCCH configured with the
30 unidirectional second IDS-RNTI to indicate transmission from UE2. Note that the unidirectional IDS-RNTI for a transmitting UE may also be indicated to receiving UEs during configuration of the inter-device session. In some embodiments using the

unidirectional IDS-RNTIs, a UE may be configured with two or more IDS-RNTIs (one that is specific for the IDS transmissions sent by the UE and other IDS-RNTIs used by other transmitting UEs from which IDS transmissions may be received).

[0061] The eNB communicates the IDS-RNTI (either session IDS-RNTI or
5 unidirectional IDS-RNTIs) as IDS configuration information to a UE. The IDS configuration information may also include a dedicated supplemental PUCCH allocation (IDS-PUCCH) for IDS feedback or other IDS uplink requests to eNB. It should be understood that the IDS-PUCCH may be in addition to a PUCCH for conventional UE-eNB operations. In the embodiment with a session IDS-RNTI, the
10 IDS configuration information may also include the UE-ID for a particular UE in the inter-device session.

[0062] In some embodiments, additional IDS configuration information may be sent, including a dedicated RNTI (TPC -IDS-RNTI) for power control commands sent to a particular UE to control power of IDS transmissions. The IDS configuration
15 may include periodic SRS configuration or other reference signal (RS) configurations specific to the IDS. IDS configuration information may also indicate an initial transmit power level for the IDS transmissions. Additionally, in some instances, the eNB will indicate how the UEs are to measure the signal strength from the other UE. In such cases, the eNB may include the other UE's session ID (within the existing UE-
20 to-UE session), SRS cyclic shift and configuration, and PUCCH RS location and configuration.

[0063] In some embodiments, on receiving configuration information from the eNB, one or more of the UEs involved in the session setup may transmit a reference signal (IDS-RS) or sounding reference signal (IDS-SRS) as directed by the eNB
25 session setup commands. One or both of the UEs send a sounding reference signal (SRS) as indicated by the eNB session setup commands (506). The SRS is used by the other UE to determine whether they are in-range to communicate and, if they are, to determine receive timing window and channel state information (CSI). In some implementations, one or both of the UEs send an IDS-PUCCH message to the eNB
30 indicating CSI of the received SRS or PUCCH from the other UE (508). From this feedback, the eNB determines whether it is feasible to start UE-to-UE resource

allocations. The eNB sends an SPS-/IDPS-Config IE allocation for direct resources (510). This may be unicast to each UE of the IDS or, in some variants of the embodiment, multicast to the UEs. In the case of the SPS allocation, the eNB activates the allocation for direct UL/DL UE-UE resources (IDS-PUSCH/PDSCH) using a
5 PDCCH DCI configured with the inter-device session (IDS) RNTI. Both UEs can decode this message, which includes information on which UE is transmitting (UE1 in this example).

[0064] The IDS-RS/SRS transmission may be used by the other UEs to determine whether they are in-range to communicate and, if they are, to determine
10 receive timing window and channel state information (CSI). In some embodiments, these IDS-RS/SRS transmissions may be the same as RS/SRS used for conventional channel sounding between the UE and eNB. If used, the location and cyclic shift/base sequence for (IDS-)SRS assigned to one UE of the attempted UE-to-UE session is given to the other UE. In this manner, the UEs may determine if there is sufficient
15 signal strength received from the other UE. This information is transmitted to the eNB on the IDS-PUCCH assigned to a UE. In some embodiments, if sufficient signal strength is received from the other UE, and both UEs communicate this information to the eNB, then the inter-device session may proceed. During the inter-device session, the IDS-SRS, if assigned, may be used for, among other things, timing alignment,
20 which may include receive window alignment by the receiving UE, timing advance adjustment by eNB to adjust transmission timing and CQI estimation by the receiving UE. In some embodiments, the UE may use IDS MAC control elements to indicate CQI per transmitter. Signaling using IDS MAC control elements may be particularly useful in cases where multiple possible transmitters are defined in the session for a
25 given receiving UE. In another embodiment, signal quality and timing information is derived from the reference signals associated with the PUCCH or IDS-PUCCH of the other UE.

[0065] An IDS specific PUCCH may be assigned to each UE for communicating information to the eNB, and the other UE, regarding the inter-device
30 session channel. This assignment may be a new PUCCH allocation in addition to a conventional PUCCH allocation for UE-to-eNB- feedback, or the assignment may be a replacement of the conventional PUCCH with IDS-PUCCH, or the assignment may

be a replacement of one or more periodic occurrences of the conventional allocated PUCCH (for example, IDS-PUCCH replaces PUCCH every n^{th} occurrence).

[0066] UE1 may send an IDS-PUCCH message to the eNB indicating CSI of the received SRS, or PUCCH RS or other reference signal from the other UE. From this feedback, the eNB determines whether it is feasible to start IDS resource allocations.

[0067] Then, eNB sends an allocation for IDS resources using a PDCCH DCI configured with the inter-device session (IDS) RNTI (512). IDS resources for direct UE-to-UE transmission are allocated via grants contained in the PDCCH, ePDCCH or other DL control channels. A resource allocation configured with the IDS-RNTI is sent in a DL control channel (for example, the PDCCH region of the subframe) using downlink control information (DCI) formats. For example, if a session IDS-RNTI is used, this allocation uses a Format 0 or 4 DCI with one additional field to indicate the transmitter granted use of the resources; the transmitter is identified by the session UE-identifier (UE-ID) provided to the UE by the eNB in the session setup message. The additional field is not required, however, for IDS-RNTIs defined for the transmitter (e.g., unidirectional IDS-RNTI). The other UE(s) configured to use the IDS-RNTI are implicitly assigned the role of receiver for this resource allocation. The timing of the UE transmission using the indicated IDS resources is relative to the grant transmission and is derived by the UEs from the timing of the grant and the network configuration.

[0068] Using the resources indicated by (e), UE1 transmits a data message to UE2 using the designated IDS-PUSCH/PDSCH resources (514). UE2 can send a HARQ ACK/NACK response regarding the received UE-to-UE transmission (515). For example, a NAK can be sent indicating the transmission was not successfully received.

[0069] The above process of allocation, transmission, HARQ ACK/NACK feedback along with periodic sounding is continued until the session is terminated is by the eNB. It should be noted that while CQI from the UE and allocation indication from the eNB are not necessary for each transmission, the eNB may provide change or adapt the allocation by sending an IDS configured PDCCH/ePDCCH DCI, or further send TPC messages to the transmitting UE.

[0070] In the above process, the UE2 sends feedback related to the IDS channel and IDS transmissions. This feedback could include CQI/CSI, ACK/NACK, scheduling request or other uplink control information. In some cases, one or more of these information elements can be sent in the same message such as an as IDS-
5 PUCCH. In other cases, the IDS-PUCCH resources for feedback may be derived from related parameters of the IDS transmission and/or assignment for the purpose of at least NACK/ACK. In some of these implementations, UE1 is configured to receive at least the ACK/NACK feedback from UE2, while the eNB may also receive some or all of the feedback from UE2, The feedback to the eNB and UE1 may be separate
10 messages, or the same message received by both. In some case, the eNB may ignore the ACK/NACK information as UE1 is making the decision on the HARQ process based on the ACK/NACK information it receives.

[0071] In some implementations of this embodiment of a UE receiving the other UE(s) IDS-PUCCH information, a UE may change its transmission power level
15 for the inter-device session based in part on either the received signal level (i.e., assuming a reciprocal channel) , or explicit CQI level indicated in the IDS-PUCCH.

[0072] In some variants of the embodiments in this section, a 1 or 2 bit packet cyclic ID is included in the PUCCH message to combat ACK/NACK errors or loss of one or more IDS-PUCCH transmissions. Note that this is a message on the IDS-
20 PUCCH sent from a first UE in advance of or concurrently with its PUSCH transmission to a second UE. This value is incremented by one with every new packet transmission, so that a UE may recover quickly in case of ACK/NACK error or missed IDS-PUCCH transmissions. The value applies to the next transmission, so that in proper operation the UE will increment the ID every time the UE receives an ACK
25 and, therefore, a new packet transmission. The behavior of the UE with a 1-bit is indicated in Table 3.

Table 3. UL HARQ Operation for UE-UE SPS Autonomous Mode with 1-bit cyclic packet ID at Receiving UE

HARQ feedback sent by the UE	Packet ID seen by the UE	UE behaviour (next SP opportunity)
NACK	Incremented	Expect New transmission; clear buffer and start receiving new packet (possible missed IDS PUCCH or ACK/NAK error)
ACK	Incremented	Expect New transmission; clear buffer and start receiving new packet
NACK	Not-incremented	Expect Retransmission
ACK	Not-incremented	Expect Retransmission. Discard as packet transmission already received correctly.

[0073] In a two bit or larger cyclic packet ID field, one or more values may be reserved to convey additional information. For example, one value of a 2-bit field may be reserved to indicate that no transmission will occur during the next resource opportunity. If this indication is received, the receiving UE will monitor further occurrences of the IDS-PUCCH from the other UE until the value is incremented.

[0074] Using the IDPS/SPS allocation, UE1 can transmit the message to UE2 using the designated IDS-PUSCH/PDSCH resources (516). For example, if a NACK is received by UE1, the UE1 can retransmit the data. Or, if an ACK is received by UE1, UE1 can send another packet. UE2 sends a HARQ ACK/NACK response regarding the last received UE-to-UE transmission (517). For example, an ACK can be sent indicating the transmission was successfully received.

[0075] Depending on the configuration assigned by the eNB, one or both of the UEs send sounding reference symbols (SRS) as indicated by the eNB session setup commands (518). The transmissions of SRS can continue until the session is terminated. One or both of the UEs send an IDS-PUCCH/PDSCH message indicating CSI of the received SRS from the other UE (520).

[0076] In addition to the configured replacement of PUCCH by IDS-PDCCH described, the eNB may allocate different resources for the PUCCH, for example, through the *cqi-PUCCH-ResourceIndex* in the CQI-ReportConfig IE, or allocate different periodicities or subframes to differentiate the IDS-PDCCH and PDCCH

transmission received at the eNB. In some of these embodiments, the C-RNTI of the UE is used to scramble the PUCCH UCI format 2/2a/2b/3, or other control signalling formats scrambled by an RNTI, when used. In some variant embodiments, the IDS-RNTI is used to scramble IDS-PUCCH UCI format 2/2a/2b/3, or other control signalling formats scrambled by an RNTI, when used. Scrambling by IDS-RNTI may be useful to differentiate the IDS-PUCCH transmissions from the PUCCH transmission, and this may enable the UE to selectively transmit either one in a given PUCCH allocation. Other UEs in the inter-device session may make use of reference signals of the PUCCH and/or IDS-PUCCH transmissions for CQI and timing information.

[0077] The IDS-PUCCH transmission may have the same functionality and format as the conventional PUCCH, except that its contents (CSI, CQI, ACK, SR, etc.) pertain to the IDS channel and IDS transmissions. The function of the IDS PUCCH is to provide feedback. In aspects of this embodiment, a first UE can be configured to receive feedback from a second UE, in response to an IDS direct transmission from the first to the second UE. In some cases, the first UE can be configured to receive at least the ACK/NACK feedback so that it can determine if further retransmissions of the packet are needed. The eNB is also able to receive feedback on the IDS-PUCCH, such as information related to channel conditions or channel state information, or scheduling requests. In some embodiments, feedback may be given for the transmitting UE when there are more than two UEs in the inter-device session but there is only one transmitting UE. In another embodiment, a UE may determine the worst CQI of multiple transmitters (by receiving and measuring other UEs signals) and report that to the eNB as the CQI of the inter-device session to reduce CQI signalling. The IDS PUCCH can be used for other functions including sending IDS HARQ ACK/NACK responses to UE-to-UE packets to be received by the other UE, making scheduling requests to the eNB (e.g., so that the requesting UE may be assigned IDS transmission resources), and in some cases providing a UL reference signal for the other UEs to measure for making CQI/timing measurements. The IDS-PUCCH message may be configured by LTE PUCCH format 1/1a/1b or format 3 when CSI is not included, and format 2, LTE PUCCH format 2a or LTE PUCCH format 2b when CSI is included.

[0078] For IDS related ACK/NACK transmission, the UE may use the UE specific assigned IDS-PUCCH resources for transmission of a message configured as LTE PUCCH format 2a or LTE PUCCH format 2b type transmissions, and in cases of extended cyclic prefix, Format 2. The IDS related ACK/NACK transmissions may also be sent on IDS-PUCCH configured resources for LTE PUCCH format 1a or LTE PUCCH format 1b type message configurations. In some embodiments for IDS-PUCCH messages configured as LTE PUCCH format 1a or LTE PUCCH format 1b, a resource of the IDS-PUCCH transmission to the eNB can be derived from a mapping of an index of a control channel element (CCE) used to send a PDCCH DCI IDS allocation to the designated transmitter in an inter-device session.

[0079] Format 1a/1b is a scheme in LTE, in which ACK/NACK is sent according to a mapping of downlink resources. The ACK/NACK feedback is sent on PUCCH (or IDS-PUCCH) based on the mapping of downlink control message resources (i.e., the ACK/NACK feedback resource is not UE specific or pre-assigned for a particular UE, but instead is simply determined based upon the downlink control message transmission).

[0080] Format 2a/2b is a scheme in LTE in which the ACK/NACK feedback is sent on a PUCCH resource that is assigned to a particular UE. Format 2a/2b is typically used for CQI reporting, but it is possible to include ACK/NACK feedback with the CQI. Format 2 is used for extended cyclic prefix configurations, or reporting without ACK/NACK feedback in UE assigned resources.

[0081] Format 3 is a scheme in LTE for sending a large number of ACK/NACK bits. The ACK/NACK feedback is scrambled by the C-RNTI of the UE providing the feedback such that the eNB, and other UE if configured to do so, can determine which UE is providing the feedback.

[0082] In some embodiments, the resources assigned to a UE for IDS-PUCCH transmissions (e.g., LTE Format 2, 2a or 2b) and/or the resources allocated for IDS related ACK/NACK responses without CQI (e.g., LTE Format 1a or 1b) may be different from the resources assigned for non-IDS PUCCH transmissions.

[0083] In some further variants, the resources assigned for UE-to-UE feedback containing at least ACK/NACK IDS feedback, are different than resources used for IDS-PUCCH feedback intended to be received by the eNB. For example, the set of resources for LTE IDS- PUCCH 1a/1b for ACK/NACK transmission from UE-to-UE
5 regarding IDS transmissions, is different from assigned IDS-PUCCH feedback messages, that may include IDS related CSI, SR, and in some variants IDS ACK/NACK, to the eNB and other non-IDS PUCCH messages.

[0084] With regard to ACK/NACK feedback, it should be understood that the above mentioned feedback formats used in conventional PUCCH operation may be
10 applied to the feedback regarding the IDS transmissions. The ACK/NACK feedback describes the feedback regarding the IDS transmission, but is provided by the receiving UE another UE. With regard to RS/SRS operations described above, the operation is used by the UEs to measure the channel and provide feedback to the eNB regarding the channel between the UEs. This may be instead of, in addition to, or
15 replaced by the standard PUCCH SRS transmission if present. In embodiments where the IDS-PUCCH may be used for the CQI measurement of the UE-to-UE channel, the CQI estimate may be approximate as the IDS-PUCCH may be transmitted on the band edges. In this configuration, the IDS-PUCCH CQI estimate may not be a valid estimate of the sub-band CQI.

[0085] In a variant of this embodiment shown in FIG. 9, the IDS-PUCCH may be defined within the PUSCH region and not at the band edges. FIG. 9 is a graphical diagram showing the sub-band allocation of resources for an inter-device session physical uplink control channel. This is different from the normal LTE PUCCH location assignments. In this variant of the embodiment, the IDS PUCCH is located in
25 the PUSCH region in order to provide RS for the other UE to measure in order to determine sub-band CQI estimates. The IDS-PUCCH (901 and 902) locations are assigned in pairs, with a different location per slot for slot i (901) and slot $i+1$ (902), as for PUCCH, with the exception that the locations are not at the band edges.

[0086] Either UE1 or UE2 or both of them send an IDS-PUCCH message to
30 the eNB indicating CSI of the received SRS, or PUCCH RS or other reference signal from the other UE. From this feedback, the eNB determines whether it is feasible to

start IDS resource allocations. Then, eNB sends an allocation for IDS resources using a PDCCH DCI configured with the inter-device session (IDS) RNTI (540).

[0087] The ACK/NACK response can be sent using IDS-PUCCH resources as previously described. In some cases, the ACK/NACK response is sent via UE-specific assigned IDS-PUCCH, for example, in a LTE Format 2a or 2b (or format 2) type message. In other cases, the ACK/NACK response is sent via IDS-PUCCH resources, for example, in a LTE Format 1a or 1b type message. In cases where a LTE Format 1a or 1b type message is used, the specific IDS-PUCCH resources used for the transmission is derived from a mapping of the location of a resource used to send the DL control message to IDS-PUCCH resources.

[0088] In some embodiments, the resource allocation is “asynchronous HARQ” such that the PDCCH DCI allocates resources for a single IDS transmission; after an IDS transmission, UE1 receives an ACK/NACK response from UE2 corresponding to the IDS transmission according to the embodiments described herein. UE1 can interpret the ACK/NACK feedback on its own and determine to retransmit if necessary in the next IDS transmission to UE2. The next IDS transmission maybe allocated by another PDCCH DCI transmission, for example.

[0089] In some other embodiments, the resource allocation is “synchronous HARQ” such that the PDCCH message allocates resources for one or more periodic resources for an IDS packet transmission and potential retransmissions up to a maximum number of retransmissions; after an IDS transmission, UE1 receives an ACK/NACK response from UE2 corresponding to the IDS transmission according to the embodiments described herein and possibly a further PDCCH DCI corresponding to the IDS transmission from the eNB. or. If a PDCCH DCI corresponding to the IDS transmission is received, in a first variant of interpreting a further PDCCH DCI, UE1 can determine if a new packet transmissions or retransmission is scheduled from the New Data Indicator (NDI). In a second variant of interpreting a further PDCCH DCI, ignores the PDCCH DCI NDI information and proceeds according to ACK/NACK feedback from UE2. In either variant, the UE1 applies resources assignment or other information to the transmission as appropriate. If a PDCCH DCI corresponding to the IDS transmission is not received or the PDCCH DCI NDI is ignored, the UE can

determine interpret the ACK/NACK feedback from the UE2 corresponding to the IDS transmission, and determine to retransmit if necessary in the next IDS transmission to UE2 according the synchronous HARQ assignment. If a NACK was received, then UE1 can retransmit the IDS transmission to UE2 according the synchronous HARQ assignment. If an ACK was received, then UE1 cease transmission of this packet. In some variants of this embodiment, the eNB may also receive the ACK from UE2 and therefore determine that resources for further synchronous HARQ transmission of this packet are not needed, and can be assigned otherwise.

[0090] The above mentioned process of allocation/transmission of HARQ ACK/NACK feedback along with periodic sounding may continue until the inter-device session is terminated or the IDS is otherwise reconfigured by the eNB.

[0091] Depending on the configuration assigned by the eNB, one or both of the UEs send sounding reference signals (SRS) as indicated by the eNB session setup commands (530). The sounding reference signal may be specifically assigned for use in an IDS (i.e. an IDS-SRS), or the SRS may be the SRS normally assigned to a UE for UE-eNB communications.

[0092] Either UE1 or UE2 or both send an IDS-PUCCH/PDSCH message to the eNB indicating CSI of the received (IDS-)SRS from the other UE. In this example, the current receiver, UE2, may also send a scheduling request (SR) if UE2 has data that UE2 wishes to send to UE1.

[0093] FIG. 6 is a message sequence diagram 600 illustrating an example network operation for an inter-device session. In this packet oriented UE-initiated mechanism 600, a first UE 610a (UE1) initiates a device-to-device setup to a second UE 610b (UE2) by sending a bearer resource allocation request to the network (625). The network can chose to ignore or grant this request based on device and network capabilities, as well as policies and traffic loading. If allowed, Mobility Management Entity (MME 615) sends a request to eNB 605 to initiate a device-to-device radio bearer connection between UE1 and UE2 (630). eNB 605 can provide IDS-RNTI and other setup information, and instructs UE1 and UE2 to report CQI received from the other UE's SRS/PUCCH/IDS-PUCCH signals (635). UE1 and UE2 report received channel conditions (e.g., CQI) of the device-to-device channel to eNB 605 (640). If

device-to-device channel conditions are sufficient to establish a session, eNB 605 propagates successful “ACK” to the MME (645). The eNB 605 allocates PUSCH/PDSCH resources using IDS-RNTI encoded grants in PDCCH so that packet exchange between UE1 and UE2 now occurs over the device-to-device connection, bypassing the network infrastructure (650), as described in FIG. 5.

[0094] FIG. 7 is a flow chart 700 illustrating an example process of inter-device session communications that may be performed by a network node of a mobile communications network. The network node may be an evolved Node B (eNB) of a communications network, such as a long term evolution (LTE) network, or another network node, described above. The network node can receive an indication (702) that a first UE (UE1) wants to communicate with a second UE (UE2). This indication can be a received data packet addressed to the second UE, or the indication can be a request for resources. The indication can also include a request or indication that UE1 wants to communicate with UE2 in an inter-device session (704). In certain instances, the network node can determine (706) that an inter-device session may be possible between UE1 and UE2. The network node can make this determination based on known information about UE1 and UE2, such as whether the UEs are in the same cell. The network node can also base this determination on network loads and channel conditions – information that is known or that can be discovered through feedback received from the UEs (discussed more below). The network node can also determine, without an explicit request from the UEs, that an inter-device session can occur and can initiate an inter-device session without a request from the UEs. In short, the UE or the network node can initiate the inter-device session.

[0095] In certain instances, the network node can receive a request (e.g., from UE1) for resources to communicate data from UE1 to UE2 (707). The network node can use the request for resources to initiate an inter-device session between UE1 and UE2. Such an initiation can be executed based on a number of other factors, including those listed above.

[0096] In some embodiments after the network node has determined that the network will initiate an inter-device session, the network node can configure a first IDS-PUCCH message for UE1 (708). The network node can also configure a second

IDS-PUCCH message for UE2 (710). The network node can also allocate resources for the UEs to transmit and/or receive data in an inter-device session (712). The resources may be allocated using a PDCCH DCI configured with an IDS-Identifier.

[0097] The network node can transmit to UE1 UE1-configuration information for an inter-device session (IDS) between UE1 and UE2 (714). The UE1 configuration information can include a radio network identifier. Similarly, configuration information can be sent to UE2 (716). This configuration information may include configuration information used by UE2 to measure signals from UE1. The configuration information transmitted to UE1 (714) and UE2 (716) may also contain the first IDS-PUCCH configuration (708) and the second IDS-PUCCH configuration, respectively. The network node can also transmit a control message that is configured with the radio network identifier and identifies a radio resource for the IDS, such that UE1 is permitted to transmit data directly to UE2 via the radio resource (718). In some cases, the control message (718) may be the same as the allocation message (712). Put differently, the network node can transmit a setup message to UE1. The set-up message can include an IDS-physical uplink control channel (IDS-PUCCH), a radio network identifier, such as an IDS-radio network temporary identifier (IDS-RNTI), etc. In certain implementations, configuration information can be used by UE1 to measure signals from UE2 for feedback purposes, such as channel state indicators, rank indicators, precoding matrix indicators, etc., from physical uplink control channel (PUCCH), reference signals, sounding reference signal (SRS), etc.

[0098] In certain implementations, UE1 configuration information can be transmitted in a radio resource control (RRC) message. The RRC message can be transmitted via a downlink shared channel, such as a physical downlink shared channel (PDSCH).

[0099] A first reference signal can be configured for UE1. Configuration information including the first reference signal configuration can be provided to UE2, e.g., in a radio resource control (RRC) message. The first reference signal configuration can identify a sounding reference signal (SRS) resource. The first reference signal configuration may be associated with a physical uplink control channel configuration. The physical uplink control channel configuration may be an

IDS-specific physical control channel configuration for an inter-device session between UE1 and UE2, or the configuration may be the physical uplink control channel normally allocated to a UE for UE-eNB communications.

[00100] The reference signal configuration identifies a reference signal for UE2
5 to monitor from UE1, which may be a reference signal resource specifically allocated
for the inter-device session. The reference signal can be used by UE2 to determine a
channel state between UE1 and UE2. The reference signal can also be used by UE2 to
determine timing alignment for the inter-device session. The network node can
receive channel state indicator (CSI) from UE2. For example, the network node can
10 receive a channel state indicator on an IDS-specific physical uplink control channel.
The channel state indicator can indicate a channel state between UE1 and UE2. The
channel state indicator can be received from UE2 via an IDS-specific physical uplink
control channel. The channel state indicator can include one or more of a channel
quality indicator (CQI), precoding matrix index (PMI), rank indicator (RI), or
15 precoding type indicator (PTI). The CSI can report a channel state of a direct radio
channel from UE1 to UE2.

[00101] The network node can determine, based on feedback from at least one
of UE1 or UE2, that the IDS has been established. For example, the network node can
determine, based on the channel state indicator received from UE2, that the IDS has
20 been established.

[00102] In certain implementations, transmission timing for the IDS radio
resource can be based on a timing alignment for an uplink resource from UE1 to the
network node.

[00103] In certain implementations, the configuration information and/or
25 control messages can be shared between the UEs or can be different for the different
UEs. For example, a first IDS physical uplink control channel (IDS-PUCCH1) can be
configured for use by UE1. The first IDS-PUCCH1 can provide an uplink resource for
UE1 to transmit an uplink control message related to the IDS. A second IDS physical
uplink control channel (IDS-PUCCH2) can be configured for use by UE2. The second
30 IDS-PUCCH2 can provide an uplink resource for UE2 to transmit an uplink control
message related to the IDS. The uplink control message can include one or more of an

IDS schedule request, IDS channel state reporting, or IDS acknowledgement/negative acknowledgement (ACK/NACK) feedback. The IDS-PUCCH2 can be associated with the radio network identifier, such as a RNTI.

[00104] In certain implementations, an IDS physical uplink control channel
5 (IDS-PUCCH1) can be configured that is associated with the inter-device session. The IDS-PUCCH1 can be configured for use with the (IDS-) radio network identifier. The IDS-PUCCH1 may be configured for use with the CRNTI of UE1. The IDS-PUCCH1 may be in addition to a physical uplink control channel (PUCCH) associated with a CRNTI of UE1. The IDS-PUCCH1 may be configured in a sub-band associated with
10 the IDS radio resource for the inter-device session. In some implementations, the IDS-PUCCH may be allocated in sub-bands other than at the edges of the UL spectrum. In certain implementations, the IDS-PUCCH1 is configured prior to transmitting the control message. A configuration message can be transmitted to UE2, the configuration message indicating one or both of the IDS-PUCCH1 or a reference
15 signal associated with the IDS-PUCCH1, wherein at least a portion of the IDS-PUCCH1 or the reference signal associated with the at least a portion of the IDS-PUCCH1 is used by UE2 to determine a channel state for the sub-band associated with the IDS radio resource for the inter-device session. An IDS radio resource sub-band can be determined based, at least in part, on the channel state for the sub-band
20 associated with the IDS radio resource.

[00105] The network node can also configure an IDS physical uplink control channel (IDS-PUCCH1) that is associated with the inter-device session and configured for use with the (IDS-) radio network identifier. The IDS-PUCCH1 can be transmitting in addition to a physical uplink control channel (PUCCH) associated with
25 a CRNTI of UE1. The IDS-PUCCH1 and the PUCCH can be configured in the same radio resources. In some instances, the IDS-PUCCH1 can be configured for use by only UE1. In these instances, a second IDS physical uplink control channel (IDS-PUCCH2) can be configured for the inter-device session. The IDS-PUCCH2 would be configured for use by only UE2. The IDS-PUCCH2 may be configured for
30 acknowledgement (ACK) or negative acknowledgement (NACK) feedback from UE2 associated with the inter-device session.

[00106] UE1 can receive a feedback message from UE2 that includes feedback indicating whether UE2 received a transmission from UE1. The feedback message from UE2 can be received on an uplink transmission resource that is derived from a mapping of an index of the downlink control channel allocation message. The uplink transmission resource may be an IDS uplink transmission resource that is different from a further uplink transmission resource for ACK/NACK feedback for eNB-to-UE downlink transmissions. The uplink transmission resource may be dedicated for ACK/NACK feedback for UE-to-UE IDS transmissions. In some instances, the DL control message indicating the IDS allocation resources is transmitted using a PDCCH resource configured with the radio network identifier. The feedback message from UE2 may be received on an IDS-PUCCH resource derived from a mapping of a control channel element (CCE) of the PDCCH. As UE2 also receives the DL control message indicating the IDS allocation resources, UE1 is able to derive the location of the IDS-PUCCH resources from UE2. In some instances, the feedback may include a hybrid automatic repeat request (HARQ) acknowledgement/negative acknowledgement (ACK/NACK) response from UE2. When the HARQ ACK/NACK response is a NACK, the network node can transmit a further control message that includes an allocation of a further radio resource for UE1 to retransmit the previous transmission. The feedback indicator may include a channel quality indicator regarding the quality of the transmission from UE1 to UE2.

[00107] The IDS PUCCH provides feedback to network node. In aspects of this embodiment, UE1 can be configured to receive feedback from UE2, in response to an IDS direct transmission from the UE1 to UE2. In some cases, UE1 can be configured to receive at least the ACK/NACK feedback so that it can determine if further retransmissions of the packet are needed. The eNB is also able to receive feedback on the IDS-PUCCH, such as information related to channel conditions or channel state information, or scheduling requests. The network node can configure UE1 with information needed to receive at least ACK/NACK feedback from UE2. This may include the location of the IDS- PUCCH assigned to UE2, the IDS-RNTI assigned to at least UE2 for the IDS session, and the UE-ID if applicable.

[00108] In certain aspects of the implementations, the radio resource for the inter-device session may include one of LTE physical uplink shared channel (PUSCH) resources or LTE physical downlink shared channel (PDSCH) resources.

[00109] The network node may transmit, to UE2, UE2 configuration information for the IDS between UE1 and UE2. UE2 configuration information may include the same radio network identifier as UE1. In some implementations, the radio network identifier is an inter-device session radio network temporary identifier (IDS-RNTI).

[00110] In some implementations, the UE1 configuration information further includes a session UE1-identifier (UE1-ID), and the UE2 configuration information further includes a session UE2-identifier (UE2-ID), the UE1-ID being different from the UE2-ID. The control message that includes an allocation of the radio resource for the IDS further includes the radio network identifier and an indication of either the UE1-ID or the UE2-ID. Transmitting the control message may also include or involve transmitting the control message to UE1 and UE2. The control message indicates that UE1 is to transmit and UE2 is to receive if the control message indicates the UE1-ID, and the control message indicates that UE2 is to transmit and UE1 is to receive if the control message indicates the UE2-ID.

[00111] For the same radio network identifier, the UE1 configuration information indicates that UE1 is a transmitter and the UE2 configuration information indicates that UE2 is a receiver. The UE1 configuration information can be a first UE1 configuration information, and the UE2 configuration information can be a first UE2 configuration information. The radio network identifier included in first UE1 configuration information and first UE2 configuration information can be a first radio network identifier. In certain instances, the network node can transmit a second UE1 configuration information to UE1. The network node can also transmit a second UE2 configuration information to UE2. The second UE1 configuration information and the second UE2 configuration information include a second radio network identifier. The second radio network identifier is different from the first radio network identifier and indicates that, for the second radio network identifier, UE1 is a receiver and UE2 is a transmitter.

[00112] In certain aspects of the implementations, the radio network identifier included in the UE1 configuration information is a first radio network identifier, and the UE2 configuration information includes a second radio network identifier. The first radio network identifier may be a first IDS radio network temporary identifier (IDS-RNTI-UE1), and the second radio network identifier maybe a second IDS radio network temporary identifier (IDS-RNTI-UE2).

[00113] In certain implementations, the network node may transmit, to UE1, a transmit power control radio network identifier for power control commands associated with the IDS. The transmit power control radio network identifier can be included in UE1 configuration information. The network node may transmit at least one power control command configured with the transmit power control radio network identifier, the power control command controlling the transmit power for transmissions between UE1 and UE2. The power control command can be configured to adjust transmit power of a reference signal transmitted by UE1 and received by UE2 for channel state information measurement. The transmit power control radio network identifier maybe a Radio Network Temporary Identifier (RNTI).

[00114] In some instances, more than two UEs can be involved in the inter-device session. For example, the network node can transmit, to a third UE (UE3), UE3 configuration information for the IDS among UE1, UE2, and UE3.

[00115] FIG. 8 is a flow chart 800 illustrating an example process of inter-device session communications that may be performed by a user equipment (UE) operating in a wireless communications network. The UE (UE1) may be a cellular handset, such as a cellular phone or smartphone, or may be a tablet PC, or may be any other user equipment that can communicate with other user equipment in a wireless communications network, such as a long term evolution (LTE) network. UE1 can transmit an indication that UE1 wants to communicate with a second UE (UE2) (810). This indication can be a data packet addressed to the second UE, or the indication can be a request for resources. The indication can also include a request or indication that UE1 wants to communicate with UE2 in an inter-device session. In certain instance, the network node can determine that an inter-device session can occur between UE1 and UE2.

[00116] UE1 can receive from the network node UE1-configuration information for an inter-device session (IDS) between UE1 and UE2 (815). The UE1 configuration information can include a radio network identifier. UE1 can also receive a resource allocation for transmitting/receiving feedback from UE2 (830). Put
5 differently, UE1 can receive a set-up message from the network node. The set-up message can include an IDS-physical uplink control channel (IDS-PUCCH), a radio network identifier, such as an IDS-radio network temporary identifier (IDS-RNTI), etc. In certain implementations, configuration information can be used by UE1 to measure signals from UE2, such as physical uplink control channel (PUCCH),
10 sounding reference signal (SRS), ACK/NACK feedback, channel state indicators, rank indicators, precoding matrix indicators, etc. Such signals can be used for feedback purposes, and ACK/NACK information can be used to determine whether or not further HARQ transmission are needed.. Similarly, configuration information can be sent to UE2 and used by UE2 to measure signals from UE1.

15 [00117] The UE1 can also receive a control message from the network node (820). UE1 can also receive (e.g., with the control message) a message configured with the radio network identifier and an identification of a radio resource for the IDS, such that UE1 is permitted to transmit data directly to UE2 via the radio resource (825). UE1 can send data to UE2 using the allocation information on the IDS
20 resources (835). UE1 can receive feedback information or a feedback signal from UE2 (840).

[00118] In certain implementations, UE1 configuration information can be received in a radio resource control (RRC) message. The control message can be received via a downlink control channel, such as a physical downlink control channel
25 (PDCCH) or enhanced physical downlink control channel (ePDCCH). The control message can be received in a Downlink Control Information (DCI) element of the downlink control channel.

[00119] A first reference signal can be configured for UE1. Configuration information including the first reference signal configuration can be provided to UE2,
30 e.g., in a radio resource control (RRC) message. The first reference signal configuration can identify a sounding reference signal (SRS) resource. The first

reference signal configuration may be associated with a physical uplink control channel configuration. The physical uplink control channel configuration is an IDS-specific physical control channel configuration for an inter-device session between UE1 and UE2.

5 [00120] The reference signal configuration identifies a reference signal for UE2 to monitor from UE1, and can also identify a reference signal resource for the inter-device session. The reference signal can be used by UE2 to determine a channel state between UE1 and UE2. The reference signal can also be used by UE2 to determine timing alignment for the inter-device session. The network node can receive channel
10 state indicator (CSI) from UE2. For example, the network node can receive a channel state indicator on an IDS-specific physical uplink control channel. The channel state indicator can indicate a channel state between UE1 and UE2. The channel state indicator can be received from UE2 via an IDS-specific physical uplink control channel. The channel state indicator can include one or more of a channel quality
15 indicator (CQI), precoding matrix index (PMI), rank indicator (RI), or precoding type indicator (PTI). The CSI can report a channel state of a direct radio channel from UE1 to UE2.

[00121] UE1 can provide feedback to the network node, from which the network node can determine whether the IDS has been established. For example, the
20 network node can determine, based on the channel state indicator received from UE1 or UE2, that the IDS has been established.

[00122] In certain implementations, transmission timing for the IDS radio resource can be based on a timing alignment for an uplink resource from UE1 to the network node.

25 [00123] UE1 can receive an indication of the feedback received from UE2. The indication of the feedback may be sent IDS resources, where UE1 has been configured to derive the location and and receive at least ACK/NACK HARQ feedback to IDS transmissions. The indication of the feedback may be sent IDS-PUCCH resources. The IDS-PUCCH resources may be different from an uplink transmission resource for
30 acknowledgement/negative acknowledgement (ACK/NACK) feedback for eNB to UE downlink transmissions.

[00124] In certain aspects of the implementations, the radio resource for the inter-device session may include one of LTE physical uplink shared channel (PUSCH) resources or LTE physical downlink shared channel (PDSCH) resources.

[00125] The network node may transmit, to UE2, UE2 configuration information for the IDS between UE1 and UE2. UE2 configuration information may include the same radio network identifier as UE1. In some implementations, the radio network identifier is an inter-device session radio network temporary identifier (IDS-RNTI).

[00126] In some implementations, the UE1 configuration information further includes a session UE1-identifier (UE1-ID), and the UE2 configuration information further includes a session UE2-identifier (UE2-ID), the UE1-ID being different from the UE2-ID. The control message that includes an allocation of the radio resource for the IDS further includes the radio network identifier and an indication of either the UE1-ID or the UE2-ID. Transmitting the control message may also include or involve transmitting the control message to the UE1 and UE2, and the control message indicates that UE1 is to transmit and UE2 is to receive if the control message indicates the UE1-ID and the control message indicates that UE2 is to transmit and UE1 is to receive if the control message indicates the UE2-ID.

[00127] In implementations where a single radio network identifier is used, the UE1 configuration information can indicate that the UE1 is a transmitter and the UE2 configuration information indicates that UE2 is a receiver (e.g., in situations where that is true). The UE1 configuration information can be a first UE1 configuration information and the UE2 configuration information can be a first UE2 configuration information. The radio network identifier included in first UE1 configuration information and first UE2 configuration information can be a first radio network identifier. In certain instances, the network node can transmit a second UE1 configuration information to UE1. The network node can also transmit a second UE2 configuration information to UE2. The second UE1 configuration information and the second UE2 configuration information includes a second radio network identifier, the second radio network identifier different from the first radio network identifier and

indicates that, for the second radio network identifier, UE1 is a receiver and UE2 is a transmitter.

[00128] While several implementations have been provided in the present disclosure, it should be understood that the disclosed systems and methods may be embodied in many other specific forms without departing from the scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

[00129] Also, techniques, systems, subsystems and methods described and illustrated in the various implementations as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as coupled or directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component, whether electrically, mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the spirit and scope disclosed herein.

[00130] While the above detailed description has shown, described, and pointed out the fundamental novel features of the disclosure as applied to various implementations, it will be understood that various omissions and substitutions and changes in the form and details of the system illustrated may be made by those skilled in the art, without departing from the intent of the disclosure. In addition, the order of method steps not implied by the order they appear in the claims.

25

What is claimed is:

1. A method performed by a first user equipment (UE) of a wireless communications network, the method comprising:
 - 5 receiving configuration information for the first UE (UE1 configuration information) for an inter-device session (IDS) between the first UE and a second UE, the UE1 configuration information including a radio network identifier;
receiving a control message configured with the radio network identifier and a radio resource identifier;
 - 10 transmitting data directly from the first UE to the second UE during the IDS using the identified radio resource; and
receiving a feedback signal directly from the second UE in response to at least one IDS transmission.
- 15 2. The method of claim 1, wherein transmission timing for the radio resource is based on a timing alignment for an uplink resource from the first UE to the network node.
3. The method of claim 1, further comprising transmitting a request, to a
20 network node, for a transmission resource to send data from the first UE to the second UE.
4. The method of claim 1, further comprising transmitting data directly to
the second UE during the IDS.
- 25 5. The method of claim 1, further comprising:
receiving a set-up message, the set-up message including an IDS physical uplink control channel (IDS-PUCCH1) that is associated with the IDS and configured for use with the radio network identifier; and
30 transmitting an uplink control message using an uplink resource provided by the IDS-PUCCH1.

6. The method of claim 5, wherein the uplink control message includes one or more of: an IDS schedule request, IDS channel state reporting, or IDS acknowledgement/negative acknowledgement (ACK/NACK) feedback.
- 5 7. The method of claim 1, further comprising measuring signals received from the second UE based at least partly upon the UE1 configuration information, and using the measurement to determine the IDS channel quality.
8. The method of claim 1, wherein the feedback signal is an
10 acknowledgement/negative acknowledgement (ACK/NACK).
9. A first user equipment (UE) comprising:
a transceiver configured to:
receive configuration information for the first UE (UE1 configuration information) for
15 an inter-device session (IDS) between the first UE and a second UE, the UE1
configuration information including a radio network identifier;
receive a control message configured with the radio network identifier and a radio
resource identifier;
transmit data directly from the first UE to the second UE during the IDS using the
20 identified radio resource; and
receive a feedback signal directly from the second UE in response to at least one IDS
transmission.
10. The UE of claim 9, wherein transmission timing for the radio resource
25 is based on a timing alignment for an uplink resource from the first UE to the network
node.
11. The UE of claim 9, wherein the transceiver is further configured to
transmit a request, to a network node, for a transmission resource to send data from the
30 first UE to the second UE.
12. The UE of claim 9, wherein the transceiver is further configured to
transmit data directly to the second UE during the IDS.

13. The UE of claim 9, wherein the transceiver is further configured to:
receive a set-up message, the set-up message including an IDS physical uplink control
channel (IDS-PUCCH1) that is associated with the IDS and configured for use with
5 the radio network identifier, and
transmit an uplink control message using an uplink resource provided by the IDS-
PUCCH1.
14. The UE of claim 13, wherein the uplink control message includes one
10 or more of: an IDS schedule request, IDS channel state reporting, or IDS
acknowledgement/negative acknowledgement (ACK/NACK) feedback.
15. The UE of claim 9 further comprising a processor configured to
measure signals received from the second UE based at least partly upon the UE1
configuration information, and using the measurement to determine the IDS channel
15 quality.
16. The UE of claim 9, wherein the feedback signal is an
acknowledgment/negative acknowledgement (ACK/NACK).
- 20 17. A first user equipment (UE) comprising:
a transceiver configured to:
receive, from a network node, configuration information for an inter-device session
(IDS) between the first UE and a second UE, the configuration information including a
radio network identifier;
25 receive data directly from the second UE during the IDS using the identified radio
resource; and
transmit a feedback signal directly to the second UE in response to at least one IDS
transmission.
- 30 18. The UE of claim 17, wherein the transceiver is further configured to
transmit data directly to the second UE during the IDS.

19. The UE of claim 17, wherein transmission timing for the radio resource is based on a timing alignment for an uplink resource from the second UE to the network node.
- 5 20. The UE of claim 17, wherein the feedback signal is an acknowledgment/negative acknowledgement (ACK/NACK).

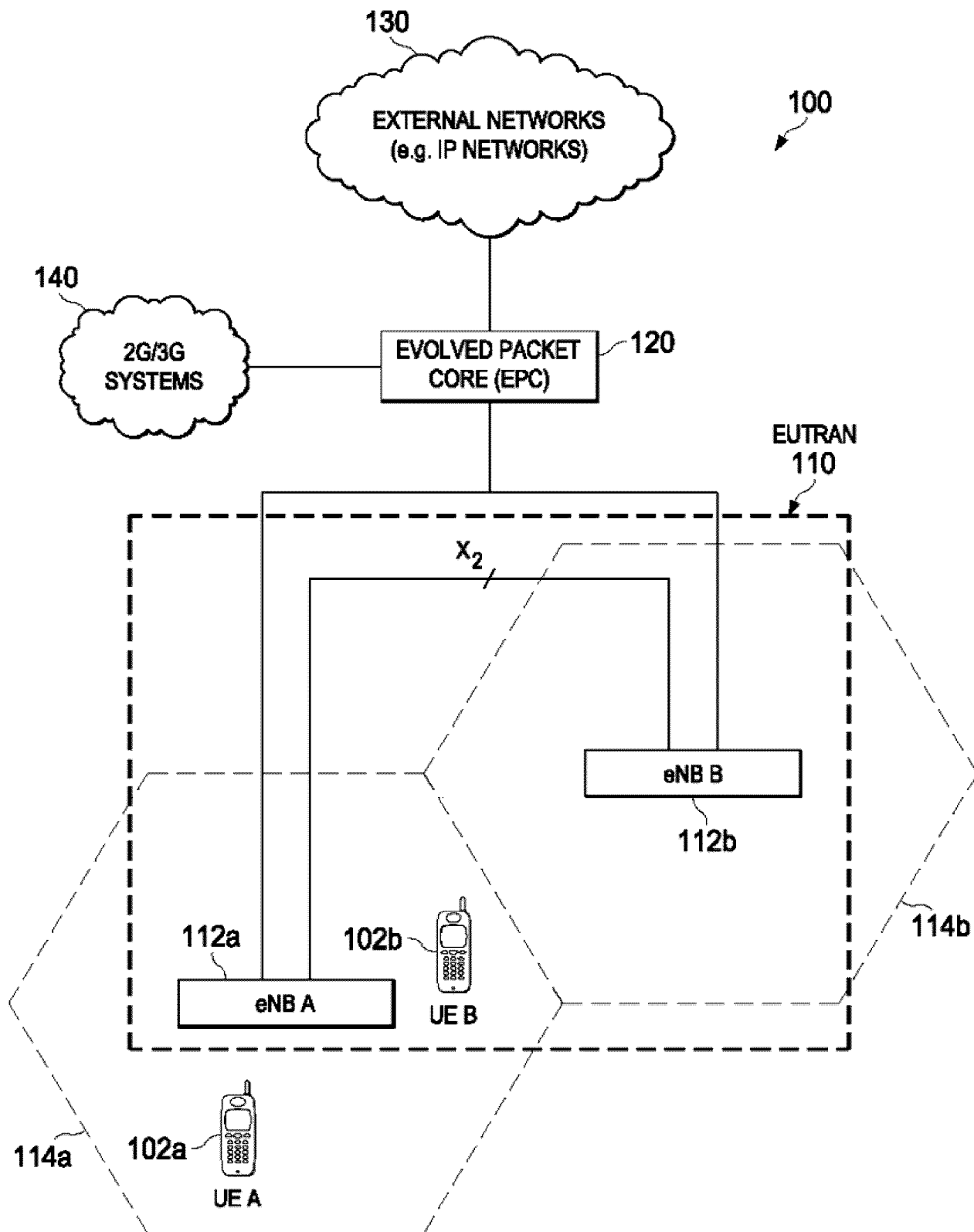
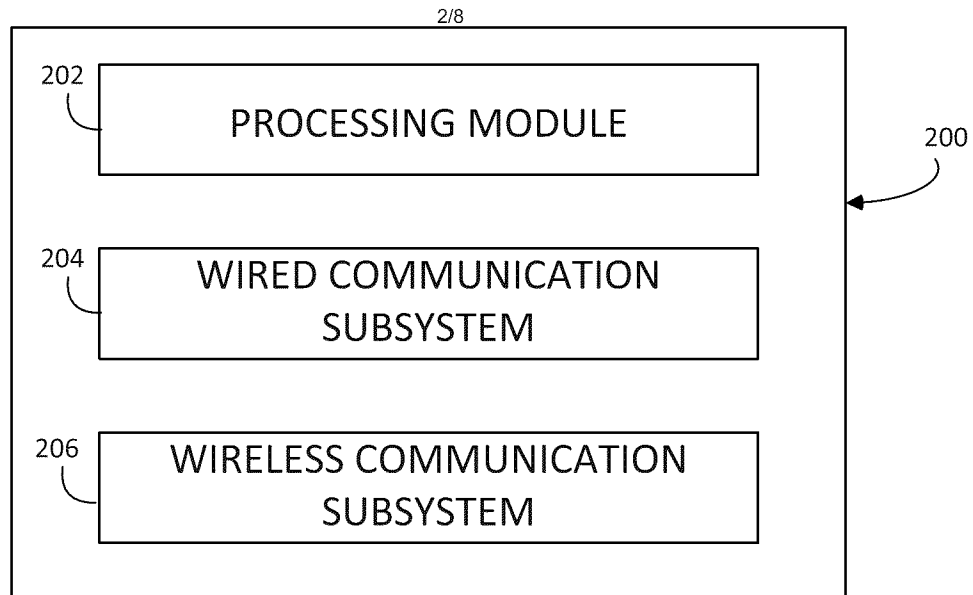
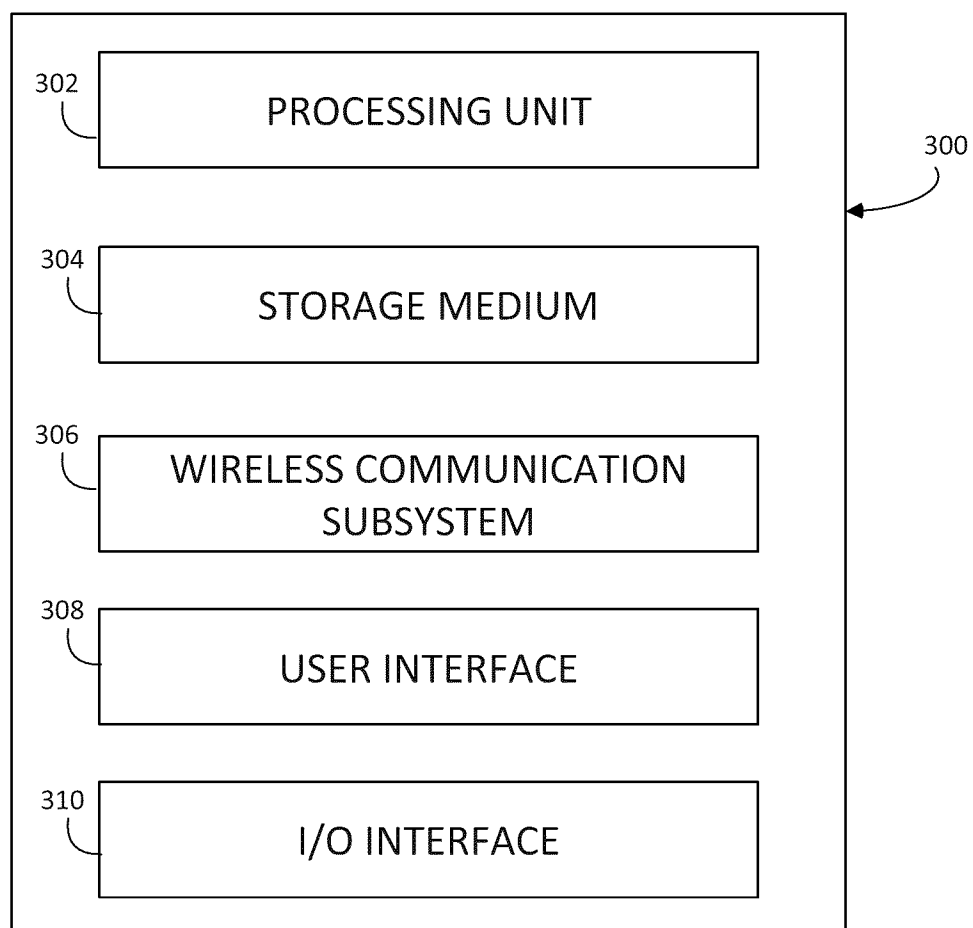
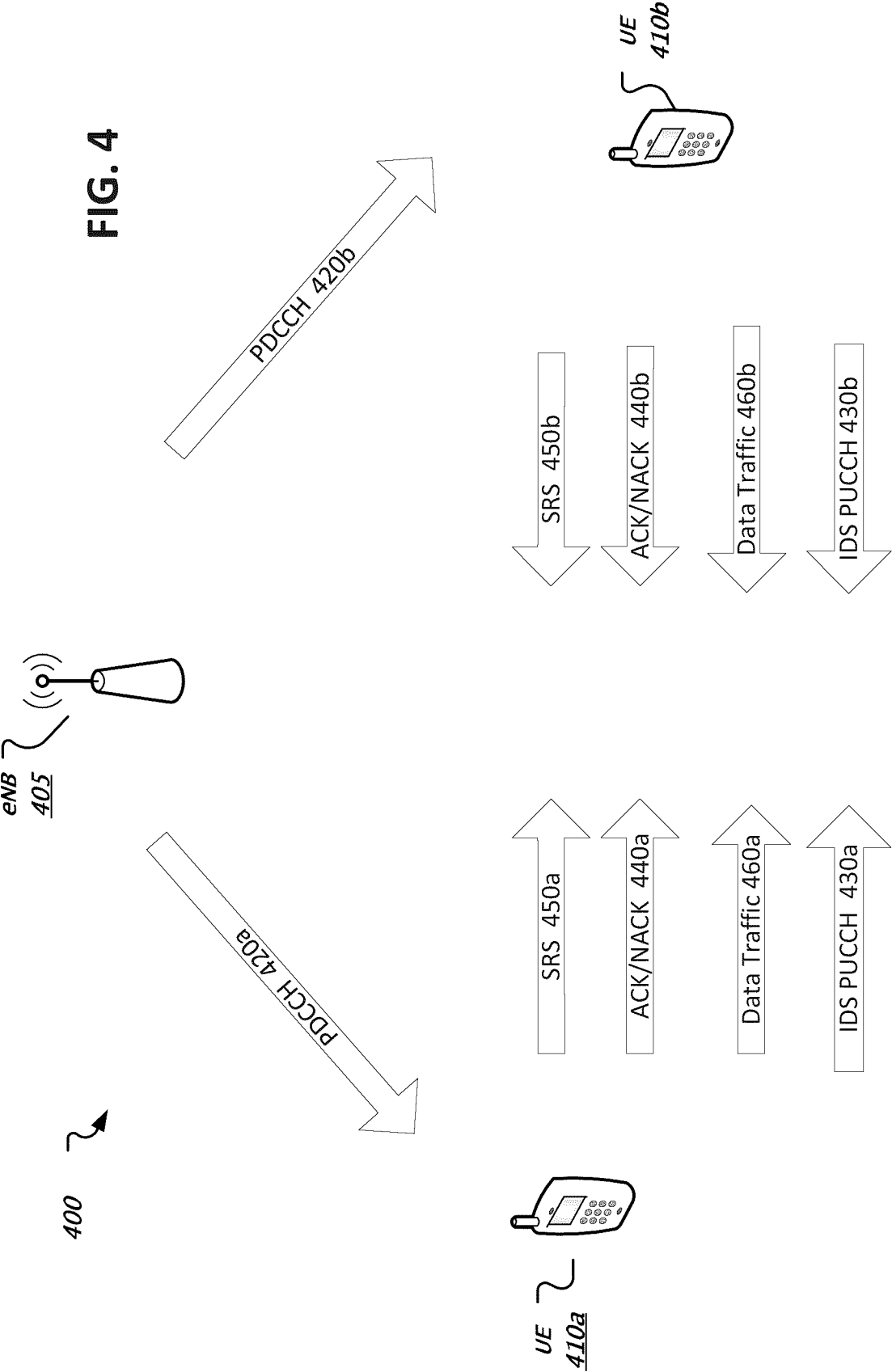


FIG. 1

**FIG. 2****FIG. 3**



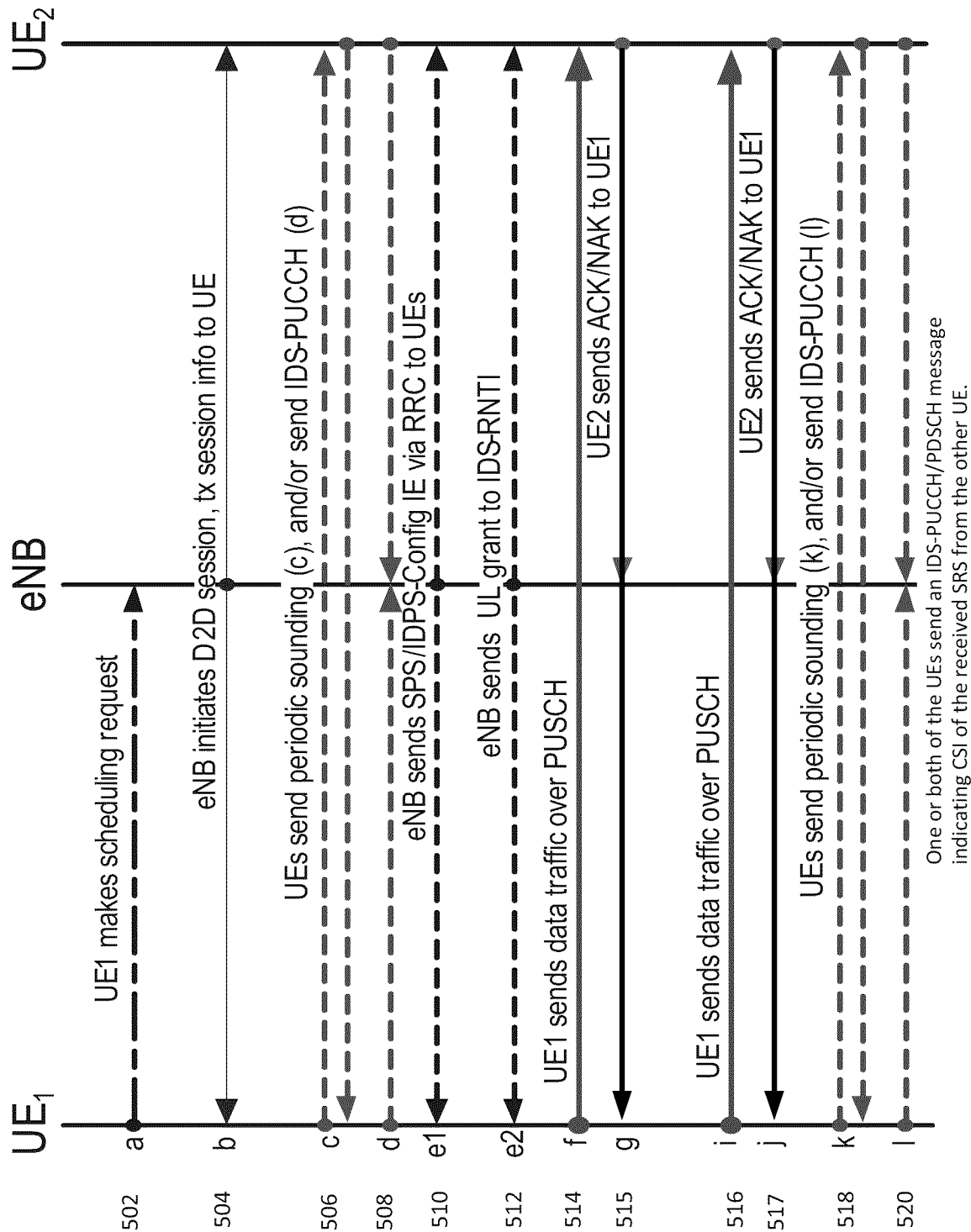


FIG. 5

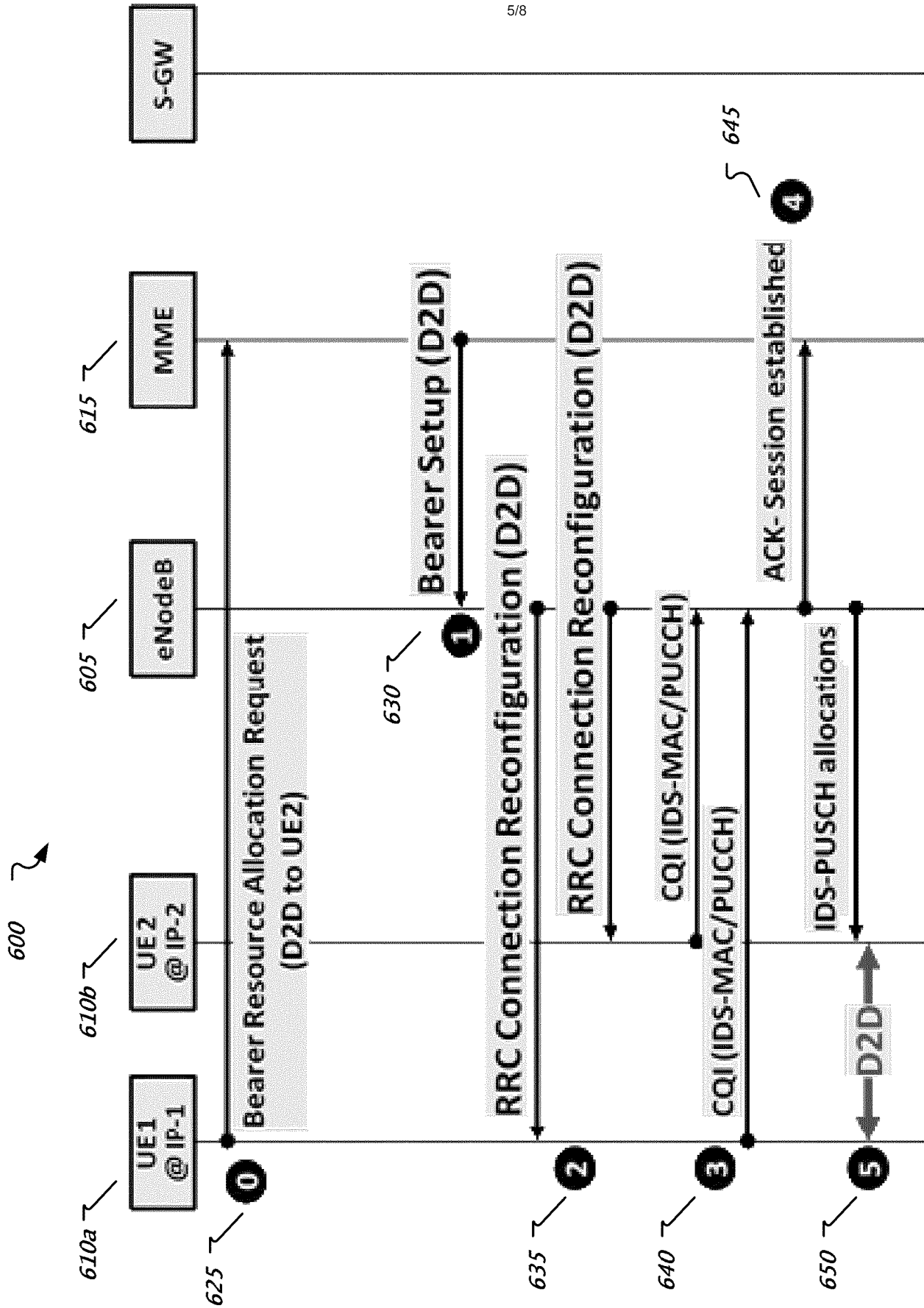
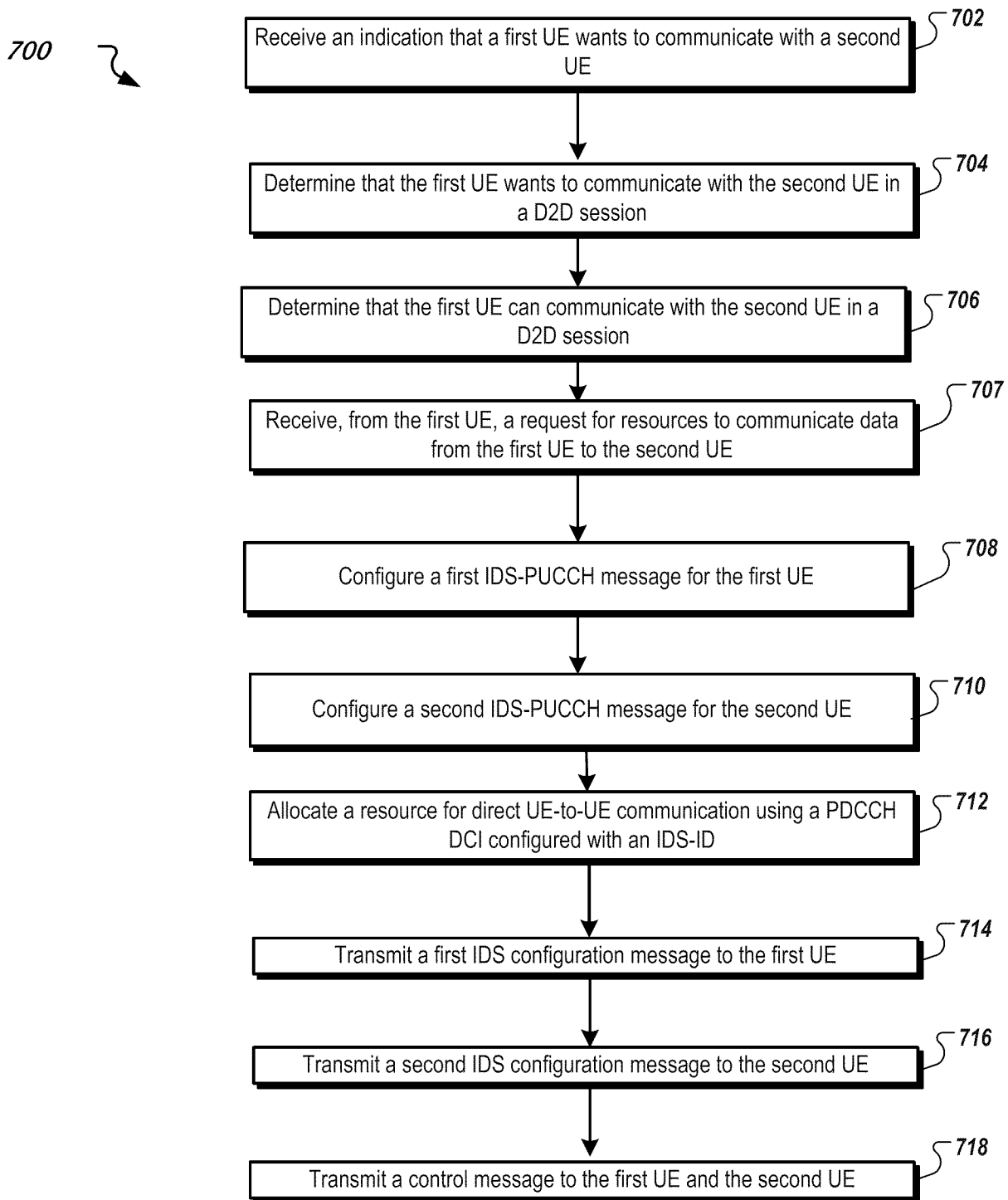
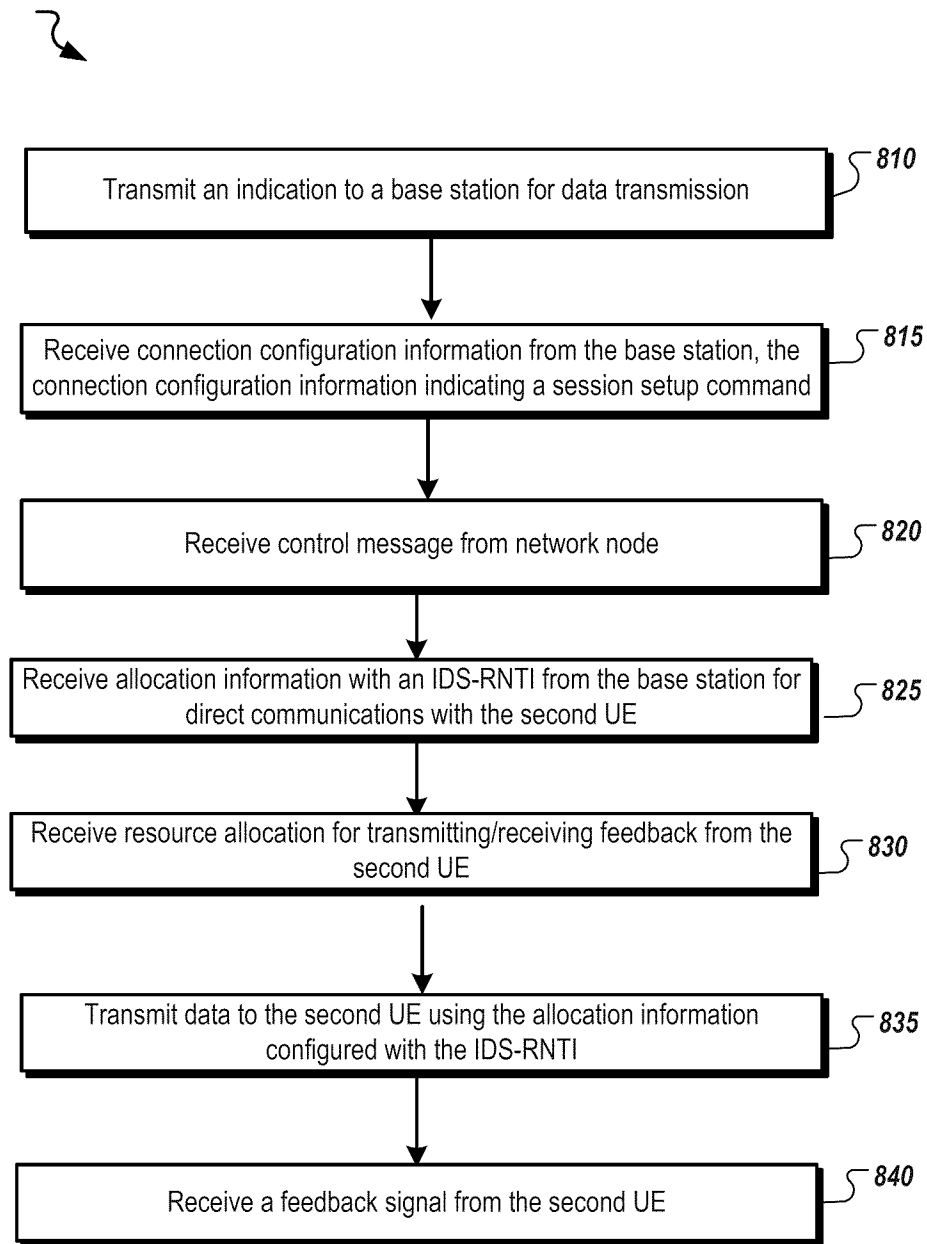


FIG. 6

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**FIG. 7**

800

**FIG. 8**

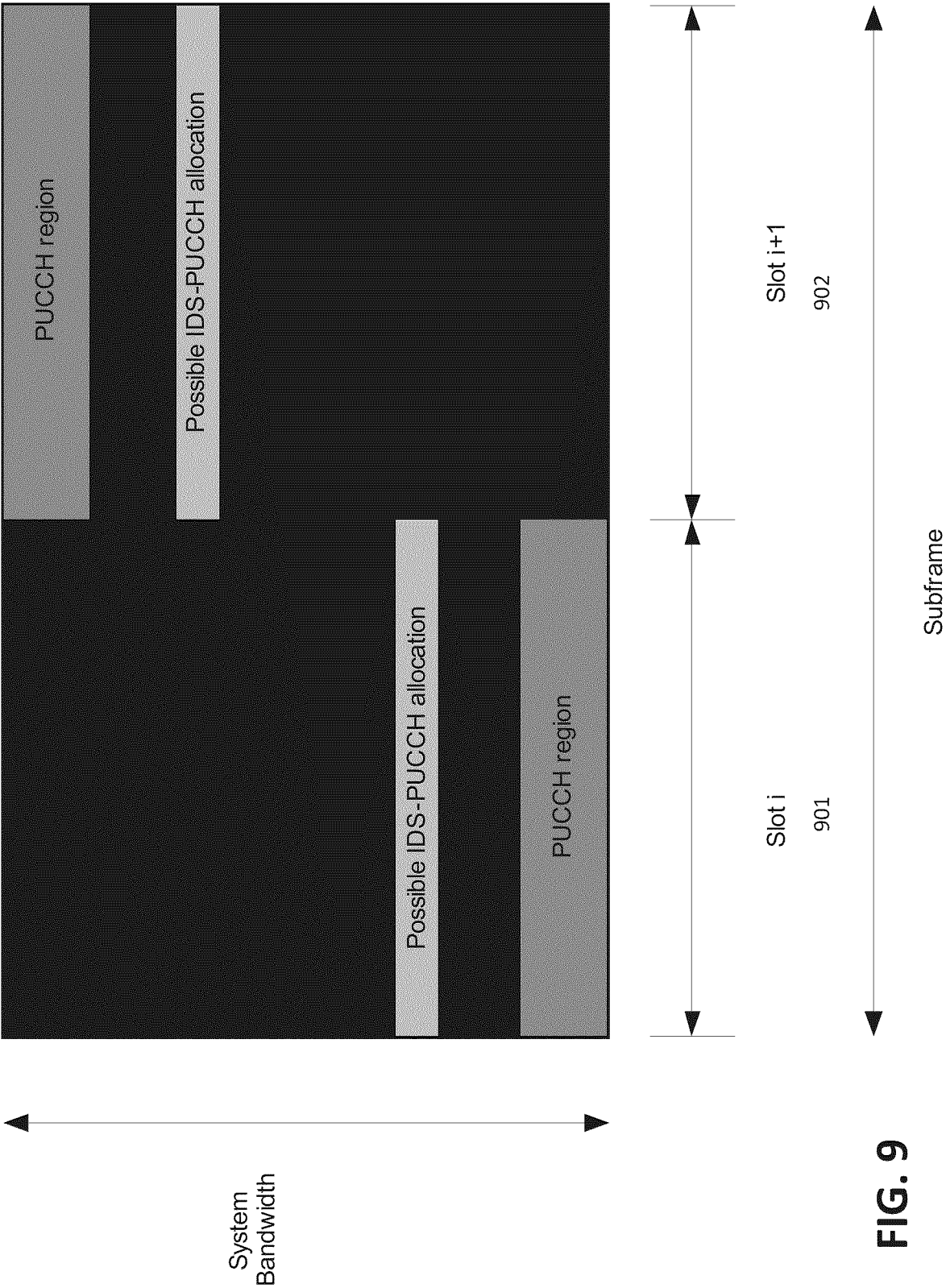


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/051002

A. CLASSIFICATION OF SUBJECT MATTER IPC: <i>H04W 72/04</i> (2009.01) 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) IPC: <i>H04W 72/04</i> (2009.01)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Database: TotalPatent Keywords: wireless communications network, UE, message, IDS, uplink, equipment, network, feedback, inter-device, signal transmit, identifier, control, device, wireless, signal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US2012/0294199 A1 (22 November 2012) Anchan (22-11-2012) *abstract, fig. 3A-3B & 5A-10; para. 0028-0041*	1-20
X	US2012/0302239 A1 (29 November 2012) Hu et al. (29-11-2012) *para. 0036-0051*	1-20
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 13 February 2014 (13-02-2014)	Date of mailing of the international search report 24 February 2014 (24-02-2014)	
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Coralie Gill (819) 934-5143	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2013/051002

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