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(54) METHOD AND APPARATUS OF ALLOCATING RESOURCE FOR MULTIPLE DEVICE-TO-DEVICE RESOURCE POOLS IN A WIRELESS COMMUNICATION SYSTEM

VERFAHREN UND VORRICHTUNG ZUR ZUWEISUNG VON RESSOURCEN FÜR MEHRERE VORRICHTUNG-ZU-VORRICHTUNG-RESSOURCENPOOLS IN EINEM DRAHTLOSKOMMUNIKATIONSSYSTEM

PROCÉDÉ ET APPAREIL D'ATTRIBUTION DE RESSOURCES POUR PLUSIEURS GROUPES DE RESSOURCES DE DISPOSITIF DANS UN SYSTÈME DE COMMUNICATION SANS FIL

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(73) Proprietor: **ASUSTek Computer Inc.**
Taipei City 112 (TW)

(72) Inventors:
- **CHEN, Wei-Yu**
  Taipei City 112 (TW)
- **TSENG, Li-Chih**
  Taipei City 112 (TW)
- **PAN, Li-Te**
  Taipei City 112 (TW)
- **LI, Ming-Che**
  Taipei City 112 (TW)

(74) Representative: **Hoefer & Partner Patentanwälte mbB**
Pilgersheimer Straße 20
81543 München (DE)

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Description

FIELD

[0001] This disclosure generally relates to wireless communication networks, and more particularly, to a method and apparatus of allocating resource for multiple device-to-device resource pools in a wireless communication system.

BACKGROUND

[0002] With the rapid rise in demand for communication of large amounts of data to and from mobile communication devices, traditional mobile voice communication networks are evolving into networks that communicate with Internet Protocol (IP) data packets. Such IP data packet communication can provide users of mobile communication devices with voice over IP, multimedia, multicast and on-demand communication services.

[0003] An exemplary network structure is an Evolved Universal Terrestrial Radio Access Network (E-UTRAN). The E-UTRAN system can provide high data throughput in order to realize the above-noted voice over IP and multimedia services. A new radio technology for the next generation (e.g., 5G) is currently being discussed by the 3GPP standards organization. Accordingly, changes to the current body of 3GPP standard are currently being submitted and considered to evolve and finalize the 3GPP standard.

[0004] WO 2018/021297 A1 discloses a communication technique based on a D2D interface, according to which a wireless signal is transmitted on the basis of a resource associated with the acquired geographical position of the communication device.

[0005] WO 20187055813 A1 discloses a method that support direct communication to provide flexibel resource pool sharing, in which the sidelink resource is selected by the UE.

[0006] EP 3051736 A1 discloses a method for allocating radio resources to logical channels when performing a logical channel prioritization procedure in a user equipment.

[0007] WO 2018/062857 A1 discloses a condition for a MAC entitiy in UE reselecting a sidelink resource in a wireless communication system. The use of resource pools is also illustrated in EP3614763 A1.

SUMMARY

[0008] A method and apparatus are disclosed from the perspective of a communication device and are defined in the independent claims. The dependent claims define preferred embodiments thereof. In one embodiment, the method includes the communication device being configured with a plurality of resource pools by a base station for a cell. The method further includes the communication device receiving a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools through a resource pool index in the grant. The method also includes the communication device using the resource to perform a transmission on a device-to-device interface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 shows a diagram of a wireless communication system according to one exemplary embodiment.

FIG. 2 is a block diagram of a transmitter system (also known as access network) and a receiver system (also known as user equipment or UE) according to one exemplary embodiment.

FIG. 3 is a functional block diagram of a communication system according to one exemplary embodiment.

FIG. 4 is a functional block diagram of the program code of FIG. 3 according to one exemplary embodiment.

FIG. 5 is a reproduction of Figure 6.1.6-1 of 3GPP TS 36.321 V15.2.0.

FIG. 6 is a reproduction of Figure 6.1.6-2 of 3GPP TS 36.321 V15.2.0.

FIG. 7 is a reproduction of Figure 6.1.6-3 of 3GPP TS 36.321 V15.2.0.

FIG. 8 is a reproduction of Figure 6.1.6-3a of 3GPP TS 36.321 V15.2.0.

FIG. 9 is a reproduction of Figure 6.1.6-4 of 3GPP TS 36.321 V15.2.0.

FIG. 10 is a reproduction of Table 6.2.4-1 of 3GPP TS 36.321 V15.2.0.

FIG. 11 is a reproduction of Table 6.2.4-2 of 3GPP TS 36.321 V15.2.0.

FIG. 12 is a reproduction of Figure 5.6.10.1-1 of 3GPP TS 36.331 V15.2.0.

FIG. 13 is a reproduction of Figure 5.10.2-1 of 3GPP TS 36.331 V15.2.0.

FIG. 14 is a reproduction of Figure 5.2.2.1-1 of 3GPP TS 38.331 V15.2.0.

FIG. 15 is a diagram according to one exemplary embodiment.

FIG. 16 is a flow chart according to one exemplary embodiment.

FIG. 17 is a flow chart according to one exemplary embodiment.

FIG. 18 is a flow chart according to one exemplary embodiment.

FIG. 19 is a flow chart according to a related art.

FIG. 20 is a flow chart according to another related art.

DETAILED DESCRIPTION

[0010] The exemplary wireless communication systems and devices described below employ a wireless communication system, supporting a broadcast service. Wireless communication systems are widely deployed to provide various types of communication such as voice, data, and so on. These systems may be based on code division multiple access (CDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), 3GPP LTE (Long Term Evolution) wireless access, 3GPP LTE-A or LTE-Advanced (Long Term Evolution Advanced), 3GPP2 UMB (Ultra Mobile Broadband), WiMax, 3GPP NR (New Radio), or some other modulation techniques.

[0011] In particular, the exemplary wireless communication systems devices described below may be designed to support one or more standards such as the standard offered by a consortium named "3rd Generation Partnership Project" referred to herein as 3GPP, including: TS 36.321 V15.2.0, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification"; TS 36.331 V15.2.0, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification"; TS 38.321 V15.2.0, "Medium Access Control (MAC) protocol specification"; and TS 38.331 V15.2.1, "Radio Resource Control (RRC) protocol specification". The standards and documents listed above are hereby expressly incorporated by reference in their entirety.

[0012] FIG. 1 shows a multiple access wireless communication system according to one embodiment of the invention. An access network 100 (AN) includes multiple antenna groups, one including 104 and 106, another including 108 and 110, and an additional including 112 and 114. In FIG. 1, only two antennas are shown for each antenna group, however, more or fewer antennas may be utilized for each antenna group. Access terminal 116 (AT) is in communication with antennas 112 and 114, where antennas 112 and 114 transmit information to access terminal 116 over forward link 120 and receive information from access terminal 116 over reverse link 118. Access terminal (AT) 122 is in communication with antennas 106 and 108, where antennas 106 and 108 transmit information to access terminal (AT) 122 over forward link 126 and receive information from access terminal (AT) 122 over reverse link 124. In a FDD system, communication links 118, 120, 124 and 126 may use different frequency for communication. For example, forward link 120 may use a different frequency then that used by reverse link 118.

[0013] Each group of antennas and/or the area in which they are designed to communicate is often referred to as a sector of the access network. In the embodiment, antenna groups each are designed to communicate to access terminals in a sector of the areas covered by access network 100.

[0014] In communication over forward links 120 and 126, the transmitting antennas of access network 100 may utilize beamforming in order to improve the signal-to-noise ratio of forward links for the different access terminals 116 and 122. Also, an access network using beamforming to transmit to access terminals scattered randomly through its coverage causes less interference to access terminals in neighboring cells than an access network transmitting through a single antenna to all its access terminals.

[0015] An access network (AN) may be a fixed station or base station used for communicating with the terminals and may also be referred to as an access point, a Node B, a base station, an enhanced base station, an evolved Node B (eNB), or some other terminology. An access terminal (AT) may also be called user equipment (UE), a wireless communication device, terminal, access terminal or some other terminology.

[0016] FIG. 2 is a simplified block diagram of an embodiment of a transmitter system 210 (also known as the access network) and a receiver system 250 (also known as access terminal (AT) or user equipment (UE)) in a MIMO system 200. At the transmitter system 210, traffic data for a number of data streams is provided from a data source 212 to a transmit (TX) data processor 214.

[0017] In one embodiment, each data stream is transmitted over a respective transmit antenna. TX data processor 214 formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

[0018] The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e., symbol mapped) based on a particular modulation scheme (e.g., BPSK, QPSK, M-PSK, or M-QAM) selected for that data stream to provide modulation symbols. The data rate, coding, and modulation for each data stream may be determined by instructions performed by processor 230.

[0019] The modulation symbols for all data streams are then provided to a TX MIMO processor 220, which

may further process the modulation symbols (e.g., for OFDM). TX MIMO processor 220 then provides N_T modulation symbol streams to N_T transmitters (TMTR) 222a through 222t. In certain embodiments, TX MIMO processor 220 applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.

[0020] Each transmitter 222 receives and processes a respective symbol stream to provide one or more analog signals, and further conditions (e.g., amplifies, filters, and upconverts) the analog signals to provide a modulated signal suitable for transmission over the MIMO channel. N_T modulated signals from transmitters 222a through 222t are then transmitted from N_T antennas 224a through 224t, respectively.

[0021] At receiver system 250, the transmitted modulated signals are received by N_R antennas 252a through 252r and the received signal from each antenna 252 is provided to a respective receiver (RCVR) 254a through 254r. Each receiver 254 conditions (e.g., filters, amplifies, and downconverts) a respective received signal, digitizes the conditioned signal to provide samples, and further processes the samples to provide a corresponding "received" symbol stream.

[0022] An RX data processor 260 then receives and processes the N_R received symbol streams from N_R receivers 254 based on a particular receiver processing technique to provide N_T "detected" symbol streams. The RX data processor 260 then demodulates, deinterleaves, and decodes each detected symbol stream to recover the traffic data for the data stream. The processing by RX data processor 260 is complementary to that performed by TX MIMO processor 220 and TX data processor 214 at transmitter system 210.

[0023] A processor 270 periodically determines which pre-coding matrix to use (discussed below). Processor 270 formulates a reverse link message comprising a matrix index portion and a rank value portion.

[0024] The reverse link message may comprise various types of information regarding the communication link and/or the received data stream. The reverse link message is then processed by a TX data processor 238, which also receives traffic data for a number of data streams from a data source 236, modulated by a modulator 280, conditioned by transmitters 254a through 254r, and transmitted back to transmitter system 210.

[0025] At transmitter system 210, the modulated signals from receiver system 250 are received by antennas 224, conditioned by receivers 222, demodulated by a demodulator 240, and processed by a RX data processor 242 to extract the reserve link message transmitted by the receiver system 250. Processor 230 then determines which pre-coding matrix to use for determining the beamforming weights then processes the extracted message.

[0026] Turning to FIG. 3, this figure shows an alternative simplified functional block diagram of a communication device according to one embodiment of the invention. As shown in FIG. 3, the communication device 300 in a wireless communication system can be utilized for realizing the UEs (or ATs) 116 and 122 in FIG. 1 or the base station (or AN) 100 in FIG. 1, and the wireless communications system is preferably the NR system. The communication device 300 may include an input device 302, an output device 304, a control circuit 306, a central processing unit (CPU) 308, a memory 310, a program code 312, and a transceiver 314. The control circuit 306 executes the program code 312 in the memory 310 through the CPU 308, thereby controlling an operation of the communications device 300. The communications device 300 can receive signals input by a user through the input device 302, such as a keyboard or keypad, and can output images and sounds through the output device 304, such as a monitor or speakers. The transceiver 314 is used to receive and transmit wireless signals, delivering received signals to the control circuit 306, and outputting signals generated by the control circuit 306 wirelessly. The communication device 300 in a wireless communication system can also be utilized for realizing the AN 100 in FIG. 1.

[0027] FIG. 4 is a simplified block diagram of the program code 312 shown in FIG. 3 in accordance with one embodiment of the invention. In this embodiment, the program code 312 includes an application layer 400, a Layer 3 portion 402, and a Layer 2 portion 404, and is coupled to a Layer 1 portion 406. The Layer 3 portion 402 generally performs radio resource control. The Layer 2 portion 404 generally performs link control. The Layer 1 portion 406 generally performs physical connections.

[0028] 3GPP TS 36.321 describes the D2D (Device-to-Device) V2X (Vehicle-to-Everything) procedures in MAC (Medium Access Control) as follows:

5.14 SL-SCH Data transfer

5.14.1 SL-SCH Data transmission

5.14.1.1 SL Grant reception and SCI transmission

[0029] In order to transmit on the SL-SCH the MAC entity must have at least one sidelink grant. Sidelink grants are selected as follows for sidelink communication:

- if the MAC entity is configured to receive a single sidelink grant dynamically on the PDCCH and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall:
  - using the received sidelink grant determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
  - consider the received sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first avail-

able SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was received, overwriting a previously configured sidelink grant occurring in the same SC period, if available;

- clear the configured sidelink grant at the end of the corresponding SC Period;

- else, if the MAC entity is configured by upper layers to receive multiple sidelink grants dynamically on the PDCCH and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall for each received sidelink grant:
  - using the received sidelink grant determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
  - consider the received sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first available SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was received, overwriting a previously configured sidelink grant received in the same subframe number but in a different radio frame as this configured sidelink grant occurring in the same SC period, if available;
  - clear the configured sidelink grant at the end of the corresponding SC Period;
- else, if the MAC entity is configured by upper layers to transmit using one or multiple pool(s) of resources as indicated in subclause 5.10.4 of [8] and more data is available in STCH than can be transmitted in the current SC period, the MAC entity shall for each sidelink grant to be selected:
  - if configured by upper layers to use a single pool of resources:
    - select that pool of resources for use;
  - else, if configured by upper layers to use multiple pools of resources:
    - select a pool of resources for use from the pools of resources configured by upper layers whose associated priority list includes the priority of the highest priority of the sidelink logical channel in the MAC PDU to be transmitted;

    NOTE: If more than one pool of resources has an associated priority list which includes the priority of the sidelink logical channel with the highest priority in the MAC PDU to be transmitted, it is left for UE implementation which one of those pools of resources to select.

  - randomly select the time and frequency resources for SL-SCH and SCI of a sidelink grant from the selected resource pool. The random function shall be such that each of the allowed selections [2] can be chosen with equal probability;
  - use the selected sidelink grant to determine the set of subframes in which transmission of SCI and transmission of first transport block occur according to subclause 14.2.1 of [2];
  - consider the selected sidelink grant to be a configured sidelink grant occurring in those subframes starting at the beginning of the first available SC Period which starts at least 4 subframes after the subframe in which the sidelink grant was selected;
  - clear the configured sidelink grant at the end of the corresponding SC Period;

    NOTE: Retransmissions on SL-SCH cannot occur after the configured sidelink grant has been cleared.

    NOTE: If the MAC entity is configured by upper layers to transmit using one or multiple pool(s) of resources as indicated in subclause 5.10.4 of [8], it is left for UE implementation how many sidelink grants to select within one SC period taking the number of sidelink processes into account.

[0030] Sidelink grants are selected as follows for V2X sidelink communication:

- if the MAC entity is configured to receive a sidelink grant dynamically on the PDCCH and data is available in STCH, the MAC entity shall:
  - use the received sidelink grant to determine the number of HARQ retransmissions and the set of subframes in which transmission of SCI and SL-SCH occur according to subclause 14.2.1 and 14.1.1.4A of [2];
  - consider the received sidelink grant to be a configured sidelink grant;
- if the MAC entity is configured by upper layers to receive a sidelink grant on the PDCCH addressed to SL Semi-Persistent Scheduling V-RNTI, the MAC entity shall for each SL SPS configuration:

- if PDCCH contents indicate SPS activation:
  - use the received sidelink grant to determine the number of HARQ retransmissions and the set of subframes in which transmission of SCI and SL-SCH occur according to subclause 14.2.1 and 14.1.1.4A of [2];
  - consider the received sidelink grant to be a configured sidelink grant;
- if PDCCH contents indicate SPS release:
  - clear the corresponding configured sidelink grant;

- if the MAC entity is configured by upper layers to transmit using a pool of resources as indicated in subclause 5.10.13.1 of [8] based on sensing, or partial sensing, or random selection only if upper layers indicates that transmissions of multiple MAC PDUs are allowed according to subclause 5.10.13.1a of [8], and the MAC entity selects to create a configured sidelink grant corresponding to transmissions of multiple MAC PDUs, and data is available in STCH, the MAC entity shall for each Sidelink process configured for multiple transmissions:
  - if SL_RESOURCE_RESELECTION_COUNTER = 0 and when SL_RESOURCE_RESELECTION_COUNTER was equal to 1 the MAC entity randomly selected, with equal probability, a value in the interval [0, 1] which is above the probability configured by upper layers in *probResourceKeep*; or
  - if neither transmission nor retransmission has been performed by the MAC entity on any resource indicated in the configured sidelink grant during the last second; or
  - if *sl-ReselectAfter* is configured and the number of consecutive unused transmission opportunities on resources indicated in the configured sidelink grant is equal to *sl-ReselectAfter*; or
  - if there is no configured sidelink grant; or
  - if the configured sidelink grant cannot accommodate a RLC SDU by using the maximum allowed MCS configured by upper layers in *maxMCS-PSSCH* and the MAC entity selects not to segment the RLC SDU; or
    NOTE: If the configured sidelink grant cannot accommodate the RLC SDU, it is left for UE implementation whether to perform segmentation or sidelink resource reselection.
  - if transmission(s) with the configured sidelink grant cannot fulfil the latency requirement of the data in a sidelink logical channel according to the associated PPPP, and the MAC entity selects not to perform transmission(s) corresponding to a single MAC PDU; or
    NOTE: If the latency requirement is not met, it is left for UE implementation whether to perform transmission(s) corresponding to single MAC PDU or sidelink resource reselection.

  - if a pool of resources is configured or reconfigured by upper layers:
    - clear the configured sidelink grant, if available;
    - select one of the allowed values configured by upper layers in *restrictResourceReservationPeriod* and set the resource reservation interval by multiplying 100 with the selected value;

    NOTE: How the UE selects this value is up to UE implementation.

    - randomly select, with equal probability, an integer value in the interval [5, 15] for the resource reservation interval higher than or equal to 100ms, in the interval [10, 30] for the resource reservation interval equal to 50ms or in the interval [25, 75] for the resource reservation interval equal to 20ms, and set SL_RESOURCE_RESELECTION_COUNTER to the selected value;
    - select the number of HARQ retransmissions from the allowed numbers that are configured by upper layers in *allowedRetxNumberPSSCH* included in *pssch-TxConfigList* and, if configured by upper layers, overlapped in *allowedRetxNumberPSSCH* indicated in *cbr-pssch-TxConfigList* for the highest priority of the sidelink logical channel(s) and the CBR measured by lower layers according to [6] if CBR measurement results are available or the corresponding *defaultTxConfigIndex* configured by upper layers if CBR measurement results are not available;
    - select an amount of frequency resources within the range that is configured by upper layers between *minSubchannel-NumberPSSCH* and *maxSubchannel-NumberPSSCH* included in *pssch-TxConfigList* and, if configured by upper layers, over-

lapped between *minSubchannel-NumberPSSCH* and *maxSubchannel-NumberPSSCH* indicated in *cbr-pssch-TxConfigList* for the highest priority of the sidelink logical channel(s) and the CBR measured by lower layers according to [6] if CBR measurement results are available or the corresponding *defaultTxConfigIndex* configured by upper layers if CBR measurement results are not available;

- if transmission based on random selection is configured by upper layers:
  - randomly select the time and frequency resources for one transmission opportunity from the resource pool, according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;
- else:
  - randomly select the time and frequency resources for one transmission opportunity from the resources indicated by the physical layer according to subclause 14.1.1.6 of [2], according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;
- use the randomly selected resource to select a set of periodic resources spaced by the resource reservation interval for transmission opportunities of SCI and SL-SCH corresponding to the number of transmission opportunities of MAC PDUs determined in subclause 14.1.1.4B of [2];
- if the number of HARQ retransmissions is equal to 1 and there are available resources left in the resources indicated by the physical layer that meet the conditions in subclause 14.1.1.7 of [2] for more transmission opportunities:
  - randomly select the time and frequency resources for one transmission opportunity from the available resources, according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;
  - use the randomly selected resource to select a set of periodic resources spaced by the resource reservation interval for the other transmission opportunities of SCI and SL-SCH corresponding to the number of retransmission opportunities of the MAC PDUs determined in subclause 14.1.1.4B of [2];
  - consider the first set of transmission opportunities as the new transmission opportunities and the other set of transmission opportunities as the retransmission opportunities;
  - consider the set of new transmission opportunities and retransmission opportunities as the selected sidelink grant.
- else:
  - consider the set as the selected sidelink grant;
- use the selected sidelink grant to determine the set of subframes in which transmissions of SCI and SL-SCH occur according to subclause 14.2.1 and 14.1.1.4B of [2];
- consider the selected sidelink grant to be a configured sidelink grant;
- else if SL_RESOURCE_RESELECTION_COUNTER = 0 and when SL_RESOURCE_RESELECTION_COUNTER was equal to 1 the MAC entity randomly selected, with equal probability, a value in the interval [0, 1] which is less than or equal to the probability configured by upper layers in *probResourceKeep:*
  - clear the configured sidelink grant, if available;
  - randomly select, with equal probability, an integer value in the interval [5, 15] for the resource reservation interval higher than or equal to 100ms, in the interval [10, 30] for the resource reservation interval equal to 50ms or in the interval [25, 75] for the resource reservation interval equal to 20ms, and set SL_RESOURCE_RESELECTION_COUNTER to the selected value;

- use the previously selected sidelink grant for the number of transmissions of the MAC PDUs determined in subclause 14.1.1.4B of [2] with the resource reservation interval to determine the set of subframes in which transmissions of SCI and SL-SCH occur according to subclause 14.2.1 and 14.1.1.4B of [2];

- consider the selected sidelink grant to be a configured sidelink grant;

- else, if the MAC entity is configured by upper layers to transmit using a pool of resources as indicated in subclause 5.10.13.1 of [8], the MAC entity selects to create a configured sidelink grant corresponding to transmission(s) of a single MAC PDU, and data is available in STCH, the MAC entity shall for a Sidelink process:

  - select the number of HARQ retransmissions from the allowed numbers that are configured by upper layers in *allowedRetxNumberPSSCH* included in *pssch-TxConfigList* and, if configured by upper layers, overlapped in *allowedRetxNumberPSSCH* indicated in *cbr-pssch-TxConfigList* for the highest priority of the sidelink logical channel(s) and the CBR measured by lower layers according to [6] if CBR measurement results are available or the corresponding *defaultTxConfigIndex* configured by upper layers if CBR measurement results are not available;

  - select an amount of frequency resources within the range that is configured by upper layers between *minSubchannel-NumberPSSCH* and *maxSubchannel-NumberPSSCH* included in *pssch-TxConfigList* and, if configured by upper layers, overlapped between *minSubchannel-NumberPSSCH* and *maxSubchannel-NumberPSSCH* indicated in *cbr-pssch-TxConfigList for* the highest priority of the sidelink logical channel(s) and the CBR measured by lower layers according to [6] if CBR measurement results are available or the corresponding *defaultTxConfigIndex* configured by upper layers if CBR measurement results are not available;

  - if transmission based on random selection is configured by upper layers:

    - randomly select the time and frequency resources for one transmission opportunity of SCI and SL-SCH from the resource pool, according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;

  - else:

    - randomly select the time and frequency resources for one transmission opportunity of SCI and SL-SCH from the resource pool indicated by the physical layer according to subclause 14.1.1.6 of [2] , according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;

  - if the number of HARQ retransmissions is equal to 1:

    - if transmission based on random selection is configured by upper layers and there are available resources that meet the conditions in subcause 14.1.1.7 of [2] for one more transmission opportunity:

      - randomly select the time and frequency resources for the other transmission opportunity of SCI and SL-SCH corresponding to additional transmission of the MAC PDU from the available resources, according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;

    - else, if transmission based on sensing or partial sensing is configured by upper layers and there are available resources left in the resources indicated by the physical layer that meet the conditions in subcause 14.1.1.7 of [2] for one more transmission opportunity:

      - randomly select the time and frequency resources for the other transmission opportunity of SCI and SL-SCH corresponding to additional transmission of the MAC PDU from the available resources, according to the amount of selected frequency resources. The random function shall be such that each of the allowed selections can be chosen with equal probability;

    - consider a transmission opportunity which comes first in time as the new transmission opportunity and a transmission opportunity

which comes later in time as the retransmission opportunity;

- consider both of the transmission opportunities as the selected sidelink grant;

- else:

  - consider the transmission opportunity as the selected sidelink grant;

- use the selected sidelink grant to determine the subframes in which transmission(s) of SCI and SL-SCH occur according to subclause 14.2.1 and 14.1.1.4B of [2];

- consider the selected sidelink grant to be a configured sidelink grant;

  NOTE: For V2X sidelink communication, the UE should ensure the randomly selected time and frequency resources fulfill the latency requirement.

  NOTE: For V2X sidelink communication, when there is no overlapping between the chosen configuration(s) in *pssch-TxConfigList and* chosen configuration(s) indicated in *cbr-pssch-TxConfigList,* it is up to UE implementation whether the UE transmits and which transmitting parameters the UE uses between allowed configuration(s) indicated in *pssch-TxConfigList* and allowed configuration(s) indicated in *cbr-pssch-TxConfigList.*

[0031] The MAC entity shall for each subframe:

- if the MAC entity has a configured sidelink grant occurring in this subframe:

  - if SL_RESOURCE_RESELECTION_COUNTER = 1 and the MAC entity randomly selected, with equal probability, a value in the interval [0, 1] which is above the probability configured by upper layers in *probResourceKeep*:

    - set the resource reservation interval equal to 0;

  - if the configured sidelink grant corresponds to transmission of SCI:

    - instruct the physical layer to transmit SCI corresponding to the configured sidelink grant;

    - for V2X sidelink communication, deliver the configured sidelink grant, the associated HARQ information and the value of the highest priority of the sidelink logical channel(s) in the MAC PDU to the Sidelink HARQ Entity for this subframe;

  - else if the configured sidelink grant corresponds to transmission of first transport block for sidelink communication:

    - deliver the configured sidelink grant and the associated HARQ information to the Sidelink HARQ Entity for this subframe.

  NOTE: If the MAC entity has multiple configured grants occurring in one subframe and if not all of them can be processed due to the single-cluster SC-FDM restriction, it is left for UE implementation which one of these to process according to the procedure above.

5.14.1.2 Sidelink HARQ operation

5.14.1.2.1 Sidelink HARQ Entity

[0032] There is one Sidelink HARQ Entity at the MAC entity for transmission on SL-SCH, which maintains a number of parallel Sidelink processes.

[0033] For sidelink communication, the number of transmitting Sidelink processes associated with the Sidelink HARQ Entity is defined in [8].

[0034] For V2X sidelink communication, the maximum number of transmitting Sidelink processes associated with the Sidelink HARQ Entity is 8. A sidelink process may be configured for transmissions of multiple MAC PDUs. For transmissions of multiple MAC PDUs, the maximum number of transmitting Sidelink processes with the Sidelink HARQ Entity is 2.

[0035] A delivered and configured sidelink grant and its associated HARQ information are associated with a Sidelink process.

[0036] For each subframe of the SL-SCH and each Sidelink process, the Sidelink HARQ Entity shall:

- if a sidelink grant corresponding to a new transmission opportunity has been indicated for this Sidelink process and there is SL data, for sidelink logical channels of ProSe destination associated with this sidelink grant, available for transmission:

  - obtain the MAC PDU from the "Multiplexing and assembly" entity;

  - deliver the MAC PDU and the sidelink grant and the HARQ information to this Sidelink process;

  - instruct this Sidelink process to trigger a new

transmission.

- else, if this subframe corresponds to retransmission opportunity for this Sidelink process:
  - instruct this Sidelink process to trigger a retransmission.

NOTE: The resources for retransmission opportunities are specified in subclause 14.2.1 of [2] unless specified in subclause 5.14.1.1.

5.14.1.2.2 Sidelink process

[0037] The Sidelink process is associated with a HARQ buffer.

[0038] The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is updated modulo 4.

[0039] New transmissions and retransmissions either for a given SC period in sidelink communication or in V2X sidelink communication are performed on the resource indicated in the sidelink grant as specified in subclause 5.14.1.1 and with the MCS configured by upper layers (if configured) unless selected below.

[0040] If the sidelink process is configured to perform transmissions of multiple MAC PDUs for V2X sidelink communication the process maintains a counter SL_RESOURCE_RESELECTION_COUNTER. For other configurations of the sidelink process, this counter is not available.

[0041] If the Sidelink HARQ Entity requests a new transmission, the Sidelink process shall:

- for V2X sidelink communication in UE autonomous resource selection:
  - select a MCS which is, if configured, within the range that is configured by upper layers between *minMCS-PSSCH* and *maxMCS-PSSCH* included in *pssch-TxConfigList* and, if configured by upper layers, overlapped between *minMCS-PSSCH* and *maxMCS-PSSCH* indicated in *cbr-pssch-TxConfigList* for the highest priority of the sidelink logical channel(s) in the MAC PDU and the CBR measured by lower layers according to [6] if CBR measurement results are available or the corresponding *defaultTxConfigIndex* configured by upper layers if CBR measurement results are not available;

    NOTE 1: MCS selection is up to UE implementation if the MCS or the corresponding range is not configured by upper layers.

    NOTE 2: For V2X sidelink communication, when there is no overlapping between the chosen configuration(s) included in *pssch-TxConfigList and* chosen configuration(s) indicated in *cbr-pssch-TxConfigList,* it is up to UE implementation whether the UE transmits and which transmitting parameters the UE uses between allowed configuration(s) indicated in *pssch-TxConfigList* and allowed configuration(s) indicated in *cbr-pssch-TxConfigList.*
  - set CURRENT_IRV to 0;
  - store the MAC PDU in the associated HARQ buffer;
  - store the sidelink grant received from the Sidelink HARQ Entity;
  - generate a transmission as described below.

[0042] If the Sidelink HARQ Entity requests a retransmission, the Sidelink process shall:

- generate a transmission as described below.

[0043] To generate a transmission, the Sidelink process shall:

- if there is no uplink transmission; or if the MAC entity is able to perform uplink transmissions and transmissions on SL-SCH simultaneously at the time of the transmission; or if there is a MAC PDU to be transmitted in this TTI in uplink, except a MAC PDU obtained from the Msg3 buffer and transmission of V2X sidelink communication is prioritized over uplink transmission; and
- if there is no Sidelink Discovery Gap for Transmission or no transmission on PSDCH at the time of the transmission; or, in case of transmissions of V2X sidelink communication, if the MAC entity is able to perform transmissions on SL-SCH and transmissions on PSDCH simultaneously at the time of the transmission:
  - instruct the physical layer to generate a transmission according to the stored sidelink grant with the redundancy version corresponding to the CURRENT_IRV value.
- increment CURRENT_IRV by 1;
- if this transmission corresponds to the last transmission of the MAC PDU:
  - decrement SL_RESOURCE_RESELECTION_COUNTER by 1, if available.

[0044] The transmission of V2X sidelink communica-

tion is prioritized over uplink transmission if the following conditions are met:

- if the MAC entity is not able to perform uplink transmissions and transmissions of V2X sidelink communication simultaneously at the time of the transmission; and
- if uplink transmission is not prioritized by upper layer according to [15]; and
- if the value of the highest priority of the sidelink logical channel(s) in the MAC PDU is lower than *thresSL-TxPrioritization* if *thresSL-TxPrioritization* is configured.

5.14.1.3 Multiplexing and assembly

[0045] For PDU(s) associated with one SCI, MAC shall consider only logical channels with the same Source Layer-2 ID-Destination Layer-2 ID pair.

[0046] Multiple transmissions within overlapping SC periods to different ProSe Destinations are allowed subject to single-cluster SC-FDM constraint.

[0047] In V2X sidelink communication, multiple transmissions for different Sidelink processes are allowed to be independently performed in different subframes.

5.14.1.3.1 Logical channel prioritization

[0048] The Logical Channel Prioritization procedure is applied when a new transmission is performed. Each sidelink logical channel has an associated priority which is the PPPP. Multiple sidelink logical channels may have the same associated priority. The mapping between priority and LCID is left for UE implementation.

[0049] The MAC entity shall perform the following Logical Channel Prioritization procedure either for each SCI transmitted in an SC period in sidelink communication, or for each SCI corresponding to a new transmission in V2X sidelink communication:

- The MAC entity shall allocate resources to the sidelink logical channels in the following steps:
  - Only consider sidelink logical channels not previously selected for this SC period and the SC periods (if any) which are overlapping with this SC period, to have data available for transmission in sidelink communication.
  - Step 0: Select a ProSe Destination, having the sidelink logical channel with the highest priority, among the sidelink logical channels having data available for transmission;
- For each MAC PDU associated to the SCI:
  - Step 1: Among the sidelink logical channels belonging to the selected ProSe Destination and having data available for transmission, allocate resources to the sidelink logical channel with the highest priority;
  - Step 2: if any resources remain, sidelink logical channels belonging to the selected ProSe Destination are served in decreasing order of priority until either the data for the sidelink logical channel(s) or the SL grant is exhausted, whichever comes first. Sidelink logical channels configured with equal priority should be served equally.
- The UE shall also follow the rules below during the scheduling procedures above:
  - the UE should not segment an RLC SDU (or partially transmitted SDU) if the whole SDU (or partially transmitted SDU) fits into the remaining resources;
  - if the UE segments an RLC SDU from the sidelink logical channel, it shall maximize the size of the segment to fill the grant as much as possible;
  - the UE should maximise the transmission of data;
  - if the MAC entity is given a sidelink grant size that is equal to or larger than 10 bytes (for sidelink communication) or 11 bytes (for V2X sidelink communication) while having data available for transmission, the MAC entity shall not transmit only padding.

5.14.1.3.2 Multiplexing of MAC SDUs

[0050] The MAC entity shall multiplex MAC SDUs in a MAC PDU according to subclauses 5.14.1.3.1 and 6.1.6.

5.14.1.4 Buffer Status Reporting

[0051] The sidelink Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of sidelink data available for transmission in the SL buffers associated with the MAC entity. RRC controls BSR reporting for the sidelink by configuring the two timers periodic-BSR-TimerSL and retx-BSR-TimerSL. Each sidelink logical channel belongs to a ProSe Destination. Each sidelink logical channel is allocated to an LCG depending on the priority of the sidelink logical channel and the mapping between LCG ID and priority which is provided by upper layers in logicalChGroupInfoList [8]. LCG is defined per ProSe Destination.

[0052] A sidelink Buffer Status Report (BSR) shall be triggered if any of the following events occur:

- if the MAC entity has a configured SL-RNTI or a configured SL-V-RNTI:
  - SL data, for a sidelink logical channel of a ProSe Destination, becomes available for transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively) and either the data belongs to a sidelink logical channel with higher priority than the priorities of the sidelink logical channels which belong to any LCG belonging to the same ProSe Destination and for which data is already available for transmission, or there is currently no data available for transmission for any of the sidelink logical channels belonging to the same ProSe Destination, in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR";
  - UL resources are allocated and number of padding bits remaining after a Padding BSR has been triggered is equal to or larger than the size of the Sidelink BSR MAC control element containing the buffer status for at least one LCG of a ProSe Destination plus its subheader, in which case the Sidelink BSR is referred below to as "Padding Sidelink BSR";
  - *retx-BSR-TimerSL* expires and the MAC entity has data available for transmission for any of the sidelink logical channels, in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR";
  - *periodic-BSR-TimerSL* expires, in which case the Sidelink BSR is referred below to as "Periodic Sidelink BSR";
- else:
  - An SL-RNTI or an SL-V-RNTI is configured by upper layers and SL data is available for

    transmission in the RLC entity or in the PDCP entity (the definition of what data shall be considered as available for transmission is specified in [3] and [4] respectively), in which case the Sidelink BSR is referred below to as "Regular Sidelink BSR".

[0053] For Regular and Periodic Sidelink BSR:

- if the number of bits in the UL grant is equal to or larger than the size of a Sidelink BSR containing buffer status for all LCGs having data available for transmission plus its subheader:
  - report Sidelink BSR containing buffer status for all LCGs having data available for transmission;
- else report Truncated Sidelink BSR containing buffer status for as many LCGs having data available for transmission as possible, taking the number of bits in the UL grant into consideration.

[0054] For Padding Sidelink BSR:

- if the number of padding bits remaining after a Padding BSR has been triggered is equal to or larger than the size of a Sidelink BSR containing buffer status for all LCGs having data available for transmission plus its subheader:
  - report Sidelink BSR containing buffer status for all LCGs having data available for transmission;
- else report Truncated Sidelink BSR containing buffer status for as many LCGs having data available for transmission as possible, taking the number of bits in the UL grant into consideration.

[0055] If the Buffer Status reporting procedure determines that at least one Sidelink BSR has been triggered and not cancelled:

- if the MAC entity has UL resources allocated for new transmission for this TTI and the allocated UL resources can accommodate a Sidelink BSR MAC control element plus its subheader as a result of logical channel prioritization:
  - instruct the Multiplexing and Assembly procedure to generate the Sidelink BSR MAC control element(s);
  - start or restart periodic-BSR-TimerSL except when all the generated Sidelink BSRs are Truncated Sidelink BSRs;
  - start or restart *retx-BSR-TimerSL*;
- else if a Regular Sidelink BSR has been triggered:
  - if an uplink grant is not configured:
    - a Scheduling Request shall be triggered.

[0056] A MAC PDU shall contain at most one Sidelink BSR MAC control element, even when multiple events trigger a Sidelink BSR by the time a Sidelink BSR can be transmitted in which case the Regular Sidelink BSR and the Periodic Sidelink BSR shall have precedence over the padding Sidelink BSR.

[0057] The MAC entity shall restart retx-BSR-TimerSL upon reception of an SL grant.

[0058] All triggered regular Sidelink BSRs shall be can-

celled in case the remaining configured SL grant(s) valid for this SC Period can accommodate all pending data available for transmission in sidelink communication or in case the remaining configured SL grant(s) valid can accommodate all pending data available for transmission in V2X sidelink communication. All triggered Sidelink BSRs shall be cancelled in case the MAC entity has no data available for transmission for any of the sidelink logical channels. All triggered Sidelink BSRs shall be cancelled when a Sidelink BSR (except for Truncated Sidelink BSR) is included in a MAC PDU for transmission. All triggered Sidelink BSRs shall be cancelled, and retx-BSR-TimerSL and periodic-BSR-TimerSL shall be stopped, when upper layers configure autonomous resource selection.

[0059] The MAC entity shall transmit at most one Regular/Periodic Sidelink BSR in a TTI. If the MAC entity is requested to transmit multiple MAC PDUs in a TTI, it may include a padding Sidelink BSR in any of the MAC PDUs which do not contain a Regular/Periodic Sidelink BSR.

[0060] All Sidelink BSRs transmitted in a TTI always reflect the buffer status after all MAC PDUs have been built for this TTI. Each LCG shall report at the most one buffer status value per TTI and this value shall be reported in all Sidelink BSRs reporting buffer status for this LCG.

NOTE: A Padding Sidelink BSR is not allowed to cancel a triggered Regular/Periodic Sidelink BSR. A Padding Sidelink BSR is triggered for a specific MAC PDU only and the trigger is cancelled when this MAC PDU has been built.

5.14.2 SL-SCH Data reception

5.14.2.1 SCI reception

[0061] SCI transmitted on the PSCCH indicate if there is a transmission on SL-SCH and provide the relevant HARQ information.

[0062] The MAC entity shall:

- for each subframe during which the MAC entity monitors PSCCH:
  - if SCI for this subframe has been received on the PSCCH for sidelink communication with a Group Destination ID of interest to this MAC entity:
    - determine the set of subframes in which reception of the first transport blocks occur according to subclause 14.2.2 of [2] using the received SCI;
    - store the SCI and associated HARQ information as SCI valid for the subframes corresponding to first transmission of each transport block;
  - else if SCI for this subframe has been received on the PSCCH for V2X sidelink communication:
    - determine the set of subframes in which reception of the transport block occur according to subclause 14.1.2 of [2] using the received SCI;
    - store the SCI and associated HARQ information as SCI valid for the subframes corresponding to transmission(s) of the transport block;
- for each subframe for which the MAC entity has a valid SCI:
  - deliver the SCI and the associated HARQ information to the Sidelink HARQ Entity.

5.14.2.2 Sidelink HARQ operation

5.14.2.2.1 Sidelink HARQ Entity

[0063] There is one Sidelink HARQ Entity at the MAC entity for reception of the SL-SCH which maintains a number of parallel Sidelink processes.

[0064] Each Sidelink process is associated with SCI in which the MAC entity is interested. If SCI includes the Group Destination ID, this interest is as determined by the Group Destination ID of the SCI. The Sidelink HARQ Entity directs HARQ information and associated TBs received on the SL-SCH to the corresponding Sidelink processes.

[0065] The number of Receiving Sidelink processes associated with the Sidelink HARQ Entity is defined in [8].

[0066] For each subframe of the SL-SCH, the Sidelink HARQ Entity shall:

- for each SCI valid in this subframe:
  - allocate the TB received from the physical layer and the associated HARQ information to a Sidelink process, associate this Sidelink process with this SCI and consider this transmission to be a new transmission.
- for each Sidelink process:
  - if this subframe corresponds to retransmission opportunity for the Sidelink process according to its associated SCI:
    - allocate the TB received from the physical layer and the associated HARQ information to the Sidelink process and consider this transmission to be a retransmission.

5.14.2.2.2 Sidelink process

[0067] For each subframe where a transmission takes place for the Sidelink process, one TB and the associated HARQ information is received from the Sidelink HARQ Entity.

[0068] The sequence of redundancy versions is 0, 2, 3, 1. The variable CURRENT_IRV is an index into the sequence of redundancy versions. This variable is updated modulo 4.

[0069] For each received TB and associated HARQ information, the Sidelink process shall:

- if this is a new transmission:
  - set CURRENT_IRV to 0;
  - store the received data in the soft buffer and optionally attempt to decode the received data according to CURRENT_IRV.
- else if this is a retransmission:
  - if the data for this TB has not yet been successfully decoded:
    - increment CURRENT_IRV by 1;
    - combine the received data with the data currently in the soft buffer for this TB and optionally attempt to decode the combined data according to the CURRENT_IRV.
  - if the data which the MAC entity attempted to decode was successfully decoded for this TB:
    - if this is the first successful decoding of the data for this TB:
      - if the DST field of the decoded MAC PDU subheader is equal to the 16 MSB of any of the Destination Layer-2 ID(s) of the UE for which the 8 LSB are equal to the Group Destination ID in the corresponding SCI:
        - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.
      - else if the DST field of the decoded MAC PDU subheader is equal to any of the Destination Layer-2 ID(s) of the UE:
        - deliver the decoded MAC PDU to the disassembly and demultiplexing entity.

5.14.2.3 Disassembly and demultiplexing

[0070] The MAC entity shall disassemble and demultiplex a MAC PDU as defined in subclause 6.1.6. [...]

6.1.6 MAC PDU (SL-SCH)

[0071] A MAC PDU consists of a MAC header, one or more MAC Service Data Units (MAC SDU), and optionally padding; as described in Figure 6.1.6-4.

[0072] Both the MAC header and the MAC SDUs are of variable sizes.

[0073] A MAC PDU header consists of one SL-SCH subheader, one or more MAC PDU subheaders; each subheader except SL-SCH subheader corresponds to either a MAC SDU or padding.

[0074] The SL-SCH subheader consists of the seven header fields V/R/R/R/R/SRC/DST.

[0075] A MAC PDU subheader consists of the six header fields R/R/E/LCID/F/L but for the last subheader in the MAC PDU. The last subheader in the MAC PDU consists solely of the four header fields R/R/E/LCID. A MAC PDU subheader corresponding to padding consists of the four header fields R/R/E/LCID.

[Figure 6.1.6-1 of 3GPP TS 36.321 V15.2.0, entitled "R/R/E/LCID/F/L MAC subheader", is reproduced as FIG. 5]

[Figure 6.1.6-2 of 3GPP TS 36.321 V15.2.0, entitled "R/R/E/LCID MAC subheader", is reproduced as FIG. 6]

[Figure 6.1.6-3 of 3GPP TS 36.321 V15.2.0, entitled "SL-SCH MAC subheader for V =’0001’ and ’0010"’, is reproduced as FIG. 7]

[Figure 6.1.6-3a of 3GPP TS 36.321 V15.2.0, entitled "SL-SCH MAC subheader for V =’0011’", is reproduced as FIG. 8]

[0076] MAC PDU subheaders have the same order as the corresponding MAC SDUs and padding.

[0077] Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the MAC entity shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

[0078] When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed after the SL-SCH subheader and before any other MAC PDU subheader.

[0079] A maximum of one MAC PDU can be transmitted per TB.

[Figure 6.1.6-3a of 3GPP TS 36.321 V15.2.0, entitled "Example of MAC PDU consisting of MAC header, MAC SDUs and padding", is reproduced as FIG. 9]

[0080] [...]

6.2.4 MAC header for SL-SCH

[0081] The MAC header is of variable size and consists of the following fields:

- V: The MAC PDU format version number field indicates which version of the SL-SCH subheader is used. In this version of the specification three format versions are defined, and this field shall therefore be set to "0001", "0010", and "0011". If the DST field is 24 bits this field shall be set to "0011". The V field size is 4 bits;

- SRC: The Source Layer-2 ID field carries the identity of the source. It is set to the ProSe UE ID. The SRC field size is 24 bits;

- DST: The DST field can be 16 bits or 24 bits. If it is 16 bits, it carries the 16 most significant bits of the Destination Layer-2 ID. If it is 24 bits, it is set to the Destination Layer-2 ID. For sidelink communication, the Destination Layer-2 ID is set to the ProSe Layer-2 Group ID or Prose UE ID. For V2X sidelink communication, the Destination Layer-2 ID is set to the identifier provided by upper layers as defined in [14]. If the V field is set to "0001", this identifier is a groupcast identifier. If the V field is set to "0010", this identifier is a unicast identifier;

- LCID: The Logical Channel ID field uniquely identifies the logical channel instance within the scope of one Source Layer-2 ID and Destination Layer-2 ID pair of the corresponding MAC SDU or padding as described in table 6.2.4-1. There is one LCID field for each MAC SDU or padding included in the MAC PDU. In addition to that, one or two additional LCID fields are included in the MAC PDU, when single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU. The LCID field size is 5 bits;

- L: The Length field indicates the length of the corresponding MAC SDU in bytes. There is one L field per MAC PDU subheader except for the last subheader. The size of the L field is indicated by the F field;

- F: The Format field indicates the size of the Length field as indicated in table 6.2.4-2. There is one F field per MAC PDU subheader except for the last subheader. The size of the F field is 1 bit. If the size of the MAC SDU is less than 128 bytes, the value of the F field is set to 0, otherwise it is set to 1;

- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least R/R/E/LCID fields. The E field is set to "0" to indicate that either a MAC SDU or padding starts at the next byte;

- R: Reserved bit, set to "0".

[0082] The MAC header and subheaders are octet aligned.

[Table 6.2.4-1 of 3GPP TS 36.321 V15.2.0, entitled "Values of LCID for SL-SCH", is reproduced as FIG. 10]

[Table 6.2.4-2 of 3GPP TS 36.321 V15.2.0, entitled "Values of F field:", is reproduced as FIG. 11]

[0083] 3GPP TS 36.331 describes D2D V2X procedures in RRC (Radio Resource Control) as follows:

5.6.10 UE Assistance Information

5.6.10.1 General

[Figure 5.6.10.1-1 of 3GPP TS 36.331 V15.2.0, entitled "UE Assistance Information", is reproduced as FIG. 12]

[0084] The purpose of this procedure is to inform E-UTRAN of the UE's power saving preference and SPS assistance information, maximum PDSCH/PUSCH bandwidth configuration preference, overheating assistance information, or the UE's delay budget report carrying desired increment/decrement in the Uu air interface delay or connected mode DRX cycle length and for BL UEs or UEs in CE of the RLM event ("early-out-of-sync" or "early-in-sync") and RLM information. Upon configuring the UE to provide power preference indications E-UTRAN may consider that the UE does not prefer a configuration primarily optimised for power saving until the UE explictly indicates otherwise.

5.6.10.2 Initiation

[0085] A UE capable of providing power preference indications in RRC_CONNECTED may initiate the procedure in several cases including upon being configured to provide power preference indications and upon change of power preference. A UE capable of providing SPS assistance information in RRC_CONNECTED may initiate the procedure in several cases including upon being configured to provide SPS assistance information and upon change of SPS assistance information.

[0086] A UE capable of providing delay budget report

in RRC_CONNECTED may initiate the procedure in several cases, including upon being configured to provide delay budget report and upon change of delay budget preference.

[0087] A UE capable of CE mode and providing maximum PDSCH/PUSCH bandwidth preference in RRC_CONNECTED may initiate the procedure upon being configured to provide maximum PDSCH/PUSCH bandwidth preference and/or upon change of maximum PDSCH/PUSCH bandwidth preference.

[0088] A UE capable of providing overheating assistance information in RRC_CONNECTED may initiate the procedure if it was configured to do so, upon detecting internal overheating, or upon detecting that it is no longer experiencing an overheating condition.

[0089] Upon initiating the procedure, the UE shall:

1> if configured to provide power preference indications:

2> if the UE did not transmit a *UEAssistanceInformation* message with *powerPrefIndication* since it was configured to provide power preference indications; or

2> if the current power preference is different from the one indicated in the last transmission of the *UEAssistanceInformation* message and timer T340 is not running:
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

1> if configured to provide maximum PDSCH/PUSCH bandwidth preference:

2> if the UE did not transmit a *UEAssistanceInformation* message with *bw-Preference* since it was configured to provide maximum PDSCH/PUSCH bandwidth preference; or

2> if the current maximum PDSCH/PUSCH bandwidth preference is different from the one indicated in the last transmission of the *UEAssistanceInformation* message and timer T341 is not running;
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

1> if configured to provide SPS assistance information:

2> if the UE did not transmit a *UEAssistanceInformation* message with *sps-AssistanceInformation* since it was configured to provide SPS assistance information; or

2> if the current SPS assistance information is different from the one indicated in the last transmission of the *UEAssistanceInformation* message:
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

1> if configured to report RLM events:

2> if "early-out-of-sync" event has been detected and T343 is not running; or

2> if "early-in-sync" event has been detected and T344 is not running:
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

1> if configured to provide delay budget report:

2> if the UE did not transmit a *UEAssistanceInformation* message with *delayBudgetReport* since it was configured to provide delay budget report; or

2> if the current delay budget is different from the one indicated in the last transmission of the *UEAssistanceInformation* message and timer T342 is not running:
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

1> if configured to provide overheating assistance information:

2> if the overheating condition has been detected and T345 is not running; or
2> if the current overheating assistance information is different from the one indicated in the last transmission of the *UEAssistanceInformation* message and timer T345 is not running:
3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.6.10.3;

5.6.10.3 Actions related to transmission of *UEAssistanceInformation* message

[0090] The UE shall set the contents of the *UEAssistanceInformation* message for power preference indications:

1> if configured to provide power preference indication and if the UE prefers a configuration primarily optimised for power saving:
2> set *powerPrefIndication* to *lowPowerConsump-*

tion;

1> else if configured to provide power preference indication:

2> start or restart timer T340 with the timer value set to the *powerPrefIndicationTimer*;

2> set *powerPrefIndication* to *normal;*

[0091] The UE shall set the contents of the *UEAssistanceInformation* message for SPS assistance information:

1> if configured to provide SPS assistance information:

2> if there is any traffic for V2X sidelink communication which needs to report SPS assistance information:
3> include *trafficPatternInfoListSL* in the *UEAssistanceInformation* message;

2> if there is any traffic for uplink communication which needs to report SPS assistance information:
3> include *trafficPatternInfoListUL* in the *UEAssistanceInformation* message;

[0092] The UE shall set the contents of the *UEAssistanceInformation* message for bandwidth preference indications:

1> start timer T341 with the timer value set to the *bw-PreferenceIndicationTimer*;
1> set *bw-Preference* to its preferred configuration;

[0093] The UE shall set the contents of the *UEAssistanceInformation* message for delay budget report:
1> if configured to provide delay budget report:

2> if the UE prefers an adjustment in the connected mode DRX cycle length:
3> set *delayBudgetReport* to *type1* according to a desired value;
2>else if the UE prefers coverage enhancement configuration change:
3> set *delayBudgetReport* to *type2* according to a desired value;
2> start or restart timer T342 with the timer value set to the *delayBudgetReportingProhibitTimer*;

[0094] The UE shall set the contents of the *UEAssistanceInformation* message for the RLM report:

1> if T314 has expired:

2> set *rlm-event* to *earlyOutOfSync;*

2> start timer T343 with the timer value set to the *rlmReportTimer*:

1> if T315 has expired:

2> set *rlm-event* to *earlyInSync*;
2> start timer T344 with the timer value set to the *rlmReportTimer*:
2> if configured to report *rlmReportRep-MPDCCH*:
3> set *excessRep-MPDCCH* to the value indicated by lower layers;

[0095] The UE shall set the contents of the *UEAssistanceInformation* message for overheating assistance indication:

1> if the UE experiences internal overheating:

2> if the UE prefers to temporarily reduce its DL category and UL category:

3> include *reducedUE-Category* in the *OverheatingAssistance* IE;

3> set *reducedUE-CategoryDL* to the number to which the UE prefers to temporarily reduce its DL category;

3> set *reducedUE-CategoryUL* to the number to which the UE prefers to temporarily reduce its UL category;

2> if the UE prefers to temporarily reduce the number of maximum secondary component carriers:

3> include *reducedMaxCCs* in the *OverheatingAssistance* IE;

3> set *reducedCCsDL* to the number of maximum SCells the UE prefers to be temporarily configured in downlink;

3> set *reducedCCsUL* to the number of maximum SCells the UE prefers to be temporarily configured in uplink;

2> start timer T345 with the timer value set to the *overheatingIndicationProhibitTimer*;

1> else (if the UE no longer experiences an overheating condition):

2> do not include *reducedUE-Category* and *reducedMaxCCs* in OverheatingAssistance IE;

2> start timer T345 with the timer value set to

the *overheatingIndicationProhibitTimer*;

[0096] The UE shall submit the *UEAssistanceInformation* message to lower layers for transmission.

NOTE 1: It is up to UE implementation when and how to trigger SPS assistance information.

NOTE 2: It is up to UE implementation to set the content of *trafficPatternInfoListSL* and *trafficPatternInfoListUL.*

NOTE 3: Traffic patterns for different Destination Layer 2 IDs are provided in different entries in *trafficPatternInfoListSL.*

5.10.1 Introduction

[0097] The sidelink communication and associated synchronisation resource configuration applies for the frequency at which it was received/ acquired. Moreover, for a UE configured with one or more SCells, the sidelink communication and associated synchronisation resource configuration provided by dedicated signalling applies for the PCell/ the primary frequency. The sidelink discovery and associated synchronisation resource configuration applies for the frequency at which it was received/ acquired or the indicated frequency in the configuration. For a UE configured with one or more SCells, the sidelink discovery and associated synchronisation resource configuration provided by dedicated signalling applies for the PCell/ the primary frequency / any other indicated frequency.

NOTE 1: Upper layers configure the UE to receive or transmit sidelink communication on a specific frequency, to monitor or transmit non-PS related sidelink discovery announcements on one or more frequencies or to monitor or transmit PS related sidelink discovery announcements on a specific frequency, but only if the UE is authorised to perform these particular ProSe related sidelink activities.

NOTE 2: It is up to UE implementation which actions to take (e.g. termination of unicast services, detach) when it is unable to perform the desired sidelink activities, e.g. due to UE capability limitations.

[0098] Sidelink communication consists of one-to-many and one-to-one sidelink communication. One-to-many sidelink communication consists of relay related and non-relay related one-to-many sidelink communication. One-to-one sidelink communication consists of relay related and non-relay related one-to-one sidelink communication. In relay related one-to-one sidelink communication the communicating parties consist of one sidelink relay UE and one sidelink remote UE.

[0099] Sidelink discovery consists of public safety related (PS related) and non-PS related sidelink discovery. PS related sidelink discovery consists of relay related and non-relay related PS related sidelink discovery. Upper layers indicate to RRC whether a particular sidelink announcement is PS related or non-PS related.

[0100] Upper layers indicate to RRC whether a particular sidelink procedure is V2X related or not.

[0101] The specification covers the use of UE to network sidelink relays by specifying the additional requirements that apply for a sidelink relay UE and a sidelink remote UE. I.e. for such UEs the regular sidelink UE requirements equally apply unless explicitly stated otherwise.

5.10.1d Conditions for V2X sidelink communication operation

[0102] When it is specified that the UE shall perform V2X sidelink communication operation only if the conditions defined in this section are met, the UE shall perform V2X sidelink communication operation only if:

1> if the UE's serving cell is suitable (RRC_IDLE or RRC_CONNECTED); and if either the selected cell on the frequency used for V2X sidelink communication operation belongs to the registered or equivalent PLMN as specified in TS 24.334 [69] or the UE is out of coverage on the frequency used for V2X sidelink communication operation as defined in TS 36.304 [4, 11.4]; or

1> if the UE's serving cell (for RRC_IDLE or RRC_CONNECTED) fulfils the conditions to support V2X sidelink communication in limited service state as specified in TS 23.285 [78, 4.4.8]; and if either the serving cell is on the frequency used for V2X sidelink communication operation or the UE is out of coverage on the frequency used for V2X sidelink communication operation as defined in TS 36.304 [4, 11.4]; or

1> if the UE has no serving cell (RRC_IDLE);

5.10.2 Sidelink UE information

5.10.2.1 General

[Figure 5.10.2-1 of 3GPP TS 36.331 V15.2.0, entitled "Sidelink UE information", is reproduced as FIG. 13]

[0103] The purpose of this procedure is to inform E-UTRAN that the UE is interested or no longer interested to receive sidelink communication or discovery, to receive V2X sidelink communication, as well as to request assignment or release of transmission resources for sidelink communication or discovery announcements or V2X sidelink communication or sidelink discovery gaps, to report parameters related to sidelink discovery from system

information of inter-frequency/PLMN cells and to report the synchronization reference used by the UE for V2X sidelink communication.

5.10.2.2 Initiation

[0104] A UE capable of sidelink communication or V2X sidelink communication or sidelink discovery that is in RRC_CONNECTED may initiate the procedure to indicate it is (interested in) receiving sidelink communication or V2X sidelink communication or sidelink discovery in several cases including upon successful connection establishment, upon change of interest, upon change to a PCell broadcasting *SystemInformationBlockType18* or *SystemInformationBlockType19* or *SystemInformationBlockType21* including *sl-V2X-ConfigCommon.* A UE capable of sidelink communication or V2X sidelink communication or sidelink discovery may initiate the procedure to request assignment of dedicated resources for the concerned sidelink communication transmission or discovery announcements or V2X sidelink communication transmission or to request sidelink discovery gaps for sidelink discovery transmission or sidelink discovery reception and a UE capable of inter-frequency/PLMN sidelink discovery parameter reporting may initiate the procedure to report parameters related to sidelink discovery from system information of inter-frequency/PLMN cells.

NOTE 1: A UE in RRC_IDLE that is configured to transmit sidelink communication / V2X sidelink communication / sidelink discovery announcements, while *SystemInformationBlockType18*/*SystemInformationBlockType19*/ *SystemInformationBlockType21* including *sl-V2X-ConfigCommon* does not include the resources for transmission (in normal conditions), initiates connection establishment in accordance with 5.3.3.1a.

[0105] Upon initiating the procedure, the UE shall: parameters and stop T370;

1> if *SystemInformationBlockType21* including *sl-V2X-ConfigCommon* is broadcast by the PCell:

2>ensure having a valid version of *SystemInformationBlockType21* for the PCell;

2> if configured by upper layers to receive V2X sidelink communication on a primary frequency or on one or more frequencies included in *v2x-InterFreqInfoList,* if included in *SystemInformationBlockType21* of the PCell:

3> if the UE did not transmit a *SidelinkUEInformation* message since last entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType21* including *sl-V2X-ConfigCommon;* or

3> if the last transmission of the *SidelinkUEInformation* message did not include *v2x-CommRxInterestedFreqList*; or if the frequency(ies) configured by upper layers to receive V2X sidelink communication on has changed since the last transmission of the *SidelinkUEInformation* message:

4> initiate transmission of the *SidelinkUEInformation* message to indicate the V2X sidelink communication reception frequency(ies) of interest in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *v2x-CommRxInterestedFreqList*:

4> initiate transmission of the *SidelinkUEInformation* message to indicate it is no longer interested in V2X sidelink communication reception in accordance with 5.10.2.3;

2> if configured by upper layers to transmit V2X sidelink communication on a primary frequency or on one or more frequencies included in *v2x-InterFreqInfoList,* if included in *SystemInformationBlockType21* of the PCell:

3> if the UE did not transmit a *SidelinkUEInformation* message since last entering RRC_CONNECTED state; or

3> if since the last time the UE transmitted a *SidelinkUEInformation* message the UE connected to a PCell not broadcasting *SystemInformationBlockType21* including *sl-V2X-ConfigCommon;* or

3> if the last transmission of the *SidelinkUEInformation* message did not include *v2x-CommTxResourceReq;* or if the information carried by the *v2x-CommTxResourceReq* has changed since the last transmission of the *SidelinkUEInformation* message:

4> initiate transmission of the *SidelinkUEInformation* message to indicate the V2X sidelink communication transmission resources required by the UE in accordance with 5.10.2.3;

2> else:

3> if the last transmission of the *SidelinkUEInformation* message included *v2x-CommTxResourceReq:*

4> initiate transmission of the *SidelinkUEInformation* message to indicate it no longer requires V2X sidelink communication transmission resources in accordance with 5.10.2.3;

5.10.2.3 Actions related to transmission of *SidelinkUEInformation* message

[0106] The UE shall set the contents of the *SidelinkUEInformation* message as follows:
1> if the UE initiates the procedure to indicate it is (no more) interested to receive sidelink communication or discovery or receive V2X sidelink communication or to request (configuration/ release) of sidelink communication or V2X sidelink communication or sidelink discovery transmission resources (i.e. UE includes all concerned information, irrespective of what triggered the procedure):
[...]
2> if *SystemInformationBlockType21* is broadcast by the PCell and *SystemInformationBlockType21* includes *sl-V2X-ConfigCommon:*

3> if configured by upper layers to receive V2X sidelink communication:
4> include *v2x-CommRxInterestedFreqList* and set it to the frequency(ies) for V2X sidelink communication reception;

3> if configured by upper layers to transmit V2X sidelink communication:

4> if configured by upper layers to transmit P2X related V2X sidelink communication:
5> include *p2x-CommTxType* set to *true;*

4> include *v2x-CommTxResourceReq* and set its fields as follows for each frequency on which the UE is configured for V2X sidelink communication transmission:

5> set *carrierFreqCommTx* to indicate the frequency for V2X sidelink communication transmission;

5> set *v2x-TypeTxSync* to the current synchronization reference type used on the associated *carrierFreqCommTx* for V2X sidelink communication transmission;

5> set *v2x-DestinationInfoList* to include the V2X sidelink communication transmission destination(s) for which it requests E-UTRAN to assign dedicated resources;

[0107] [...]
[0108] The UE shall submit the SidelinkUEInformation message to lower layers for transmission.
[0109] [...]

5.10.12 V2X sidelink communication monitoring

[0110] A UE capable of V2X sidelink communication that is configured by upper layers to receive V2X sidelink communication shall:
1> if the conditions for sidelink operation as defined in 5.10.1d are met:

2> if in coverage on the frequency used for V2X sidelink communication, as defined in TS 36.304 [4, 11.4]:

3> if the frequency used to receive V2X sidelink communication is included in *v2x-InterFreqInfoList* within *RRCConnectionReconfiguration* or in *v2x-InterFreqInfoList* within *SystemInformationBlockType21* of the serving cell/Pcell, and *v2x-CommRxPool* is included in *SL-V2X-InterFreqUE-Config* within *v2x-UE-ConfigList* in the entry of *v2x-InterFreqInfoList* for the concerned frequency:
4> configure lower layers to monitor sidelink control information and the corresponding data using the pool of resources indicated in *v2x-CommRxPool;*

3> else:

4> if the cell chosen for V2X sidelink communication reception broadcasts *SystemInformationBlockType21* including *v2x-CommRxPool* in *sl-V2X-ConfigCommon* or,

4> if the UE is configured with *v2x-CommRxPool* included in *mobilityControlInfoV2X* in *RRCConnectionReconfiguration:*
5> configure lower layers to monitor sidelink control information and the corresponding data using the pool of resources indicated in *v2x-CommRxPool*;

2>else (i.e. out of coverage on the frequency used for V2X sidelink communication, as defined in TS 36.304 [4, 11.4]):

3> if the frequency used to receive V2X sidelink communication is included in *v2x-InterFreqInfoList* within *RRCConnectionReconfiguration* or in *v2x-InterFreqInfoList* within *SystemInformationBlockType21* of the serving cell/PCell, and *v2x-CommRxPool* is included in *SL-V2X-InterFreqUE-Config* within *v2x-UE-ConfigList* in the entry of *v2x-InterFreqInfoList* for the concerned frequency:
4> configure lower layers to monitor sidelink control information and the corresponding data using the pool of resources indicated in *v2x-CommRxPool;*

3> else:
4> configure lower layers to monitor sidelink control information and the corresponding data using the pool of resources that were preconfigured (i.e. *v2x-CommRxPoolList* in *SL-V2X-Preconfiguration* defined in 9.3);

5.10.13 V2X sidelink communication transmission

5.10.13.1 Transmission of V2X sidelink communication

[0111] A UE capable of V2X sidelink communication that is configured by upper layers to transmit V2X sidelink communication and has related data to be transmitted shall:
1> if the conditions for sidelink operation as defined in 5.10.1d are met:

2> if in coverage on the frequency used for V2X sidelink communication as defined in TS 36.304 [4, 11.4]; or

2> if the frequency used to transmit V2X sidelink communication is included in *v2x-InterFreqInfoList* in *RRCConnectionReconfiguration* or in *v2x-InterFreqInfoList* within *SystemInformationBlockType21*:

3> if the UE is in RRC_CONNECTED and uses the PCell or the frequency included in *v2x-InterFreqInfoList* in *RRCConnectionReconfiguration* for V2X sidelink communication:

4> if the UE is configured, by the current PCell with *commTxResources* set to *scheduled*:

5> if T310 or T311 is running; and if the PCell at which the UE detected physical layer problems or radio link failure broadcasts *SystemInformationBlockType21* including *v2x-CommTxPoolExceptional* in *sl-V2X-ConfigCommon,* or *v2x-CommTxPoolExceptional* is included in *v2x-InterFreqInfoList* for the concerned frequency in *SystemInformationBlockType21* or *RRCConnectionReconfiguration;* or

5> if T301 is running and the cell on which the UE initiated connection reestablishment broadcasts *SystemInformationBlockType21* including *v2x-CommTxPoolExceptional* in *sl-V2X-ConfigCommon,* or *v2x-CommTxPoolExceptional* is included in *v2x-InterFreqInfoList* for the concerned frequency in *SystemInformationBlockType21*; or

5> if T304 is running and the UE is configured with *v2x-CommTxPoolExceptional* included in *mobilityControlInfoV2X* in *RRCConnectionReconfiguration* or in *v2x-InterFreqInfoList* for the concerned frequency in *RRCConnectionReconfiguration:*
6> configure lower layers to transmit the sidelink control information and the corresponding data based on random selection using the pool of resources indicated by *v2x-CommTxPoolExceptional* as defined in TS 36.321 [6];

5> else:
6> configure lower layers to request E-UTRAN to assign transmission resources for V2X sidelink communication;

4> else if the UE is configured with *v2x-CommTxPoolNormalDedicated* or *v2x-CommTxPoolNormal* or *p2x-CommTxPoolNormal* in the entry of *v2x-InterFreqInfoList* for the concerned frequency in *sl-V2X-ConfigDedicated* in *RRCConnectionReconfiguration:*

5> if the UE is configured to transmit non-P2X related V2X sidelink communication and a result of sensing on the resources configured in *v2x-CommTxPoolNormalDedicated* or *v2x-CommTxPoolNormal* in the entry of *v2x-InterFreqInfoList* for the concerned frequency in *RRCConnectionReconfiguration* is not available in accordance with TS 36.213 [23]; or

5> if the UE is configured to transmit P2X related V2X sidelink communication and selects to use partial sensing according to 5.10.13.1a, and a result of partial sensing on the resources configured in *v2x-CommTxPoolNormalDedicated* or *p2x-CommTxPoolNormal* in the entry of *v2x-InterFreqInfoList* for the concerned frequency in *RRCConnectionReconfiguration* is not available in accordance with TS 36.213 [23]:

6> if *v2x-CommTxPoolExceptional* is included in *mobilityControlInfoV2X* in *RRC-*

ConnectionReconfiguration (i.e., handover case); or

6> if *v2x-CommTxPoolExceptional* is included in the entry of *v2x-InterFreqInfoList* for the concerned frequency in *RRCConnectionReconfiguration;* or

6> if the PCell broadcasts *SystemInformationBlockType21* including v2x-*CommTxPoolExceptional* in *sl-V2X-ConfigCommon* or *v2x-CommTxPoolExceptional* in *v2x-InterFreqInfoList* for the concerned frequency:
7> configure lower layers to transmit the sidelink control information and the corresponding data based on random selection using the pool of resources indicated by *v2x-CommTxPoolExceptional* as defined in TS 36.321 [6];

5> else if the UE is configured to transmit P2X related V2X sidelink communication:

6> select a resource pool according to 5.10.13.2;

6> perform P2X related V2X sidelink communication according to 5.10.13.1a;

5> else if the UE is configured to transmit non-P2X related V2X sidelink communication:
6> configure lower layers to transmit the sidelink control information and the corresponding data based on sensing (as defined in TS 36.321 [6] and TS 36.213 [23]) using one of the resource pools indicated by *v2x-commTxPoolNormalDedicated* or *v2x-CommTxPoolNormal* in the entry of *v2x-InterFreqInfoList* for the concerned frequency, which is selected according to 5.10.13.2;

3> else:
4> if the cell chosen for V2X sidelink communication transmission broadcasts *System Information BlockType2 1:*

5> if the UE is configured to transmit non-P2X related V2X sidelink communication, and if *SystemInformationBlockType21* includes *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency in *sl-V2X-ConfigCommon* and a result of sensing on the resources configured in *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency is available in accordance with TS 36.213 [23]:
6> configure lower layers to transmit the sidelink control information and the corresponding data based on sensing (as defined in TS 36.321 [6] and TS 36.213 [23]) using one of the resource pools indicated by *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency, which is selected according to 5.10.13.2;

5> else if the UE is configured to transmit P2X related V2X sidelink communication, and if *SystemInformationBlockType21* includes *p2x-CommTxPoolNormalCommon* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency in *sl-V2X-ConfigCommon,* and if the UE selects to use random selection according to 5.10.13.1a, or selects to use partial sensing according to 5.10.13.1a and a result of partial sensing on the resources configured in *p2x-CommTxPoolNormalCommon* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency is available in accordance with TS 36.213 [23]:

6> select a resource pool from *p2x-CommTxPoolNormalCommon* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency according to 5.10.13.2, but ignoring *zoneConfig* in *System Information Block Type 21;*

6> perform P2X related V2X sidelink communication according to 5.10.13.1a;

5> else if *SystemInformationBlockType21* includes *v2x-CommTxPoolExceptional* in *sl-V2X-ConfigCommon* or *v2x-CommTxPoolExceptional* in *v2x-InterFreqInfoList* for the concerned frequency:

6> from the moment the UE initiates connection establishment until receiving an *RRCConnectionReconfiguration including sl-V2X-ConfigDedicated,* or until receiving an *RRCConnection-*

Release or an *RRCConnectionReject;* or

6> if the UE is in RRC_IDLE and a result of sensing on the resources configured in *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency in *Systeminformationblocktype21* is not available in accordance with TS 36.213 [23]; or

6> if the UE is in RRC_IDLE and UE selects to use partial sensing according to 5.10.13.1a and a result of partial sensing on the resources configured in *p2x-CommTxPoolNormalCommon* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency in *Systeminformationblocktype21* is not available in accordance with TS 36.213 [23]:
7> configure lower layers to transmit the sidelink control information and the corresponding data based on random selection (as defined in TS 36.321 [6]) using the pool of resources indicated in *v2x-CommTxPoolExceptional*;

2> else:
3> configure lower layers to transmit the sidelink control information and the corresponding data based on sensing (as defined in TS 36.321 [6] and TS 36.213 [23]) using one of the resource pools indicated by *v2x-CommTxPoolList* in *SL-V2X-Preconfiguration* in case of non-P2X related V2X sidelink communication, which is selected according to 5.10.13.2, or using one of the resource pools indicated by *p2x-CommTxPoolList* in *SL-V2X-Preconfiguration* in case of P2X related V2X sidelink communication, which is selected according to 5.10.13.2, and in accordance with the timing of the selected reference as defined in 5.10.8;

[0112] The UE capable of non-P2X related V2X sidelink communication that is configured by upper layers to transmit V2X sidelink communication shall perform sensing on all pools of resources which may be used for transmission of the sidelink control information and the corresponding data. The pools of resources are indicated by *SL-V2X-Preconfiguration, v2x-CommTxPoolNormalCommon, v2x-CommTxPoolNormalDedicated* in *sl-V2X-ConfigDedicated,* or *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* for the concerned frequency, as configured above.
NOTE 1: If there are multiple frequencies for which normal or exceptional pools are configured, it is up to UE implementation which frequency is selected for V2X sidelink communication transmission.

5.10.13.2 V2X sidelink communication transmission pool selection

[0113] For a frequency used for V2X sidelink communication, if *zoneConfig* is not ignored as specified in 5.10.13.1, the UE configured by upper layers for V2X sidelink communication shall only use the pool which corresponds to geographical coordinates of the UE, if *zoneConfig* is included in *SystemInformationBlockType21* of the serving cell (RRC_IDLE)/ PCell (RRC_CONNECTED) or in *RRCConnectionReconfiguration* for the concerned frequency, and the UE is configured to use resource pools provided by RRC signalling for the concerned frequency; or if *zoneConfig* is included in *SL-V2X-Preconfiguration* for the concerned frequency, and the UE is configured to use resource pools in *SL-V2X-Preconfiguration* for the frequency, according to 5.10.13.1. The UE shall only use the pool which is associated with the synchronization reference source selected in accordance with 5.10.8.2.

1> if the UE is configured to transmit on *p2x-CommTxPoolNormalCommon* or on *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* in *SystemInformationBlockType21* according to 5.10.13.1; or

1> if the UE is configured to transmit on *p2x-CommTxPoolList-r14* in *SL-V2X-Preconfiguration* according to 5.10.13.1; or

1> if *zoneConfig* is not included in *SystemInformationBlockType21* and the UE is configured to transmit on *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormalDedicated;* or

1> if *zoneConfig* is included in *SystemInformationBlockType21* and the UE is configured to transmit on *v2x-CommTxPoolNormalDedicated* for P2X related V2X sidelink communication and *zoneID* is not included in *v2x-CommTxPoolNormalDedicated*; or

1> if *zoneConfig* is not included in the entry of *v2x-InterFreqInfoList* for the concerned frequency and the UE is configured to transmit on *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* in *RRCConnectionReconfiguration;* or

1> if *zoneConfig* is not included in *SL-V2X-Preconfiguration* for the concerned frequency and the UE is configured to transmit on *v2x-CommTxPoolList* in *SL-V2X-Preconfiguration* for the concerned frequency:

2>select the first pool associated with the synchronization reference source selected in accordance with 5.10.8.2;

1> if *zoneConfig* is included in *SystemInformationBlockType21* and the UE is configured to transmit on *v2x-CommTxPoolNormalCommon* or *v2x-CommTxPoolNormalDedicated* for non-P2X related V2X sidelink communication; or

1> if *zoneConfig* is included in *SystemInformationBlockType21* and the UE is configured to transmit on *v2x-CommTxPoolNormalDedicated* for P2X related V2X sidelink communication and *zoneID* is included in *v2x-CommTxPoolNormalDedicated;* or

1> if *zoneConfig* is included in the entry of *v2x-InterFreqInfoList* for the concerned frequency and the UE is configured to transmit on *v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* in *RRCConnectionReconfiguration;* or

1> if *zoneConfig* is included in *SL-V2X-Preconfiguration* for the concerned frequency and the UE is configured to transmit on *v2x-CommTxPoolList* in *SL-V2X-Preconfiguration* for the concerned frequency:
2>select the pool configured with *zoneID* equal to the zone identity determined below and associated with the synchronization reference source selected in accordance with 5.10.8.2;

[0114] The UE shall determine an identity of the zone (i.e. Zone_id) in which it is located using the following formulae, if *zoneConfig* is included in *SystemInformationBlockType21* or in *SL-V2X-Preconfiguration:*

$$x_1 = \text{Floor}\ (x / L)\ \text{Mod}\ Nx;$$

$$y_1 = \text{Floor}\ (y / W)\ \text{Mod}\ Ny;$$

$$\text{Zone\_id} = y_1 * Nx + x_1.$$

[0115] The parameters in the formulae are defined as follows:

L is the value of *zoneLength* included in *zoneConfig* in *SystemInformationBlockType21* or in *SL-V2X-Preconfiguration;*

W is the value of *zoneWidth* included in *zoneConfig* in *SystemInformationBlockType21* or in *SL-V2X-Preconfiguration;*

Nx is the value of *zoneIdLongiMod* included in *zoneConfig* in *SystemInformationBlockType21* or in *SL-V2X-Preconfiguration;*

Ny is the value of *zoneIdLatiMod* included in *zoneConfig* in *SystemInformationBlockType21* or in *SL-V2X-Preconfiguration;*

x is the geodesic distance in longitude between UE's current location and geographical coordinates (0, 0) according to WGS84 model [80] and it is expressed in meters;

y is the geodesic distance in latitude between UE's current location and geographical coordinates (0, 0) according to WGS84 model [80] and it is expressed in meters.

[0116] The UE shall select a pool of resources which includes a *zoneID* equals to the Zone_id calculated according to above mentioned formulae and indicated by *v2x-CommTxPoolNormalDedicated, v2x-CommTxPoolNormalCommon, v2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* or *p2x-CommTxPoolNormal* in *v2x-InterFreqInfoList* in *RRCConnectionReconfiguration,* or *v2x-CommTxPoolList* according to 5.10.13.1.

NOTE 1: The UE uses its latest geographical coordinates to perform resource pool selection.

NOTE 2: If geographical coordinates are not available and zone specific TX resource pools are configured for the concerned frequency, it is up to UE implementation which resource pool is selected for V2X sidelink communication transmission.

[0117] 3GPP TS 38.331 describes how to derive system information and configuration from network as follows:

5.2.2 System information acquisition

5.2.2.1 General UE requirements

[Figure 5.2.2.1-1 of 3GPP TS 38.331 V15.2.0, entitled "System information acquisition", is reproduced as FIG. 14]

[0118] The UE applies the SI acquisition procedure to acquire the AS- and NAS information. The procedure applies to UEs in RRC_IDLE, in RRC_INACTIVE and in RRC_CONNECTED.

[0119] The UE in RRC_IDLE and RRC_INACTIVE shall ensure having a valid version of (at least) the *MasterInformationBlock, SystemInformationBlockType1* as well as *SystemInformationBlockTypeX* through *System-*

InformationBlockTypeY (depending on support of the concerned RATs for UE controlled mobility).

[0120] The UE in RRC_CONNECTED shall ensure having a valid version of (at least) the *MasterInformationBlock, SystemInformationBlockType1* as well as *SystemInformationBlockTypeX* (depending on support of mobility towards the concerned RATs).

[0121] The UE shall store relevant SI acquired from the currently camped/serving cell. A version of the SI that the UE acquires and stores remains valid only for a certain time. The UE may use such a stored version of the SI e.g. after cell re-selection, upon return from out of coverage or after SI change indication.

[0122] Regarding resource for V2X communication on D2D interface, a UE could use the resource based on network scheduling and/or autonomously selection. For network scheduling case, a UE could be configured with resource pool(s) and receives corresponding scheduling for indicating assigned resource in the resource pool(s). For UE autonomous selection, the UE will be configured with resource pool(s) and will select resource from the resource pool(s) if the UE wants to perform V2X communication through D2D interface. Preferably, the resource selection could be random selection. The UE could do energy sensing for determining available resource for performing random selection. A possible example for network scheduling and autonomously selection is shown in FIG. 15.

[0123] To achieve V2X communication on D2D interface, a UE may need to derive resource from the resource pool. Based on LTE design, a RRC CONNECTED UE could be configured as network scheduling mode or UE selecting mode. And a RRC IDLE UE may only work as UE selecting mode. The network scheduling mode could include dynamic scheduling and semi-persistent scheduling. The dynamic scheduling is that a base station transmits a SL grant a UE based on Sidelink BSR from the UE. The semi-persistent scheduling (SPS) is that a base station transmits a SL grant to activate a sidelink SPS configuration in a UE.

[0124] In NR, SPS could also refer to grant-free. Grant-free could mean that the configured SL grant information is included in the sidelink SPS configuration instead of indicating through the activation command (e.g. DCI, PDCCH signal) from the base station. Grant-free could mean that the configured SL grant information is included in the sidelink SPS configuration. The sidelink SPS configuration could directly be activated without activation command after the UE is configured. The UE selecting mode is that a UE will determine available resource in a resource pool and select a resource from the available resource set. The selecting could be random selection or selection based on the UE's demand (e.g. reliability, TB size, etc.). The available resource could be determined based on resource pool configuration and/or sensing procedure. For example, all resource in a resource pool could be considered as available resource. As another example, a UE could remove or prevent to use some resource within a resource pool based on resource pool configuration or transmission parameter configuration related to the resource pool. As another example, a UE could remove or prevent to use some resource within a resource pool based on a result of a sensing procedure (e.g. prevent using resource with strong interference or resource being occupied).

[0125] Preferably, the allocated resource mentioned in below could be interpreted based on a resource pool and/or a resource pool configuration.

[0126] Preferably, a resource pool could be defined based on a resource pool configuration. A resource pool could be a set of flexible slots and/or flexible symbols in or associated with one or multiple BWPs. The examples are shown in solution 2 of method 2 or method 3 for FDD or TDD mentioned above. Preferably, the one or multiple bandwidth parts could be uplink BWP(s). Alternatively preferably, the one or multiple bandwidth parts could be downlink BWP(s).

[0127] A resource pool could be a bandwidth part. Preferably, the bandwidth part could be a special bandwidth part for V2X as method 1 for FDD or TDD above. Alternatively preferably, the bandwidth part could be an uplink BWP or a downlink BWP.

[0128] **Network scheduling mode** - Regarding the resource deployment and multiple numerologies concept, a UE configured as network scheduling mode may need to receive a sidelink grant from a base station. Based on numerologies discussion on the above, one possible way is a control signaling carrying numerology index for indicating a transmission within a resource pool. On the other hand, a UE could also be configured with multiple resource pools for a cell. The multiple resource pools could be used for some conditions. The possible conditions could be one or multiple conditions listed below:

1. Supporting different bandwidth parts
2. Supporting different numerologies
3. Supporting different geographic location (e.g. zone, GPS location, cell direction, associated SSBs)

[0129] For condition 1, a UE could be configured with multiple BWPs (e.g. for uplink and/or for downlink and/or for V2X communication on D2D). However, the UE could have only one activated BWP in NR rel-15. If a resource pool is associated with bandwidth part, the bandwidth part switching could cause V2X service interruption. For preventing the interruption, a network could provide different resource pools on different bandwidth parts. Preferably, the UE could use only one resource pool within the multiple configured resource pool at a time.

[0130] For condition 2, if a resource pool is associated with one numerology, a UE may need multiple resource pools for supporting different numerologies. For condition 3, considering resource efficiency, the same resource could be shared by different areas, in which a resource will not interfere by same resource belonging to other areas. The UE could be configured with different

resource pools for supporting different locations.

[0131] Given a UE being configured as network scheduling mode and configured with multiple resource pools, it may be necessary for UE to understand a received sidelink grant is for which resource pool. For establishing the association between a sidelink grant and resource pool, some possible solutions could be considered.

[0132] Solution 1 - A network indicates the association to the UE through a DCI. In this solution, the network may transmit a DCI (e.g. SL grant) to provide both sidelink resource and association between the sidelink resource and the resource pool. The association could be indicated through an explicit field. One possible way is that a sidelink grant indicates a bandwidth part index. If a bandwidth part is associated with only one resource pool, the bandwidth part index could help UE to understand the association between the sidelink grant and the resource pool.

[0133] Another possible way is that a sidelink grant could indicate an index or identity of the resource pool. In such case, the association will be clear. Furthermore, the sidelink grant could indicate both an index of a bandwidth part and an index of a resource pool. The sidelink grant could also indicate an index of numerology. Based on one-to-one mapping between numerology and resource pool, the UE may understand the association between the sidelink grant and a resource pool.

[0134] Another possible way is that a sidelink grant could indicate a geographic related information. Preferably, the information could be SSB related information or zone index.

[0135] Solution 2 - A network could indicate or establish the association to the UE through a configuration. In this solution, the network may allocate the configuration to a UE for establishing the association. For example, the association could be established based on including a resource pool ID or a bandwidth part ID into a SPS configuration. The SPS (e.g. grant-free, SPS, configured grant) could directly be associated with the resource pool or resource pool corresponding to the BWP when the SPS is activated or configured. As another example, the network could allocate resource pool with an association with information of a sidelink grant. The information could be one or multiple candidates listed below:

1. control resource region for monitoring corresponding sidelink grant (e,g, coreset, search space)
2. RNTI (e.g. different resource pool will be associated with different RNTIs)
3. Control Signal Format
4. Control signal length
5. Zone related information (e.g. SSB related information, TCI state, zone ID)

[0136] For example, if the sidelink grant is received based on the candidate(s) information, the UE may understand the sidelink grant is allocated on which resource pool. The association could be allocated through a RRC dedicated signal (e.g. RRC reconfiguration) or through a system information (E.g. other SI, SIB for V2X, MIB, SIB1). The association could also be allocated by including the information into a configuration related to the resource pool (e.g. corset configuration or Index in a resource pool configuration).

[0137] Solution 3 (implicit rule) - In this solution, the association could be established based on predefined rule or predefined understanding. One possible way could be a SL grant received on a bandwidth part will only be used for scheduling the resource pool associated with or located in the bandwidth part. The network may need to switch a bandwidth part for scheduling SL grant on another resource pool associated with or located in another bandwidth part. Preferably, the association between a resource pool and a bandwidth part could refer to Method 1 and Method 2 mentioned above for FDD or TDD system.

[0138] FIG. 16 is a flow chart 1600 according to one exemplary embodiment from the perspective of a first communication device. In step 1605, the first communication device is configured with a plurality of resource pools by a base station for a cell. In step 1610, the first communication device receives a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools through a resource pool index in the grant. In step 1615, the first communication device uses the resource to perform a transmission on a device-to-device interface.

[0139] Preferably, the resource pool could be configured with the resource pool index. Furthermore, a field in the grant could indicate the resource pool index or identity of the resource pool.

[0140] Preferably, the association is indicated through a bandwidth part index in the grant. The resource pool could be associated with a bandwidth part configured with the bandwidth part index. The plurality of resource pools could be for V2X communication on D2D interface.

[0141] Preferably, the cell could be a SpCell (Special Cell) or PCell (Primary Cell). Alternatively, the cell could be a SCell (Secondary Cell).

[0142] Preferably, the grant could be a sidelink grant or a grant for D2D interface. Receiving the grant could refer to receiving a downlink control signal (e.g. PDCCH signal) for scheduling the resource. Receiving the grant could also refer to being configured or activated with a configured grant by the base station.

[0143] Preferably, the transmission could be a unicast transmission, a multicast transmission, or a broadcast transmission. Furthermore, the transmission could be for a second communication device.

[0144] Referring back to FIGS. 3 and 4, in one exemplary embodiment of a communication device, the device 300 includes a program code 312 stored in the memory 310. The CPU 308 could execute program code 312 to enable the communication device (i) to be configured with a plurality resource pools by a base station for a cell, (ii) to receive a grant from the base station, wherein the grant

indicates a resource associated with a resource pool of the plurality of resource pools through a resource pool index in the grant, and (iii) to use the resource to perform a transmission on a device-to-device interface. Furthermore, the CPU 308 can execute the program code 312 to perform all of the above-described actions and steps or others described herein.

[0145] FIG. 17 is a flow chart 1700 according to one exemplary embodiment from the perspective of a first communication device. In step 1705, the first communication device is configured with a plurality of resource pools by a base station for a cell. In step 1710, the first communication device is configured with a configuration for sidelink SPS (Semi-Persistent Scheduling), wherein the configuration includes a resource pool index. In step 1715, the first communication device uses a resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface based on the configuration, wherein the resource pool is associated with the resource pool index.

[0146] Preferably, the transmission could be a unicast transmission, a multicast transmission, or a broadcast transmission. Furthermore, the transmission could be for a second communication device.

[0147] Preferably, the sidelink SPS could be used without activation signaling. Furthermore, the sidelink SPS could be used after receiving an activation signaling from the base station.

[0148] Referring back to FIGS. 3 and 4, in one exemplary embodiment of a communication device, the device 300 includes a program code 312 stored in the memory 310. The CPU 308 could execute program code 312 to enable the communication device (i) to be configured with a plurality of resource pools by a base station for a cell, (ii) to be configured with a configuration for sidelink SPS, wherein the configuration includes a resource pool index, and (iii) to use a resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface based on the configuration, wherein the resource pool is associated with the resource pool index. Furthermore, the CPU 308 can execute the program code 312 to perform all of the above-described actions and steps or others described herein.

[0149] FIG. 18 is a flow chart 1800 according to one exemplary embodiment from the perspective of a first communication device. In step 1805, the first communication device is configured with a plurality of resource pools by a base station for a cell. In step 1810, the first communication device receives a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools. In step 1815, the first communication device uses the resource to perform a transmission on a device-to-device interface.

[0150] Preferably, the association could be indicated through a resource pool index in the grant, and the resource pool could be configured with the resource pool index. The association could also be indicated through a numerology index in the grant, and the resource pool could be associated with a numerology configured with the numerology index. In addition, the association could be indicated through a bandwidth part index in the grant, and the resource pool could be associated with a bandwidth part configured with the bandwidth part index. Furthermore, the association could be indicated through a TCI (Transmission Configuration Indication) state in the grant, and the resource pool could be associated with the TCI state. The association could be indicated through a SSB (Synchronization Signal Block) related information in the grant, and the resource pool could be associated with a SSB indicated by the SSB related information. The plurality of resource pools could be for V2X communication on D2D interface.

[0151] Preferably, the cell could be a SpCell or PCell. The cell could also be a SCell.

[0152] Preferably, the grant could be a sidelink grant or a grant for D2D interface. Receiving the grant could refer to receiving a downlink control signal (e.g. PDCCH signal) for scheduling the resource. Receiving the grant could also refer to being configured with a configured grant by the base station.

[0153] Preferably, the transmission could be a unicast transmission, a multicast transmission, or a broadcast transmission. Furthermore, the transmission could be for a second device.

[0154] Referring back to FIGS. 3 and 4, in one exemplary embodiment of a first communication device, the device 300 includes a program code 312 stored in the memory 310. The CPU 308 could execute program code 312 to enable the first communication device (i) to be configured with a plurality of resource pools by a base station for a cell, (ii) to receive a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools, and (iii) to use the resource to perform a transmission on a device-to-device interface. Furthermore, the CPU 308 can execute the program code 312 to perform all of the above-described actions and steps or others described herein.

[0155] FIG. 19 is a flow chart 1900 according to a related art from the perspective of a first communication device. In step 1905, the first communication device is configured with a plurality of resource pools by a base station for a cell. In step 1910, the first communication device is configured with a configuration for associating a resource pool of the plurality of resource pools with an information. In step 1915, the first communication device receives a grant for scheduling a resource from the base station based on the information. In step 1920, the first communication device uses the resource to perform a transmission on a device-to-device interface.

[0156] Preferably, the information could be an identity for scrambling the grant, a search space configuration, a CORESET (Control Resource Set) configuration, a CORESET index or identity, a TCI state or an index of a TCI state, or a SSB index or a time and/or frequency

resource information related to a SSB.

[0157] Preferably, the plurality of resource pools could be for V2X communication on D2D interface. The cell could be a SpCell or PCell. The cell could also be a SCell.

[0158] Preferably, the grant could be a sidelink grant or a grant for D2D interface. Receiving the grant could refer to receiving a downlink control signal (e.g. PDCCH signal) for scheduling the resource. Receiving the grant could also refer to being configured with a configured grant by the base station.

[0159] Preferably, the transmission could be a unicast transmission, a multicast transmission, or a broadcast transmission. The transmission could also be for a second device.

[0160] Referring back to FIGS. 3 and 4, in a related art of a first communication device, the device 300 includes a program code 312 stored in the memory 310. The CPU 308 could execute program code 312 to enable the first communication device (i) to be configured with a plurality resource pools by a base station for a cell, (ii) to be configured with a configuration for associating a resource pool of the plurality of resource pools with an information, (iii) to receive a grant for scheduling a resource from the base station based on the information, and (iv) to use the resource to perform a transmission on a device-to-device interface. Furthermore, the CPU 308 can execute the program code 312 to perform all of the above-described actions and steps or others described herein.

[0161] FIG. 20 is a flow chart 2000 according to another related art from the perspective of a first communication device. In step 2005, the first communication device is configured with a first bandwidth part for a cell. In step 2010, the first communication device is configured with a plurality of resource pools by a base station for the cell. In step 2015, the first communication device receives a grant on the first bandwidth part for scheduling a resource from the base station. In step 2020, the first communication device uses the resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface, wherein the resource pool is the only resource pool of the plurality of resource pools associated with the first bandwidth part.

[0162] Preferably, the first communication device could be configured with a second bandwidth part. The plurality of resource pools could be for V2X communication on D2D interface. The cell could be a SpCell or PCell. The cell could also be a SCell.

[0163] Preferably, the grant could be a sidelink grant or a grant for D2D interface. Receiving the grant could refer to receiving a downlink control signal (e.g. PDCCH signal) for scheduling the resource. Receiving the grant could also refer to being configured with a configured grant by the base station.

[0164] Preferably, the transmission could be a unicast transmission, a multicast transmission, or a broadcast transmission. The transmission could also be for a second device.

[0165] Referring back to FIGS. 3 and 4, in another related art of a first communication device, the device 300 includes a program code 312 stored in the memory 310. The CPU 308 could execute program code 312 to enable the first communication device (i) to be configured with a first bandwidth part for a cell, (ii) to be configured with a plurality of resource pools by a base station for the cell, (iii) to receive a grant on the first bandwidth part for scheduling a resource from the base station, and (iii) to use the resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface, wherein the resource pool is the only resource pool of the plurality of resource pools associated with the first bandwidth part. Furthermore, the CPU 308 can execute the program code 312 to perform all of the above-described actions and steps or others described herein.

[0166] Various aspects of the disclosure have been described above. It should be apparent that the teachings herein could be embodied in a wide variety of forms and that any specific structure, function, or both being disclosed herein is merely representative. Based on the teachings herein one skilled in the art should appreciate that an aspect disclosed herein could be implemented independently of any other aspects and that two or more of these aspects could be combined in various ways. For example, an apparatus could be implemented or a method could be practiced using any number of the aspects set forth herein. In addition, such an apparatus could be implemented or such a method could be practiced using other structure, functionality, or structure and functionality in addition to or other than one or more of the aspects set forth herein. As an example of some of the above concepts, in some aspects concurrent channels could be established based on pulse repetition frequencies. In some aspects concurrent channels could be established based on pulse position or offsets. In some aspects concurrent channels could be established based on time hopping sequences. In some aspects concurrent channels could be established based on pulse repetition frequencies, pulse positions or offsets, and time hopping sequences.

[0167] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0168] Those of skill would further appreciate that the various illustrative logical blocks, modules, processors, means, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware (e.g., a digital implementation, an analog implementation, or a combination of the two, which may be designed using source coding or some other technique), various forms of program or design code incorporating instructions (which may be referred

to herein, for convenience, as "software" or a "software module"), or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0169] In addition, the various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented within or performed by an integrated circuit ("IC"), an access terminal, or an access point. The IC may comprise a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, electrical components, optical components, mechanical components, or any combination thereof designed to perform the functions described herein, and may execute codes or instructions that reside within the IC, outside of the IC, or both. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0170] It is understood that any specific order or hierarchy of steps in any disclosed process is an example of a sample approach. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the present disclosure. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0171] The steps of a method or algorithm described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module (e.g., including executable instructions and related data) and other data may reside in a data memory such as RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of computer-readable storage medium known in the art. A sample storage medium may be coupled to a machine such as, for example, a computer/processor (which may be referred to herein, for convenience, as a "processor") such the processor can read information (e.g., code) from and write information to the storage medium. A sample storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in user equipment. In the alternative, the processor and the storage medium may reside as discrete components in user equipment. Moreover, in some aspects any suitable computer-program product may comprise a computer-readable medium comprising codes relating to one or more of the aspects of the disclosure. In some aspects a computer program product may comprise packaging materials.

[0172] While the invention has been described in connection with various aspects, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptation of the invention as defined in the appended claims.

Claims

1. A method for a first communication device, comprising:

   being configured as network scheduling mode and configured with a plurality of resource pools by a base station for a cell (1605);
   receiving a grant from the base station, wherein the grant indicates a resource (1610); and
   using the resource to perform a transmission on a device-to-device, in the following also referred to as D2D, interface (1615),
   wherein
   the grant further includes a resource pool index, and the resource is associated with a resource pool of the plurality of resource pools through the resource pool index in the grant.

2. The method of claim 1, wherein the resource pool is configured with the resource pool index.

3. The method of claim 1 or 2, wherein a field in the grant indicates the resource pool index or identity of the resource pool.

4. The method of any one of claims 1 to 3, wherein the method is for Vehicle-to-Everything, in the following also referred to as V2X, communication on D2D interface, and the association is indicated through a bandwidth part index in the grant;
   wherein preferably the resource pool is associated with a bandwidth part configured with the bandwidth part index.

5. The method of any one of claims 1 to 4, wherein the grant is a sidelink grant or a grant for D2D interface.

6. The method of any one of claims 1 to 5, wherein receiving the grant refers to receiving a downlink control signal for scheduling the resource; and/or
wherein receiving the grant refers to being configured or activated with a configured grant by the base station.

7. A method for a first communication device, comprising:

being configured as network scheduling mode and configured with a plurality of resource pools by a base station for a cell (1705);
being configured with a configuration for sidelink Semi-Persistent Scheduling, in the following also referred to as SPS, (1710);
and
using a resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface based on the configuration for sidelink SPS, wherein the resource is indicated in the configuration for sidelink SPS (1715),
the configuration for sidelink SPS further includes a resource pool identity, in the following also referred to as ID, and
the resource is associated with the resource pool of the plurality of resource pools through the resource pool ID in the configuration for sidelink SPS.

8. The method of claim 7, wherein the sidelink SPS is used without receiving an activation signaling used to activate a sidelink SPS from the base station.

9. The method of any one of claims 1 to 8, wherein the plurality of resource pools is for Vehicle-to-Everything, in the following also referred to as V2X, communication on D2D interface.

10. The method of any one of claims 1 to 9, wherein the cell is a Special Cell, in the following also referred to as SpCell, Primary Cell, in the following also referred to as PCell, or a Secondary Cell, in the following also referred to as SCell.

11. The method of any one of claims 1 to 10, wherein the transmission is a unicast transmission, a multicast transmission, or a broadcast transmission.

12. The method of any one of claims 1 to 11, wherein the transmission is for a second communication device.

13. A first communication device, comprising:

a control circuit (306);
a processor (308) installed in the control circuit (306); and
a memory (310) installed in the control circuit (306) and operatively coupled to the processor (308);
characterized in that the processor (308) is configured to execute a program code (312) stored in the memory (310) to perform the method steps a defined in any one of the preceding claims.

Patentansprüche

1. Verfahren für eine erste Kommunikationsvorrichtung, umfassend:

Konfiguriert-Werden als Netzwerk-Zeitplanungsmodus und konfiguriert mit einer Mehrzahl von Ressourcenpools durch eine Basisstation für eine Zelle (1605);
Empfangen einer Bewilligung von der Basisstation, wobei die Bewilligung eine Ressource anzeigt (1610); und
Verwenden der Ressource, um eine Übertragung auf einer Vorrichtung-zu-Vorrichtung-, im Folgenden auch als D2D bezeichnet, Schnittstelle auszuführen (1615),
wobei
die Bewilligung weiter einen Ressourcenpoolindex aufweist, und die Ressource durch den Ressourcenpoolindex in der Bewilligung mit einem Ressourcenpool der Mehrzahl von Ressourcenpools verknüpft ist.

2. Verfahren gemäß Anspruch 1, wobei der Ressourcenpool mit dem Ressourcenpoolindex konfiguriert ist.

3. Verfahren gemäß Anspruch 1 oder 2, wobei ein Feld in der Bewilligung den Ressourcenpoolindex oder eine Identität des Ressourcenpools anzeigt.

4. Verfahren gemäß einem der Ansprüche 1 bis 3, wobei das Verfahren für eine Fahrzeug-zu-Allem-, im Folgenden auch als V2X bezeichnet, Kommunikation auf der D2D-Schnittstelle ist und die Verknüpfung durch einen Bandbreitenteilindex in der Bewilligung angezeigt wird;
wobei vorzugsweise der Ressourcenpool mit einem Bandbreitenteil verknüpft ist, der mit dem Bandbreitenteilindex konfiguriert ist.

5. Verfahren gemäß einem der Ansprüche 1 bis 4, wobei die Bewilligung eine Sidelink-Bewilligung oder eine Bewilligung für eine D2D-Schnittstelle ist.

6. Verfahren gemäß einem der Ansprüche 1 bis 5, wobei sich das Empfangen der Bewilligung auf ein

Empfangen eines Downlink-Steuersignals für ein zeitliches Planen der Ressource bezieht; und/oder wobei sich das Empfangen der Bewilligung auf ein Konfiguriert- oder Aktiviert-Werden mit einer konfigurierten Bewilligung durch die Basisstation bezieht.

7. Verfahren für eine erste Kommunikationsvorrichtung, umfassend:

Konfiguriert-Werden als Netzwerk-Zeitplanungsmodus und konfiguriert mit einer Mehrzahl von Ressourcenpools durch eine Basisstation für eine Zelle (1705);
Konfiguriert-Werden mit einer Konfiguration für eine Sidelink-Semi-Persistent-Zeitplanung, im Folgenden auch als SPS bezeichnet, (1710); und
Verwenden einer Ressource in einem Ressourcenpool der Mehrzahl von Ressourcenpools, um eine Übertragung auf einer Vorrichtung-zu-Vorrichtung-Schnittstelle basierend auf der Konfiguration für die Sidelink-SPS auszuführen, wobei die Ressource in der Konfiguration für die Sidelink-SPS angezeigt wird (1715),
die Konfiguration für die Sidelink-SPS weiter eine Ressourcenpoolidentität, im Folgenden auch als ID bezeichnet, aufweist, und
die Ressource durch die Ressourcenpool-ID in der Konfiguration für die Sidelink-SPS mit dem Ressourcenpool der Mehrzahl von Ressourcenpools verknüpft ist.

8. Verfahren gemäß Anspruch 7, wobei die Sidelink-SPS verwendet wird, ohne eine Aktivierungssignalisierung, die verwendet wird, um eine Sidelink-SPS zu aktivieren, von der Basisstation zu empfangen.

9. Verfahren gemäß einem der Ansprüche 1 bis 8, wobei die Mehrzahl von Ressourcenpools für eine Fahrzeug-zu-Allem-, im Folgenden auch als V2X bezeichnet, Kommunikation auf der D2D-Schnittstelle ist.

10. Verfahren gemäß einem der Ansprüche 1 bis 9, wobei die Zelle eine Spezialzelle, im Folgenden auch als SpCell bezeichnet, eine Primärzelle, im Folgenden auch als PCell bezeichnet, oder eine Sekundärzelle, im Folgenden auch als SCell bezeichnet, ist.

11. Verfahren gemäß einem der Ansprüche 1 bis 10, wobei die Übertragung eine Unicast-Übertragung, eine Multicast-Übertragung oder eine Broadcast-Übertragung ist.

12. Verfahren gemäß einem der Ansprüche 1 bis 11, wobei die Übertragung für eine zweite Kommunikationsvorrichtung ist.

13. Erste Kommunikationsvorrichtung, aufweisend:

eine Steuerungsschaltung (306);
einen Prozessor (308), der in der Steuerungsschaltung (306) installiert ist; und
einen Speicher (310), der in der Steuerungsschaltung (306) installiert und betriebsfähig mit dem Prozessor (308) verbunden ist;
dadurch gekennzeichnet, dass der Prozessor (308) eingerichtet ist, einen Programm-Code (312), der in dem Speicher (310) gespeichert ist, auszuführen, um die in einem der vorstehenden Ansprüche definierten Verfahrensschritte auszuführen.

Revendications

1. Procédé pour un premier dispositif de communication, comprenant :

étant configuré en mode de planification de réseau et configuré avec une pluralité de pools de ressources par une station de base pour une cellule (1605) ;
la réception d'une autorisation de la station de base, où l'autorisation indique une ressource (1610) ; et
l'utilisation de la ressource pour effectuer une transmission sur une interface de dispositif à dispositif, ci-après également appelée D2D, (1615),
dans lequel
l'autorisation comprend en outre un index de pool de ressources, et la ressource est associée à un pool de ressources de la pluralité de pools de ressources par l'intermédiaire de l'index de pool de ressources dans l'autorisation.

2. Procédé de la revendication 1, dans lequel le pool de ressources est configuré avec l'index de pool de ressources.

3. Procédé de la revendication 1 ou 2, dans lequel un champ dans l'autorisation indique l'index de pool de ressources ou l'identité du pool de ressources.

4. Procédé de l'une quelconque des revendications 1 à 3, dans lequel le procédé est pour une communication de Véhicule à X, ci-après également appelée V2X, sur l'interface D2D, et l'association est indiquée par l'intermédiaire d'un indice de partie de bande passante dans l'autorisation ;
dans lequel, de préférence, le pool de ressources est associé à une partie de bande passante configurée avec l'index de partie de bande passante.

5. Procédé de l'une quelconque des revendications 1

à 4, dans lequel l'autorisation est une autorisation de liaison latérale ou une autorisation d'interface D2D.

6. Procédé de l'une quelconque des revendications 1 à 5, dans lequel la réception de l'autorisation fait référence à la réception d'un signal de commande de liaison descendante pour planifier la ressource ; et/ou
dans lequel la réception de l'autorisation fait référence à la configuration ou à l'activation avec une autorisation configurée par la station de base.

7. Procédé pour un premier dispositif de communication, comprenant :

étant configuré en mode de planification de réseau et configuré avec une pluralité de pools de ressources par une station de base pour une cellule (1705) ;
étant configuré avec une configuration pour la planification semi-persistante de liaison latérale, ci-après également appelée SPS (1710) ; et
l'utilisation d'une ressource dans un pool de ressources de la pluralité de pools de ressources pour effectuer une transmission sur une interface de dispositif à dispositif sur la base de la configuration pour SPS de liaison latérale, où la ressource est indiquée dans la configuration pour SPS de liaison latérale (1715),
la configuration pour SPS de liaison latérale comprend en outre une identité de pool de ressources, ci-après également appelée 10, et
la ressource est associée au pool de ressources de la pluralité de pools de ressources par l'intermédiaire de l'ID de pool de ressources dans la configuration pour SPS de liaison latérale.

8. Procédé de la revendication 7, dans lequel la SPS de liaison latérale est utilisée sans recevoir une signalisation d'activation utilisée pour activer une SPS de liaison latérale depuis la station de base.

9. Procédé de l'une quelconque des revendications 1 à 8, dans lequel la pluralité de pools de ressources est destinée à une communication de Véhicule à X, ci-après également appelée V2X, sur l'interface D2D.

10. Procédé de l'une quelconque des revendications 1 à 9, dans lequel la cellule est une cellule spéciale, ci-après également appelée SpCell, une cellule primaire, ci-après également appelée PCell, ou une cellule secondaire, ci-après également appelée SCell.

11. Procédé de l'une quelconque des revendications 1 à 10, dans lequel la transmission est une transmission monodiffusion, une transmission multidiffusion ou une transmission de diffusion.

12. Procédé de l'une quelconque des revendications 1 à 11, dans lequel la transmission est destinée à un deuxième dispositif de communication.

13. Premier dispositif de communication, comprenant :

un circuit de commande (306) ;
un processeur (308) installé dans le circuit de commande (306) ; et
une mémoire (310) installée dans le circuit de commande (306) et fonctionnellement couplée au processeur (308) ;
caractérisé en ce que le processeur (308) est configuré pour exécuter un code de programme (312) stocké dans la mémoire (310) pour effectuer les étapes de procédé telles que définies dans l'une quelconque des revendications précédentes.

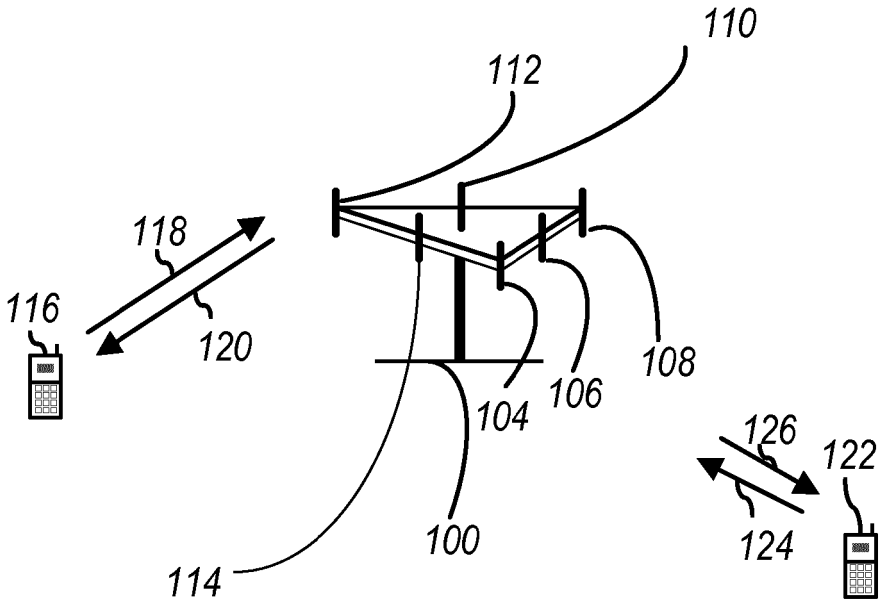


FIG. 1

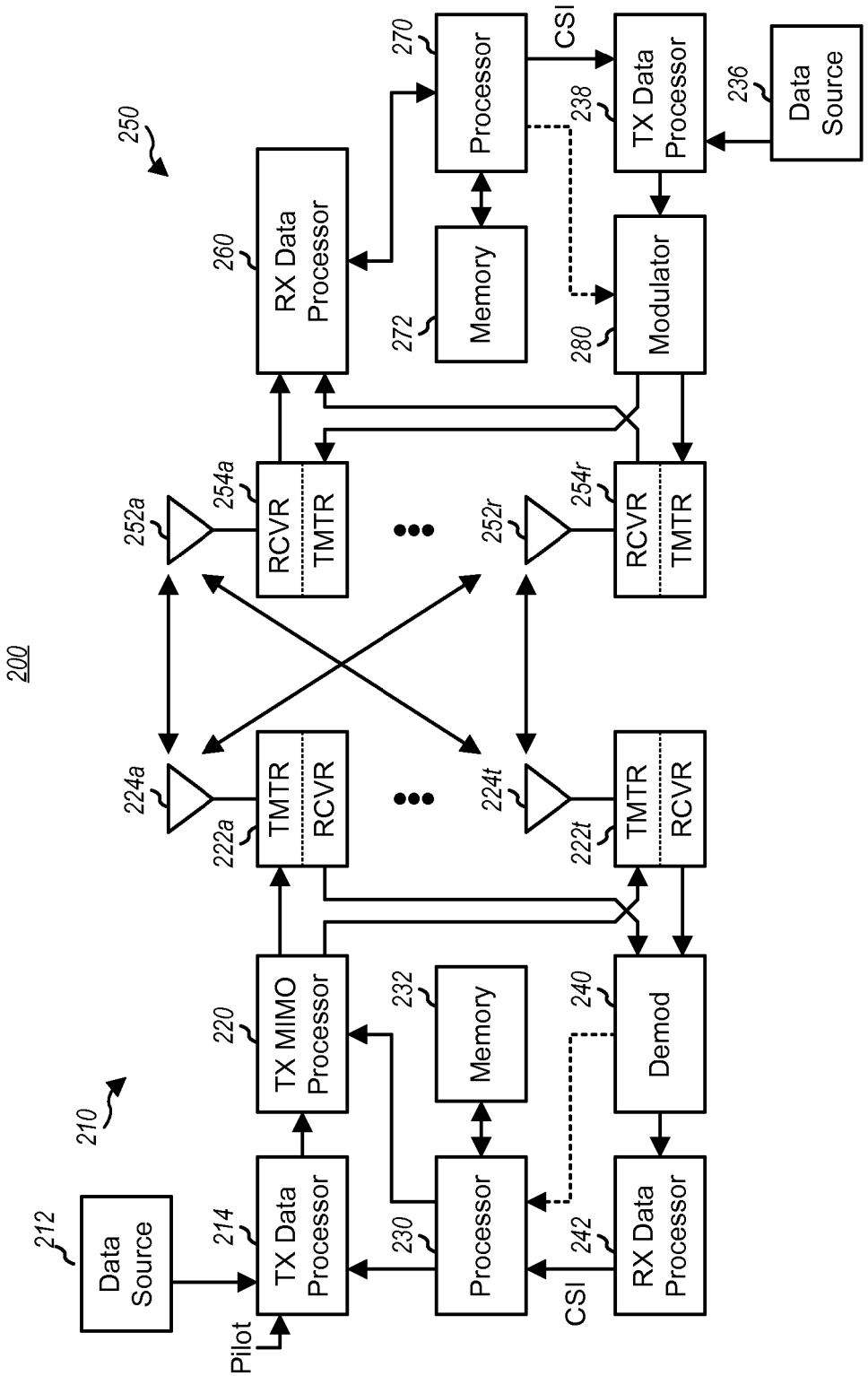

200
210
212
Data Source
214
TX Data Processor
Pilot
220
TX MIMO Processor
222a
TMTR
RCVR
224a
224t
222t
230
Processor
232
Memory
240
Demod
242
RX Data Processor
CSI
250
252a
254a
RCVR
TMTR
252r
254r
260
RX Data Processor
270
Processor
272
Memory
280
Modulator
238
CSI
TX Data Processor
236
Data Source

FIG. 2

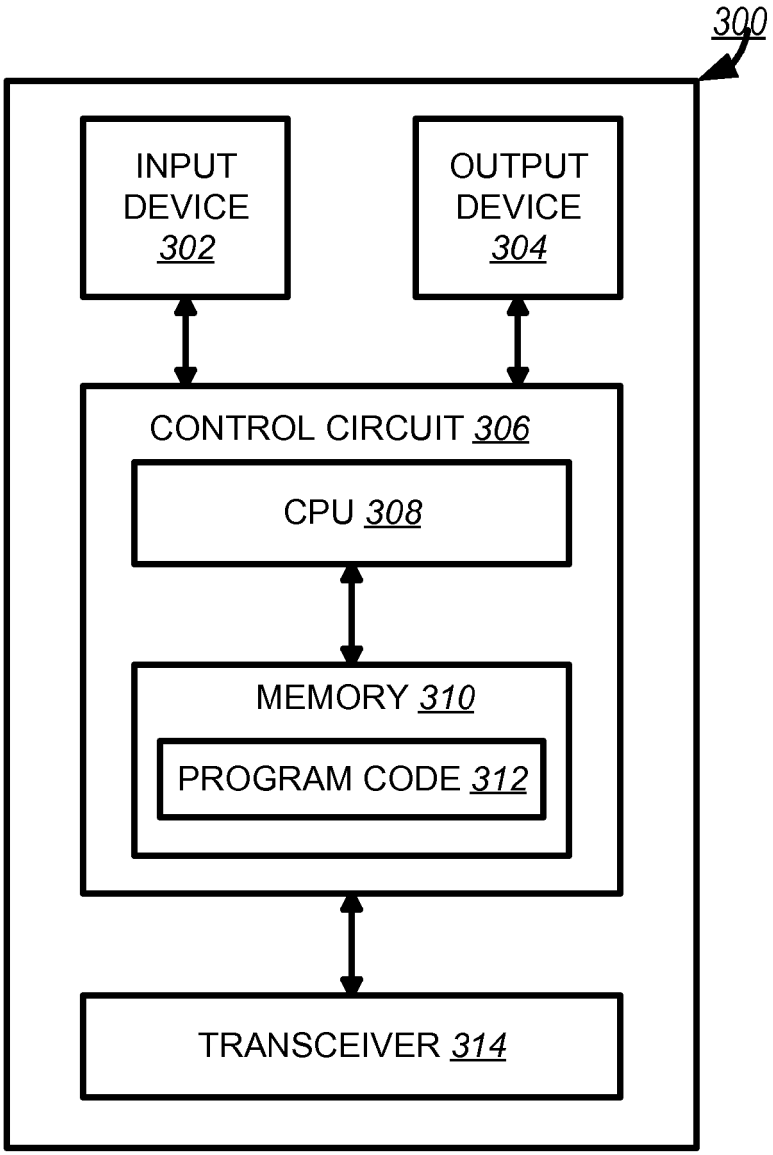

300
INPUT DEVICE 302
OUTPUT DEVICE 304
CONTROL CIRCUIT 306
CPU 308
MEMORY 310
PROGRAM CODE 312
TRANSCEIVER 314

FIG. 3

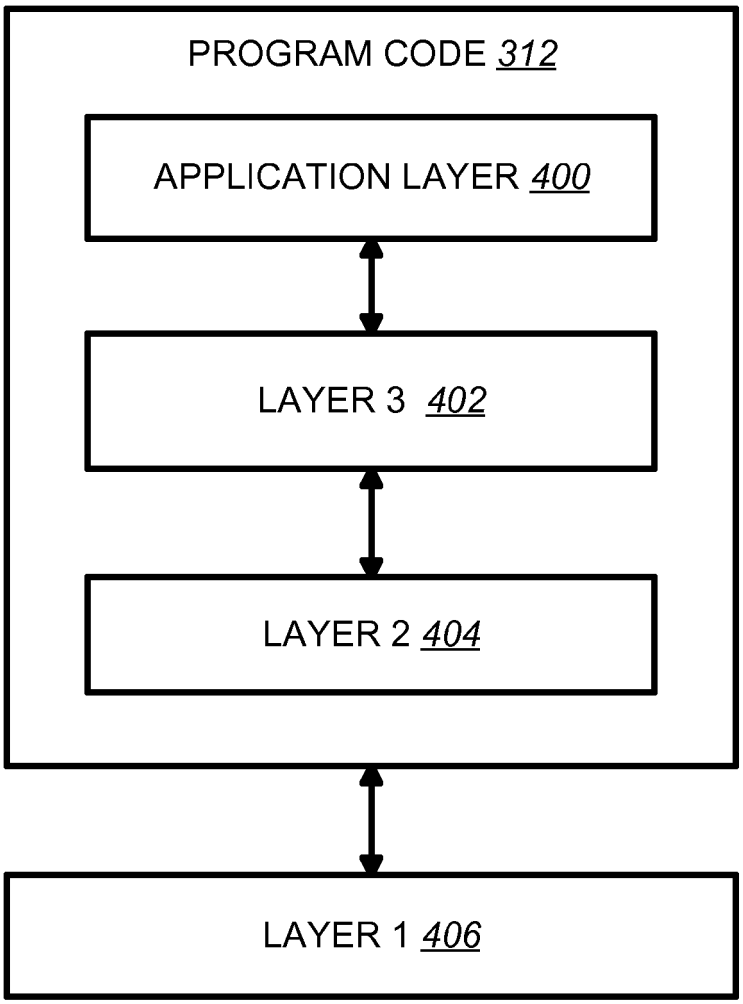

PROGRAM CODE 312
APPLICATION LAYER 400
LAYER 3 402
LAYER 2 404
LAYER 1 406

FIG. 4

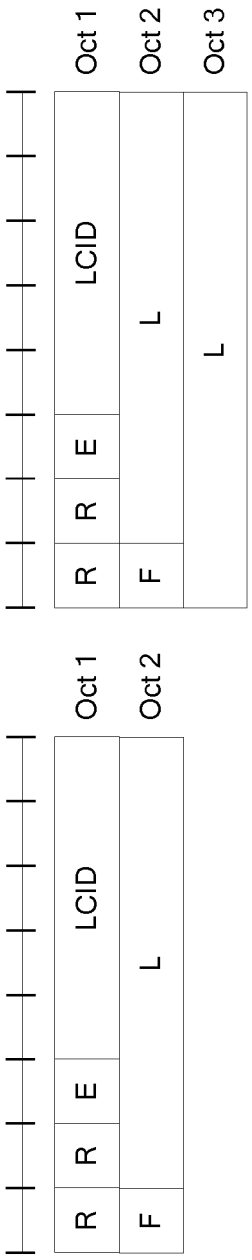
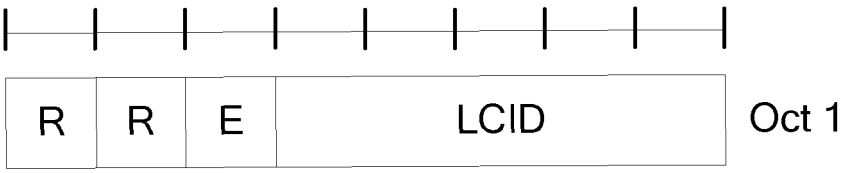


FIG. 5 (PRIOR ART)



R/R/E/LCID sub-header

FIG. 6 (PRIOR ART)

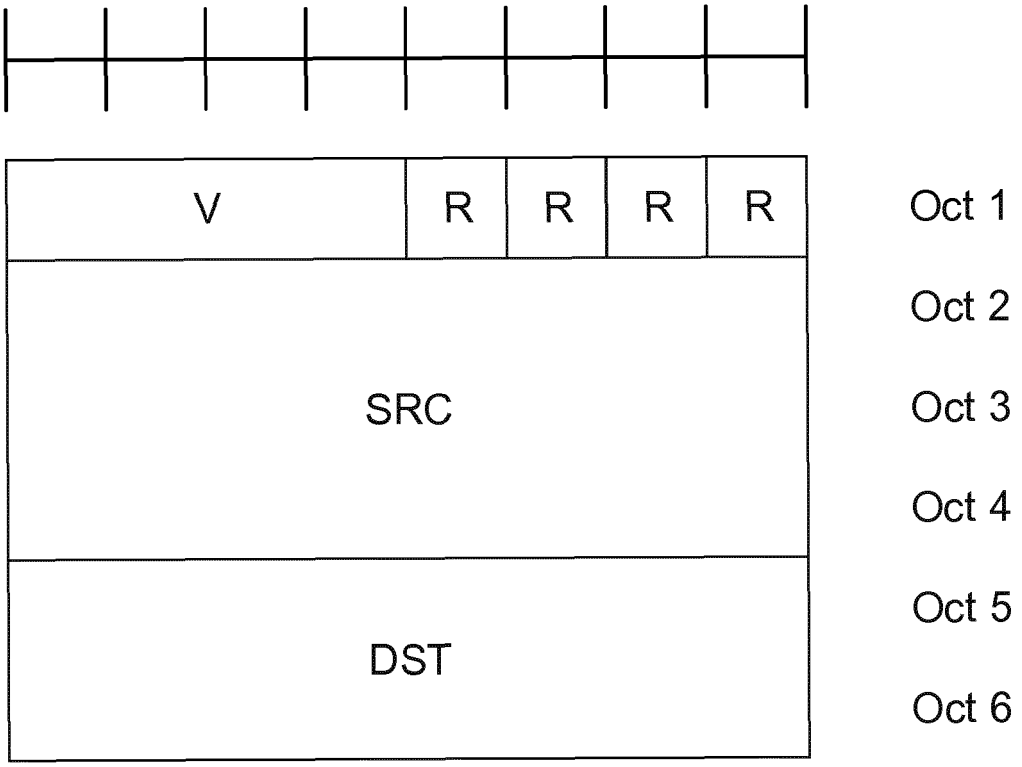


FIG. 7 (PRIOR ART)

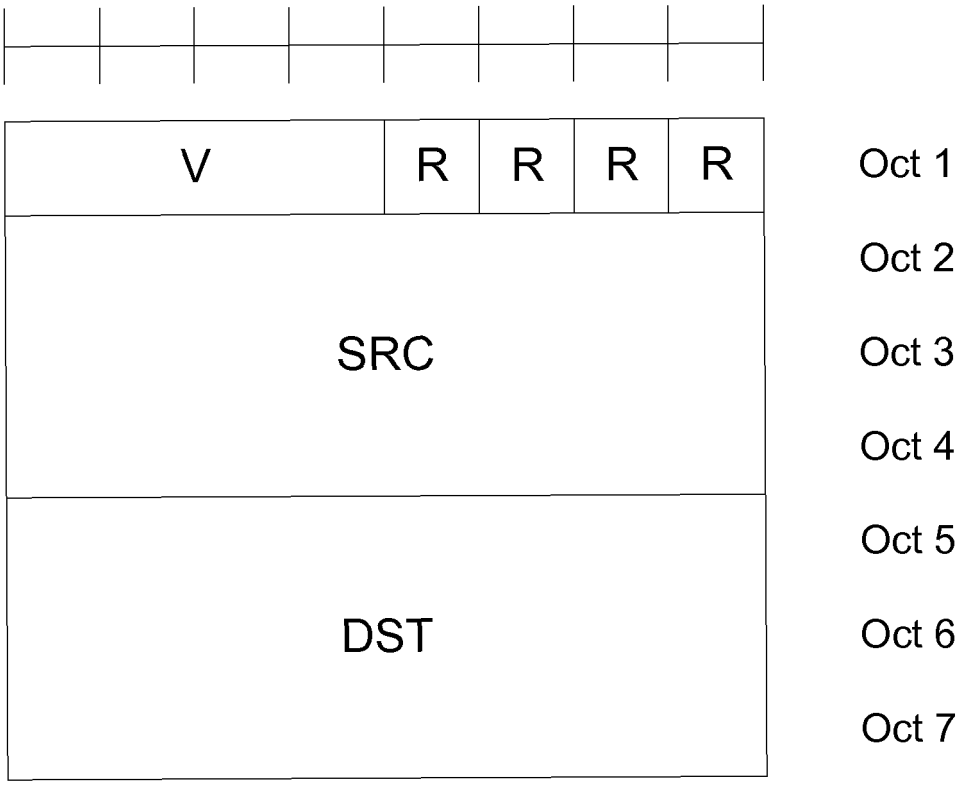


FIG. 8 (PRIOR ART)

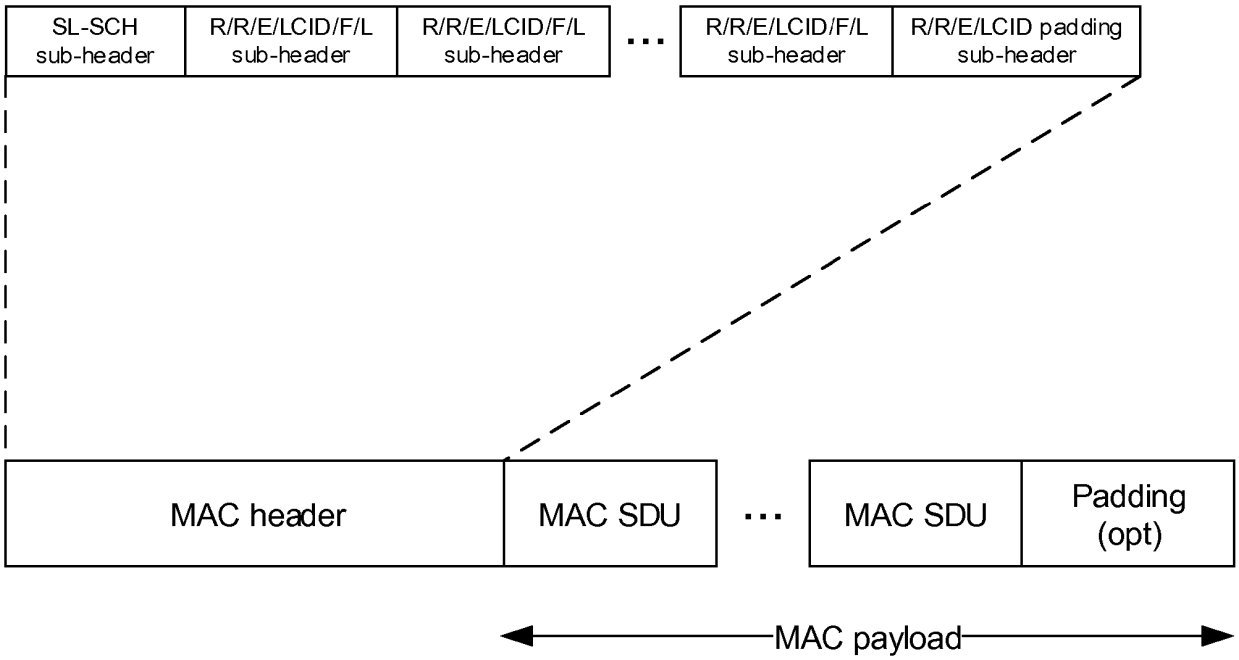


FIG. 9 (PRIOR ART)

Index	LCID values
00000	Reserved
00001-01010	Identity of the logical channel
01011-11011	Reserved
11100	PC5-S messages that are not protected
11101	PC5-S messages "Direct Security Mode Command" and "Direct Security Mode Complete"
11110	Other PC5-S messages that are protected
11111	Padding

FIG. 10 (PRIOR ART)

Index	Size of Length field (in bits)
0	7
1	15

FIG. 11 (PRIOR ART)

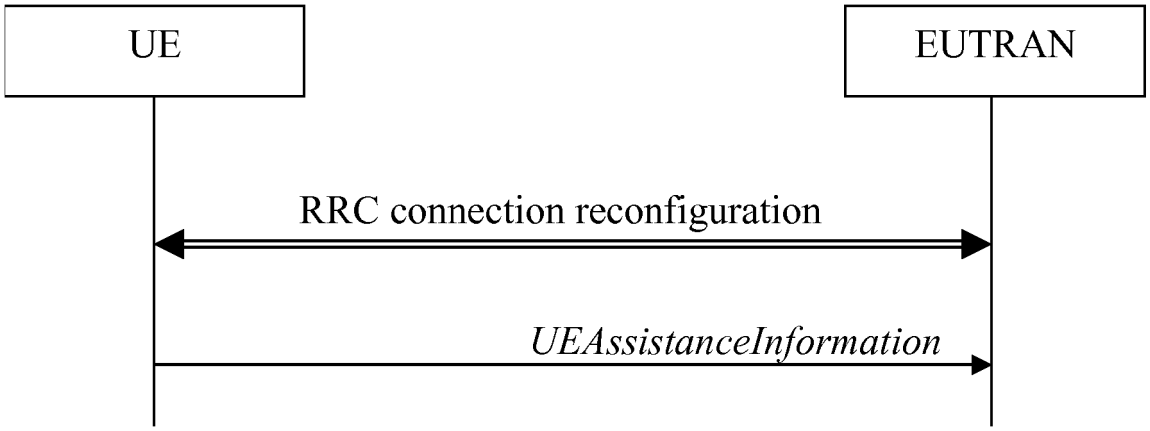


FIG. 12 (PRIOR ART)

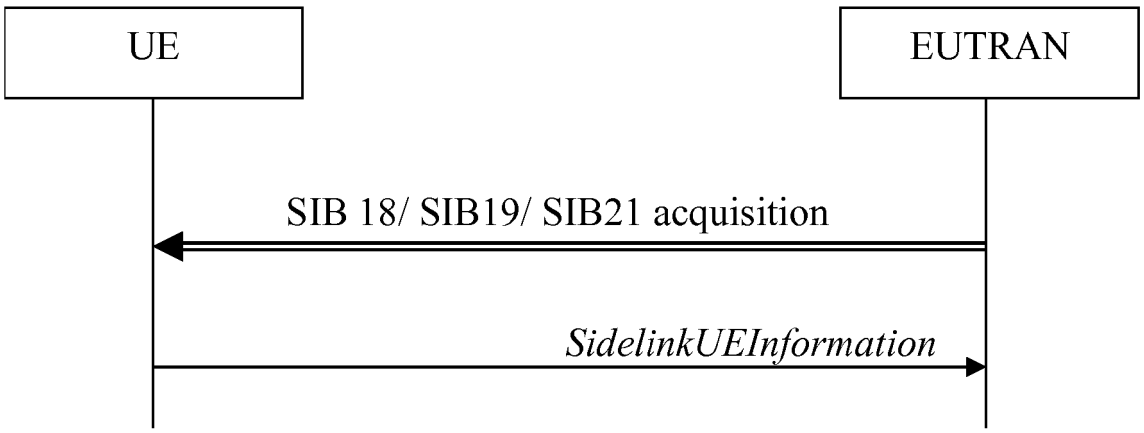


FIG. 13 (PRIOR ART)

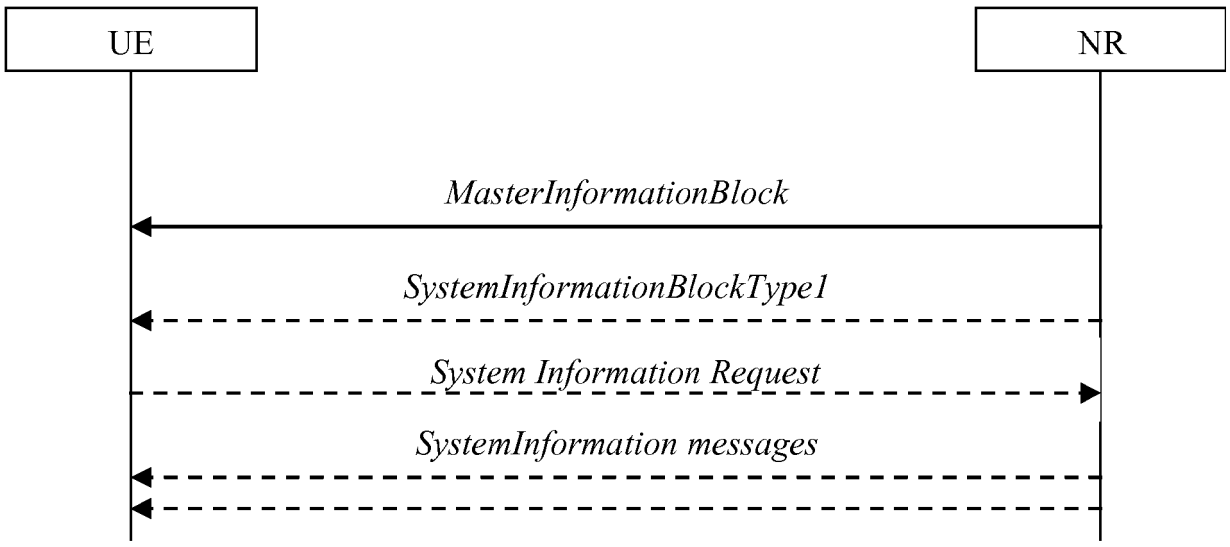


FIG. 14 (PRIOR ART)

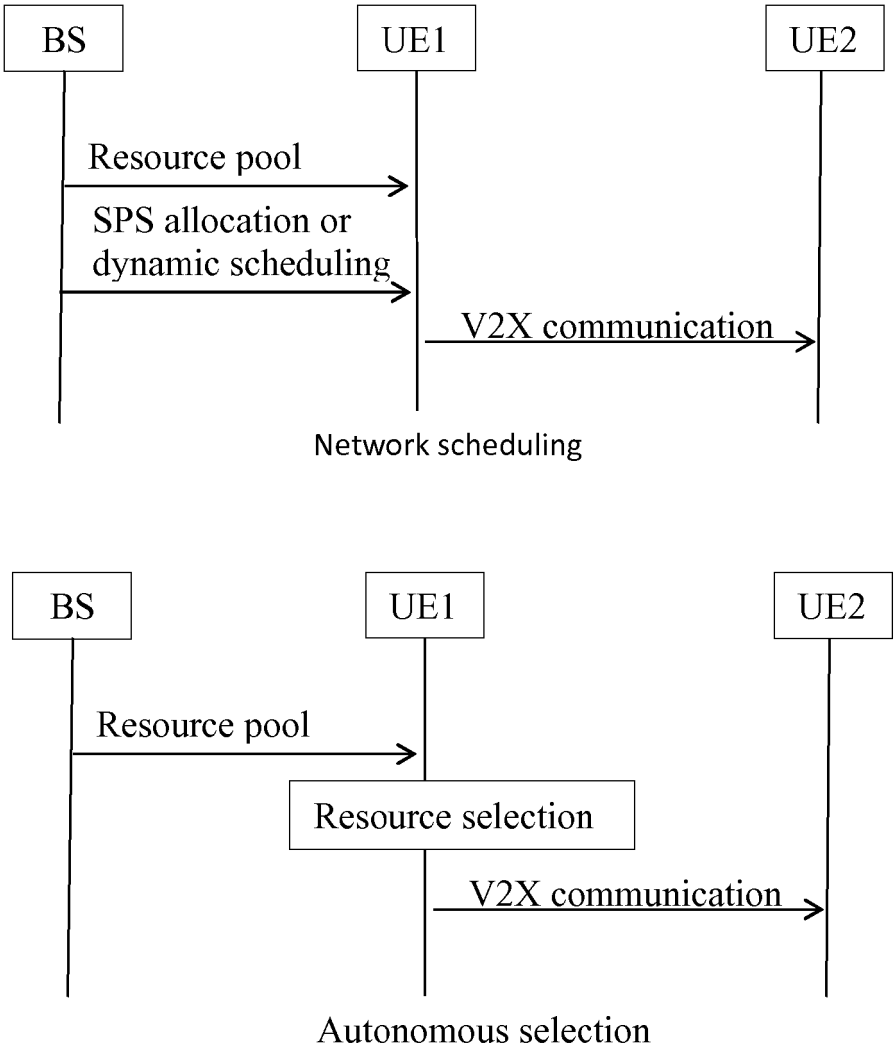

BS
UE1
UE2
Resource pool
SPS allocation or
dynamic scheduling
V2X communication
Network scheduling
BS
UE1
UE2
Resource pool
Resource selection
V2X communication
Autonomous selection

FIG. 15

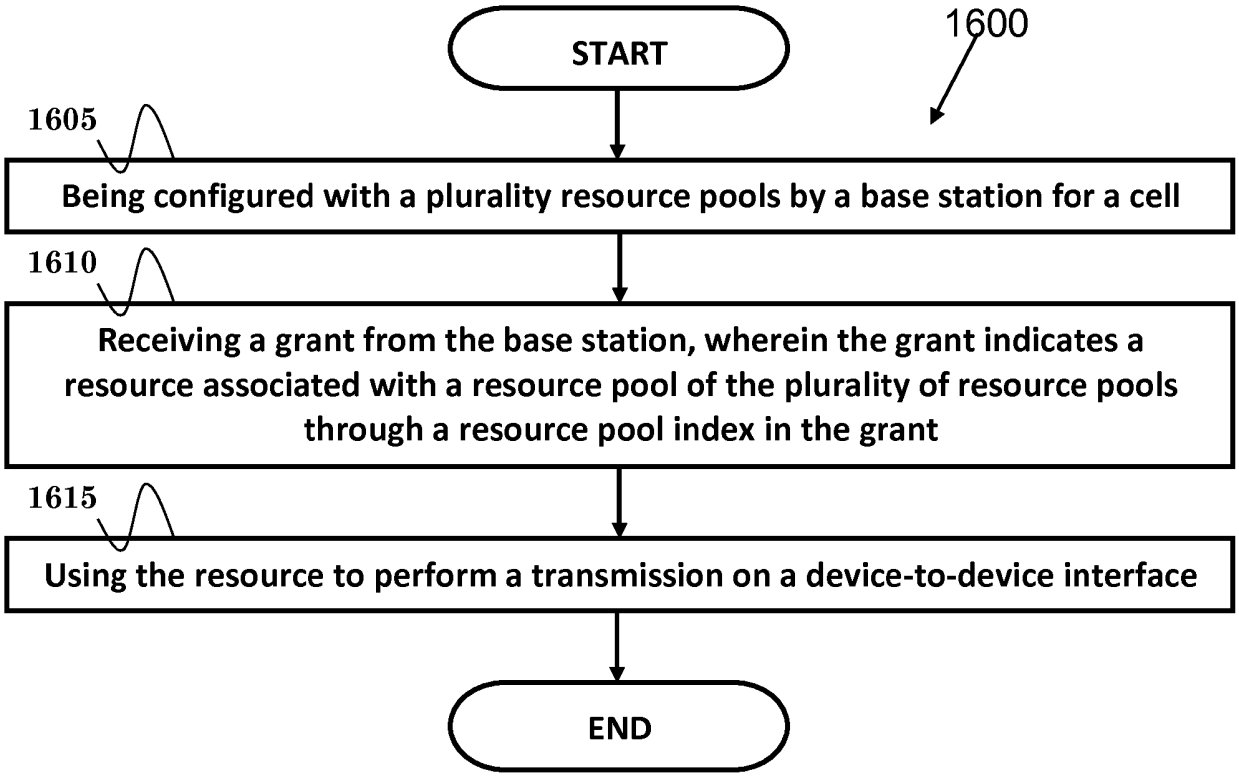

START
1600
1605
Being configured with a plurality resource pools by a base station for a cell
1610
Receiving a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools through a resource pool index in the grant
1615
Using the resource to perform a transmission on a device-to-device interface
END

FIG. 16

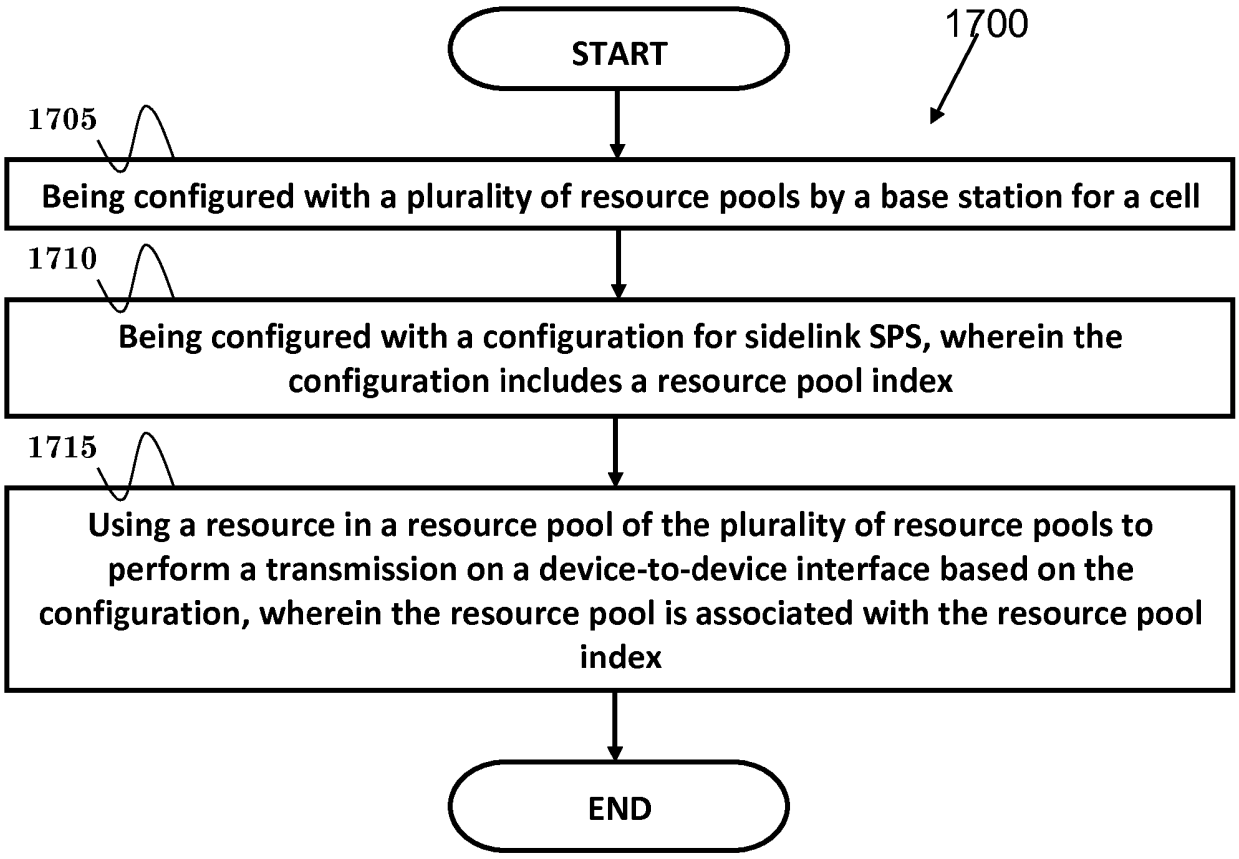

START
1700
1705
Being configured with a plurality of resource pools by a base station for a cell
1710
Being configured with a configuration for sidelink SPS, wherein the configuration includes a resource pool index
1715
Using a resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface based on the configuration, wherein the resource pool is associated with the resource pool index
END

FIG. 17

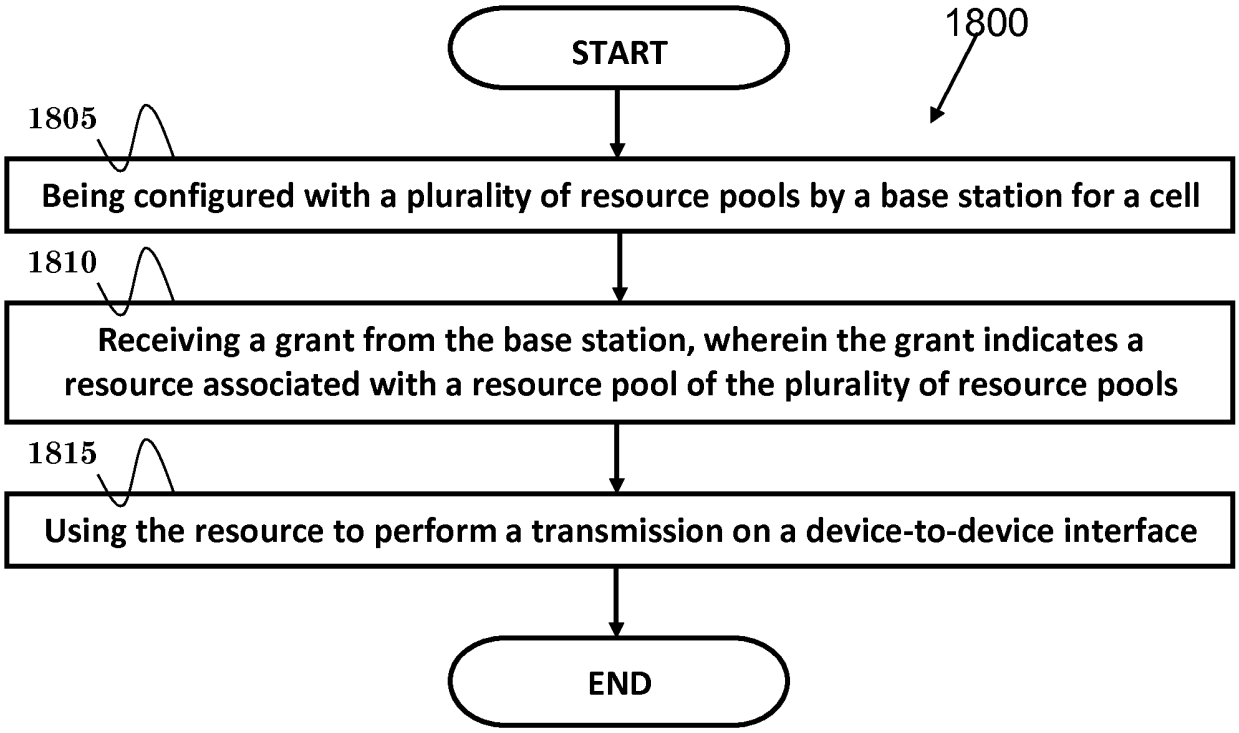

1800
START
1805
Being configured with a plurality of resource pools by a base station for a cell
1810
Receiving a grant from the base station, wherein the grant indicates a resource associated with a resource pool of the plurality of resource pools
1815
Using the resource to perform a transmission on a device-to-device interface
END

FIG. 18

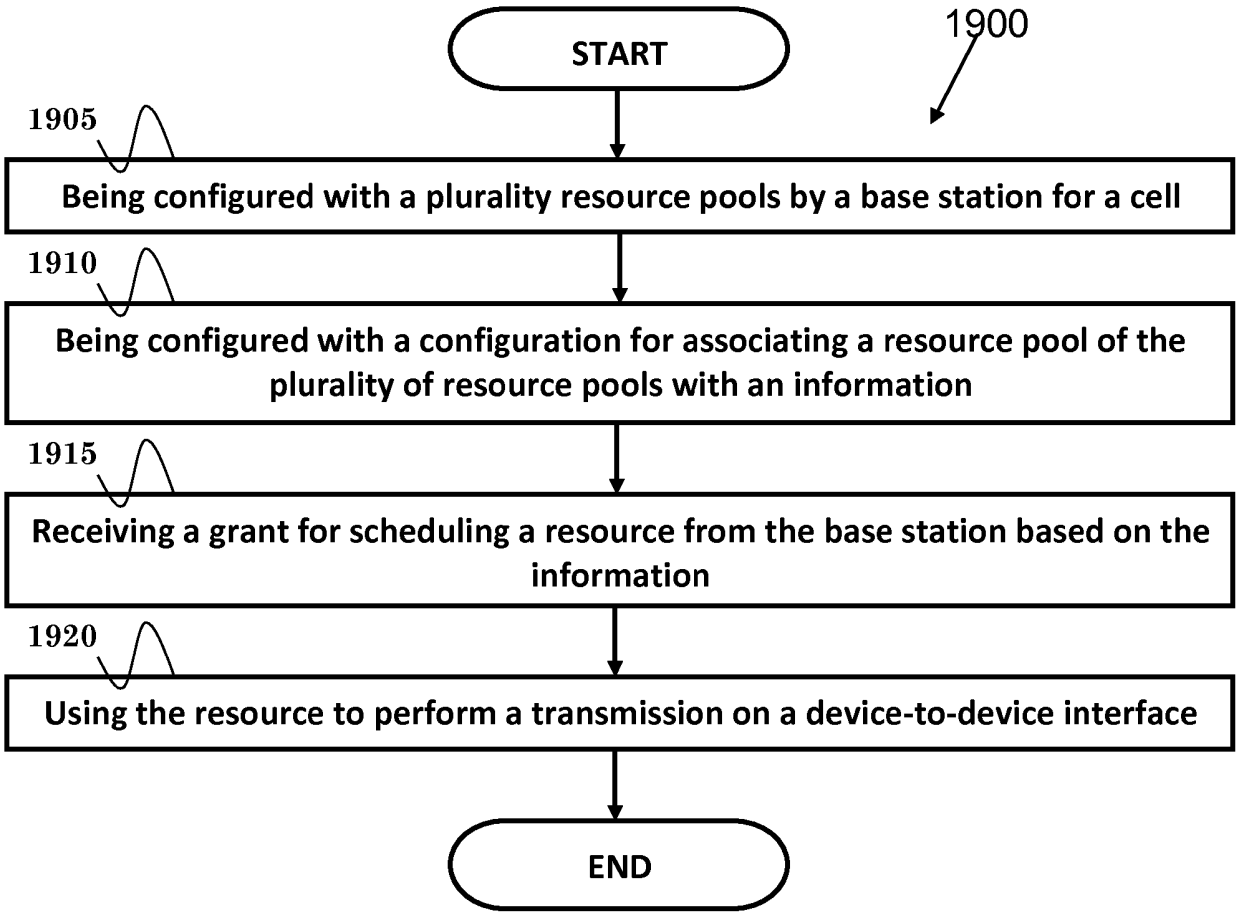

START
1900
1905
Being configured with a plurality resource pools by a base station for a cell
1910
Being configured with a configuration for associating a resource pool of the plurality of resource pools with an information
1915
Receiving a grant for scheduling a resource from the base station based on the information
1920
Using the resource to perform a transmission on a device-to-device interface
END

FIG. 19

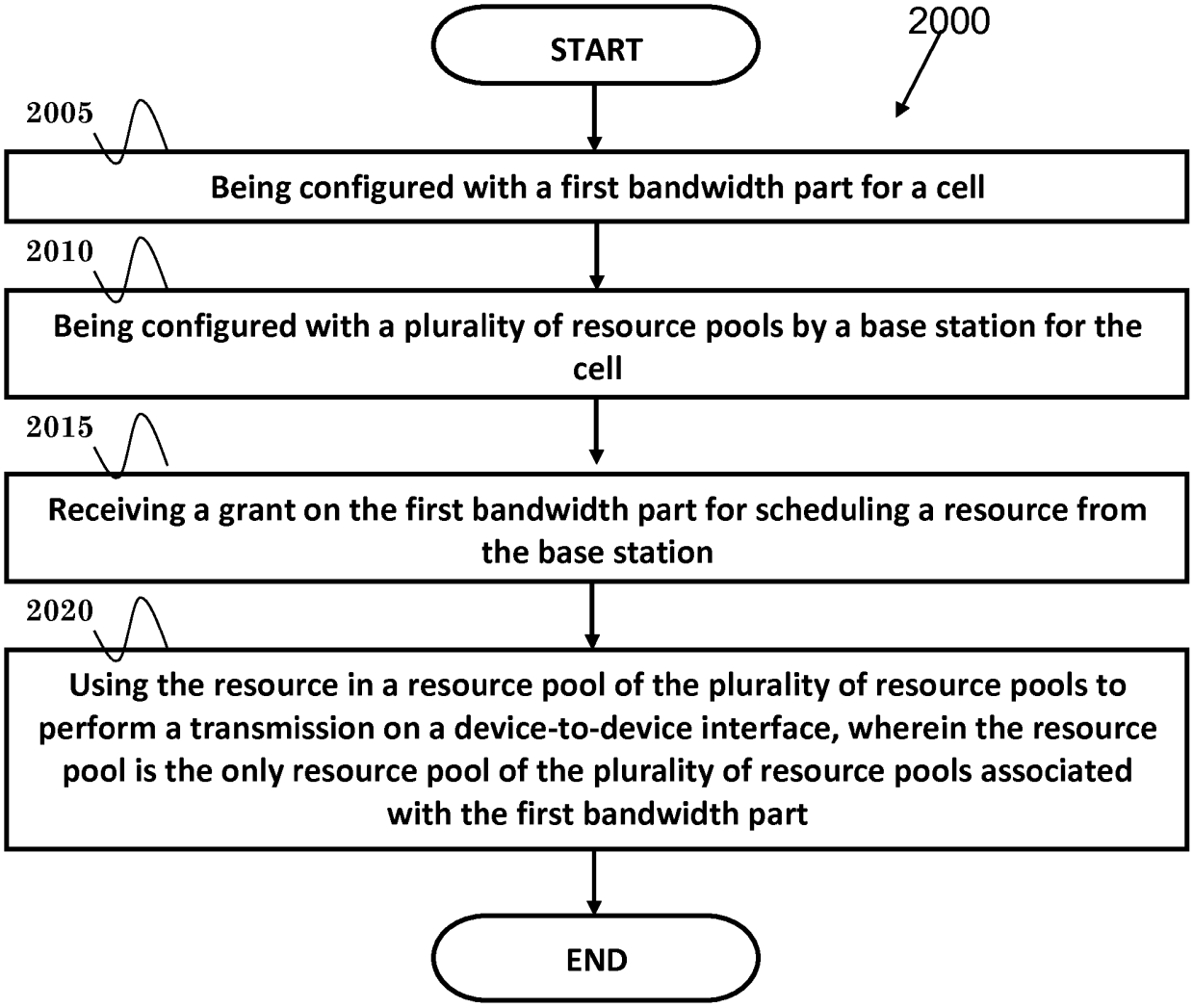

START
2000
2005
Being configured with a first bandwidth part for a cell
2010
Being configured with a plurality of resource pools by a base station for the cell
2015
Receiving a grant on the first bandwidth part for scheduling a resource from the base station
2020
Using the resource in a resource pool of the plurality of resource pools to perform a transmission on a device-to-device interface, wherein the resource pool is the only resource pool of the plurality of resource pools associated with the first bandwidth part
END

FIG. 20

REFERENCES CITED IN THE DESCRIPTION

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- WO 20187055813 A1 **[0005]**
- EP 3051736 A1 **[0006]**
- WO 2018062857 A1 **[0007]**
- EP 3614763 A1 **[0007]**