US012396050B2

(12) **United States Patent**
Park et al.

(10) **Patent No.: US 12,396,050 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **METHOD AND DEVICE FOR RLF IN NR V2X**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 411 days.

(21) Appl. No.: **17/926,381**

(22) PCT Filed: **Apr. 16, 2021**

(86) PCT No.: **PCT/KR2021/004784**
§ 371 (c)(1),
(2) Date: **Nov. 18, 2022**

(87) PCT Pub. No.: **WO2021/235705**
PCT Pub. Date: **Nov. 25, 2021**

(65) **Prior Publication Data**

US 2023/0189370 A1 Jun. 15, 2023

(30) **Foreign Application Priority Data**

May 19, 2020 (KR) 10-2020-0059864

(51) **Int. Cl.**
H04W 72/04 (2023.01)
H04L 1/1829 (2023.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 76/18*** (2018.02); ***H04L 1/1848*** (2013.01); ***H04L 1/1854*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04W 76/18; H04W 76/28; H04W 76/14; H04W 76/19; H04W 72/25;
(Continued)

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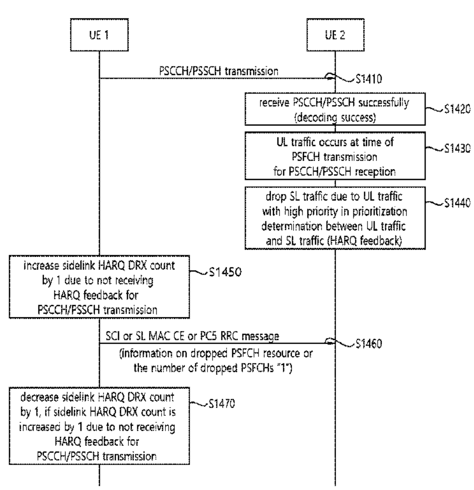
(Continued)

Primary Examiner — Mahbubul Bar Chowdhury
(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

Provided are a method for a first device carrying out wireless communication, and an apparatus supporting same. The method may comprise the steps of: transmitting sidelink control information (SCI) to a second device via a physical sidelink control channel (PSCCH); transmitting data to the second device via a physical sidelink shared channel (PSSCH) which is associated with the PSCCH; determining a physical sidelink feedback channel (PSFCH) resource on the basis of a slot and subchannel associated with the PSSCH: increasing a DTX counter by one on the basis of failing to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receiving, from the second device, information related to dropping the transmission

(Continued)



of the HARQ feedback; and decreasing the DTX counter by N on the basis of the information related to dropping the transmission of the HARQ feedback. Sidelink (SL) radio link failure (RLF) may be declared on the basis that the DTX counter reaches the maximum number of DTXs, and N may be a positive integer.

18 Claims, 22 Drawing Sheets

(51) **Int. Cl.**

H04L 5/00	(2006.01)
H04W 72/25	(2023.01)
H04W 76/18	(2018.01)
H04W 76/28	(2018.01)
H04L 1/1812	(2023.01)

(52) **U.S. Cl.**
CPC ***H04L 5/0055*** (2013.01); ***H04W 72/25*** (2023.01); ***H04W 76/28*** (2018.02); *H04L 1/1812* (2013.01)

(58) **Field of Classification Search**
CPC H04W 72/231; H04W 4/40; H04L 1/1848; H04L 1/1854; H04L 1/1812; H04L 1/1864; H04L 1/0026; H04L 1/1861; H04L 5/0055; H04L 2001/0093; H04B 7/0695; H04B 7/088
See application file for complete search history.

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FIG. 1

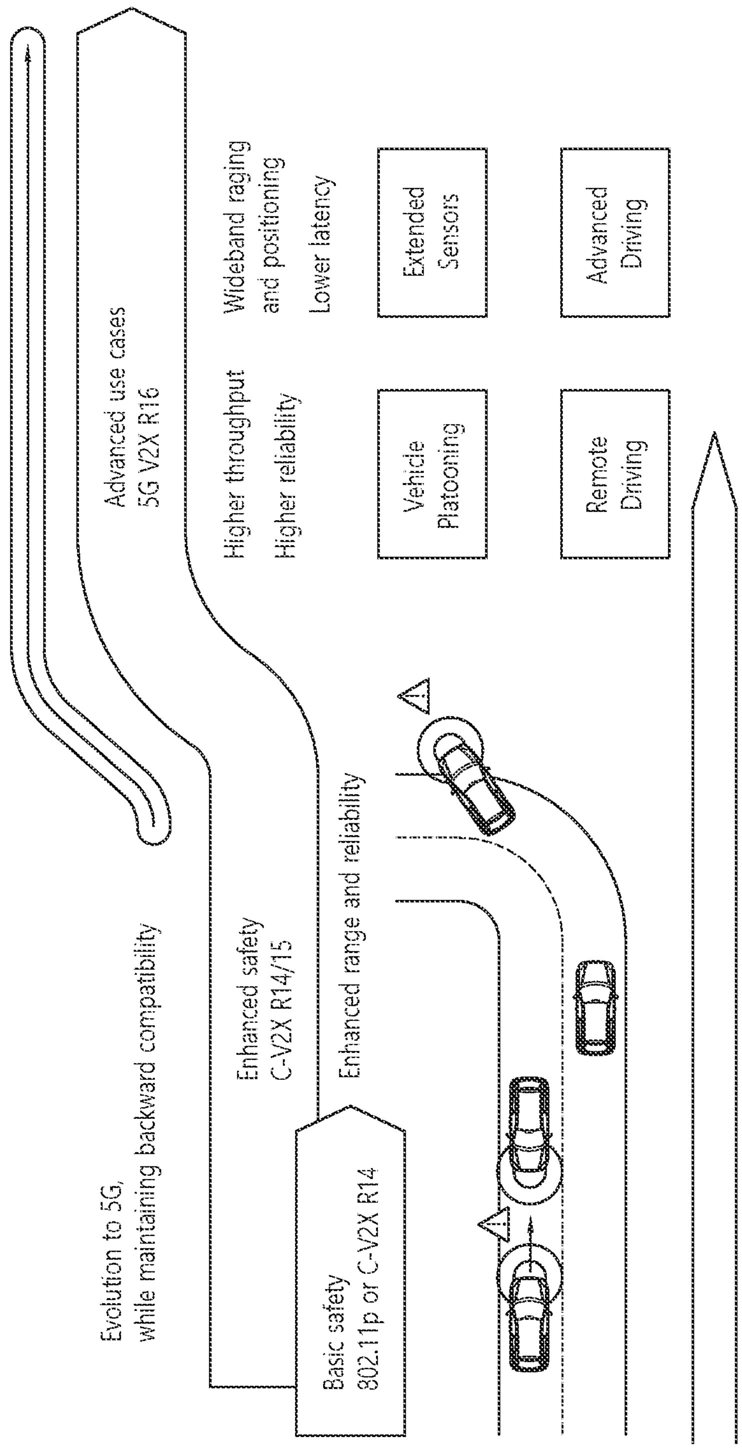

Evolution to 5G,
while maintaining backward compatibility
Basic safety
802.11p or C-V2X R14
Enhanced safety
C-V2X R14/15
Enhanced range and reliability
Advanced use cases
5G V2X R16
Higher throughput
Higher reliability
Wideband raging
and positioning
Lower latency
Vehicle
Platooning
Extended
Sensors
Remote
Driving
Advanced
Driving

FIG. 2

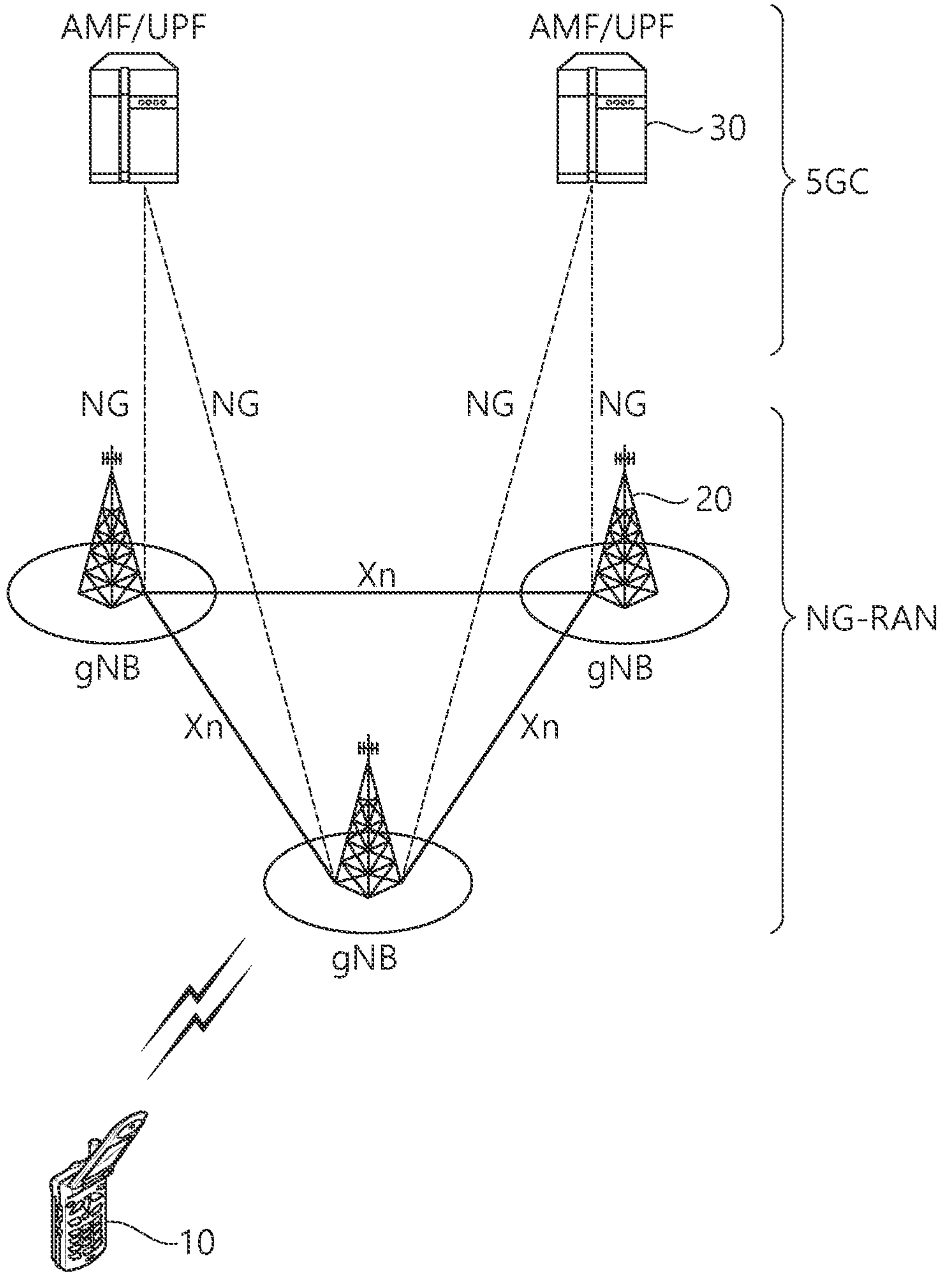


FIG. 3

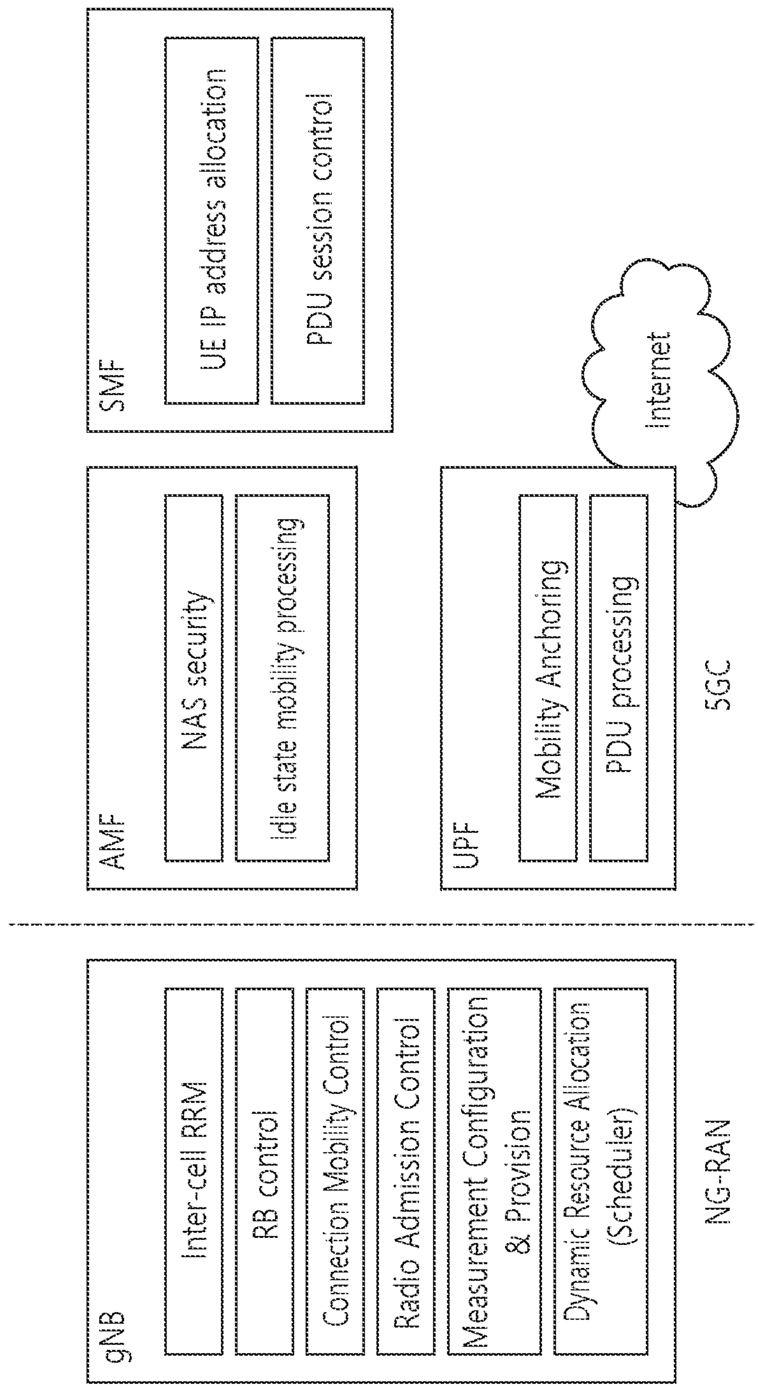
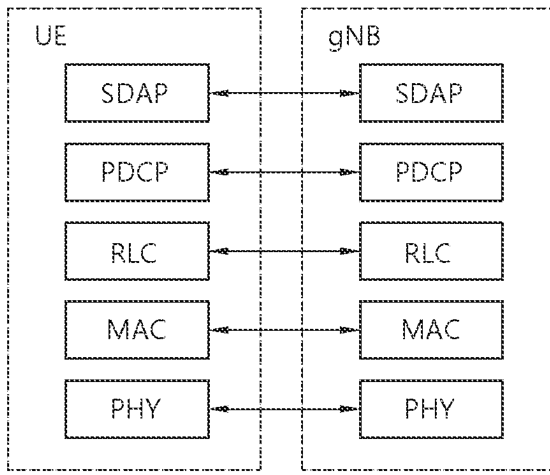
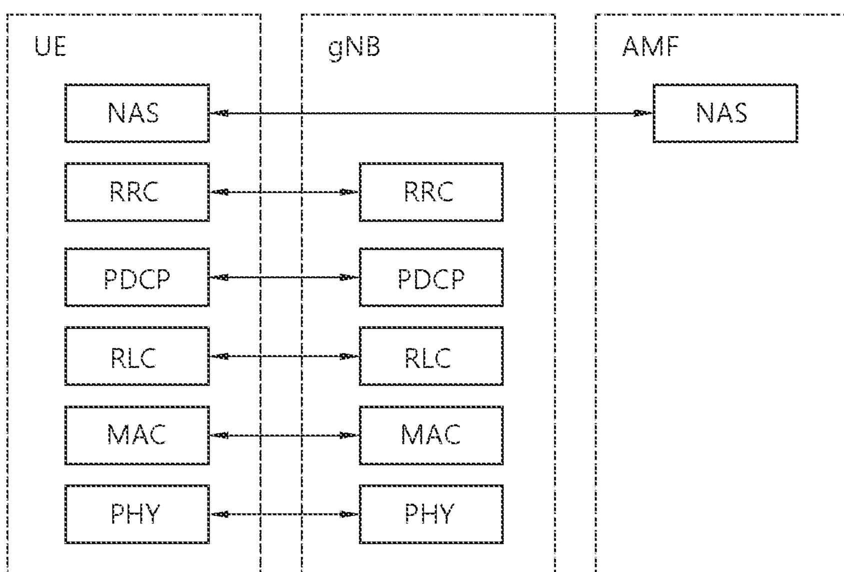

gNB
Inter-cell RRM
RB control
Connection Mobility Control
Radio Admission Control
Measurement Configuration & Provision
Dynamic Resource Allocation (Scheduler)
NG-RAN
AMF
NAS security
Idle state mobility processing
UPF
Mobility Anchoring
PDU processing
SMF
UE IP address allocation
PDU session control
Internet
5GC

FIG. 4


UE
gNB
SDAP
SDAP
PDCP
PDCP
RLC
RLC
MAC
MAC
PHY
PHY

(a)


UE
gNB
AMF
NAS
NAS
RRC
RRC
PDCP
PDCP
RLC
RLC
MAC
MAC
PHY
PHY

(b)

FIG. 5

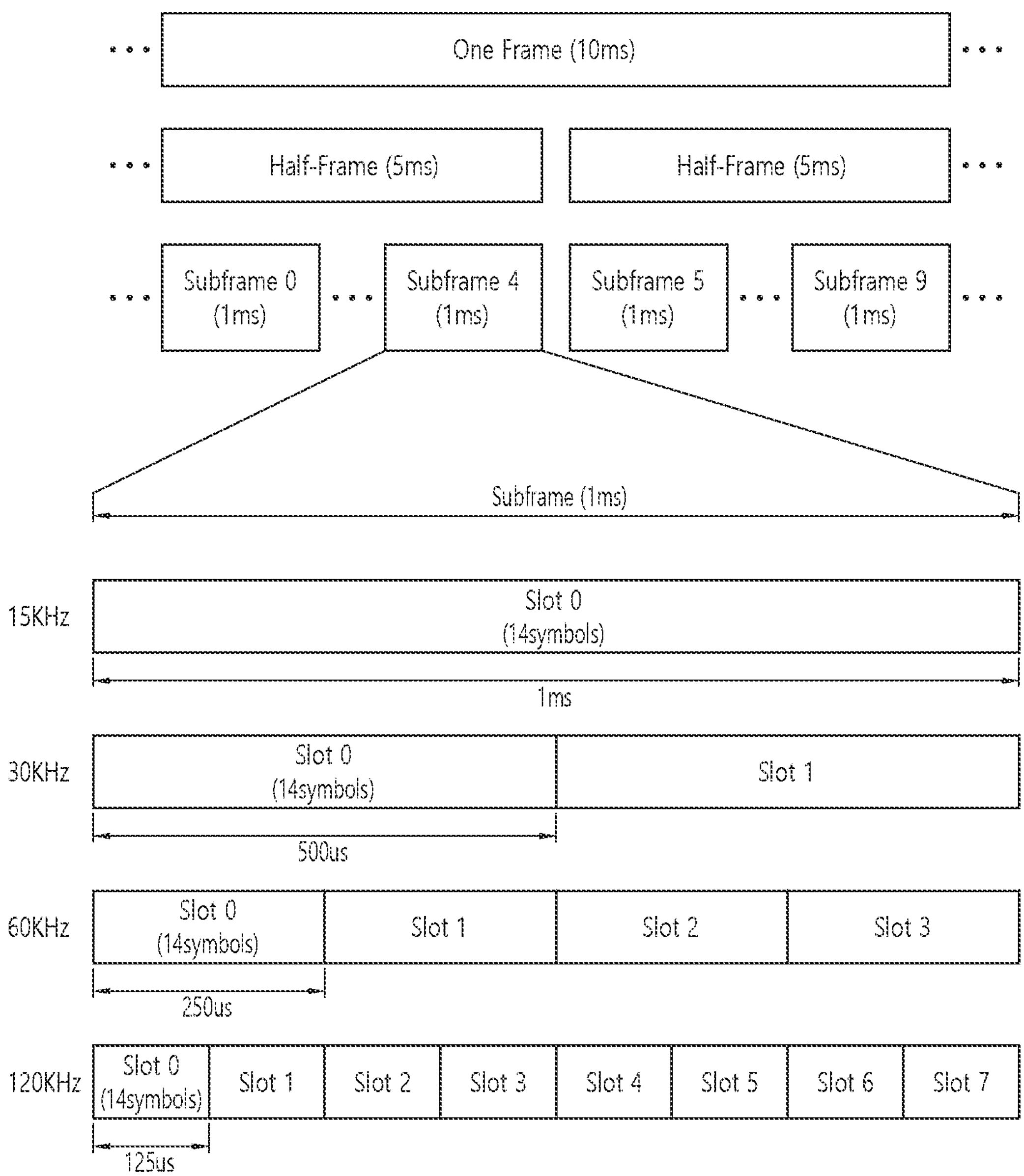

One Frame (10ms)
Half-Frame (5ms)
Half-Frame (5ms)
Subframe 0 (1ms)
Subframe 4 (1ms)
Subframe 5 (1ms)
Subframe 9 (1ms)
Subframe (1ms)
15KHz
Slot 0 (14symbols)
1ms
30KHz
Slot 0 (14symbols)
Slot 1
500us
60KHz
Slot 0 (14symbols)
Slot 1
Slot 2
Slot 3
250us
120KHz
Slot 0 (14symbols)
Slot 1
Slot 2
Slot 3
Slot 4
Slot 5
Slot 6
Slot 7
125us

FIG. 6

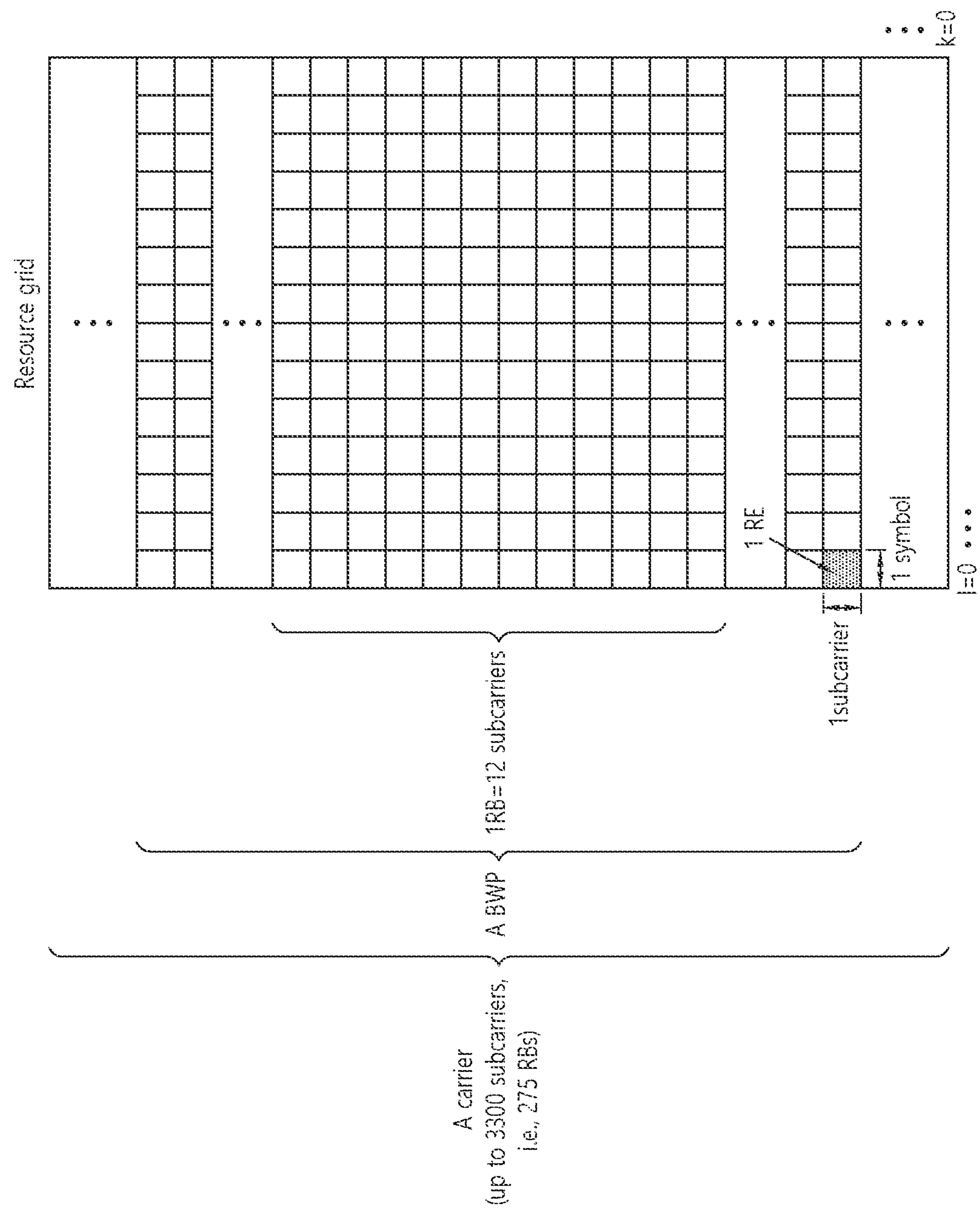

Resource grid
1RB=12 subcarriers
A BWP
A carrier
(up to 3300 subcarriers,
i.e., 275 RBs)
1 RE
1 symbol
1subcarrier
k=0
l=0

FIG. 7

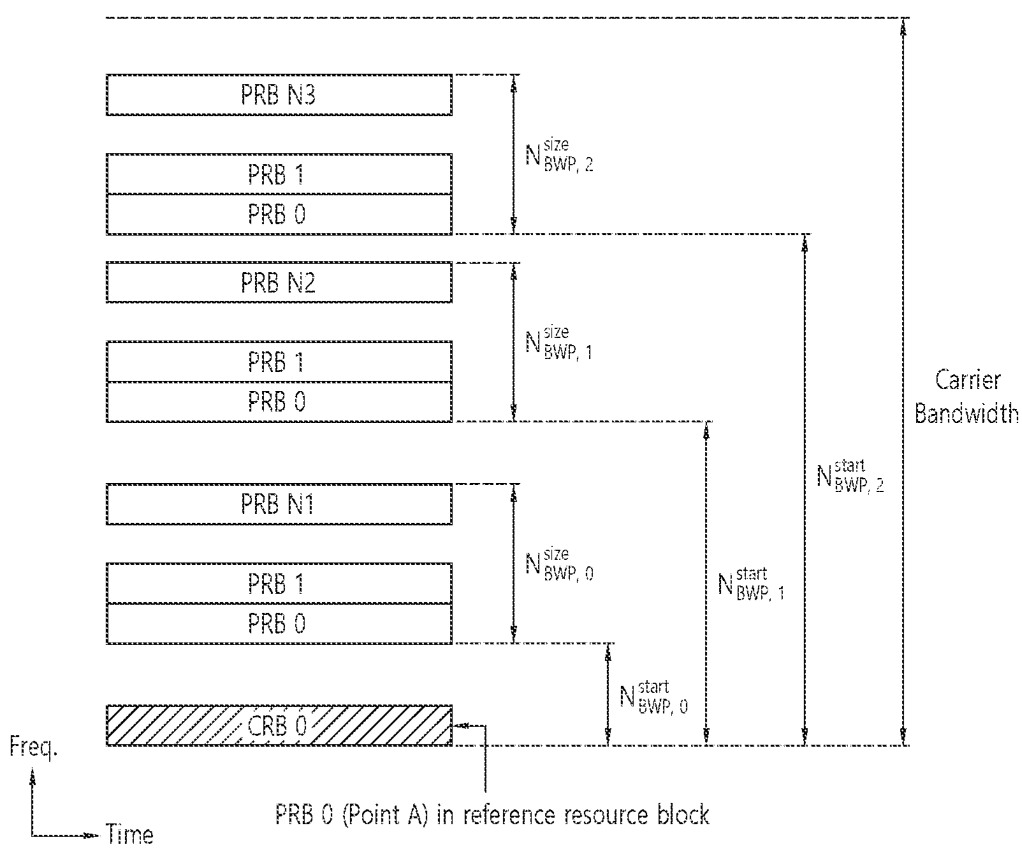

PRB N3
PRB 1
PRB 0
$N^{size}_{BWP,2}$
PRB N2
PRB 1
PRB 0
$N^{size}_{BWP,1}$
PRB N1
PRB 1
PRB 0
$N^{size}_{BWP,0}$
CRB 0
$N^{start}_{BWP,0}$
$N^{start}_{BWP,1}$
$N^{start}_{BWP,2}$
Carrier Bandwidth
Freq.
Time
PRB 0 (Point A) in reference resource block

FIG. 8

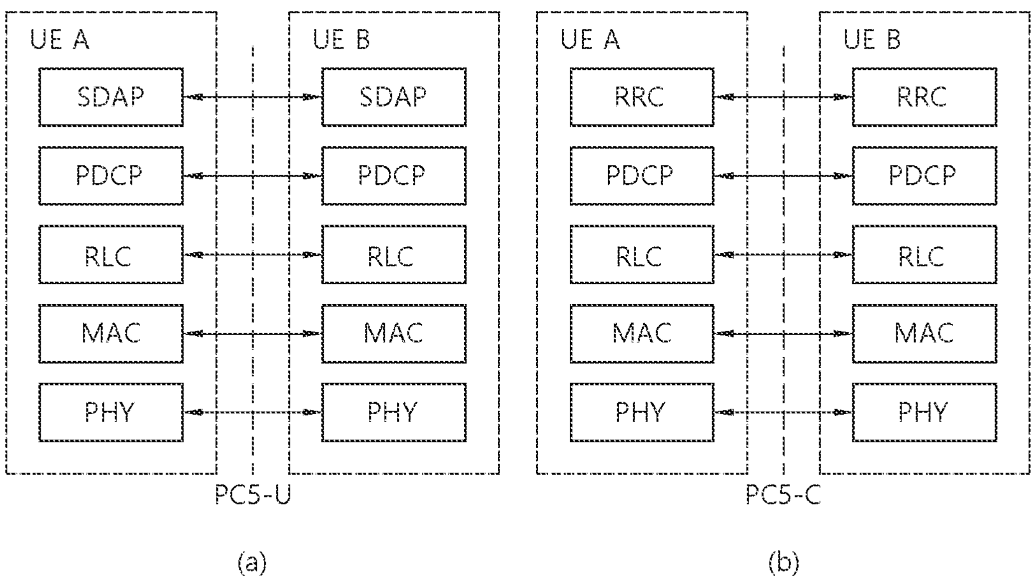

UE A
SDAP
PDCP
RLC
MAC
PHY
UE B
SDAP
PDCP
RLC
MAC
PHY
PC5-U
(a)
UE A
RRC
PDCP
RLC
MAC
PHY
UE B
RRC
PDCP
RLC
MAC
PHY
PC5-C
(b)

FIG. 9

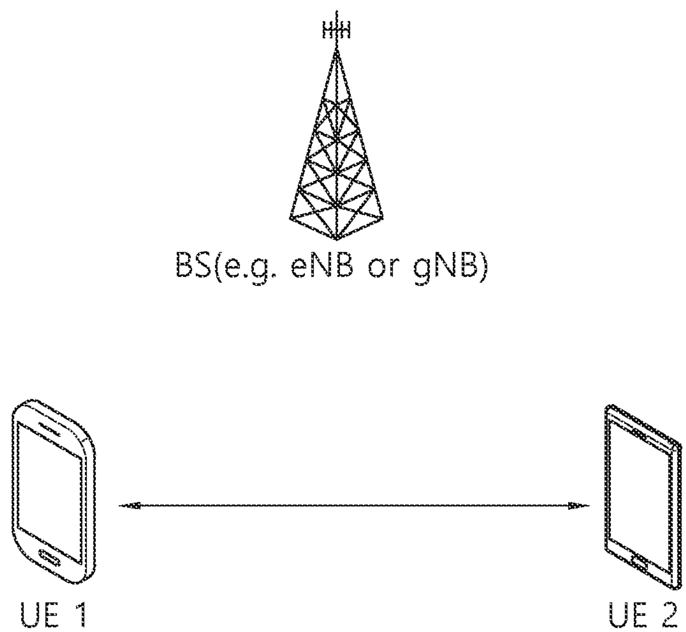


FIG. 10

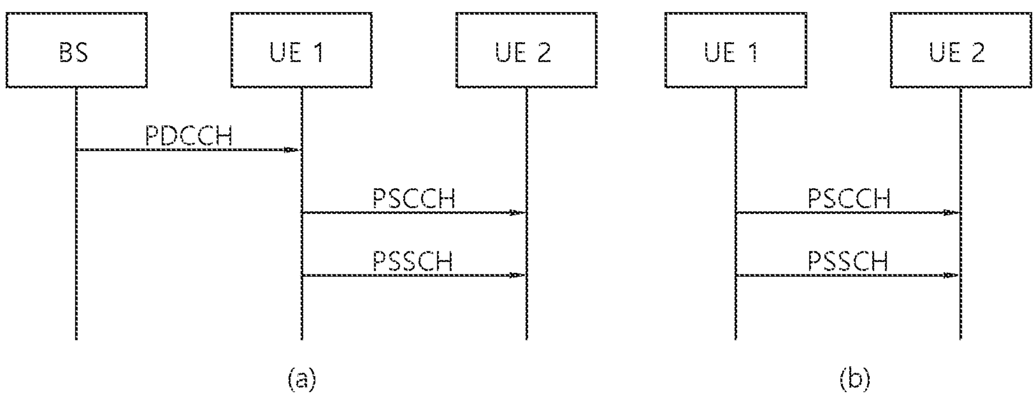


FIG. 11

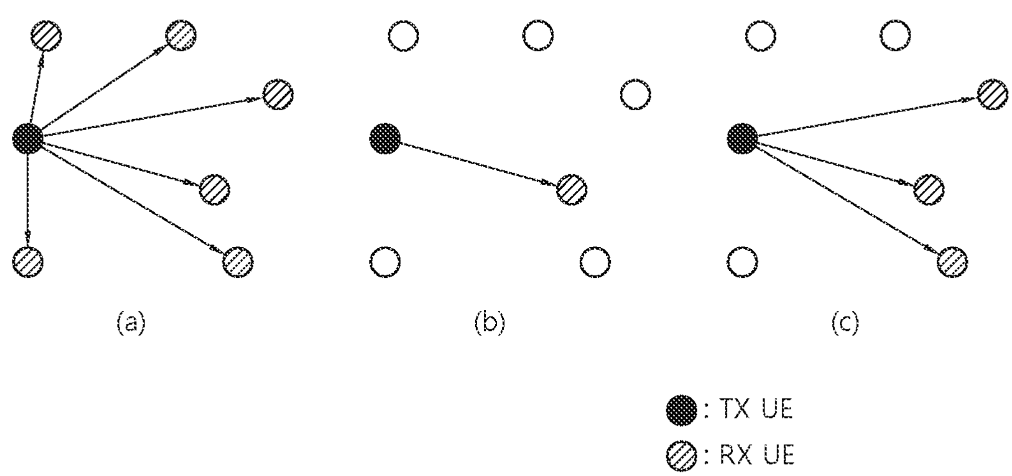


FIG. 12

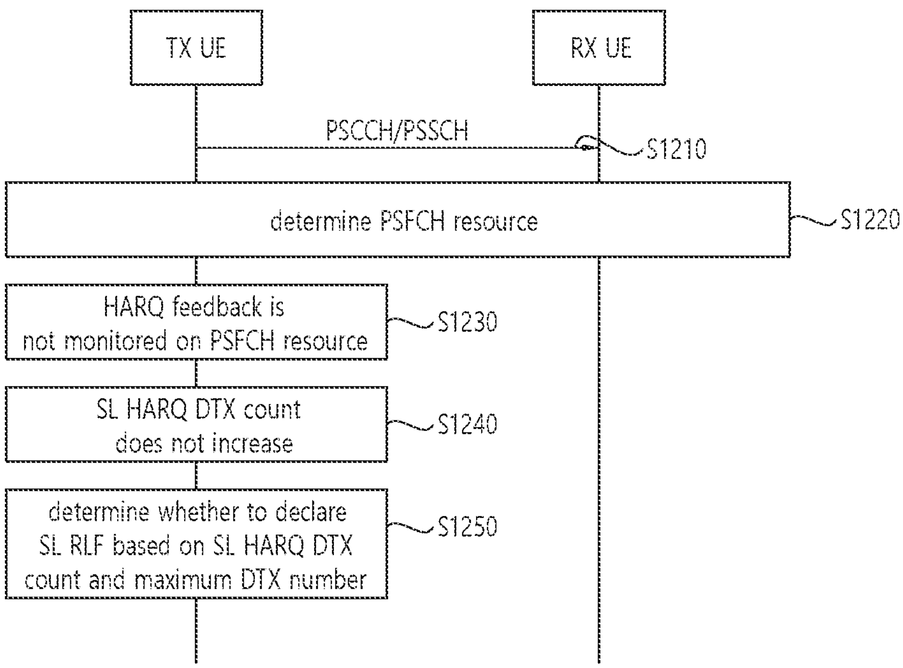

TX UE
RX UE
PSCCH/PSSCH
S1210
determine PSFCH resource
S1220
HARQ feedback is not monitored on PSFCH resource
S1230
SL HARQ DTX count does not increase
S1240
determine whether to declare SL RLF based on SL HARQ DTX count and maximum DTX number
S1250

FIG. 13

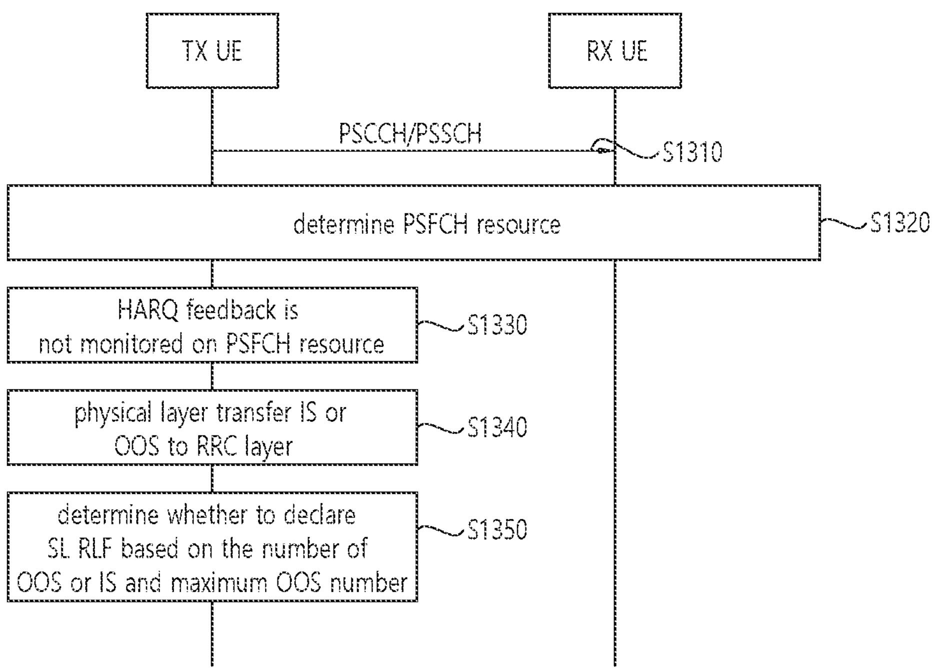
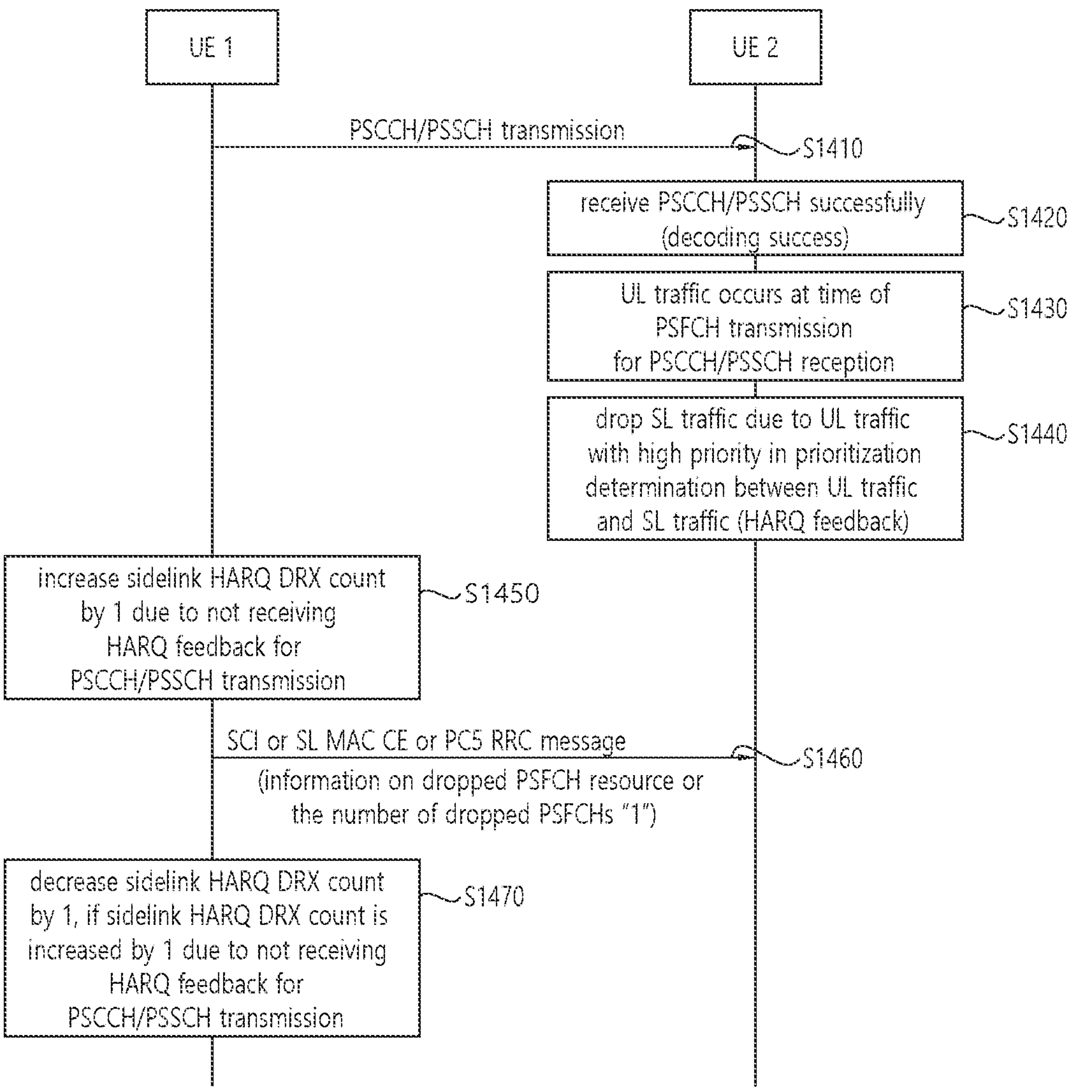

TX UE
RX UE
PSCCH/PSSCH
S1310
determine PSFCH resource
S1320
HARQ feedback is
not monitored on PSFCH resource
S1330
physical layer transfer IS or
OOS to RRC layer
S1340
determine whether to declare
SL RLF based on the number of
OOS or IS and maximum OOS number
S1350

FIG. 14



UE 1
UE 2
PSCCH/PSSCH transmission
S1410
receive PSCCH/PSSCH successfully (decoding success)
S1420
UL traffic occurs at time of PSFCH transmission for PSCCH/PSSCH reception
S1430
drop SL traffic due to UL traffic with high priority in prioritization determination between UL traffic and SL traffic (HARQ feedback)
S1440
increase sidelink HARQ DRX count by 1 due to not receiving HARQ feedback for PSCCH/PSSCH transmission
S1450
SCI or SL MAC CE or PC5 RRC message
(information on dropped PSFCH resource or the number of dropped PSFCHs "1")
S1460
decrease sidelink HARQ DRX count by 1, if sidelink HARQ DRX count is increased by 1 due to not receiving HARQ feedback for PSCCH/PSSCH transmission
S1470

FIG. 15

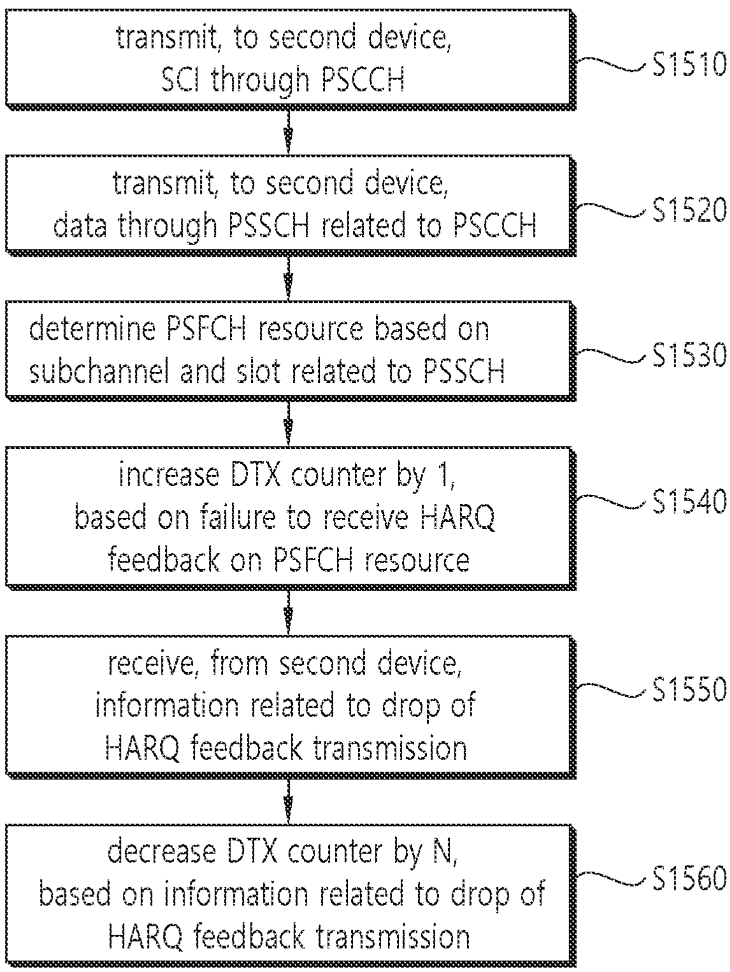

transmit, to second device, SCI through PSCCH
S1510
transmit, to second device, data through PSSCH related to PSCCH
S1520
determine PSFCH resource based on subchannel and slot related to PSSCH
S1530
increase DTX counter by 1, based on failure to receive HARQ feedback on PSFCH resource
S1540
receive, from second device, information related to drop of HARQ feedback transmission
S1550
decrease DTX counter by N, based on information related to drop of HARQ feedback transmission
S1560

FIG. 16

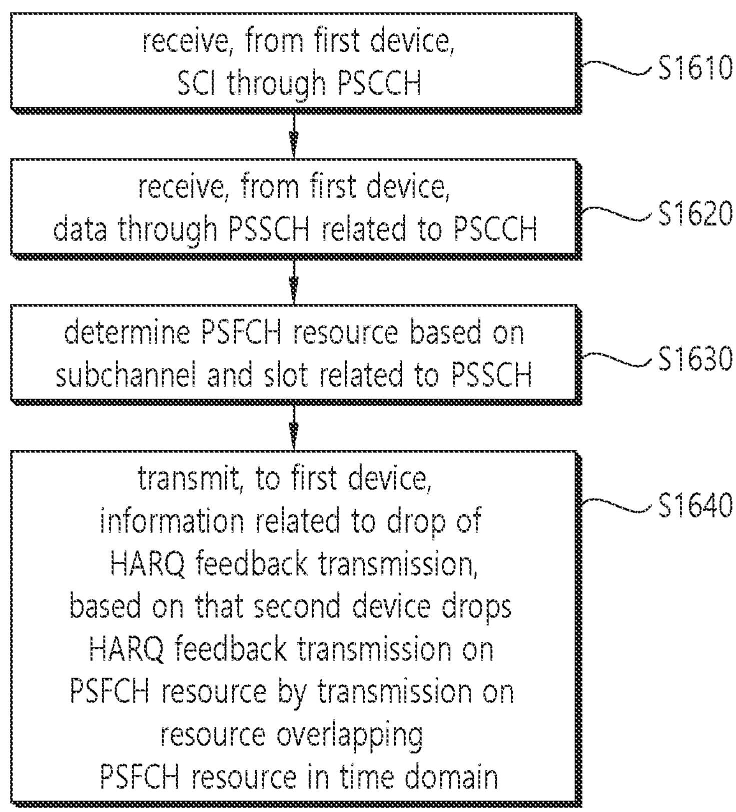

receive, from first device,
SCI through PSCCH
S1610
receive, from first device,
data through PSSCH related to PSCCH
S1620
determine PSFCH resource based on
subchannel and slot related to PSSCH
S1630
transmit, to first device,
information related to drop of
HARQ feedback transmission,
based on that second device drops
HARQ feedback transmission on
PSFCH resource by transmission on
resource overlapping
PSFCH resource in time domain
S1640

FIG. 17

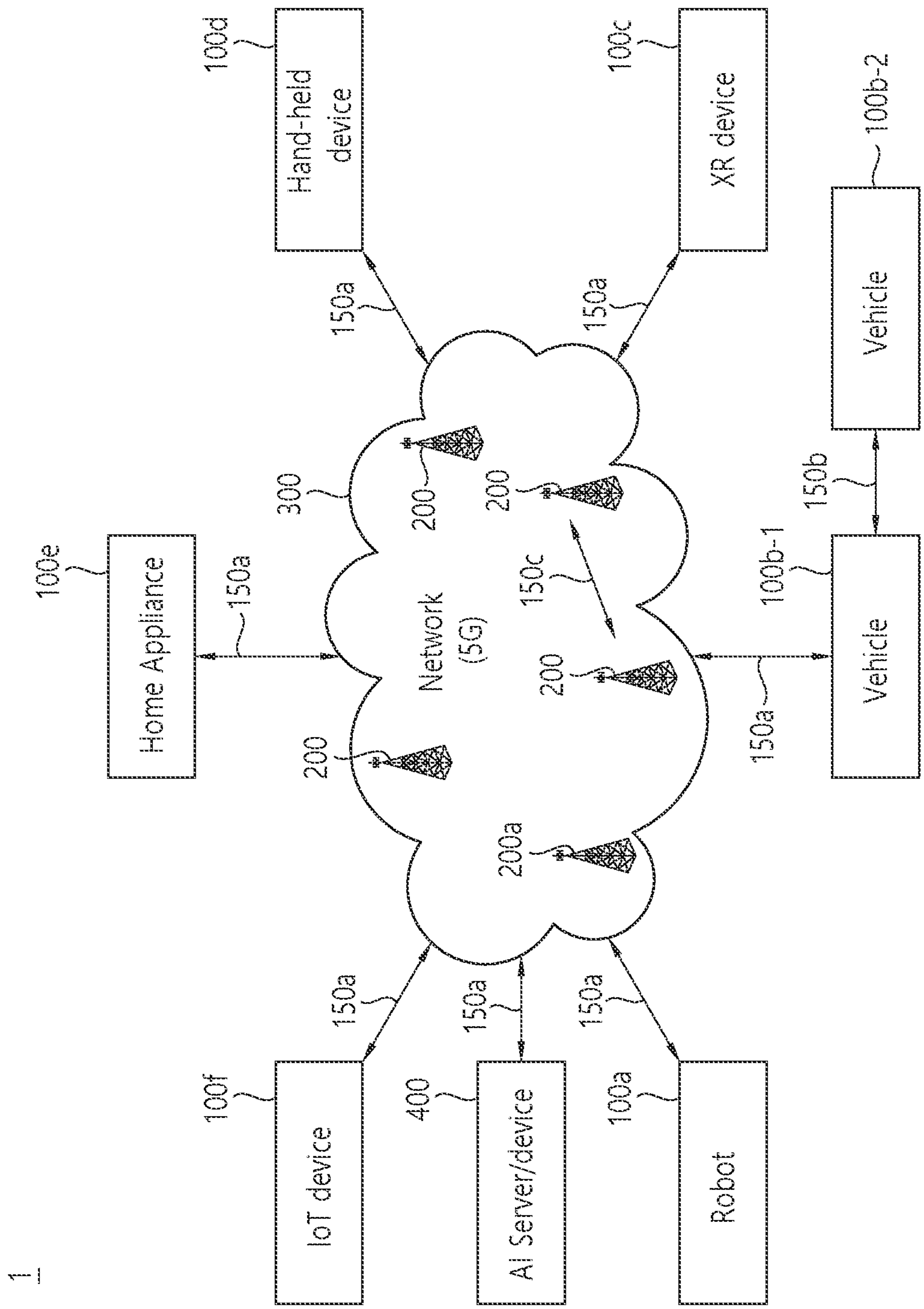
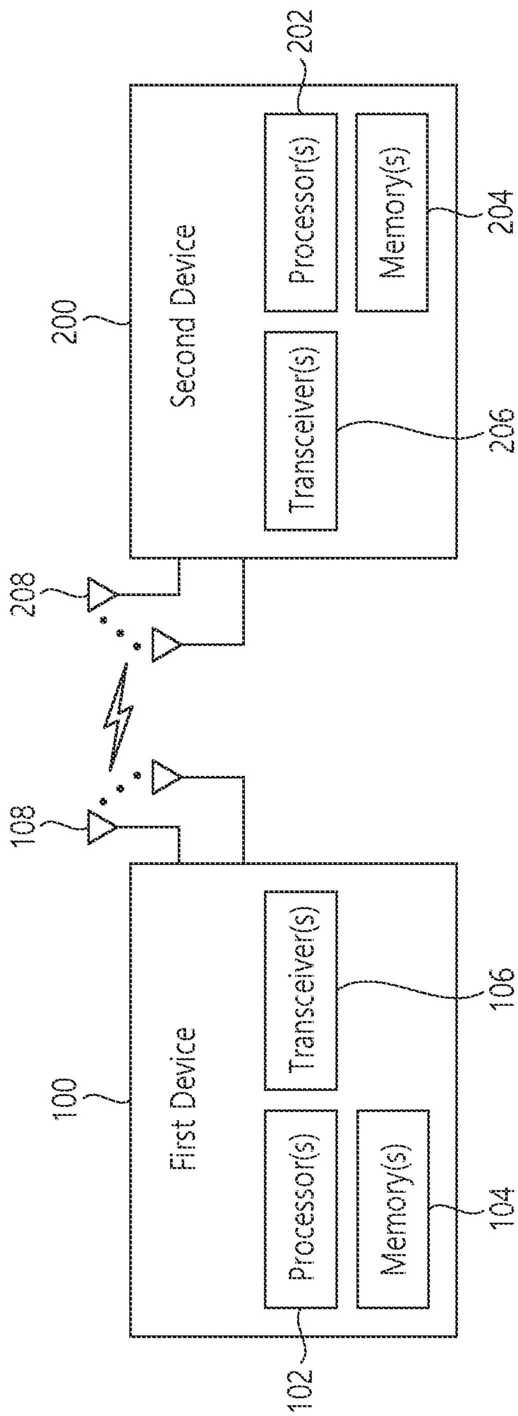

1
IoT device
100f
AI Server/device
400
Robot
100a
150a
150a
150a
Home Appliance
100e
150a
Network
(5G)
300
200
200
200
200
200a
150c
Hand-held
device
100d
150a
XR device
100c
150a
Vehicle
100b-1
150a
Vehicle
100b-2
150b

FIG. 18



First Device
100
Processor(s)
102
Memory(s)
104
Transceiver(s)
106
108
Second Device
200
Processor(s)
202
Memory(s)
204
Transceiver(s)
206
208

FIG. 19

1000(102/106, 202/206)

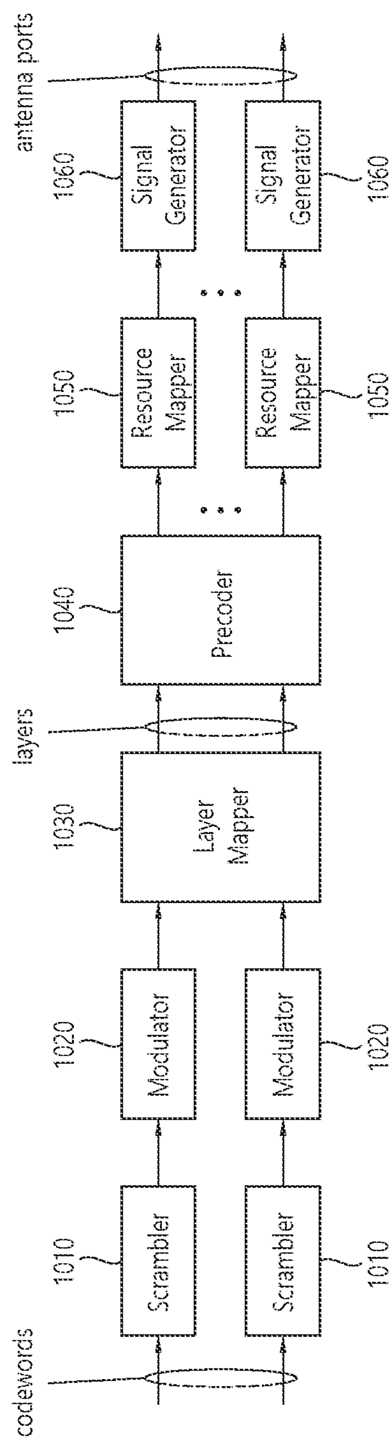


FIG. 20

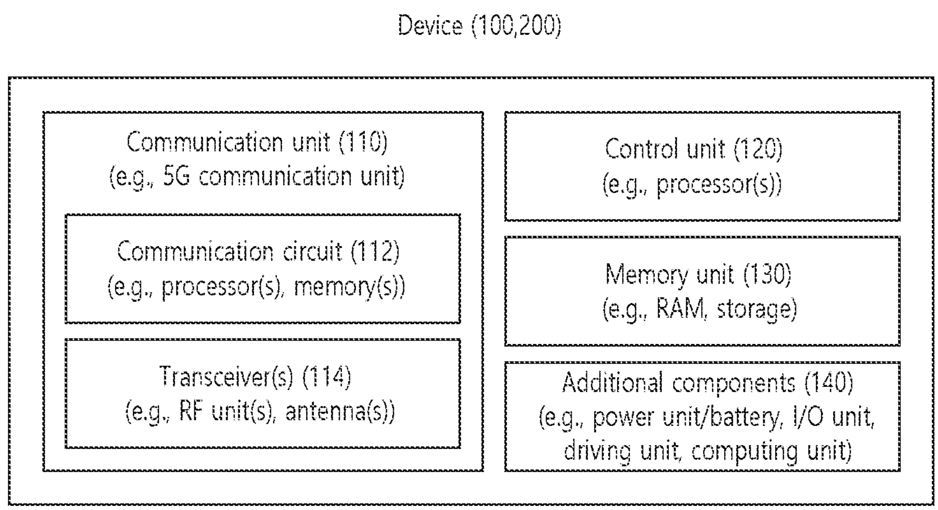

Device (100,200)
Communication unit (110)
(e.g., 5G communication unit)
Communication circuit (112)
(e.g., processor(s), memory(s))
Transceiver(s) (114)
(e.g., RF unit(s), antenna(s))
Control unit (120)
(e.g., processor(s))
Memory unit (130)
(e.g., RAM, storage)
Additional components (140)
(e.g., power unit/battery, I/O unit,
driving unit, computing unit)

FIG. 21

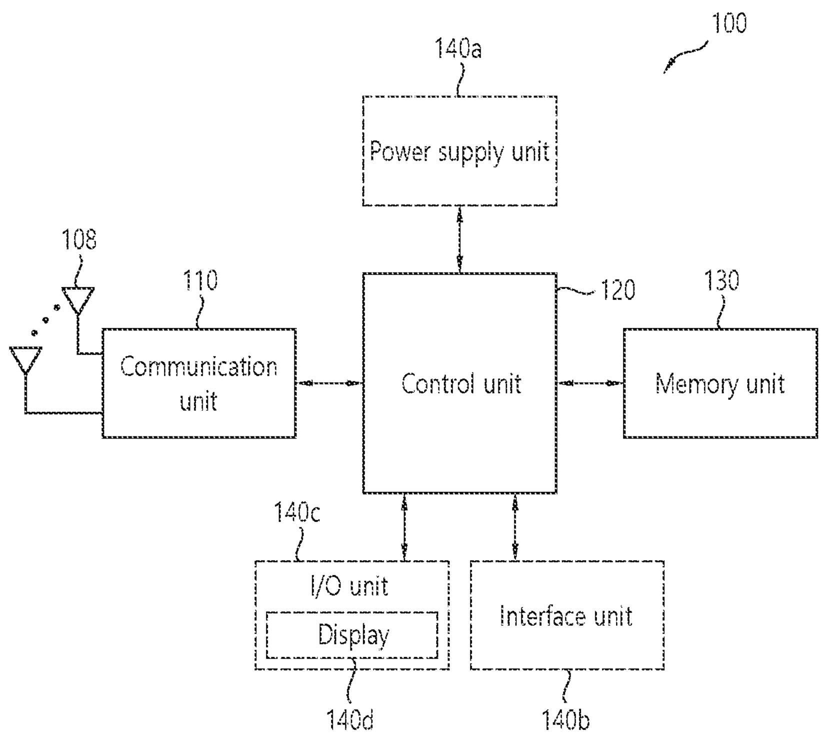
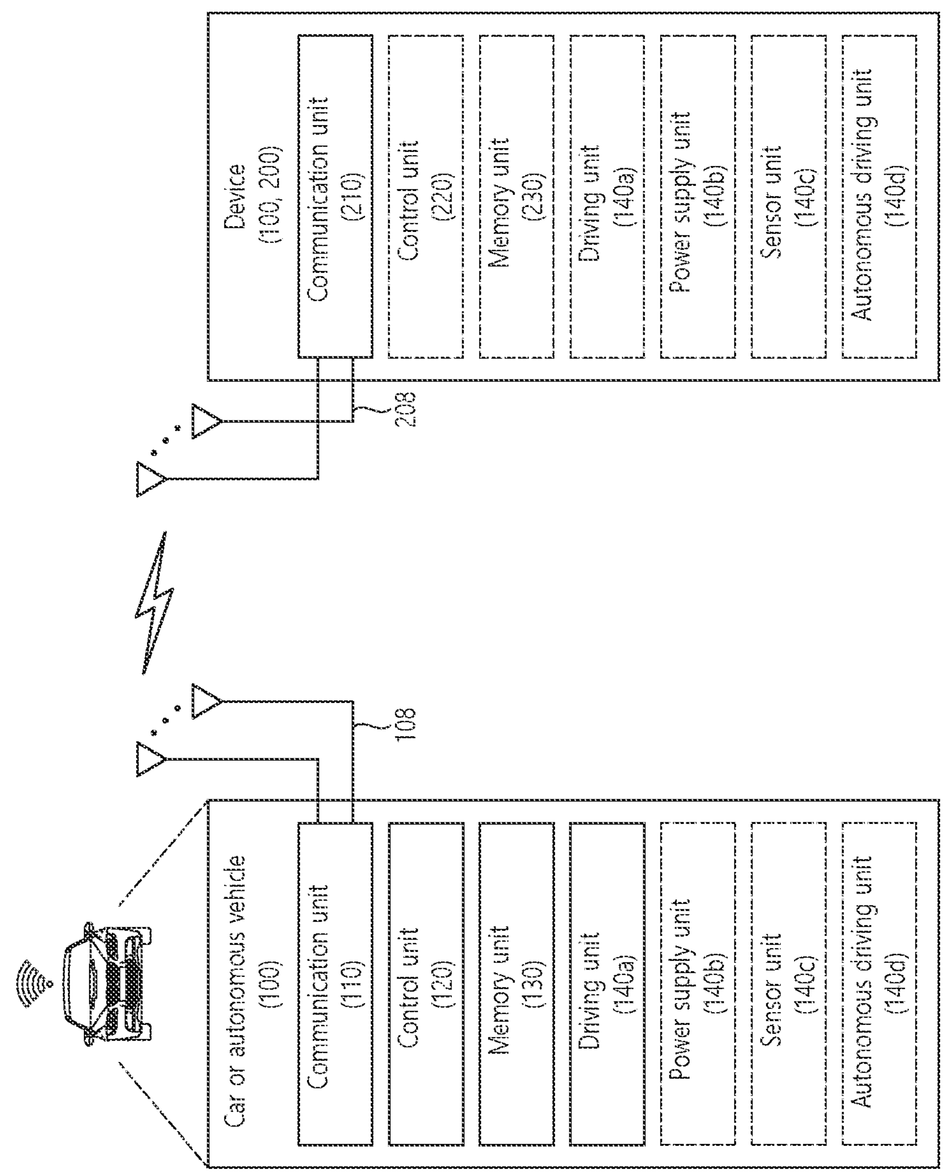

100
140a
Power supply unit
108
110
Communication unit
120
Control unit
130
Memory unit
140c
I/O unit
Display
Interface unit
140d
140b

FIG. 22


Car or autonomous vehicle
(100)
Communication unit
(110)
Control unit
(120)
Memory unit
(130)
Driving unit
(140a)
Power supply unit
(140b)
Sensor unit
(140c)
Autonomous driving unit
(140d)
108
208
Device
(100, 200)
Communication unit
(210)
Control unit
(220)
Memory unit
(230)
Driving unit
(140a)
Power supply unit
(140b)
Sensor unit
(140c)
Autonomous driving unit
(140d)

METHOD AND DEVICE FOR RLF IN NR V2X

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Stage application under 35 U.S.C. § 371 of International Application No. PCT/KR2021/004784, filed on Apr. 16, 2021, which claims the benefit of Korean Patent Application No. 10-2020-0059864, filed on May 19, 2020. The disclosures of the prior applications are incorporated by reference in their entirety.

TECHNICAL FIELD

This disclosure relates to a wireless communication system.

BACKGROUND

Sidelink (SL) communication is a communication scheme in which a direct link is established between User Equipments (UEs) and the UEs exchange voice and data directly with each other without intervention of an evolved Node B (eNB). SL communication is under consideration as a solution to the overhead of an eNB caused by rapidly increasing data traffic.

Vehicle-to-everything (V2X) refers to a communication technology through which a vehicle exchanges information with another vehicle, a pedestrian, an object having an infrastructure (or infra) established therein, and so on. The V2X may be divided into 4 types, such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-network (V2N), and vehicle-to-pedestrian (V2P). The V2X communication may be provided via a PC5 interface and/or Uu interface.

Meanwhile, as a wider range of communication devices require larger communication capacities, the need for mobile broadband communication that is more enhanced than the existing Radio Access Technology (RAT) is rising. Accordingly, discussions are made on services and user equipment (UE) that are sensitive to reliability and latency. And, a next generation radio access technology that is based on the enhanced mobile broadband communication, massive Machine Type Communication (MTC), Ultra-Reliable and Low Latency Communication (URLLC), and so on, may be referred to as a new radio access technology (RAT) or new radio (NR). Herein, the NR may also support vehicle-to-everything (V2X) communication.

FIG. **1** is a drawing for describing V2X communication based on NR, compared to V2X communication based on RAT used before NR. The embodiment of FIG. **1** may be combined with various embodiments of the present disclosure.

Regarding V2X communication, a scheme of providing a safety service, based on a V2X message such as Basic Safety Message (BSM), Cooperative Awareness Message (CAM), and Decentralized Environmental Notification Message (DENM) is focused in the discussion on the RAT used before the NR. The V2X message may include position information, dynamic information, attribute information, or the like. For example, a UE may transmit a periodic message type CAM and/or an event triggered message type DENM to another UE.

For example, the CAM may include dynamic state information of the vehicle such as direction and speed, static data of the vehicle such as a size, and basic vehicle information

such as an exterior illumination state, route details, or the like. For example, the UE may broadcast the CAM, and latency of the CAM may be less than 100 ms. For example, the UE may generate the DENM and transmit it to another UE in an unexpected situation such as a vehicle breakdown, accident, or the like. For example, all vehicles within a transmission range of the UE may receive the CAM and/or the DENM. In this case, the DENM may have a higher priority than the CAM.

Thereafter, regarding V2X communication, various V2X scenarios are proposed in NR. For example, the various V2X scenarios may include vehicle platooning, advanced driving, extended sensors, remote driving, or the like.

For example, based on the vehicle platooning, vehicles may move together by dynamically forming a group. For example, in order to perform platoon operations based on the vehicle platooning, the vehicles belonging to the group may receive periodic data from a leading vehicle. For example, the vehicles belonging to the group may decrease or increase an interval between the vehicles by using the periodic data.

For example, based on the advanced driving, the vehicle may be semi-automated or fully automated. For example, each vehicle may adjust trajectories or maneuvers, based on data obtained from a local sensor of a proximity vehicle and/or a proximity logical entity. In addition, for example, each vehicle may share driving intention with proximity vehicles.

For example, based on the extended sensors, raw data, processed data, or live video data obtained through the local sensors may be exchanged between a vehicle, a logical entity, a UE of pedestrians, and/or a V2X application server. Therefore, for example, the vehicle may recognize a more improved environment than an environment in which a self-sensor is used for detection.

For example, based on the remote driving, for a person who cannot drive or a remote vehicle in a dangerous environment, a remote driver or a V2X application may operate or control the remote vehicle. For example, if a route is predictable such as public transportation, cloud computing based driving may be used for the operation or control of the remote vehicle. In addition, for example, an access for a cloud-based back-end service platform may be considered for the remote driving.

Meanwhile, a scheme of specifying service requirements for various V2X scenarios such as vehicle platooning, advanced driving, extended sensors, remote driving, or the like is discussed in NR-based V2X communication.

SUMMARY

Meanwhile, according to HARQ DTX-based SL radio link failure (RLF) operation, if a TX UE fails to monitor SL HARQ feedback transmitted by an RX UE due to a half-duplex problem or if the RX UE does not transmit SI, HARQ feedback due to drop according to transmission priority, a problem in which the TX UE increases a SL HARQ DTX generation count may occur. Therefore, despite a good link quality between the TX UE and the RX UE, SL RLF may be unnecessarily declared.

In one embodiment, provided is a method for performing wireless communication by a first device. The method may comprise: transmitting, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); transmitting, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determining a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot

related to the PSSCH; increasing a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receiving, from the second device, information related to drop of HARQ feedback transmission; and decreasing the DTX counter by N, based on the information related to drop of HARQ feedback transmission. Based on the DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

In one embodiment, provided is a first device adapted to perform wireless communication. The first device may comprise: one or more memories storing instructions; one or more transceivers; and one or more processors connected to the one or more memories and the one or more transceivers. The one or more processors may execute the instructions to: transmit, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); transmit, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receive, from the second device, information related to drop of HARQ feedback transmission; and decrease the DIX counter by N, based on the information related to drop of HARQ feedback transmission. Based on the DTX counter reaching a maximum DTX number; a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

The user equipment WE) may efficiently perform SL communication.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a drawing for describing V2X communication based on NR, compared to V2X communication based on RAF used before NR,

FIG. **2** shows a structure of an NR system, based on an embodiment of the present disclosure.

FIG. **3** shows a functional division between an NG-RAN and a 5GC, based on an embodiment of the present disclosure,

FIG. **4** shows a radio protocol architecture, based on an embodiment of the present disclosure.

FIG. **5** shows a structure of an NR system, based on an embodiment of the present disclosure.

FIG. **6** shows a structure of a slot of an NR frame, based on an embodiment of the present disclosure.

FIG. **7** shows an example of a BWP, based on an embodiment of the present disclosure.

FIG. **8** shows a radio protocol architecture for a SE communication, based on an embodiment of the present disclosure.

FIG. **9** shows a UE performing V2X or SL communication, based on an embodiment of the present disclosure.

FIG. **10** shows a procedure of performing V2X or SL communication by a UE based on a transmission mode, based on an embodiment of the present disclosure.

FIG. **11** shows three cast types, based on an embodiment of the present disclosure.

FIG. **12** shows a procedure for a UE to determine whether to declare SE REF based on a SL HARQ DTX count, based on an embodiment of the present disclosure.

FIG. **13** shows a procedure for a UE to determine whether to declare SL RLF based on OOS and/or IS, based on an embodiment of the present disclosure.

FIG. **14** shows a procedure for a UE to determine whether to declare SL RLF based on a SL HARQ DTX count, based on an embodiment of the present disclosure.

FIG. **15** shows a method for a first device to perform wireless communication, based on an embodiment of the present disclosure.

FIG. **16** shows a method for a second device to perform wireless communication, based on an embodiment of the present disclosure.

FIG. **17** shows a communication system **1**, based on an embodiment of the present disclosure.

FIG. **18** shows wireless devices, based on an embodiment of the present disclosure.

FIG. **19** shows a signal process circuit for a transmission signal, based on an embodiment of the present disclosure.

FIG. **20** shows another example of a wireless device, based on an embodiment of the present disclosure.

FIG. **21** shows a hand-held device, based on an embodiment of the present disclosure.

FIG. **22** shows a vehicle or an autonomous vehicle, based on an embodiment of the present disclosure.

DETAILED DESCRIPTION

In the present disclosure, "A or B" may mean "only A", "only B" or "both A and B." In other words, in the present disclosure. "A or B" may be interpreted as "A and/or B". For example, in the present disclosure, "A, B, or C" may mean "only A", "only B", "only C", air "any combination of A, B, C".

A slash (/) or comma used in the present disclosure may mean "and/or". For example, "A/B" may mean "A and/or B". Accordingly, "A/B" may mean "only A", "only B", or "both A and B". For example, "A, B. C" may mean "A, B, or C".

In the present disclosure, "at least one of A and B" may mean "only A", "only B", or "both A and B", In addition, in the present disclosure, the expression "at least one of A or B" or "at least one of A and/or B" may be interpreted as "at least one of A and B".

In addition, in the present disclosure, "at least one of A, B, and C" may mean "only A", "only B", "only C", or "any combination of A, B, and C", In addition, "at least one of A, B, or C" or "at least one of A, B. and/or C" may mean "at least one of A, B, and C".

In addition, a parenthesis used in the present disclosure may mean "for example". Specifically, when indicated as "control information (PDCCH)", it may mean that "PDCCH" is proposed as an example of the "control information". In other words, the "control information" of the present disclosure is not limited to "PDCCH", and "PDCCH" may be proposed as an example of the "control information". In addition, when indicated as "control information (i.e., PDCCH)", it may also mean that "PDCCH" is proposed as an example of the "control information".

A technical feature described individually in one figure in the present disclosure may be individually implemented, or may be simultaneously implemented.

The technology described below may be used in various wireless communication systems such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), and so on. The CDMA may be implemented with a radio technology, such as universal terrestrial radio access (UTRA) or CDMA-2000. The TDMA may be implemented with a radio technology, such as global system for mobile communications (GSM)/general packet ratio service (GPRS)/enhanced data rate for GSM evolution (EDGE). The OFDMA may be implemented with a radio technology, such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, evolved UTRA (E-UTRA), and so on. IEEE 802.16m is an evolved version of IEEE 802.16e and provides backward compatibility with a system based on the IEEE 802.16e. The UTRA is part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is part of an evolved UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE uses the OFDMA in a downlink and uses the SC-TDMA in an uplink, LTE-advanced (UE-A) is an evolution of the LTE.

5G NR is a successive technology of LTE-A corresponding to a new Clean-slate type mobile communication system having the characteristics of high performance, low latency, high availability, and so on. 5G NR may use resources of all spectrum available for usage including low frequency bands of less than 1 GHz, middle frequency bands ranging from 1 GHz to 10GHz, high frequency (millimeter waves) of 24GHz or more, and so on.

For clarity in the description, the following description will mostly focus on LTE-A or 5G NR. However, technical features according to an embodiment of the present disclosure will not be limited only to this.

FIG. **2** shows a structure of an NR system, based on an embodiment of the present disclosure. The embodiment of FIG. **2** may be combined with various embodiments of the present disclosure.

Referring to FIG. **2**, a next generation-radio access network (NG-RAN) may include a BS **20** providing a UE **10** with a user plane and control plane protocol termination. For example, the BS **20** may include a next generation-Node B (gNB) and/or an evolved-NodeB (eNB). For example, the UE **10** may be fixed or mobile and may be referred to as other terms, such as a mobile station (MS), a user terminal (UT), a subscriber station (SS), a mobile terminal (MT), wireless device, and so on. For example, the BS may be referred to as a fixed station which communicates with the UE **10** and may be referred to as other terms, such as a base transceiver system (BTS), an access point (AP), and so on.

The embodiment of FIG. **2** exemplifies a case where only the gNB is included. The BSs **20** may be connected to one another via Xn interface. The BS **20** may be connected to one another via 5th generation (5G) core network (5GC) and NG interface. More specifically, the BSs **20** may be connected to an access and mobility management function (AMF) **30** via. NG-C interface, and may be connected to a user plane function (UPP) **30** via NG-U interface.

FIG. **3** shows a functional division between an NG-RAN and a 5GC, based on an embodiment of the present disclosure. The embodiment of FIG. **3** may be combined with various embodiments of the present disclosure.

Referring to FIG. **3**, the gNB may provide functions, such as Inter Cell Radio Resource Management (RRM), Radio Bearer (RB) control, Connection Mobility Control, Radio Admission Control, Measurement Configuration & Provision, Dynamic Resource Allocation, and so on. An AMF may provide functions, such as Non Access Stratum (NAS) security, idle state mobility processing, and so on. A UPF may provide functions, such as Mobility Anchoring, Protocol Data Unit (PDU) processing, and so on. A Session Management Function (SW) may provide functions, such as user equipment (UE) Internet Protocol (IP) address allocation, PDU session control, and so on.

Layers of a radio interface protocol between the UE and the network can be classified into a first layer (L**1**), a second layer (L**2**), and a third layer (L**3**) based on the lower three layers of the open system interconnection (OSI) model that is well-known in the communication system. Among them, a physical (PHY) layer belonging to the first layer provides an information transfer service by using a physical channel, and a radio resource control (RRC) layer belonging to the third layer serves to control a radio resource between the UE and the network. For this, the RRC layer exchanges an RRC message between the UE and the BS,

FIG. **4** shows a radio protocol architecture, based on an embodiment of the present disclosure. The embodiment of FIG. **4** may be combined with various embodiments of the present disclosure. Specifically, FIG. **4**(*a*) shows a radio protocol architecture for a user plane, and FIG. **4**(*b*) shows a radio protocol architecture for a control plane. The user plane corresponds to a protocol stack for user data transmission, and the control plane corresponds to a protocol stack for control signal transmission.

Referring to FIG. **4**, a physical layer provides an upper layer with an information transfer service through a physical channel. The physical layer is connected to a median access control (MAC) layer which is an upper layer of the physical layer through a transport channel. Data is transferred between the MAC layer and the physical layer through the transport channel. The transport channel is classified according to how and with what characteristics data is transmitted through a radio interface.

Between different physical layers, i.e., a physical layer of a transmitter and a physical layer of a receiver, data are transferred through the physical channel. The physical channel is modulated using an orthogonal frequency division multiplexing (OFDM) scheme, and utilizes time and frequency as a radio resource.

The MAC layer provides services to a radio link control (RLC) layer, which is a higher layer of the MAC layer, via a logical channel. The MAC layer provides a function of mapping multiple logical channels to multiple transport channels. The MAC layer also provides a function of logical channel multiplexing by mapping multiple logical channels to a single transport channel. The MAC layer provides data transfer services over logical channels.

The RLC layer performs concatenation, segmentation, and reassembly of Radio Link Control Service Data Unit (RLC SDU). In order to ensure diverse quality of service (QoS) required by a radio bearer (RB), the RLC layer provides three types of operation modes, i.e., a transparent mode (TM), an unacknowledged mode (UM), and an acknowledged mode (AM). An AM RLC provides error correction through an automatic repeat request (ARQ).

A radio resource control (RRC) layer is defined only in the control plane. The RRC layer serves to control the logical channel, the transport channel, and the physical channel in association with configuration, reconfiguration and release of RBs. The RB is a logical path provided by the first layer (i.e., the physical layer or the PITY layer) and the second layer (i.e., the MAC layer, the RLC layer, and the packet data convergence protocol (PDCP) layer) for data delivery between the UE and the network.

Functions of a packet data convergence protocol (PDCP) layer in the user plane include user data delivery, header compression, and ciphering. Functions of a PDCP layer in the control plane include control-plane data delivery and ciphering/'integrity protection.

A service data adaptation protocol (SDAP) layer is defined only in a user plane. The SDAP layer performs mapping between a Quality of Service (QoS) flow and a data radio bearer (DRB) and QoS flow ID (QFI) marking in both DL and UL packets.

The configuration of the RB implies a process for specifying a radio protocol layer and channel properties to provide a particular service and for determining respective detailed parameters and operations. The RB can be classified into two types, i.e., a signaling RB (SRB) and a data. RB (DRB). The SRB is used as a path for transmitting an RRC message in the control plane. The DRB is used as a path for transmitting user data in the user plane.

When an RRC connection is established between an RRC layer of the UE and an RRC layer of the E-UTRAN, the UE is in an RRC_CONNECTED state, and, otherwise, the UE may be in an RRC_IDLE state. In case of the NR, an RRC: INACTIVE state is additionally defined, and a UE being in the RRC_INACTIVE state may maintain its connection with a core network whereas its connection with the BS is released.

Data is transmitted from the network to the UE through a downlink transport channel. Examples of the downlink transport channel include a broadcast channel (BCH) for transmitting system information and a downlink-shared channel (SCH) for transmitting user traffic or control messages. Traffic of downlink multicast or broadcast services or the control messages can be transmitted on the downlink-SCH or an additional downlink multicast channel (MCH). Data is transmitted from the UE to the network through an uplink transport channel. Examples of the uplink transport channel include a random access channel (RACH) for transmitting an initial control message and an uplink SCH for transmitting user traffic or control messages.

Examples of logical channels belonging to a higher channel of the transport channel and mapped onto the transport channels include a broadcast channel (BCCH), a paging control channel (PCCH), a common control channel (CCCH), a multicast control channel (MCCH), a multicast traffic channel (MTCH), etc.

The physical channel includes several OFDM symbols in a time domain and several sub-carriers in a frequency domain. One sub-frame includes a plurality of OFDM symbols in the time domain. A resource block is a unit of resource allocation, and consists of a plurality of OFDM symbols and a plurality of sub-carriers. Further, each subframe may use specific sub-carriers of specific OFDM symbols (e.g., a first OFDM symbol) of a corresponding subframe for a physical downlink control channel (PDCCH), i.e., an L**1**/L**2** control channel. A transmission time interval (TTI) is a unit time of subframe transmission.

FIG. **5** shows a structure of an NR system, based on an embodiment of the present disclosure. The embodiment of FIG. **5** may be combined with various embodiments of the present disclosure.

Referring to FIG. **5**, in the NR, a radio frame may be used for performing uplink and downlink transmission. A radio frame has a length of 10 ms and may be defined to be configured of two half-frames (HFs). A half-frame may include five 1 ms subframes (SFs). A subframe (SF) may be divided into one or more slots, and the number of slots within a subframe may be determined based on subcarrier spacing (SCS). Each slot ma include 12 or 14 OFDM(A) symbols according to a cyclic prefix (CP).

In case of using a normal CP, each slot may include 14 symbols. In case of using an extended CP, each slot may include 12 symbols. Herein, a symbol may include an OFDM symbol (or CP-OFDM symbol) and a Single Carrier-FDMA (SC-TDMA) symbol (or Discrete Fourier Transform-spread-OFDM (DFT-s-OFDM) symbol).

Table 1 shown below represents an example of a number of symbols per slot (N^{slot}_{symb}), a number slots per frame ($N^{frame.u}_{slot}$), and a umber of slots per subframe ($N^{subframe.u}_{slot}$)based on an SCS configuration (u), in a case where a normal CP is used.

TABLE 1

SCS ($15*2^u$)	N^{slot}_{symb}	$N^{frame,u}_{slot}$	$N^{subframe,u}_{slot}$
15 KHz (u = 0)	14	10	1
30 KHz (u = 1)	14	20	2
60 KHz (u = 2)	14	40	4
120 KHz (u = 3)	14	80	8
240 KHz (u = 4)	14	160	16

Table 2 shows an example of a number of symbols per slot, a number of slots per frame, and a number of slots per subframe based on the SCS, in a case where an extended CP is used.

TABLE 2

SCS ($15*2^u$)	N^{slot}_{symb}	$N^{frame,u}_{slot}$	$N^{subframe,u}_{slot}$
60 KHz (u = 2)	12	40	4

In an NR system, OFDM(A) numerologies (e.g., SCS, CP length, and so on) between multiple cells being integrate to one UE may be differently configured. Accordingly, a (absolute time) duration (or section) of a time resource (e.g., subframe, slot or TTI) (collectively referred to as a time unit (TV) for simplicity) being configured of the same number of symbols may be differently configured in the integrated cells.

In the NR, multiple numerologies or SCSs for supporting diverse 5G services may be supported. For example, in case an SCS is 15kHz, a wide area of the conventional cellular bands may be supported, and, in case an SCS is 30kHz/60 kHz a dense-urban, lower latency, wider carrier bandwidth may be supported. In case the SCS is 60 kHz or higher, a bandwidth that is greater than 24.25GHz may be used in order to overcome phase noise.

An NR frequency band may be defined as two different types of frequency ranges. The two different types of frequency ranges may be FR**1** and FR**2**. The values of the frequency ranges may be changed (or varied), and, for example, the two different types of frequency ranges may be as shown below in Table 3. Among the frequency ranges that are used in an NR system, FR**1** may mean a "sub 6GHz range", and FR**2** may mean an "above 6 GHz range" and may also be referred to as a millimeter wave (mmW).

TABLE 3

Frequency Range designation	Corresponding frequency range	Subcarrier Spacing (SCS)
FR1	450 MHz-6000 MHz	15, 30, 60 kHz
FR2	24250 MHz-52600 MHz	60, 120, 240 kHz

As described above, the values of the frequency ranges in the NR system may be changed (or varied). For example, as shown below in Table 4, FR**1** may include a band within a range of 410 MHz to 7125MHz. More specifically, FR**1** may include a frequency band of 6 GHz (or 5850, 5900, 5925

MHz, and so on) and higher. For example, a frequency band of 6GHz (or 5850, 5900, 5925 MHz, and so on) and higher being included in FR1 mat include an unlicensed band. The unlicensed band may be used for diverse purposes, e.g., the unlicensed band for vehicle-specific communication (e.g., automated driving),

TABLE 4

Frequency Range designation	Corresponding frequency range	Subcarrier Spacing (SCS)
FR1	410 MHz-7125 MHz	15, 30, 60 kHz
FR2	24250 MHz-52600 MHz	60, 120, 240 kHz

FIG. **6** shows a structure of a slot of an NR frame, based on an embodiment of the present disclosure. The embodiment of FIG. **6** may be combined with various embodiments of the present disclosure.

Referring to FIG. **6**, a slot includes a plurality of symbols in a time domain. For example, in case of a normal CP, one slot may include 14 symbols. However, in case of an extended. CP, one slot may include 12 symbols. Alternatively, in case of a normal CP, one slot may include 7 symbols. However, in case of an extended CP, one slot may include 6 symbols.

A carrier includes a plurality of subcarriers in a frequency domain. A Resource Block (RB) may be defined as a plurality of consecutive subcarriers (e.g., 12 subcarriers) in the frequency domain. A Bandwidth Part (BWP) may be defined as a plurality of consecutive (Physical) Resource Blocks ((P)RBs) in the frequency domain, and the BWP may correspond to one numerology (e.g., SCS, CP length, and so on). A carrier may include a maximum of N number BWPs (e.g., 5 BWPs). Data communication may be performed via an activated BWP. Each element may be referred to as a Resource Element (RE) within a resource grid and one complex symbol may be mapped to each element.

Meanwhile, a radio interface between a UE and another UE or a radio interface between the UE and a network may consist of an L**1** layer, an L**2** layer, and an L**3** layer. In various embodiments of the present disclosure, the L**1** layer may imply a physical layer. In addition, for example, the L**2** layer may imply at least one of a MAC layer, an RLC layer, a PDCP layer, and an SDAP layer. In addition, for example, the L**3** layer may imply an RRC layer.

Hereinafter, a bandwidth part (BWP) and a carrier will be described.

The BWP may be a set of consecutive physical resource blocks (PRBs) in a given numerology. The PRB may be selected from consecutive sub-sets of common resource blocks (CRBs) for the given numerology on a given carrier.

When using bandwidth adaptation (BA), a reception bandwidth and transmission bandwidth of a UE are not necessarily as large as a bandwidth of a cell, and the reception bandwidth and transmission bandwidth of the BS may be adjusted. For example, a network/BS may inform the UE of bandwidth adjustment. For example, the UE receive information/configuration for bandwidth adjustment from the network/BS. In this case, the UE may perform bandwidth adjustment based on the received information configuration. For example, the bandwidth adjustment may include an increase/decrease of the bandwidth, a position change of the bandwidth, or a change in subcarrier spacing of the bandwidth.

For example, the bandwidth may be decreased during a period in which activity is low to save power. For example, the position of the bandwidth may move in a frequency domain. For example, the position of the bandwidth may move in the frequency domain to increase scheduling flexibility. For example, the subcarrier spacing of the bandwidth may be changed. For example, the subcarrier spacing of the bandwidth may be changed to allow a different service. A subset of a total cell bandwidth of a cell may be called a bandwidth part (BWP). The BA may be performed when the BS/network configures the BWP to the UE and the BS/network informs the UE of the BWP currently in an active state among the configured BWPs.

For example, the BWP may be at least any one of an active BWP, an initial BWP, and/or a default BWP. For example, the UE may not monitor downlink radio link quality in a DL BWP other than an active DL BAT on a primary cell (PCell). For example, the UE may not receive PDCCH, physical downlink shared channel (PDSCH), or channel state information—reference signal (CSI-RS) (excluding RRM) outside the active DL BWP. For example, the UE may not trigger a channel state information (CSI) report for the inactive DL BWP. For example, the UE may not transmit physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH) outside an active UL BWP. For example, in a downlink case, the initial BWP may be given as a consecutive RB set for a remaining minimum system information (RMSI) control resource set (CORESET) (configured by physical broadcast channel (PBCH)). For example, in an uplink case, the initial BWP may be given by system information block (SIB) for a random access procedure. For example, the default BWP may be configured by a higher layer. For example, an initial value of the default BWP may be an initial DL BWP. For energy saving, if the UE fails to detect downlink control information (DCI) during a specific period, the UE may switch the active BWP of the UE to the default BWP.

Meanwhile, the BWP may be defined for SL. The same SI. BWP may be used in transmission and reception. For example, a transmitting UE may transmit a SI, channel or a SL signal on a specific BWP, and a receiving UE may receive the SL channel or the SL signal on the specific BWP. In a licensed carrier, the SL BWP may be defined separately from a Uu BWP, and the SL BWP may have configuration signaling separate from the Uu BWP. For example, the UE may receive a configuration for the SL BWP from the BS/network. The SL BWP may be (pre-)configured in a carrier with respect to an out-of-coverage NR V2X UE and an RRC_IDLE UE. For the UE in the RRC_CONNECTED mode, at least one SL BWP may be activated in the carrier.

FIG. **7** shows an example of a MVP, based on an embodiment of the present disclosure. The embodiment of FIG. **7** may be combined with various embodiments of the present disclosure. It is assumed in the embodiment of FIG. **7** that the number of BWPs is 3.

Referring to FIG. **7**, a common resource block (CRB) may be a carrier resource block numbered from one end of a carrier band to the other end thereof. In addition, the PRB may be a resource block numbered within each BWP. A point A may indicate a common reference point for a resource block grid.

The BWP may be configured by a point A, an offset N^{start}_{BWP} from the point A. and a bandwidth N^{size}_{BWP}. For example, the point A may be an external reference point of a PRB of a carrier in which a subcarrier 0 of all numerologies (e.g., all numerologies supported by a network on that carrier) is aligned. For example, the offset may be a PRB interval between a lowest subcarrier and the point A in a given numerology. For example, the bandwidth may be the number of PRBs in the given numerology.

Hereinafter, V2X or SL communication will be described.

FIG. **8** shows a radio protocol architecture for a SL communication, based on an embodiment of the present disclosure. The embodiment of FIG. **8** may be combined with various embodiments of the present disclosure. More specifically, FIG. **8**(*a*) shows a user plane protocol stack, and FIG. **8**(*b*) shows a control plane protocol stack.

Hereinafter, a sidelink synchronization signal (SLSS) and synchronization information will be described.

The SLSS may include a primary sidelink synchronization signal (PSSS) and a secondary sidelink synchronization signal (SSSS), as a SL-specific sequence. The PSSS may be referred to as a sidelink primary synchronization signal (S-PSS), and the SSSS may be referred to as a sidelink secondary synchronization signal (S-SSS). For example, length-127 M-sequences may be used for the S-PSS, and length-127 gold sequences may be used for the S-SSS. For example, a UE may use the S-PSS for initial signal detection and for synchronization acquisition. For example, the UE may use the S-PSS and the S-SSS for acquisition of detailed synchronization and for detection of a synchronization signal PD.

A physical sidelink broadcast channel (PSBCH) may be a (broadcast) channel for transmitting default (system) information which must be first known by the UE before SL signal transmission/reception. For example, the default information may be information related to SLSS, a duplex mode (DM), a time division duplex (TDD) uplink/downlink (UL/DL) configuration, information related to a resource pool, a type of an application related to the SLSS, a subframe offset, broadcast information, or the like. For example, for evaluation of PSBCH performance, in NR V2X, a payload size of the PSBCH ma be 56 bits including 24-bit cyclic redundancy check (CRC).

The S-PSS, the S-SSS, and the PSBCH may be included in a block format (e.g., SL synchronization signal (SS)/PSBCH block, hereinafter, sidelink-synchronization signal block (S-SSB)) supporting periodical transmission. The S-SSB may have the same numerology (i.e., SCS and CP length) as a physical sidelink control channel (PSCCH)/physical sidelink shared channel (PSSCH) in a carrier, and a transmission bandwidth may exist within a (pre-)configured sidelink (SL) MVP, For example, the S-SSB may have a bandwidth of 11 resource blocks (RBs). For example, the PSBCH may exist across 11 RBs. In addition, a frequency position of the S-SSB may be (pre-)configured. Accordingly, the UE does not have to perform hypothesis detection at frequency to discover the S-SSB in the carrier.

FIG. **9** shows a UE performing V2X or SL communication, based on an embodiment of the present disclosure. The embodiment of FIG. **9** may be combined with various embodiments of the present disclosure.

Referring to FIG. **9**, in V2X or St, communication, the term 'UE' may generally imply a UE of a user. However, if a network equipment such as a BS transmits/receives a signal according to a communication scheme between UEs, the BS may also be regarded as a sort of the UE. For example, a UE **1** may be a first apparatus **100**, and a UE **2** may be a second apparatus **200**.

For example, the UE **1** may select a resource unit corresponding to a specific resource in a resource pool which implies a set of series of resources. In addition, the UE **1** may transmit a St, signal by using the resource unit. For example, a resource pool in which the UE **1** is capable of transmitting a signal may be configured to the UE **2** which is a receiving UE, and the signal of the UE **1** may be detected in the resource pool.

Herein, if the UE **1** is within a connectivity range of the BS, the BS may inform the UE **1** of the resource pool. Otherwise, if the UE **1** is out of the connectivity range of the BS, another UE may inform the UE **1** of the resource pool, or the UE **1** may use a pre-configured resource pool.

In general, the resource pool may be configured in unit of a plurality of resources, and each UE may select a unit of one or a plurality of resources to use it in SL signal transmission thereof.

Hereinafter, resource allocation in SL will be described.

FIG. **10** shows a procedure of performing V2X or SI, communication by a UE based on a transmission mode, based on an embodiment of the present disclosure. The embodiment of FIG. **10** may be combined with various embodiments of the present disclosure. In various embodiments of the present disclosure, the transmission mode may be called a mode or a resource allocation mode. Hereinafter, for convenience of explanation, in LTE, the transmission mode may be called an LTE transmission mode. In NR, the transmission mode may be called an NR resource allocation mode.

For example, FIG. **10**(*a*) shows a LT operation related to an LTE transmission mode **1** or an LTE transmission mode **3**. Alternatively, for example, FIG. **10**(*a*) shows a UE operation related to an NR resource allocation mode **1**. For example, the LTE transmission mode **1** may be applied to general SL communication, and the LTE transmission mode **3** may be applied to V2X communication.

For example, FIG. **10**(*b*) shows a UE operation related to an LTE transmission mode **2** or an LTE transmission mode **4**. Alternatively, for example, FIG. **10**(*h*) shows a UE operation related to an NR resource allocation mode **2**.

Referring to FIG. **10**(*a*), in the LTE transmission mode **1**, the LTE transmission mode **3**, or the NR resource allocation mode **1**, a BS may schedule a SL resource to be used by the UE for SL transmission. For example, the BS may perform resource scheduling to a UE through a PDCCH (more specifically, downlink control information (DCI)), and the UE **1** may perform V2X or SL communication with respect to a UE **2** according to the resource scheduling. For example, the UE **1** may transmit a sidelink control information (SCI) to the UE **2** through a physical sidelink control channel (PSCCH), and thereafter transmit data based on the SCI to the UE **2** through a physical sidelink shared channel (PSSCH).

Referring to FIG. **10**(*b*), in the LTE transmission mode **2**, the LTE transmission mode **4**, or the NR resource allocation mode **2**, the UE may determine a SL transmission resource within a SL resource configured by a BS/network or a pre-configured SL resource. For example, the configured SL resource or the pre-configured St: resource may be a resource pool. For example, the UE may autonomously select or schedule a resource for SL transmission. For example, the UE may perform SL communication by autonomously selecting a resource within a configured resource pool. For example, the UE may autonomously select a resource within a selective window by performing a sensing and resource (re)selection procedure. For example, the sensing may be performed in unit of subchannels. In addition, the UE **1** which has autonomously selected the resource within the resource pool may transmit the SCI to the UE **2** through a PSCCH, and thereafter may transmit data based on the SCI to the UE **2** through a PSSCH.

FIG. **11** shows three cast types, based on an embodiment of the present disclosure. The embodiment of FIG. **11** may be combined with various embodiments of the present disclosure. Specifically, FIG. **11**(*a*) shows broadcast-type SL communication, FIG. **11**(*b*) shows unicast type-SI, communication, and FIG. **11**(*c*) shows groupcast-type SL communication. In case of the unicast-type SL communication, a UE may perform one-to-one communication with respect to another UE. In case of the groupcast-type SL transmission, the UE may perform SL communication with respect to one or more UEs in a group to which the UE belongs. In various embodiments of the present disclosure, SL groupcast communication may be replaced with SL, multicast communication, SI, one-to-many communication, or the like.

Hereinafter, a hybrid automatic repeat request (HARQ) procedure will be described.

An error compensation scheme is used to secure communication reliability. Examples of the error compensation scheme may include a forward error correction (FEC) scheme and an automatic repeat request (ARQ) scheme. In the FEC scheme, errors in a receiving end are corrected by attaching an extra error correction code to information bits. The FEC scheme has an advantage in that time delay is small and no information is additionally exchanged between a transmitting end and the receiving end but also has a disadvantage in that system efficiency deteriorates in a good channel environment. The ARQ scheme has an advantage in that transmission reliability can be increased but also has a disadvantage in that a time delay occurs and system efficiency deteriorates in a poor channel environment.

A hybrid automatic repeat request (HARQ) scheme is a combination of the FEC scheme and the ARQ scheme. In the HARQ scheme, it is determined whether an unrecoverable error is included in data received by a physical layer, and retransmission is requested upon detecting the error, thereby improving performance.

In case of SL unicast and groupcast, HARQ feedback and HARQ combining in the physical layer may be supported. For example, when a receiving UE operates in a resource allocation mode **1** or **2**, the receiving UE may receive the PSSCH from a transmitting UE, and the receiving UE may transmit HARQ feedback for the PSSCH to the transmitting UE by using a sidelink feedback control information (SFCI) format through a physical sidelink feedback channel (PSFCH).

For example, the SL HARQ feedback may be enabled for unicast. In this case, in a non-code block group (non-CBG) operation, if the receiving UE decodes a PSCCH of which a target is the receiving UE and if the receiving UE successfully decodes a transport block related to the PSCCH, the receiving LTE may generate HARQ-ACK. In addition, the receiving UE tray transmit the HARQ-ACK to the transmitting UE. Otherwise, if the receiving UE cannot successfully decode the transport block after decoding the PSCCH of which the target is the receiving UE, the receiving UE may generate the HARQ-NACK. In addition, the receiving UE may transmit HARQ-NACK to the transmitting LE.

For example, the SL HARQ feedback may be enabled for groupcast. For example, in the non-CBG operation, two HARQ feedback options may be supported for groupcast.

(1) Groupcast option 1: After the receiving UE decodes the PSCCH of which the target is the receiving UE, if the receiving UE fails in decoding of a transport block related to the PSCCH, the receiving UE may transmit HARQ-NACK to the transmitting UE through a PSFCH, Otherwise, if the receiving UE decodes the PSCCH of which the target is the receiving UE and if the receiving UE, successfully decodes the transport block related to the PSCCH, the receiving UE may not transmit the HARQ-ACK to the transmitting UE.

(2) Groupcast option 2: After the receiving UE decodes the PSCCH of which the target is the receiving UE, if the receiving UE fails in decoding of the transport block related to the PSCCH, the receiving UE may transmit HARQ-NACK to the transmitting UE through the PSFCH. In addition, if the receiving UE decodes the PSCCH of which the target is the receiving UE and if the receiving UE successfully decodes the transport block related to the PSCCH, the receiving UE may transmit the HARM-ACK to the transmitting UE through the PSFCH.

For example, if the groupcast option 1 is used in the SL HARQ feedback, all UEs performing groupcast communication may share a PSFCH resource. For example, UEs belonging to the same group may transmit HARQ feedback by using the same PSFCH resource.

For example, if the groupcast option 2 is used in the SL HARQ feedback, each UE performing groupcast communication may use a different PSFCH resource for HARQ feedback transmission. For example, UEs belonging to the same group may transmit HARQ feedback by using different PSFCH resources.

For example, when the SL HARQ feedback is enabled for groupcast, the receiving UE may determine whether to transmit the HARQ feedback to the transmitting UE based on a transmission-reception (TX-RX) distance and/or RSRP.

For example, in the groupcast option 1, in case of the TX-RX distance-based HARQ feedback, if the TX-RX distance is less than or equal to a communication range requirement, the receiving UE may transmit HARQ feedback for the PSSCH to the transmitting UE. Otherwise, if the TX-RX distance is greater than the communication range requirement, the receiving UE may not transmit the HARQ feedback for the PSSCH to the transmitting UE. For example, the transmitting UE may inform the receiving UE of a location of the transmitting UE through SCI related to the PSSCH. For example, the SCI related to the PSSCH may be second SCI. For example, the receiving UE may estimate or obtain the TX-RX distance based on a location of the receiving UE and the location of the transmitting UE. For example, the receiving UE may decode the SCI related to the PSSCH and thus may know the communication range requirement used in the PSSCH.

For example, in case of the resource allocation mode **1**, a time (offset) between the PSFCH and the PSSCH may be configured or pre-configured. In case of unicast and groupcast, if retransmission is necessary on SL, this may be indicated to a BS by an in-coverage UE which uses the PUCCH. The transmitting UE may transmit an indication to a serving BS of the transmitting UE in a form of scheduling request (SR)/buffer status report (BSR), not a form of HARQ ACK/NAM. In addition, even if the BS does not receive the indication, the BS may schedule an SL retransmission resource to the UE. For example, in case of the resource allocation mode **2**, a time (offset) between the PSFCH and the PSSCH may be configured or pre-configured.

For example, from a perspective of UE transmission in a carrier, TDM between the PSCCH/PSSCH and the PSFCH may be allowed for a PSFCH format for SL in a slot. For example, a sequence-based PSFCH format having a single symbol may be supported. Herein, the single symbol may not an AGC duration. For example, the sequence-based PSFCH format may be applied to unicast and groupcast.

For example, in a slot related to a resource pool, a PSFCH resource may be configured periodically as N slot durations, or may be pre-configured. For example, N may be configured as one or more values greater than or equal to 1. For example, N may be 1, 2, or 4. For example, HARQ feedback for transmission in a specific resource pool may be transmitted only through a PSFCH on the specific resource pool.

For example, if the transmitting UE transmits the PSSCH to the receiving UE across a slot #X to a slot #N, the receiving UE may transmit HARQ feedback for the PSSCH to the transmitting UE in a slot #(N-FA). For example, the slot #(N-FA) may include a PSFCH resource. Herein, for example, A may be a smallest integer greater than or equal to K. For example, K may be the number of logical slots. In this case, K may be the number of slots in a resource pool. Alternatively, for example, K may be the number of physical slots. In this case, K may be the number of slots inside or outside the resource pool.

For example, if the receiving UE transmits HARQ feedback on a PSFCH resource in response to one PSSCH transmitted by the transmitting UE to the receiving UE, the receiving UE may determine a frequency domain and/or code domain of the PSYCH resource based on an implicit mechanism in a configured resource pool. For example, the receiving UE may determine the frequency domain and/or code domain of the PSFCH resource, based on at least one of a slot index related to PSCCH/PSSCH/PSFCH, a subchannel related to PSCCH/PSSCH, and/or an identifier for identifying each receiving UE in a group for HARQ feedback based on the groupcast option 2. Additionally/alternatively, for example, the receiving UE may determine the frequency domain and/or code domain of the PSFCH resource, based on at least one of SL RSRP, SINR, L**1** source ID, and/or location information.

For example, if HARQ feedback transmission through the PSFCH of the UE and HARQ feedback reception through the PSFCH overlap, the UE may select any one of HARQ feedback transmission through the PSFCH and HARQ feedback reception through the PSFCH based on a priority rule. For example, the priority rule may be based on at least priority indication of the related PSCCH/PSSCH.

For example, if HARQ feedback transmission of a UE through a PSFCH for a plurality of UEs overlaps, the UE may select specific HARQ feedback transmission based on the priority rule. For example, the priority rule may be based on at least priority indication of the related PSC CH/P S SCH.

Hereinafter, SL radio link monitoring (RLM) will be described.

In case of AS-level link management of unicast, SL radio link monitoring (RLM) and/or radio link failure (Rif) declaration may be supported. In case of RIX acknowledged mode (AM) in SL unicast, the RLF declaration may be triggered by an indication from RLC indicating that the maximum number of retransmissions has been reached. An AS-level link status (e.g., failure) may need to be informed to a higher layer. Unlike the RLM procedure for unicast, a groupcast-related RLM design may not be considered. The RLM and/or RLF declarations may not be necessary between group members for groupcast.

For example, a transmitting UE may transmit a reference signal to a receiving UE, and the receiving UE may perform SL RLM by using the reference signal. For example, the receiving UE may declare SL RLF by using the reference signal. For example, the reference signal may be referred to as an SL reference signal.

Hereinafter, SL measurement and reporting will be described.

For the purpose of QoS prediction, initial transmission parameter setting, link adaptation, link management, admission control, or the like, SL measurement and reporting (e.g., RSRP, RSRQ) between UEs may be considered in SL, For example, a receiving UE may receive a reference signal from a transmitting UE, and the receiving UE may measure a channel state for the transmitting UE based on the reference signal. In addition, the receiving UE may report channel state information (CSI) to the transmitting UE, SE-related measurement and reporting may include measurement and reporting of CBR and reporting of location information. Examples of channel status information (CSI) for V2X may include a channel quality indicator (CQI), a precoding matrix index (PM), a rank indicator (RI), reference signal received power (RSRP), reference signal received quality (RSRQ), pathgain/pathloss, a sounding reference symbol (SRS) resource indicator (SRI), a SRI-RS resource indicator (CRI), an interference condition, a vehicle motion, or the like. In case of unicast communication, CQI, RI, and PMI or some of them may be supported in a non-subband-based aperiodic CSI report under the assumption of four or less antenna ports. A CSI procedure may not be dependent on a standalone reference signal (RS). A CSI report may be activated or deactivated based on a configuration.

For example, the transmitting UE may transmit CSI-RS to the receiving UE, and the receiving UE may measure CQI or RI based on the CSI-RS. For example, the CSI-RS may be referred to as SL CSI-RS. For example, the CSI-RS may be confined within PSSCH transmission. For example, the transmitting UE may perform transmission to the receiving UE by including the CSI-RS on the PSSCH.

Meanwhile, in conventional NR V2X, HARQ DTX-based SL RLF operation may be supported. That is, if a transmitting UE (hereinafter referred to as TX UE) detects/determines that the number of consecutive SE HARQ DTXs is reached by the maximum number of SL HARQ DTXs, the TX UE may declare St, REF. Herein, for example, even though the TX UE transmits SL data (e.g., transport block (TB), MAC PDU, etc.) to another receiving UE (hereinafter referred to as RX UE), if the TX UE does not receive HARQ feedback (e.g., HARQ ACK or HARQ NACK) from the RX UE, the TX UE may consider/determine the SI, HARQ DTX situation.

Table 5 shows an example of a procedure for the UE to declare RLF based on HARQ DTX(s).

TABLE 5

HARQ-based Sidelink RLF detection
The HARQ-based Sidelink RLF detection procedure is used to detect Sidelink RLF based on a number of consecutive DTX on PSFCH reception occasions for a PC5-RRC connection.
RRC configures the following parameter to control HARQ-based Sidelink RLF detection:
- sl-maxNumConsecutiveDTX,
The following UE variable is used for HARQ-based Sidelink RLF detection.
- numConsecutiveDTX, which is maintained for each PC5-RRC connection.

TABLE 5-continued

HARQ-based Sidelink RLF detection		
The Sidelink HARQ Entity shall (re-)initialize numConsecutiveDTX to zero for each PC5-RRC connection which has been established by upper layers, if any, upon establishment of the PC5-RRC connection or (re)configuration of sl-maxNumConsecutiveDTX.		
The Sidelink HARQ Entity shall for each PSFCH reception occasion associated to the PSSCH transmission:		
1>	if PSFCH reception is absent on the PSFCH reception occasion:	
	2>	increment numConsecutiveDTX by 1:
	2>	if numConsecutiveDTX reaches sl-maxNumConsecutiveDTX:
		3> indicate HARQ-based Sidelink RLF detection to RRC.
1>	else:	
	2>	re-initialize numConsecutiveDTX to zero.

11401 However, according to the prior art (i.e., HARQ DTX-based SL RLF operation), the following problems may occur from the viewpoint of the TX UE or the RX UE.

(1) Problems arising from the TX UE's point of view: After the TX UE transmits a. PSCCH/PSSCH to the RX UE, the TX UE may receive SL HARQ feedback transmitted by the RX UE. Specifically, for example, if the TX UE transmits a MAC PDU for which HARQ feedback is enabled to the RX UE, the RX UE may transmit HARQ feedback for the MAC PDU to the TX UE. However, due to a half-duplex problem (e.g., a problem caused by the UE not being able to transmit and receive simultaneously), there may be a case where the TX UE fails to monitor the SL HARQ feedback transmitted by the RX UE. In this case, there is no operation in the prior art for whether the TX UE, determines the situation as SL HARQ DTX or not. In addition, if the TX UE determines that the above situation is SL HARQ DTX, a problem in which the TX UE increases the SL HARQ DTX generation count may occur even though the RX UE actually transmits HARQ feedback to the TX UE. In this case, even though actual SL RLF does not have to occur, a problem in which the TX UE, declares SL RLF may occur due to the SL HARQ DTX generation count reaching a maximum HARQ DTX threshold. In the present disclosure, for example, the SL HARQ DTX generation count may be referred to as various terms such as DTX count. SL DTX count, HARQ DTX count, SL HARQ DTX count, numConsecutiveDTX, etc. In the present disclosure, for example, the maximum HARQ DTX threshold may be referred to as various terms such as maximum DTX number, maximum DTX count, maximum SL DTX count, maximum HARQ DTX count, maximum SL HARQ DTX count, sl-maxNumConsecutiveDTX, etc.

(2) Problems arising from the RX UE perspective: If the RX UE has UL traffic to be transmitted (e.g., UL traffic/data transmitted by the RX UE to the base station) and SL traffic (e.g., SL HARQ feedback for SI, traffic/data transmitted by the TX UE) at the same time, the RX UE may determine a priority of UL traffic and a priority of SL traffic in order to drop one of the two traffic. For example, the RX UE may perform prioritization for UL traffic and SL traffic. In this case, the RX UE may drop low-priority traffic (i.e., traffic with a large priority value). That is, the RX UE may transmit high-priority traffic (i, e., traffic having a small priority value) first. In this case, if the priority of UL traffic is higher than the priority of SI. HARQ feedback to be transmitted from the RX UE to the TX UE, a problem in which the RX UE fails to transmit the HARQ feedback to the TX UE may occur. In this case, despite the good SI, channel condition, the RX UE may not be able to transmit HARQ feedback to the TX UE. In this case, the TX UE may determine the above situation as SL HARQ DTX. Due to this, a problem of increasing the SL HARQ DTX count may occur. In this case, even though actual SL RLF does not have to occur, a problem in which the TX UE declares SI, RLF may occur due to the SL HARQ DTX generation count reaching the maximum HARQ DTX threshold.

Based on various embodiments of the present disclosure, a method for preventing a problem in which the TX UE declares SL RLF due to the SL HARQ DTX generation count reaching the maximum HARQ DTX threshold, even though actual SI, RLF does not have to occur, and the device(s) supporting the same are proposed.

Based on an embodiment of the present disclosure, after the TX UE transmits a PSCCH/PSSCH to the RX UE, the TX UE may expect to receive SL HARQ feedback transmitted by the RX UE, Specifically, for example, if the TX UE transmits a MAC PDU for which HARQ feedback is enabled to the RX UE, the TX UE may expect that the RX UE, transmits HARQ feedback (e.g., HARQ ACK or HARQ NACK) for the MAC PDU to the TX UE. In this case, due to the half-duplex problem (e.g., a problem caused by the UE not being able to transmit and receive simultaneously), there may be a case where the TX UE fails to monitor the SL HARQ feedback transmitted by the RX UE. Herein, based on an embodiment of the present disclosure, if the TX UE fails to monitor the SL HARQ feedback transmitted by the RX UE due to the half-duplex problem, the TX UE may not decide/determine that it is SI, HARQ DIX.

FIG. **12** shows a procedure for a UE to determine whether to declare SI, RLF based on a SL HARQ DTX count, based on an embodiment of the present disclosure. The embodiment of FIG. **12** may be combined with various embodiments of the present disclosure.

Referring to FIG. **12**, in step S**1210**, the TX UE may transmit a PSCCH/PSSCH to the RX UE. In step S**1220**, the TX UE may determine a PSFCH resource. For example, the TX UE and the RX UE may determine the PSFCH resource based on an index of a subchannel and an index of a slot through which the PSSCH is transmitted. In this case, the TX UE may expect HARQ feedback transmission by the RX UE on the PSFCH resource.

In step S**1230**, although the TX UE should receive/monitor HARQ feedback transmitted by the RX UE, the TX UE may not be able to receive/monitor HARQ feedback transmitted by the RX UE. For example, although the TX UE should receive/monitor HARQ feedback transmitted by the RX UE, the TX UE may not be able to receive/monitor SI, HARQ feedback transmitted by the RX UE due to the half-duplex problem. In this case, there is no operation in the prior art for whether the TX UE determines the situation as SL HARQ DTX or not. In addition, if the TX UE determines that the above situation is SL HARQ DTX, a problem in which the TX UE increases the SL HARQ DTX generation count may occur even though the RX UE actually transmits HARQ feedback to the TX UE. In this case, even though actual SL RLF does not have to occur, a problem in which the TX UE declares SL RLF may occur due to the SL HARQ DTX generation count reaching the maximum HARQ DTX threshold. Therefore, based on an embodiment of the present disclosure, if the TX UE which has transmitted the PSCCH/PSSCH fails to monitor SL HARQ feedback transmitted by the RX UE due to the half-duplex problem, the TX UE may not decide/determine that it is SL HARQ DTX.

In step S**1240**, the TX UE may not increase the SL HARQ DTX count. Specifically, for example, if the TX UE which has transmitted the PSCCH/PSSCH fails to receive/monitor SL HARQ feedback transmitted by the RX UE due to the half-duplex problem, the TX UE may not increase the SL HARQ DTX count. Alternatively, for example, even though the TX UE which has transmitted the PSCCH/PSSCH attempts to detect SL HARQ feedback on the PSFCH resource, if the TX UE fails to receive/monitor SL HARQ feedback transmitted by the RX UE, the TX UE may increase the SL HARQ DTX count.

In step S**1250**, the TX UE may determine whether to declare SL RLF based on the SL HARQ DTX count and the maximum DTX number. For example, if the SL HARQ DTX count reaches the maximum DTX number, the TX UE may declare SL RLF.

Based on an embodiment of the present disclosure, when In Sync (IS) and/or Out of Sync (OOS) based SL HARQ DTX occurs, a physical layer of the TX UE may transfer an OOS indicator to an RRC layer of the TX UE. Fax example, a SL RLF method based on IS and/or OOS by considering SL HARQ DTX is proposed.

FIG. **13** shows a procedure for a UE to determine whether to declare SL RLF based on OOS and/or IS, based on an embodiment of the present disclosure. The embodiment of FIG. **13** may be combined with various embodiments of the present disclosure.

Referring to FIG. **13**, in step S**1310**, the TX UE may transmit a PSCCH/PSSCH to the RX UE. In step S**1320**, the TX UE, may determine a PSFCH resource. For example, the TX UE and the RX UE may determine the PSFCH resource based on an index of a subchannel and an index of a slot through which the PSSCH is transmitted. In this case, the TX UE may expect HARQ feedback transmission by the RX UE on the PSFCH resource.

For example, if a physical layer of the TX UE detects SL HARQ DTX, the physical layer of the TX UE may determine that it is OOS, and the physical layer of the TX UE may transfer an OOS indicator to an RRC layer. On the other hand, if the physical layer of the TX UE receives SL HARQ feedback (e.g., HARQ ACK or HARQ HACK) from the RX UE, the physical layer of the TX UE may determine that it is IS, and the physical layer of the TX UE may transfer an IS indicator to the RRC layer. For example, if the RRC layer of the TX UE receives OOS indicators consecutively by the maximum OOS number from the physical layer, the TX UE may declare SL RLF.

In step S**1330**, although the TX UE should receive/monitor HARQ feedback transmitted by the RX UE, the TX UE may not be able to receive/monitor SL HARQ feedback transmitted by the RX UE. For example, although the TX UE should receive/monitor HARQ feedback transmitted by the RX UE, the TX UE may not be able to receive/monitor SL HARQ feedback transmitted by the RX UE due to the half-duplex problem.

In step S**1340**, if the TX UE fails to receive/monitor SL HARQ feedback transmitted by the RX UE due to the half-duplex problem, the TX UE may not determine that it is SL HARQ DTX, and the physical layer of the TX UE may not transfer the OOS indicator to the RRC layer of the TX UE. For example, if the TX UE fails to receive/monitor SL HARQ feedback transmitted by the RX UE due to the half-duplex problem, the TX UE may not determine that it is SL HARQ DTX, and the physical layer of the TX UE may transfer the IS indicator to the RRC layer of the TX UE.

Based on an embodiment of the present disclosure, if the RX UE fails to transmit HARQ feedback to the TX UE due to a drop according to UL/SL prioritization, the RX UE may inform the TX UE of this information through at least one of a MAC CE, a PC5 RRC message, and/or SCI. If the TX UE receives the above information from the RX UE, the TX UE may decrease the DTX count, which has increased by 1, by 1.

For example, if the RX UE has UL traffic to be transmitted (e.g., UL traffic/data transmitted by the RX UE to the base station) and SL traffic (e.g., SL HARQ feedback for SL traffic/data transmitted by the TX UE) at the same time, the RX UE may determine a priority of UL traffic and a priority of SL traffic in order to drop one of the two traffic. For example, the RX UE may perform prioritization for UL traffic and SL traffic. In this case, the RX UE may drop low-priority traffic (i.e., traffic with a large priority value). That is, the RX UE may transmit high-priority traffic (i.e., traffic having a small priority value) first. In this case, if the priority of UL traffic is higher than the priority of SL HARQ feedback to be transmitted from the RX UE to the TX UE, a problem in which the RX UE fails to transmit the HARQ feedback to the TX UE may occur. In this case, despite the good SL channel condition, the RX UE may not be able to transmit HARQ feedback to the TX UE, In this case, the TX UE may determine the above situation as SL HARQ DIX. Due to this, a problem of increasing the SL HARQ DTX count may occur. In this case, even though actual SL RLF does not have to occur, a problem in which the TX UE declares SL RLF may occur due to the SL HARQ DTX generation count reaching the maximum HARQ DTX threshold.

Therefore, based on an embodiment of the present disclosure, if the RX UE transmits UL traffic with a high priority based on priority comparison between UL traffic and SL traffic (i.e., if the RX UE does not transmit SI, traffic (i.e., SL HARQ feedback) with a low priority), the RX UE may transmit this information (specifically, the RX UE drops SL traffic (i.e., SL HARQ feedback) according to a prioritization rule between UL traffic and SL traffic because the priority of UL traffic is higher than that of SL traffic) to the TX UE through at least one of a SI, MAC CE, a PC5 RRC message, and/or SCI. If the TX UE receives a report of the information from the RX UE, the TX UE may decrease the SL HARQ DTX count, which has increased by 1, by 1.

For example, at least one of a SI. MAC CE, a PC5 RRC message, and/or SCI transmitted by the RX UE to the TX UE may include a PSFCH dropped cause. For example, if the RX UE drops St, traffic (e.g., SI, HARQ feedback) with a lower priority than UL traffic based on a prioritization rule between UL traffic and SL traffic, the PSFCH dropped cause may have a value of 0. Otherwise, the PSFCH dropped cause may have any one value from 1 to N. For example, N may be a positive integer. For example, N may be a reserved value.

For example, the RX UE which has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped. PSFCH transmission associated with the PSCCH/PSSCH by transmitting a PSCCH (e.g., SCI) to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE, For example, the RX UE may transmit the information to the TX UE through SCI. For example, the RX UE may transmit the information to the TX UE through a new MAC CE. For example, the RX UE may transmit the information to the TX UE through an RRC message. For example, the TX UE which has received at least one of the SCI, the MAC CE, and/or the RRC message may decrease the SL HARQ DTX count by the number of dropped PSFCH transmissions.

For example, if the RX UE drops PSFCH transmission, the RX UE may trigger a SL CSI Reporting MAC CE. Specifically, for example, if the RX UE drops PSFCH transmission, the RX UE may transmit a CSI Reporting MAC CE to the peer TX UE. In this case, the RX UE which has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped PSFCH transmission associated with the PSCCH/PSSCH by transmitting the SL CSI Reporting MAC CE to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource and information related to a type (e.g., HARQ ACK or HARQ HACK) of the dropped PSFCH transmission to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE. For example, the TX UE which has received the SL MAC CE may decrease the SL HARQ DTX count by the number of dropped PSFCH transmissions included in the SL MAC CE. Alternatively, for example, the TX UE which has received the St, MAC CE may maintain the SL HARQ DTX count.

For example, if the RX UE drops the PSFCH transmission, the RX UE may trigger transmission of a PC5 RRC message. For example, if the RX UE drops PSFCH transmission, the RX UE may transmit the PC5 RRC message to the peer TX UE. In this case, the RX UE that has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped PSFCH transmission associated with the PSCCH/PSSCH by transmitting the PC5 RRC message to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource and information related to a type (e.g., HARQ ACID or HARQ HACK) of the dropped PSFCH transmission to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE. For example, the TX UE which has received the PC5 RRC message may decrease the SL HARQ DTX count by the number of dropped PSFCH transmissions included in the PC5 RRC message. Alternatively, for example, the TX UE which has received the PC5 RRC message may maintain the SL HARQ DTX count.

FIG. **14** shows a procedure for a UE to determine whether to declare SL RLF based on a. SL HARQ DTX count, based on an embodiment of the present disclosure. The embodiment of FIG. **14** may be combined with various embodiments of the present disclosure.

Referring to FIG. **14**, in step **S1410**, the UE **1** may transmit a PSCCH (e.g., SCI) and a PSSCH (e.g., SL traffic) to the UE **2**.

In step **S1420**, it is assumed that the UE **2** successfully receives the PSCCH and the PSSCH transmitted by the UE **1**.

In step **S1430**, it is assumed that UL traffic of the UE **2** (e.g., traffic transmitted by the UE to the base station) occurs at the time when the UE **2** needs to perform PSFCH transmission related to the reception of the PSCCH/PSSCH.

In step **S1440**, the UE **2** may perform a priority comparison operation to determine which of SL traffic (e.g., SL HARQ feedback) and UL traffic to transmit first. Herein, if a priority value of the UL traffic is smaller than a priority value of the SL traffic based on the priority comparison operation, the UE **2** may transmit the UL traffic, and the UE **2** may drop transmission of the SL traffic (e.g., SL HARQ feedback).

In step **S1450**, the UE **1** may not be able to receive SI, HARQ feedback for PSCCH/PSSCH transmission. Accordingly, the UE **1** may increase the SL HARQ DTX count by 1.

In step **S1460**, the UE **2** may transmit information related to the dropped PSFCH resource or information related to the number of dropped PSFCH transmissions (e.g., SL HARQ feedback) to the UE **1**, For example, the UE **2** may transmit SCI including information related to the dropped PSFCH resource or information related to the number of dropped PSFCH transmissions (e.g., SL HARQ feedback) to UE **1** through a PSCCH. For example, the UE **2** may transmit information related to the dropped PSFCH resource or information related to the number of dropped PSFCH transmissions (e.g., SL HARQ feedback) to the UE **1** through a SL MAC CE, For example, the UE **2** may transmit information related to the dropped PSFCH resource or information related to the number of dropped. PSFCH transmissions (e.g., SL HARQ feedback) to the UE **1** through a PC5 RRC message. For example, in the embodiment of FIG. **14**, it is assumed that the number of dropped PSFCH transmissions (e.g., SL HARQ feedback) is 1.

In step **S1470**, the UE **1** may decrease the SL HARQ DIX count by 1, For example, the UE **1** may decrease the SL HARQ DTX count, which has increased by 1 due to not receiving SL HARQ feedback for PSCCH/PSSCH transmission in step **S1450**, by 1 again.

The above-described embodiment can be applied even if SL HARQ feedback transmission is dropped due to priority comparison between SL transmissions.

Based on an embodiment of the present disclosure, if the RX UE fails to transmit SL HARQ feedback to the TX UE due to a drop according to prioritization between SL transmissions, the RX UE may inform the TX UE of this information through at least one of a MAC CE, a PC5 RRC message, and/or SCI. If the TX UE receives the above information from the RX UE, the TX UE may decrease the DTX count, which has increased by 1, by 1. For example, the SL transmissions may include LTE SE transmission and/or NR SL transmission.

For example, if the RX UE has first St, traffic to be transmitted (e.g., LTE transmission) and second SL traffic (e.g., SL HARQ feedback for NR SL traffic/data transmitted by the TX UE) at the same time, the RX UE may determine a priority of the first SL, traffic and a priority of the second SL traffic in order to drop one of the two traffic. For example, the RX UE may perform prioritization for the first SL traffic and the second SL traffic. In this case, the RX UE may drop low priority traffic (i.e., traffic with a large priority value). That is, the RX UE may transmit high priority traffic (i.e., traffic with a small priority value) first. In this case, if the priority of the first SL traffic is higher than the priority of the second SL traffic (i.e., SL HARQ feedback) to be transmitted by the RX UE to the TX UE, a problem in which the RX UE cannot transmit HARQ feedback to the TX UE may occur.

In this case, despite the good SL channel condition, the RX UE may not be able to transmit HARQ feedback to the TX UE. In this case, the TX UE may determine the above situation as SL HARQ DTX. Due to this, a problem of increasing the St, HARQ DTX count may occur. In this case, even though actual SL RLF does not have to occur, a problem in which the TX UE declares SL RLF may occur due to the SL DTX generation count reaching the maximum HARQ DTX threshold.

Therefore, based on an embodiment of the present disclosure, if the RX UE transmits the first SL traffic with a high priority based on priority comparison between the first SL traffic and the second SL traffic (i.e., if the RX UE does not transmit the second SL traffic (i.e., SL HARQ feedback) with a low priority), the RX UE may transmit this information (specifically, the RX UE drops the second SL traffic (i.e., SL HARQ feedback) based on the prioritization rule between the first SL traffic and the second SL traffic because the priority of the first SL traffic is higher than that of the second SL traffic) to the TX UE through at least one of a SL MAC CE, a PC5 RRC message, and/or SCI. If the TX UE receives a report of the information from the RX UE, the TX UE may decrease the SL HARQ DTX count, which has increased by 1, by 1.

For example, at least one of the SL MAC CE, the PC5 RRC message, and/or the SCI transmitted by the RX UE to the TX UE may include a PSFCH dropped cause. For example, if the RX UE drops the second. SL, traffic (e.g., SL HARQ feedback) with a lower priority than the first SL traffic based on the prioritization rule between the first SL traffic and the second SL traffic, the PSFCH dropped cause may have a value of 0. Otherwise, the PSFCH dropped cause may have any one value from 1 to N. For example, N may be a positive integer. For example, N may be a reserved value.

For example, the RX UE which has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped PSFCH transmission associated with the PSCCH/PSSCH by transmitting a PSCCH (e.g., SCI) to the TX UE. For example, the RX UE may transmit information related to a location of the dropped. PSFCH resource to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE. Fax example, the RX UE may transmit the information to the TX UE through SCI. For example, the RX UE may transmit the information to the TX UE through a new MAC CE. For example, the RX UE may transmit the information to the TX UE through an RRC message. For example, the TX UE which has received at least one of the SCI, the MAC CE, and/or the RRC message may decrease the SL HARQ DTX count by the number of dropped PSFCH transmissions.

For example, if the RX UE drops PSFCH transmission, the RX UE may trigger a SL CSI Reporting MAC CE. Specifically, for example, if the RX UE drops PSFCH transmission, the RX UE may transmit a CSI Reporting MAC CE to the peer TX UE. In this case, the RX UE which has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped PSFCH transmission associated with the PSCCH/PSSCH by transmitting the SL CSI Reporting MAC CE to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource and information related to a type (e.g., HARQ ACK or HARQ HACK) of the dropped PSFCH transmission to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE. For example, the TX UE which has received the SI, MAC CE may decrease the SF HARQ DTX count by the number of dropped PSFCH transmissions included in the SF MAC CE. Alternatively, for example, the TX UE which has received the SL MAC CE may maintain the SL HARQ DTX count.

For example, if the RX UE drops the PSFCH transmission, the RX UE may trigger transmission of a PC5 RRC message. For example, if the RX UE drops PSFCH transmission, the RX UE may transmit the PC5 RRC message to the peer TX UE. In this case, the RX UE, that has received a PSCCH/PSSCH from the TX UE may inform the TX UE of the previously dropped PSFCH transmission associated with the PSCCH/PSSCH by transmitting the PC5 RRC message to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource to the TX UE. For example, the RX UE may transmit information related to a location of the dropped PSFCH resource and information related to a type (e.g., HARQ ACK or HARQ HACK) of the dropped PSFCH transmission to the TX UE. For example, the RX UE may transmit information related to the number of dropped PSFCHs to the TX UE. For example, the TX UE which has received the PC5 RRC message may decrease the SL HARQ DTX count by the number of dropped PSFCH transmissions included in the PC5 RRC message. Alternatively, for example, the TX UE which has received the PC5 RRC message may maintain the SF HARQ DTX count.

Based on various embodiments of the present disclosure, a condition for the TX UE to determine as SL HARQ DTX is newly defined. Therefore, the problem in which the TX UE determines as the SL HARQ DTX situation (e.g., the problem in which the TX UE incorrectly determines as the SI, HARQ DTX situation due to the half-duplex problem), even though the SI, channel condition is good, can be solved. Through this, the problem in which the TX UE, declares SL RLF, even though actual SL RLF does not have to occur, can be prevented. The monitoring in the above description may refer to monitoring, reception. (blind) decoding, decoding attempt, etc.

FIG. **15** shows a method for a first device to perform wireless communication, based on an embodiment of the present disclosure. The embodiment of FIG. **15** may be combined with various embodiments of the present disclosure.

Referring to FIG. **15**, in step S**1510**, the first device may transmit, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH), In step S**1520**, the first device may transmit, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH. In step S**1530**, the first device may determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH. In step S**1540**, the first device may increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource. In step S**1550**, the first device may receive, from the second device, information related to drop of HARQ feedback transmission. In step S**1560**, the first device may decrease the DTX counter by N, based on the information related to drop of HARQ feedback transmission. For example, based on the DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

For example, the information related to drop of HARQ feedback transmission may include information related to a location of the PSFCH resource.

For example, the information related to drop of HARQ feedback transmission may include information related to a number of HARQ feedback transmissions dropped by the second device, and the number of HARQ feedback transmissions dropped by the second device may be N.

For example, based on that the second device performs transmission on a resource overlapping the PSFCH resource in a time domain, the HARQ feedback transmission on the PSFCH resource may be dropped by the second device. For example, the transmission on the resource overlapping the PSFCH resource in the time domain may include uplink (UL) transmission, and a priority of the UL transmission may be higher than a priority of the HARQ feedback transmission. For example, the transmission on the resource overlapping the PSFCH resource in the time domain may include SL transmission, and a priority of the SL transmission may be higher than a priority of the HARQ feedback transmission.

For example, the information related to drop of HARQ feedback transmission may be received from the second device through SCI.

For example, the information related to drop of HARQ feedback transmission may be received from the second device through a SL medium access control (MAC) control element (CE). For example, based on that the HARQ feedback transmission is dropped by the second device on the PSFCH resource, transmission of the SL MAC CE may be triggered by the second device.

For example, the information related to drop of HARQ feedback transmission may be received from the second device through a PC5 radio resource control (RRC) message.

Additionally, for example, the first device may perform SL transmission or UL transmission based on a resource overlapping the PSFCH resource in a time domain. For example, based on the failure to receive the HARQ feedback on the PSFCH resource by the SL transmission or the UL transmission, the DTX counter may not increase.

For example, based on the failure to receive the HARQ feedback on the PSFCH resource, Out of Sync (OOS) information may be transferred from a physical layer of the first device to an RRC layer of the first device, and based on successful reception of the HARQ feedback on the PSFCH resource. In Sync (IS) information may be transferred from the physical layer of the first device to the RRC layer of the first device. For example, based on that a number of OOS information continuously received by the RRC layer of the first device reaches a maximum OOS number, the SL RLF may be declared.

The proposed method can be applied to the device(s) based on various embodiments of the present disclosure. First, the processor **102** of the first device **100** may control the transceiver **106** to transmit, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH), In addition, the processor **102** of the first device **100** may control the transceiver **106** to transmit, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH. In addition, the processor **102** of the first device **100** may determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH. In addition, the processor **102** of the first device **100** may increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource. In addition, the processor **102** of the first device **100** may control the transceiver **106** to receive, from the second device, information related to drop of HARQ feedback transmission. In addition, the processor **102** of the first device **100** may decrease the DTX counter by N, based on the information related to drop of HARQ feedback transmission. For example, based on the DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

Based on an embodiment of the present disclosure, a first device adapted to perform wireless communication may be provided. For example, the first device may comprise: one or more memories storing instructions; one or more transceivers; and one or more processors connected to the one or more memories and the one or more transceivers. For example, the one Or more processors may execute the instructions to: transmit, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH), transmit, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receive, from the second device, information related to drop of HARQ feedback transmission; and decrease the DTX counter by N, based on the information related to drop of HARQ feedback transmission. For example, based on the DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

Based on an embodiment of the present disclosure, an apparatus adapted to control a first user equipment (UE) may be provided. For example, the apparatus may comprise: one or more processors; and one or more memories operably connected to the one or more processors and storing instructions. For example, the one or more processors may execute the instructions to: transmit, to a second UE, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); transmit, to the second UE, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receive, from the second UE, information related to drop of HARQ feedback transmission; and decrease the DTX counter by N, based on the information related to drop of HARQ feedback transmission. For example, based on the DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

Based on an embodiment of the present disclosure, a non-transitory computer-readable storage medium storing instructions may be provided. For example, the instructions may, when executed, cause a first device to: transmit, to a second device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); transmit, to the second device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; increase a DTX counter by 1, based on a failure to receive hybrid automatic repeat request (HARQ) feedback on the PSFCH resource; receive, from the second device, information related to drop of HARQ feedback transmission; and decrease the DTX counter by N, based on the information related to drop of HARQ feedback transmission. For example, based on the

DTX counter reaching a maximum DTX number, a sidelink (SL) radio link failure (RLF) may be declared, and N may be a positive integer.

FIG. **16** shows a method for a second device to perform wireless communication, based on an embodiment of the present disclosure. The embodiment of FIG. **16** may be combined with various embodiments of the present disclosure.

Referring to FIG. **16**, in step S**1610**, the second device may receive, from a first device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH). In step S**1620**, the second device may receive, from the first device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH. In step S**1630**, the second device may determine a physical sidelink feedback channel (PSCCH) resource based on a subchannel and a slot related to the PSSCH. In step S**1640**, the second device may transmit, to the first device, information related to drop of hybrid automatic repeat request (HARQ) feedback transmission, based on that the second device drops the HARQ feedback transmission on the PSFCH resource by transmission on a resource overlapping the PSFCH resource in a time domain.

The proposed method can be applied to the device(s) based on various embodiments of the present disclosure. First, the processor **202** of the second device **200** may control the transceiver **206** to receive, from a first device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH). In addition, the processor **202** of the second device **200** may control the transceiver **206** to receive, from the first device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH. In addition, the processor **202** of the second device **200** may determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH. In addition, the processor **202** of the second device **200** may control the transceiver **206** to transmit, to the first device, information related to drop of hybrid automatic repeat request (HARQ) feedback transmission, based on that the second device drops the HARQ feedback transmission on the PSFCH resource by transmission on a resource overlapping the PSFCH resource in a time domain.

Based on an embodiment of the present disclosure, a second device adapted to perform wireless communication may be provided. For example, the second device may comprise: one or more memories storing instructions; one or more transceivers; and one or more processors connected to the one or more memories and the one or more transceivers. For example, the one or more processors may execute the instructions to: receive, from a first device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); receive, from the first device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSSCH) resource based on a subchannel and a slot related to the PSSCH; and transmit, to the first device, information related to drop of hybrid automatic repeat request (HARQ) feedback transmission, based on that the second device drops the HARQ feedback transmission on the PSFCH resource by transmission on a resource overlapping the PSSCH resource in a time domain.

Based on an embodiment of the present disclosure, an apparatus adapted to control a second user equipment (UE) may be provided. For example, the apparatus may comprise: one or more processors; and one or more memories operably connected to the one or more processors and storing instructions. For example, the one or more processors may execute the instructions to: receive, from a first UE, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); receive, from the first UE, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; and transmit, to the first UE, information related to drop of hybrid automatic repeat request (HARQ) feedback transmission, based on that the second UE drops the HARQ feedback transmission on the PSSCH resource by transmission on a resource overlapping the PSFCH resource in a time domain.

Based on an embodiment of the present disclosure, a non-transitory computer-readable storage medium storing instructions may be provided. For example, the instructions may, when executed, cause a second device to: receive, from a first device, sidelink control information (SCI) through a physical sidelink control channel (PSCCH); receive, from the first device, data through a physical sidelink shared channel (PSSCH) related to the PSCCH; determine a physical sidelink feedback channel (PSFCH) resource based on a subchannel and a slot related to the PSSCH; and transmit, to the first device, information related to drop of hybrid automatic repeat request (HARQ) feedback transmission, based on that the second device drops the HARQ feedback transmission on the PSFCH resource by transmission on a resource overlapping the PSFCH resource in a time domain.

Various embodiments of the present disclosure may be combined with each other.

Hereinafter, device(s) to which various embodiments of the present disclosure can be applied will be described.

The various descriptions, functions, procedures, proposals, methods, and/or operational flowcharts of the present disclosure described in this document may be applied to, without being limited to, a variety of fields requiring wireless communication/connection (e.g., 5G) between devices.

Hereinafter, a description will be given in more detail with reference to the drawings. In the following drawings/description, the same reference symbols may denote the same or corresponding hardware blocks, software blocks, or functional blocks unless described otherwise.

FIG. **17** shows a communication system **1**, based on an embodiment of the present disclosure.

Referring to FIG. **17**, a communication system **1** to which various embodiments of the present disclosure are applied includes wireless devices, Base Stations (BSs), and a network. Herein, the wireless devices represent devices performing communication using Radio Access Technology (RAT) (e.g., 5G New RAT (NR)) or Long-Term Evolution (LTE)) and may be referred to as communication/radio/5G devices. The wireless devices may include, without being limited to, a robot **100***a*, vehicles **100***b*-**1** and **100***b*-**2**, an eXtended Reality (XR) device **100***c*, a hand-held device **100***d*, a home appliance **100***e*, an Internet of Things (IoT) device **100***f*, and an Artificial Intelligence (AI) device/server **400**. For example, the vehicles may include a vehicle having a wireless communication function, an autonomous vehicle, and a vehicle capable of performing communication between vehicles. Herein, the vehicles may include an Unmanned Aerial Vehicle (UAV) (e.g., a drone). The XR device may include an Augmented Reality (AR)/Virtual Reality (VR)/Mixed Reality (MR) device and may be implemented in the form of a Head-Mourned Device (HMD), a Head-Up Display (HUD) mounted in a vehicle, a television, a smartphone, a computer, a wearable device, a home appliance device, a digital signage, a vehicle, a robot, etc. The hand-held device may include a smartphone, a smartpad, a wearable device (e.g., a smartwatch or a smartglasses), and a computer (e.g., a notebook). The home appliance may include a TV, a refrigerator, and a washing machine. The IoT device may include a sensor and a smartmeter. For example, the BSs and the network may be implemented as wireless devices and a specific wireless device **200***a* may operate as a BS/network node with respect to other wireless devices.

Here, wireless communication technology implemented in wireless devices **100***a* to **100***f* of the present disclosure may include Narrowband Internet of Things for low-power communication in addition to LTE, NR, and 6G. In this case, for example, NB-IoT technology may be an example of Low Power Wide Area Network (LPWAN) technology and may be implemented as standards such as UE Cat NB**1**, and/or LTE Cat NB**2**, and is not limited to the name described above. Additionally or alternatively, the wireless communication technology implemented in the wireless devices **100***a* to **100***f* of the present disclosure may perform communication based on LTE-M technology. In this case, as an example, the LTE-M technology may be an example of the LPWAN and may be called by various names including enhanced Machine Type Communication (eMTC), and the like. For example, the LTE-M technology may be implemented as at least any one of various standards such as 1) LTE CAT **0**, 2) LTE Cat M**1** 3) LTE Cat M**2**, 4) LTE non-Bandwidth Limited (non-BL), 5) LTE-MTC, 6) LTE Machine Type Communication, and/or 7) UE M, and is not limited to the name described above. Additionally or alternatively, the wireless communication technology implemented in the wireless devices **100***a* to **100***f* of the present disclosure may include at least one of Bluetooth, Low Power Wide Area Network (LPWAN), and ZigBee considering the low-power communication, and is not limited to the name described above. As an example, the ZigBee technology may generate personal area networks (PAN) related to small/low-power digital communication based on various standards including IEEE 802.15.4, and the like, and may be called by various names.

The wireless devices **100***a* to **100***f* may be connected to the network **300** via the BSs **200**. An AI technology may be applied to the wireless devices **100***a* to **100***f* and the wireless devices **100***a* to **100***f* may be connected to the AI server **400** via the network **300**. The network **300** may be configured using a 3G network, a 4G (e.g., UE) network, or a 5G (e.g., NR) network. Although the wireless devices **100***a* to **100***f* may communicate with each other through the BSs **200**/network **300**, the wireless devices **100***a* to **100***f* may perform direct communication (e.g., sidelink communication) with each other without passing through the BSs/network. For example, the vehicles **100***b*-**1** and **100***b*-**2** may perform direct communication (e.g. Vehicle-to-Vehicle (V2V)/Vehicle-to-everything (V2X) communication), The IoT device (e.g., a sensor) may perform direct communication with other IoT devices (e.g., sensors) or other wireless devices **100***a* to **100***f*.

Wireless communication/connections **150***a*, **150***b*, or **150***c* may be established between the wireless devices **100***a* to **100***f*/BS **200**, or BS **200**/BS **200**. Herein, the wireless communication/connections may be established through various RAT's (e.g., 5G NR) such as uplink/downlink communication **150***a*, sidelink communication **150***b* (or, D2D communication), or inter BS communication (e.g., relay, Integrated Access Backhaul (IAB)). The wireless devices and the BSs/the wireless devices may transmit/receive radio signals to/from each other through the wireless communication/connections **150***a* and **150***b*. For example, the wireless communication/connections **150***a* and **150***b* may transmit/receive signals through various physical channels. To this end, at least a part of various configuration information configuring processes, various signal processing processes (e.g., channel encoding/decoding, modulation/demodulation, and resource mapping/demapping), and resource allocating processes, for transmitting/receiving radio signals, may be performed based on the various proposals of the present disclosure.

FIG. **18** shows wireless devices, based on an embodiment of the present disclosure.

Referring to FIG. **18**, a first wireless device **100** and a second wireless device **200** may transmit radio signals through a variety of RATs (e.g., LTE and NR). Herein, {the first wireless device **100** and the second wireless device **200**} may correspond to {the wireless device **100***x* and the BS **200**} and/or {the wireless device **100***x* and the wireless device **100***x*} of FIG. **17**.

The first wireless device **100** may include one or more processors **102** and one or more memories **104** and additionally further include one or more transceivers **106** and/or one or more antennas **108**. The processor(s) **102** may control the memory(s) **104** and/or the transceiver(s) **106** and may be configured to implement the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. For example, the processor(s) **102** may process information within the memory(s) **104** to generate first information/signals and then transmit radio signals including the first information/signals through the transceiver(s) **106**. The processor(s) **102** may receive radio signals including second information/signals through the transceiver **106** and then store information obtained by processing the second information/signals in the memory(s) **104**. The memory(s) **104** may be connected to the processor(s) **102** and may store a variety of information related to operations of the processor(s) **102**, For example, the memory(s) **104** may store software code including commands for performing a part or the entirety of processes controlled by the processor(s) **102** or for performing the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. Herein, the processor(s) **102** and the memory(s) **104** may be a part of a communication modem/circuit/chip designed to implement RAF (e. L'I'E or NR), The transceiver(s) **106** may be connected to the processor(s) **102** and transmit and/or receive radio signals through one or more antennas **108**. Each of the transceiver(s) **106** may include a transmitter and/or a receiver. The transceiver(s) **106** may be interchangeably used with Radio Frequency (RF) unit(s). In the present disclosure, the wireless device may represent a communication modem/circuit/chip.

The second wireless device **200** may include one or more processors **202** and one or more memories **204** and additionally further include one or more transceivers **206** and/or one or more antennas **208**, The processor(s) **202** may control the memory(s) **204** and/or the transceiver(s) **206** and may be configured to implement the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. For example, the processor(s) **202** may process information within the memory(s) **204** to generate third information/signals and then transmit radio signals including the third information/signals through the transceiver(s) **206**. The processor(s) **202** may receive radio signals including fourth information/signals through the transceiver(s) **106** and then store information obtained by processing the fourth information/signals in the memory(s) **204**. The memory(s) **204** may be connected to the processor(s) **202** and may store a variety of information related to operations of the processor(s) **202**. For example, the memory(s) **204** may store software code including commands for performing a part or the entirety of processes controlled by the processor(s) **202** or for performing the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. Herein, the processor(s) **202** and the memory(s) **204** may be a part of a communication modem/circuit/chip designed to implement RAT (e.g., LTE or NR). The transceiver(s) **206** may be connected to the processor(s) **202** and transmit and/or receive radio signals through one or more antennas **208**, Each of the transceiver(s) **206** may include a transmitter and/or a receiver. The transceiver(s) **206** may be interchangeably used with RF unit(s). In the present disclosure, the wireless device may represent a communication modem/circuit/chip.

Hereinafter, hardware elements of the wireless devices **100** and **200** will be described more specifically. One or more protocol layers may be implemented by, without being limited to, one or more processors **102** and **202**. For example, the one or more processors **102** and **202** may implement one or more layers (e.g., functional layers such as PHY, MAC, RLC, PDCP, RRC, and SDAP). The one or more processors **102** and **202** may generate one or more Protocol Data Units (PDUs) and/or one or more Service Data Unit (SDUs) according to the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. The one or more processors **102** and **202** may generate messages, control information, data, or information according to the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document. The one or more processors **102** and **202** may generate signals (e.g., baseband signals) including PDUs, SDUs, messages, control information, data, or information according to the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document and provide the generated signals to the one or more transceivers **106** and **206**. The one or more processors **102** and **202** may receive the signals (e.g., baseband signals) from the one or more transceivers **106** and **206** and acquire the PDUs, SDUs, messages, control information, data, or information according to the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document.

The one or more processors **102** and **202** may be referred to as controllers, microcontrollers, microprocessors, or microcomputers. The one or more processors **102** and **202** may be implemented by hardware, firmware, software, or a combination thereof. As an example, one or more Application Specific Integrated Circuits (ASICs), one or more Digital Signal Processors (DSPs), one or more Digital Signal Processing Devices (DSPDs), one or more Programmable Logic Devices (PLDs), or one or more Field Programmable Gate Arrays (FPGAs) may be included in the one or more processors **102** and **202**. The descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document may be implemented using firmware or software and the firmware or software may be configured to include the modules, procedures, or functions. Firmware or software configured to perform the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document may be included in the one or more processors **102** and **202** or stored in the one or more memories **104** and **204** so as to be driven by the one or more processors **102** and **202**. The descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document may be implemented using firmware or software in the form of code, commands, and/or a set of commands.

The one or more memories **104** and **204** may be connected to the one or more processors **102** and **202** and store various types of data, signals, messages, information, programs, code, instructions, and/or commands. The one or more memories **104** and **204** may be configured by Read-Only Memories (ROMs), Random Access Memories (RAMs), Electrically Erasable Programmable Read-Only Memories (EPROMs), flash memories, hard drives, registers, cash memories, computer-readable storage media, and/or combinations thereof. The one or more memories **104** and **204** may be located at the interior and/or exterior of the one or more processors **102** and **202**. The one or more memories **104** and **204** may be connected to the one or more processors **102** and **202** through various technologies such as wired or wireless connection.

The one or more transceivers **106** and **206** may transmit user data, control information, and/or radio signals/channels, mentioned in the methods and/or operational flowcharts of this document, to one or more other devices. The one or more transceivers **106** and **206** may receive user data, control information, and/or radio signals/channels, mentioned in the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document, from one or more other devices. For example, the one or more transceivers **106** and **206** may be connected to the one or more processors **102** and **202** and transmit and receive radio signals. For example, the one or more processors **102** and **202** may perform control so that the one or more transceivers **106** and **206** may transmit user data, control information, or radio signals to one or more other devices. The one or more processors **102** and **202** may perform control so that the one or more transceivers **106** and **206** may receive user data, control information, or radio signals from one or more other devices. The one or more transceivers **106** and **206** may be connected to the one or more antennas **108** and **208** and the one or more transceivers **106** and **206** may be configured to transmit and receive user data, control information, and/or radio signals/channels, mentioned in the descriptions, functions, procedures, proposals, methods, and/or operational flowcharts disclosed in this document, through the one or more antennas **108** and **208**. In this document, the one or more antennas may be a plurality of physical antennas or a plurality of logical antennas (e.g., antenna ports). The one or more transceivers **106** and **206** may convert received radio signals/channels etc. from RF band signals into baseband signals in order to process received user data, control information, radio signals/channels, etc. using the one or more processors **102** and **202**. The one or more transceivers **106** and **206** may convert the user data, control information, radio signals/channels, etc. processed using the one or more processors **102** and **202** from the base band signals into the RF band signals. To this end, the one or more transceivers **106** and **206** may include (analog) oscillators and/or filters.

FIG. **19** shows a signal process circuit for a transmission signal, based on an embodiment of the present disclosure.

Referring to FIG. **19**, a signal processing circuit **1000** may include scramblers **1010**, modulators **1020**, a layer mapper **1030**, a precoder **1040**, resource mappers **1050**, and signal generators **1060**. An operation/function of FIG. **19** may be performed, without being limited to, the processors **102** and **202** and/or the transceivers **106** and **206** of FIG. **18**. Hardware elements of FIG. **19** may be implemented by the processors **102** and **202** and/or the transceivers **106** and **206** of FIG. **18**. For example, blocks **1010** to **1060** may be implemented by the processors **102** and **202** of FIG. **18**, Alternatively, the blocks **1010** to **1050** may be implemented by the processors **102** and **202** of FIG. **18** and the block **1060** may be implemented by the transceivers **106** and **206** of FIG. **18**.

Codewords may be converted into radio signals via the signal processing circuit **1000** of FIG. **19**. Herein, the codewords are encoded bit sequences of information blocks. The information blocks may include transport blocks (e.g., a UL-SCH transport block, a DL-SCH transport block). The radio signals may be transmitted through various physical channels (e.g., a PUSCH and a PDSCH).

Specifically, the codewords may be converted into scrambled bit sequences by the scramblers **1010**. Scramble sequences used for scrambling may be generated based on an initialization value, and the initialization value may include ID information of a wireless device. The scrambled bit sequences may be modulated to modulation symbol sequences by the modulators **1020**. A modulation scheme may include pi/2-Binary Phase Shift Keying (pi/2-BPSK), in-Phase Shift Keying (m-PSK), and m-Quadrature Amplitude Modulation (m-QAM). Complex modulation symbol sequences may be mapped to one or more transport layers by the layer mapper **1030**. Modulation symbols of each transport layer may be mapped (precoded) to corresponding antenna port(s) by the precoder **1040**. Outputs z of the precoder **1040** may be obtained by multiplying outputs y of the layer mapper **1030** by an N*M precoding matrix W Herein, N is the number of antenna ports and M is the number of transport layers. The precoder **1040** may perform precoding after performing transform precoding (e.g., DFT) for complex modulation symbols. Alternatively, the precoder **1040** may perform precoding without performing transform precoding.

The resource mappers **1050** may map modulation symbols of each antenna port to time-frequency resources. The time-frequency resources may include a plurality of symbols (e.g., a CP-OFDMA symbols and DFT-s-OFDMA symbols) in the time domain and a plurality of subcarriers in the frequency domain. The signal generators **1060** may generate radio signals from the mapped modulation symbols and the generated radio signals may be transmitted to other devices through each antenna. For this purpose, the signal generators **1060** may include Inverse Fast Fourier Transform (IFFT) modules, Cyclic Prefix (CP) inserters, Digital-to-Analog Converters (DACs), and frequency up-converters.

Signal processing procedures for a signal received in the wireless device may be configured in a reverse manner of the signal processing procedures **1010** to **1060** of FIG. **19**. For example, the wireless devices (e.g., **100** and **200** of FIG. **18**) may receive radio signals from the exterior through the antenna ports/transceivers. The received radio signals may be converted into baseband signals through signal restorers. To this end, the signal restorers may include frequency downlink converters, Analog-to-Digital Converters (ADCs), CP remover, and Fast Fourier Transform (FFT) modules. Next, the baseband signals may be restored to codewords through a resource demapping procedure, a postcoding procedure, a demodulation processor, and a descrambling procedure. The codewords may be restored to original information blocks through decoding, Therefore, a signal processing circuit (not illustrated) for a reception signal may include signal restorers, resource demappers, a postcoder, demodulators, descramblers, and decoders.

FIG. **20** shows another example of a wireless device, based on an embodiment of the present disclosure. The wireless device may be implemented in various forms according to a use-case/service (refer to FIG. **17**).

Referring to FIG. **20**, wireless devices **100** and **200** may correspond to the wireless devices **100** and **200** of FIG. **18** and may be configured by various elements, components, units/portions, and/or modules. For example, each of the wireless devices **100** and **200** may include a communication unit **110**, a control unit **120**, a memory unit **130**, and additional components **140**. The communication unit may include a communication circuit **112** and transceiver(s) **114**. For example, the communication circuit **112** may include the one or more processors **102** and **202** and/or the one or more memories **104** and **204** of FIG. **18**. For example, the transceiver(s) **114** may include the one or more transceivers **106** and **206** and/or the one or more antennas **108** and **208** of FIG. **18**. The control unit **120** is electrically connected to the communication unit **110**, the memory **130**, and the additional components **140** and controls overall operation of the wireless devices. For example, the control unit **120** may control an electric/mechanical operation of the wireless device based on programs/code/commands/information stored in the memory unit **130**, The control unit **120** may transmit the information stored in the memory unit **130** to the exterior (e.g., other communication devices) via the communication unit **110** through a wireless/wired interface or store, in the memory unit **130**, information received through the wireless/wired interface from the exterior (e.g., other communication devices) via the communication unit **110**.

The additional components **140** may be variously configured according to types of wireless devices. For example, the additional components **140** may include at least one of a power unit/battery, input/output (I/O) unit, a driving unit, and a computing unit. The wireless device may be implemented in the form of, without being limited to, the robot (**100***a* of FIG. **17**), the vehicles (**100***b*-**1** and **100***b*-**2** of FIG. **17**), the XR device (**100***c* of FIG. **17**), the hand-held device (**100***d* of FIG. **17**), the home appliance (**100***e* of FIG. **17**), the IoT device (**100***f* of FIG. **17**), a digital broadcast terminal, a hologram device, a public safety device, an MTC device, a medicine device, a fintech device (or a finance device), a security device, a climate/environment device, the AI server/device (**400** of FIG. **17**), the BSs (**200** of FIG. **17**), a network node, etc. The wireless device may be used in a mobile or fixed place according to a use-example/service.

In FIG. **20**, the entirety of the various elements, components, units/portions, and/or modules in the wireless devices **100** and **200** may be connected to each other through a wired interface or at least a part thereof may be wirelessly connected through the communication unit **110**. For example, in each of the wireless devices **100** and **200**, the control unit **120** and the communication unit **110** may be connected by wire and the control unit **120** and first units (e.g., **130** and **140**) may be wirelessly connected through the communication unit **110**. Each element, component, unit/portion, and/or module within the wireless devices **100** and **200** may further include one or more elements. For example, the control unit **120** may be configured by a set of one or more processors. As an example, the control unit **120** may be configured by a set of a communication control processor, an application processor, an Electronic Control Unit (ECU), a graphical processing unit, and a memory control processor. As another example, the memory **130** may be configured by a Random Access Memory (RAM), a Dynamic RAM (DRAM), a

Read. Only memory (ROM)), a flash memory, a volatile memory, a non-volatile memory, and/or a combination thereof.

Hereinafter, an example of implementing FIG. **20** will be described in detail with reference to the drawings.

FIG. **21** shows a hand-held device, based on an embodiment of the present disclosure. The hand-held device may include a smartphone, a smartpad, a wearable device (e.g., a smartwatch or a smartglasses), or a portable computer (e.g., a notebook). The hand-held device may be referred to as a mobile station (MS), a user terminal (UT), a Mobile Subscriber Station (MSS), a Subscriber Station (SS), an Advanced Mobile Station (AMS), or a Wireless Terminal (WT).

Referring to FIG. **21**, a hand-held device **100** may include an antenna unit **108**, a communication unit **110**, a control unit **120**, a memory unit **130**, a power supply unit **140***a*, an interface unit **140***b*, and an I/O unit **140***c*. The antenna unit **108** may be configured as a part of the communication unit **110**. Blocks **110** to **130**/**140***a* to **140***c* correspond to the blocks **110** to **130**/**140** of FIG. **20**, respectively.

The communication unit **110** may transmit and receive signals (e.g., data and control signals) to and from other wireless devices or BSs. The control unit **120** may perform various operations by controlling constituent elements of the hand-held device **100**. The control unit **120** may include an Application Processor (AP). The memory unit **130** may store data/parameters/programs/code/commands needed to drive the hand-held device **100**. The memory unit **130** may store input/output data/information. The power supply unit **140***a* may supply power to the hand-held device **100** and include a wired/wireless charging circuit, a battery, etc. The interface unit **140***h* may support connection of the hand-held device **100** to other external devices. The interface unit **140** may include various ports (e.g., an audio I/O port and a video I/O port) for connection with external devices. The I/O unit **140***c* may input or output video information/signals, audio information/signals, data, and/or information input by a user. The I/O unit **140***c* may include a camera, a microphone, a user input unit, a display unit Nod, a speaker, and/or a haptic module.

As an example, in the case of data communication, the I/O unit **140***c* may acquire information/signals (e.g., touch, text, voice, images, or video) input by a user and the acquired information/signals may be stored in the memory unit **130**. The communication unit **110** may convert the information/signals stored in the memory into radio signals and transmit the converted radio signals to other wireless devices directly or to a BS. The communication unit **110** may receive radio signals from other wireless devices or the BS and then restore the received radio signals into original information/signals. The restored information/signals may be stored in the memory unit **130** and may be output as various types (e.g., text, voice, images, video, or haptic) through the I/O unit **140***c*.

FIG. **22** shows a vehicle or an autonomous vehicle, based on an embodiment of the present disclosure. The vehicle or autonomous vehicle may be implemented by a mobile robot, a car, a train, a manned/unmanned Aerial Vehicle (AV), a ship etc.

Referring to FIG. **22**, a vehicle or autonomous vehicle **100** may include an antenna unit **108**, a communication unit **110**, a control unit **120**, a driving unit **140***a*, a power supply unit **140***b*, a sensor unit **140***c*, and an autonomous driving unit **140***d*. The antenna unit **108** may be configured as a part of the communication unit **110**. The blocks **110**/**130**/**140***a* to **140***d* correspond to the blocks **110**/**130**/**140** of FIG. **20**, respectively.

The communication unit **110** may transmit and receive signals (e.g., data and control signals) to and from external devices such as other vehicles, BSs (e.g., gNBs and road side units), and servers. The control unit **120** may perform various operations by controlling elements of the vehicle or the autonomous vehicle **100**. The control unit **120** may include an Electronic Control Unit (ECU). The driving unit **140***a* may cause the vehicle or the autonomous vehicle **100** to drive on a road. The driving unit **140***a* may include an engine, a motor, a powertrain, a wheel, a brake, a steering device, etc. The power supply unit **140***b* may supply power to the vehicle or the autonomous vehicle **100** and include a wired/wireless charging circuit, a battery, etc. The sensor unit **140***c* may acquire a vehicle state, ambient environment information, user information, etc. The sensor unit **140***c* may include an inertial Measurement Unit (IMU) sensor, a collision sensor, a wheel sensor, a speed sensor, a slope sensor, a weight sensor, a heading sensor, a position module, a vehicle forward/backward sensor, a battery sensor, a fuel sensor, a tire sensor, a steering sensor, a temperature sensor, a humidity sensor, an ultrasonic sensor, an illumination sensor, a pedal position sensor, etc. The autonomous driving unit **140***d* may implement technology for maintaining a lane on which a vehicle is driving, technology for automatically adjusting speed, such as adaptive cruise control, technology for autonomously driving along a determined path, technology for driving by automatically setting a path if a destination is set, and the like.

For example, the communication unit **110** may receive map data, traffic information data, etc, from an external server. The autonomous driving unit **140***d* may generate an autonomous driving path and a driving plan from the obtained data. The control unit **120** may control the driving unit **140***a* such that the vehicle or the autonomous vehicle **100** may move along the autonomous driving path according to the driving plan (e.g., speed/direction control). In the middle of autonomous driving, the communication unit **110** may aperiodically/periodically acquire recent traffic information data from the external server and acquire surrounding traffic information data from neighboring vehicles. In the middle of autonomous driving, the sensor unit **140***c* may obtain a vehicle state and/or surrounding environment information. The autonomous driving unit **140***d* may update the autonomous driving path and the driving plan based on the newly obtained data/information. The communication unit **110** may transfer information about a vehicle position, the autonomous driving path, and/or the driving plan to the external server. The external server may predict traffic information data using Al technology, etc., based on the information collected from vehicles or autonomous vehicles and provide the predicted traffic information data to the vehicles or the autonomous vehicles.

Claims in the present description can be combined in a various way. For instance, technical features in method claims of the present description can be combined to be implemented or performed in an apparatus, and technical features in apparatus claims can be combined to be implemented or performed in a method. Further, technical features in method claim(s) and apparatus claim(s) can be combined to be implemented or performed in an apparatus. Further, technical features in method claim(s) and apparatus claim(s) can be combined to be implemented or performed in a method.

What is claimed is:

1. A method comprising:

transmitting, by a first device, to a second device, sidelink control information (SCI) through a physical sidelink control channel;

transmitting, by the first device, to the second device, data through a physical sidelink shared channel related to the physical sidelink control channel;

determining, by the first device, a physical sidelink feedback channel resource based on a subchannel and a slot related to the physical sidelink shared channel;

incrementing, by the first device, a discontinuous transmission counter by **1**, based on a failure to receive hybrid automatic repeat request feedback on the physical sidelink feedback channel resource,

wherein the hybrid automatic repeat request feedback is related to the data through the physical sidelink shared channel;

receiving, by the first device, from the second device, information related to drop of hybrid automatic repeat request feedback transmission; and

decrementing, by the first device, the discontinuous transmission counter by N, based on the information related to drop of hybrid automatic repeat request feedback transmission,

wherein the information related to the drop of the hybrid automatic repeat request feedback transmission includes information related to a number of hybrid automatic repeat request feedback transmissions dropped by the second device,

wherein the number of hybrid automatic repeat request feedback transmissions dropped by the second device is the N,

wherein, based on the discontinuous transmission counter reaching a maximum discontinuous transmission number, a sidelink radio link failure (RLF) is declared, and

wherein the N is a positive integer.

2. The method of claim **1**, wherein the information related to drop of hybrid automatic repeat request feedback transmission includes information related to a location of the physical sidelink feedback channel resource.

3. The method of claim **1**, wherein, based on that the second device performs transmission on a resource overlapping the physical sidelink feedback channel resource in a time domain, the hybrid automatic repeat request feedback transmission on the physical sidelink feedback channel resource is dropped by the second device.

4. The method of claim **3**, wherein the transmission on the resource overlapping the physical sidelink feedback channel resource in the time domain includes uplink transmission, and wherein a priority of the uplink transmission is higher than a priority of the hybrid automatic repeat request feedback transmission.

5. The method of claim **3**, wherein the transmission on the resource overlapping the physical sidelink feedback channel resource in the time domain includes sidelink transmission, and wherein a priority of the sidelink transmission is higher than a priority of the hybrid automatic repeat request feedback transmission.

6. The method of claim **1**, wherein the information related to drop of hybrid automatic repeat request feedback transmission is received from the second device through sidelink control information.

7. The method of claim **1**, wherein the information related to drop of hybrid automatic repeat request feedback transmission is received from the second device through a sidelink medium access control (MAC) control element.

8. The method of claim **7**, wherein, based on that the hybrid automatic repeat request feedback transmission is dropped by the second device on the physical sidelink feedback channel resource, transmission of the sidelink MAC control element is triggered by the second device.

9. The method of claim **1**, wherein the information related to drop of hybrid automatic repeat request feedback transmission is received from the second device through a PC5 radio resource control (RRC) message.

10. The method of claim **1**, further comprising:

performing, by the first device, sidelink transmission or uplink transmission based on a resource overlapping the physical sidelink feedback channel resource in a time domain,

wherein, based on the failure to receive the hybrid automatic repeat request feedback on the physical sidelink feedback channel resource by the sidelink transmission or the uplink transmission, the discontinuous transmission counter does not increase.

11. The method of claim **1**, wherein, based on the failure to receive the hybrid automatic repeat request feedback on the physical sidelink feedback channel resource, Out of Sync information is transferred from a physical layer of the first device to an RRC layer of the first device, and

wherein, based on successful reception of the hybrid automatic repeat request feedback on the physical sidelink feedback channel resource, In Sync information is transferred from the physical layer of the first device to the RRC layer of the first device.

12. The method of claim **11**, wherein, based on that a number of Out of Sync information continuously received by the RRC layer of the first device reaches a maximum Out of Sync number, the sidelink radio link failure is declared.

13. A first device comprising:

at least one transceiver;

at least one processor; and

at least one memory connected to the at least one processor and storing instructions that, based on being executed by the at least one processor, perform operations comprising:

transmitting, by the first device, to a second device, sidelink control information through a physical sidelink control channel;

transmitting, by the first device, to the second device, data through a physical sidelink shared channel related to the physical sidelink control channel;

determining, by the first device, a physical sidelink feedback channel resource based on a subchannel and a slot related to the physical sidelink shared channel;

incrementing, by the first device, a discontinuous transmission counter by 1, based on a failure to receive hybrid automatic repeat request feedback on the physical sidelink feedback channel resource,

wherein the hybrid automatic repeat request feedback is related to the data through the physical sidelink shared channel;

receiving, by the first device, from the second device, information related to drop of hybrid automatic repeat request feedback transmission; and

decrementing, by the first device, the discontinuous transmission counter by N, based on the information related to drop of hybrid automatic repeat request feedback transmission,

wherein the information related to the drop of the hybrid automatic repeat request feedback transmission includes information related to a number of hybrid automatic repeat request feedback transmissions dropped by the second device,

wherein the number of hybrid automatic repeat request feedback transmissions dropped by the second device is the N,

wherein, based on the discontinuous transmission counter reaching a maximum discontinuous transmission number, a sidelink radio link failure is declared, and

wherein the N is a positive integer.

14. The first device of claim **13**, wherein the information related to drop of hybrid automatic repeat request feedback transmission includes information related to a location of the physical sidelink feedback channel resource.

15. The first device of claim **13**, wherein, based on that the second device performs transmission on a resource overlapping the physical sidelink feedback channel resource in a time domain, the hybrid automatic repeat request feedback transmission on the physical sidelink feedback channel resource is dropped by the second device.

16. The first device of claim **15**, wherein the transmission on the resource overlapping the physical sidelink feedback channel resource in the time domain includes uplink transmission, and

wherein a priority of the uplink transmission is higher than a priority of the hybrid automatic repeat request feedback transmission.

17. The first device of claim **15**, wherein the transmission on the resource overlapping the physical sidelink feedback channel resource in the time domain includes sidelink transmission, and

wherein a priority of the sidelink transmission is higher than a priority of the hybrid automatic repeat request feedback transmission.

18. A processing device adapted to control a first device, the processing device comprising:

at least one processor; and

at least one memory connected to the at least one processor and storing instructions that, based on being executed by the at least one processor, cause the first device to perform operations comprising:

transmitting, by the first device, to a second device, sidelink control information through a physical sidelink control channel;

transmitting, by the first device, to the second device, data through a physical sidelink shared channel related to the physical sidelink control channel;

determining, by the first device, a physical sidelink feedback channel resource based on a subchannel and a slot related to the physical sidelink shared channel;

incrementing, by the first device, a discontinuous transmission counter by 1, based on a failure to receive hybrid automatic repeat request feedback on the physical sidelink feedback channel resource,

wherein the hybrid automatic repeat request feedback is related to the data through the physical sidelink shared channel;

receiving, by the first device, from the second device, information related to drop of hybrid automatic repeat request feedback transmission; and

decrementing, by the first device, the discontinuous transmission counter by N, based on the information related to drop of hybrid automatic repeat request feedback transmission,

wherein the information related to the drop of the hybrid automatic repeat request feedback transmission includes information related to a number of hybrid automatic repeat request feedback transmissions dropped by the second device,

wherein the number of hybrid automatic repeat request feedback transmissions dropped by the second device is the N,

wherein, based on the discontinuous transmission counter reaching a maximum discontinuous transmission number, a sidelink radio link failure is declared, and

wherein the N is a positive integer.

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