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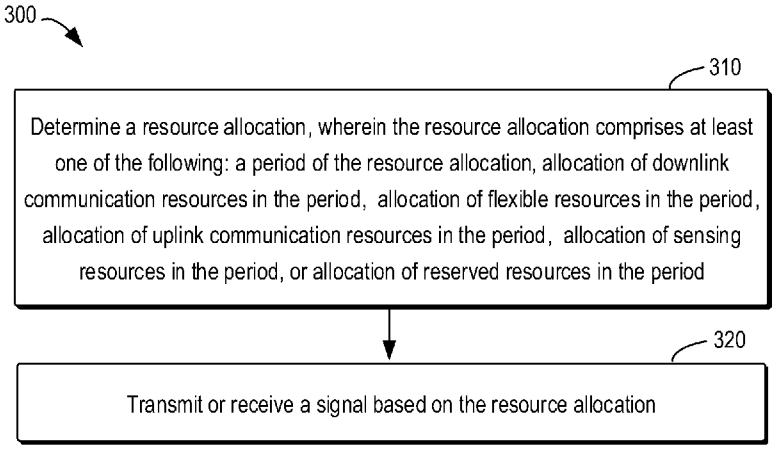

Fig. 3

(57) **Abstract:** Embodiments of the present disclosure relate to a device, method and computer readable medium for ISAC. A device determines a resource allocation. The resource allocation comprises at least one of the following: a period of the resource allocation, allocation of DE communication resources in the period, allocation of flexible resources in the period, allocation of UL communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period. In turn, the device transmits or receives a signal based on the resource allocation.

WO 2024/254881 A1

DEVICE, METHOD AND COMPUTER READABLE MEDIUM FOR INTEGRATED SENSING AND COMMUNICATION

TECHNICAL FIELD

[0001] Embodiments of the present disclosure generally relate to the field of telecommunication, and in particular, to a device, method and computer readable medium for Integrated Sensing And Communication (ISAC).

BACKGROUND

[0002] ISAC is considered as a promising topic for future wireless network extension. In the early stage of ISAC discussion in the Third Generation Partnership Project (3GPP), it may aim to build communication based sensing system. Time Division Duplexing (TDD) allocation scheme of downlink resources, flexible resources and uplink resources should be considered as baseline.

SUMMARY

[0003] In general, example embodiments of the present disclosure provide a device, method and computer readable medium for ISAC.

[0004] In a first aspect, there is provided a device. The device comprises a processor. The processor is configured to cause the device to: determine a resource allocation, wherein the resource allocation comprises at least one of the following: a period of the resource allocation, allocation of downlink communication resources in the period, allocation of flexible resources in the period, allocation of uplink communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period; and transmit or receive a signal based on the resource allocation.

[0005] In a second aspect, there is provided a method for ISAC. The method comprises: determining a resource allocation at a device, wherein the resource allocation comprises at least one of the following: a period of the resource allocation, allocation of downlink communication resources in the period, allocation of flexible resources in the period, allocation of uplink communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period; and transmitting or receiving a signal based on the resource allocation.

[0006] In a third aspect, there is provided a computer readable medium having instructions

stored thereon. The instructions, when executed on at least one processor of a device, cause the device to perform the method according to the second aspect.

[0007] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Through the more detailed description of some embodiments of the present disclosure in the accompanying drawings, the above and other objects, features and advantages of the present disclosure will become more apparent, wherein:

[0009] Figs. 1A and 1B illustrate an example communication network in which embodiments of the present disclosure can be implemented, respectively;

[0010] Figs. 2A and 2B illustrate an example of a TDD allocation scheme of communication resources in accordance with some embodiments of the present disclosure, respectively;

[0011] Fig. 3 illustrates a flowchart of an example method in accordance with some embodiments of the present disclosure;

[0012] Figs. 4A and 4B illustrate an example of a resource allocation in accordance with some embodiments of the present disclosure, respectively;

[0013] Figs. 5A and 5B illustrate an example of a resource allocation in accordance with some embodiments of the present disclosure, respectively;

[0014] Figs. 6A, 6B, 6C and 6D illustrate an example of an indication scheme for a resource allocation in accordance with some embodiments of the present disclosure, respectively;

[0015] Fig. 7 illustrates an example of a resource allocation in accordance with some embodiments of the present disclosure;

[0016] Fig. 8 illustrates examples of gaps between two types of resources adjacent in time domain in accordance with some embodiments of the present disclosure; and

[0017] Fig. 9 is a simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure.

[0018] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0019] Principle of the present disclosure will now be described with reference to some example embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitations as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0020] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0021] As used herein, the term "terminal device" refers to any device having wireless or wired communication capabilities. Examples of the terminal device include, but not limited to, user equipment (UE), personal computers, desktops, mobile phones, cellular phones, smart phones, personal digital assistants (PDAs), portable computers, tablets, wearable devices, internet of things (IoT) devices, Ultra-reliable and Low Latency Communications (URLLC) devices, Internet of Everything (IoE) devices, machine type communication (MTC) devices, device on vehicle for V2X communication where X means pedestrian, vehicle, or infrastructure/network, devices for Integrated Access and Backhaul (IAB), Small Data Transmission (SDT), mobility, Multicast and Broadcast Services (MBS), positioning, dynamic/flexible duplex in commercial networks, reduced capability (RedCap), Space borne vehicles or Air borne vehicles in Non-terrestrial networks (NTN) including Satellites and High Altitude Platforms (HAPs) encompassing Unmanned Aircraft Systems (UAS), eXtended Reality (XR) devices including different types of realities such as Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR), the unmanned aerial vehicle (UAV) commonly known as a drone which is an aircraft without any human pilot, devices on high speed train (HST), or image capture devices such as digital cameras, sensors, gaming devices, music storage and playback appliances, or Internet appliances enabling wireless or wired Internet access and browsing and the like. The 'terminal device' can further has 'multicast/broadcast' feature, to support public safety and mission critical, V2X applications, transparent IPv4/IPv6 multicast delivery, IPTV, smart TV, radio services, software delivery over wireless, group communications and IoT applications. It may also incorporate one or multiple Subscriber Identity Module (SIM) as known as Multi-SIM. The term "terminal device" can be used interchangeably with a UE, a mobile station, a subscriber station, a mobile terminal, a user terminal or a wireless device.

[0022] The term "network device" refers to a device which is capable of providing or

hosting a cell or coverage where terminal devices can communicate. Examples of a network device include, but not limited to, a Node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a next generation NodeB (gNB), a transmission reception point (TRP), a remote radio unit (RRU), a radio head (RH), a remote radio head (RRH), an IAB node, a low power node such as a femto node, a pico node, a reconfigurable intelligent surface (RIS), Network-controlled Repeaters, and the like.

[0023] The terminal device or the network device may have Artificial intelligence (AI) or Machine learning capability. It generally includes a model which has been trained from numerous collected data for a specific function, and can be used to predict some information.

[0024] The terminal or the network device may work on several frequency ranges, e.g. FR1 (410 MHz – 7125 MHz), FR2 (24.25GHz to 71GHz), frequency band larger than 100GHz as well as Tera Hertz (THz). It can further work on licensed/unlicensed/shared spectrum. The terminal device may have more than one connection with the network devices under Multi-Radio Dual Connectivity (MR-DC) application scenario. The terminal device or the network device can work on full duplex, flexible duplex and cross division duplex modes.

[0025] The network device may have the function of network energy saving, Self-Organizing Networks (SON)/Minimization of Drive Tests (MDT). The terminal may have the function of power saving.

[0026] The embodiments of the present disclosure may be performed in test equipment, e.g. signal generator, signal analyzer, spectrum analyzer, network analyzer, test terminal device, test network device, channel emulator.

[0027] The embodiments of the present disclosure may be performed according to any generation communication protocols either currently known or to be developed in the future. Examples of the communication protocols include, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G) communication protocols, 5.5G, 5G-Advanced networks, or the sixth generation (6G) networks.

[0028] As used herein, the singular forms 'a', 'an' and 'the' are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term 'includes' and its variants are to be read as open terms that mean 'includes, but is not limited to.' The term 'based on' is to be read as 'at least in part based on.' The term 'some embodiments' and 'an embodiment' are to be read as 'at least some embodiments.' The term 'another embodiment' is to be read as 'at least one other embodiment.' The terms 'first,' 'second,' and the like may refer to different or same objects. Other definitions, explicit and implicit, may be included

below.

[0029] In some examples, values, procedures, or apparatus are referred to as 'best,' 'lowest,' 'highest,' 'minimum,' 'maximum,' or the like. It will be appreciated that such descriptions are intended to indicate that a selection among many used functional alternatives can be made, and such selections need not be better, smaller, higher, or otherwise preferable to other selections.

[0030] Fig. 1A illustrates a schematic diagram of an example communication network 100A in which embodiments of the present disclosure can be implemented. As shown in Fig. 1A, the communication network 100A may include a terminal device 110, a terminal device 120, a control node 130, an Access and Mobility management Function (AMF) 140 and a Sensing Function (SF) 150.

[0031] It is to be understood that the number of devices in Fig. 1A is given for the purpose of illustration without suggesting any limitations to the present disclosure. The communication network 100A may include any suitable number of devices adapted for implementing embodiments of the present disclosure.

[0032] In some embodiments, the terminal device 110 may comprise at least one of a sensing module and a communication module. For example, as shown in Fig. 1A, the terminal device 110 comprises a sensing module 110-1 and a communication module 110-2.

[0033] In some embodiments, the sensing module 110-1 in the terminal device 110 may comprise at least one of a Uu sensing module 110-11 or a sidelink sensing module 110-12.

[0034] In some embodiments, the Uu sensing module 110-11 may be configured to perform a Uu sensing function based on the network assistance or control, and the Uu sensing function may comprise at least one of a downlink sensing function and an uplink sensing function. The sidelink sensing module 110-12 may be configured to perform a sidelink sensing function.

[0035] Similarly, in some embodiments, the terminal device 120 may comprise at least one of a sensing module and a communication module. For example, as shown in Fig. 1A, the terminal device 120 comprises a sensing module 120-1 and a communication module 120-2.

[0036] In some embodiments, the control node 130 may comprise at least one of a sensing module and a communication module. For example, as shown in Fig. 1A, the control node 130 comprises a sensing module 130-1 and a communication module 130-2.

[0037] In some embodiments, the control node 130 may be implemented as a gNB in NR.

In such embodiments, the control node 130 may be referred to as gNB 130.

[0038] Alternatively, in some embodiments, the control node 130 may be implemented as a Road Side Unit (RSU). In such embodiments, the control node 130 may be referred to as RSU 130.

[0039] In some embodiments, the AMF 140 may be a node in a core network. The AMF 140 may provide matching information about the control node 130 or the terminal device 110 according to sensing requirement.

[0040] The communications in the communication network 100A may conform to any suitable standards including, but not limited to, Global System for Mobile Communications (GSM), LTE, LTE-Evolution, LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), Code Division Multiple Access (CDMA), GSM EDGE Radio Access Network (GERAN), Machine Type Communication (MTC) and the like. Furthermore, the communications may be performed according to any generation communication protocols either currently known or to be developed in the future. Examples of the communication protocols include, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G), the sixth generation (6G) communication protocols.

[0041] In some embodiments, the communications in the communication network 100A may comprise ISAC. The communication network with ISAC may structure sharing hardware architectures, channel characteristics and signal processing, and integrate types of sensing information, such as sensory data from the environment and radar based sensing information, and communication information to achieve higher resource efficiency and provide more intelligent and integrated network solutions. The ISAC network can be applied to more extensive scenarios, including smart home, smart manufacturing, environmental monitoring, and so on.

[0042] In some embodiments, the control node 130 may comprise at least one of the following:

- a first interface between the control node 130 and the terminal device 110,
- a second interface between the control node 130 and the AMF 140, or
- a third interface between the control node 130 and the SF 150.

[0043] In some embodiments, the terminal device 110 may comprise at least one of the following:

- the first interface between the control node 130 and the terminal device 110,

- a fourth interface between the terminal device 110 and the AMF 140, or
- a fifth interface between the terminal device 110 and the terminal device 120.

[0044] In embodiments where the control node 130 is a gNB, the first interface between the control node 130 and the terminal device 110 may be a Uu interface. In some embodiments, between the control node 130 and the terminal device 110, sidelink sensing related information may be exchanged on the Uu interface.

[0045] In some embodiments, Uu sensing procedure may be performed between the control node 130 and the terminal device 110, and Uu sensing function related information may be exchanged, e.g., between the sensing module 130-1 of the control node 130 and the sensing module 110-1 of the terminal device 110.

[0046] In some embodiments, the fifth interface between the terminal device 110 and the terminal device 120 may be a Unified Air Interface, such as PC5 interface. In such embodiments, between the terminal device 110 and the terminal device 120, a sidelink sensing procedure may be performed and sidelink sensing function related information may be exchanged on the PC5 interface, i.e., between the sensing module 110-1 the terminal device 110 and the sensing module 120-1 of the terminal device 120.

[0047] In the example communication network 100A, the SF 150 comprises no interface with the control node 130. Thus, the SF 150 indirectly exchanges information with the control node 130 through the AMF 140.

[0048] In the example communication network 100A, the terminal device 110 comprises the fourth interface between the terminal device 110 and the AMF 140. The AMF 140 may transmit the sensing related information about the terminal device 110 to the terminal device 110 via the fourth interface.

[0049] Fig. 1B illustrates a schematic diagram of another example communication network 100B in which embodiments of the present disclosure can be implemented. The example communication network 100B is similar to the example communication network 100A. The example communication network 100B is different from the example communication network 100A in that in the example communication network 100B, the control node 130 comprises the third interface between the control node 130 and the SF 150. The SF 150 may exchange sensing related information with the sensing module 130-1 in the control node 130 via the third interface.

[0050] In addition, in the example communication network 100B, the terminal device 110 does not comprise the fourth interface between the terminal device 110 and the AMF 140.

The terminal device 110 may exchange information with the AMF 140 through the control node 130.

[0051] For an ISAC network, resources used for sensing and communication should be determined. If TDD band is used for the ISAC network, a TDD allocation scheme of communication resources should be considered as baseline for resource allocation for sensing and communication.

[0052] Figs. 2A and 2B illustrate an example of a TDD allocation scheme of communication resources in accordance with some embodiments of the present disclosure, respectively. In the examples of Figs. 2A and 2B, the communication resources comprise downlink (DL) resources, flexible (F) resources and uplink (UL) resources. A resource allocation for the communication resources is determined based on a TDD configuration.

[0053] In the example of Fig. 2A, the TDD configuration may comprise at least one of the following:

- Subcarrier Spacing (SCS);
- one pattern;
- for the pattern, at least one of the following is configured:
  - a period which may be equal to 0.5, 0.625, 1, 1.25, 2, 2.5, 5, or 10 ms;
  - the number of DL slots in the period, which is represented by N_d;
  - the number of DL symbols in the period, which is represented by n_d;
  - the number of UL slots in the period, which is represented by N_u;
  - the number of UL symbols in the period, which is represented by n_u; or
  - F symbols are between DL symbols and UL symbols.

[0054] In the example of Fig. 2B, the TDD configuration may comprise at least one of the following:

- SCS;
- two patterns with periods P1 and P2, respectively;
- for a first pattern, at least one of the following is configured:
  - a period (P1) which may be equal to 0.5, 0.625, 1, 1.25, 2, 2.5, 5, or 10 ms;
  - the number of DL slots in the period P1, which is represented by N1_d;
  - the number of DL symbols in the period P1, which is represented by n1_d;
  - the number of UL slots in the period P1, which is represented by N1_u;
  - the number of UL symbols in the period P1, which is represented by n1_u;
- for a second pattern, at least one of the following is configured:

- a period (P2) which may be equal to 0.5, 0.625, 1, 1.25, 2, 2.5, 5, or 10 ms;
- the number of DL slots in the period P2, which is represented by N2_d;
- the number of DL symbols in the period P2, which is represented by n2_d;
- the number of UL slots in the period P2, which is represented by N2_u;
- the number of UL symbols in the period P2, which is represented by n2_u; or
- F symbols are between DL symbols and UL symbols.

[0055] In the example of Fig. 2B, for the two patterns, a sum of the first period P1 and the second period P2 should be divided by 20 ms.

[0056] In general, Time Division Duplexing (TDM) based communication and sensing resource allocation scheme should be considered for an ISAC system. For TDD band, it is reasonable to determine a resource allocation for sensing and communication based on the TDD allocation scheme of communication resources.

[0057] In view of the above, embodiments of the present disclosure provide a solution for ISAC. In this solution, a device determines a resource allocation. The resource allocation comprises at least one of the following: a period of the resource allocation, allocation of DL communication resources in the period, allocation of flexible resources in the period, allocation of UL communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period. In turn, the device transmits or receives a signal based on the resource allocation. In this way, resources may be divided between communication and sensing with finer granularity.

[0058] Hereinafter, principle of the present disclosure will be described with reference to Figs. 2 to 9.

[0059] Fig. 3 illustrates a flowchart of an example method 300 in accordance with some embodiments of the present disclosure. In some embodiments, the method 300 can be implemented at a device, such as the terminal device 110, the terminal device 120 or the control node 130 as shown in Fig. 1A or 1B. For the purpose of discussion, the method 300 will be described with reference to Fig. 1A or 1B as performed by the terminal device 110 without loss of generality.

[0060] At block 310, the terminal device 110 determines a resource allocation. The resource allocation comprises at least one of the following: a period of the resource allocation, allocation of DL communication resources in the period, allocation of flexible resources in the period, allocation of UL communication resources in the period, allocation of sensing

resources in the period, or allocation of reserved resources in the period. Hereinafter, for brevity, DL communication resources are also referred to as DL resources (represented by D), and UL communication resources are also referred to as UL resources (represented by U). In addition, flexible resources are represented by F, sensing resources are represented by S, and reserved resources are represented by R.

[0061] At block 320, the terminal device 110 transmits or receives a signal based on the resource allocation.

[0062] With the method 300, resources may be divided between communication and sensing with finer granularity. In addition, for TDD band, D/F/U/S/R based resource allocation scheme may provide more flexible configuration for an ISAC system.

[0063] In some embodiments, the terminal device 110 may determine the resource allocation based on at least one of the following: system pre-definition, system configuration, or system pre-configuration.

[0064] In some embodiments, the resource allocation may be per one of the following: a carrier, a resource block (RB) set, or a bandwidth part (BWP).

[0065] In some embodiments, the resource allocation may be periodically repeated in time domain based on the period.

[0066] In some embodiments, the terminal device 110 may determine the allocation of sensing resources based on the resource allocation. In turn, the terminal device 110 may transmit or receive a sensing signal on at least one of the sensing resources.

[0067] In some embodiments, the terminal device 110 may determine the allocation of reserved resources based on the resource allocation. In turn, the terminal device 110 may transmit or receive at least one of the following on at least one of the reserved resources: a sensing signal, or a communication signal. Alternatively, the terminal device 110 may transmit or receive, on at least one of the reserved resources, other type of signal than the sensing signal and the communication signal. In this way, the resource allocation scheme of the present disclosure may be available for different scenarios and requirements.

[0068] Alternatively, in some embodiments, the terminal device 110 may transmit or receive no signal on the reserved resources.

[0069] Alternatively, the reserved resources may be reserved for other purpose, forward compatibility or further enhancement of a system. For example, the terminal device 110 may use at least one of the reserved resources for at least one of following: a gap between the sensing resources and the DL communication resources or the UL communication resources; switching between transmission of the sensing signal and transmission of the communication

signal; switching between transmission of the sensing signal and reception of the communication signal; switching between reception of the sensing signal and reception of the communication signal; or switching between reception of the sensing signal and transmission of the communication signal.

[0070] In some embodiments, the flexible resources may be reconfigured as DL communication resources or UL communication resources.

[0071] In some embodiments, any type of resources among the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources may be absent from the resource allocation.

[0072] In some embodiments, the resource allocation may be configured or pre-configured through a higher layer signaling, and the resource allocation may indicate the period. In other words, the period may be configured or pre-configured through the higher layer signaling.

[0073] Alternatively, in some embodiments, the period may be determined implicitly. For example, the period may be determined based on a sum of at least one of the following: a first number of time units of the DL communication resources in the period, a second number of time units of the flexible resources in the period, a third number of time units of the UL communication resources in the period, a fourth number of time units of the sensing resources in the period, or a fifth number of time units of the reserved resources in the period. Hereinafter, the period, the first number, the second number, the third number, the fourth number and the fifth number are represented by P, N_d, N_f, N_u, N_s and N_r, respectively.

[0074] In some embodiments, the terminal device 110 may determine the resource allocation based on a resource type order. The resource type order indicates an order of the at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period.

[0075] In some embodiments, the resource type order may be system pre-defined, system configured, or system pre-configured. In such embodiments, the resource type order may be a fixed order. In other words, in the period, at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources may be allocated in the fixed order.

[0076] With the fixed order of all types of resources, the resource allocation can be determined according to the number of time units of each type of resources within a period. Thus, less allocation overhead is needed.

[0077] In some embodiments, the resource type order comprises the DL communication resources start from a start boundary of the period, the DL communication resources are

followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the sensing resources, and the sensing resources are followed by the reserved resources. In other words, there is a fixed order of D-F-U-S-R in the period.

[0078] Alternatively, in some embodiments, the resource type order comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the reserved resources, the reserved resources are followed by the sensing resources, and the sensing resources are followed by the UL communication resources. In other words, there is a fixed order of D-F-R-S-U in the period.

[0079] Alternatively, in some embodiments, the resource type order comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the sensing resources, the sensing resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the reserved resources. In other words, there is a fixed order of D-S-F-U-R in the period.

[0080] Alternatively, in some embodiments, the resource type order comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the sensing resources, the sensing resources are followed by the UL communication resources. In other words, there is a fixed order of D-F-S-U in the period.

[0081] Alternatively, in some embodiments, the resource type order comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the sensing resources. In other words, there is a fixed order of D-F-U-S in the period.

[0082] In some embodiments, each type of resources comprises continuous resource units in the period.

[0083] In some embodiments, in the period, the number of resource units for each type of resources may be configured independently.

[0084] Figs. 4A and 4B illustrate an example of a resource allocation in accordance with some embodiments of the present disclosure, respectively.

[0085] In the examples of Figs. 4A and 4B, the resource type order may be system pre-defined, system configured, or system pre-configured. The resource type order is a fixed

order. Time units of the at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots.

[0086] In the example of Fig. 4A, the resource type order comprises: the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the sensing resources. In other words, there is a fixed order of D-F-U-S in the period.

[0087] In the example of Fig. 4A, the resource allocation is system configured. For example, the resource allocation is indicated by the control node 130. The resource allocation comprises a first number of time units of the DL communication resources in the period, a second number of time units of the flexible resources in the period, a third number of time units of the UL communication resources in the period, and a fourth number of time units of the sensing resources in the period. The resource allocation does not comprise allocation of the reserved resources.

[0088] In the example of Fig. 4A, the period is determined based on a sum of the first number, the second number, the third number and the fourth number. That is, $P = N\_d + N\_f + N\_u + N\_s$.

[0089] In the example of Fig. 4B, the resource type order comprises: the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the sensing resources, the sensing resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the reserved resources. In other words, there is a fixed order of D-S-F-U-R in the period.

[0090] In the example of Fig. 4B, the resource allocation is system configured. For example, the resource allocation is indicated by the control node 130. The resource allocation comprises: the period, the first number, the third number, the fourth number and the fifth number. The period is N slots. The allocation of the flexible resources is determined based on allocation of the DL communication resources, the sensing resources, the UL communication resources and the reserved resources. In other words, $N\_f = P-(N\_d + N\_u + N\_s+ N\_r)$.

[0091] In some embodiments, at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources may be allocated in a flexible order.

[0092] In embodiments where the flexible order is used, a location of at least one of the DL

communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources may be assigned explicitly or implicitly. The flexible order of types of resources in a period is implicitly indicated through the allocation of each type of resources.

[0093] In embodiments where the flexible order is used, the resource allocation comprises at least one of the following: a first location of the DL communication resources in the period, a second location of the flexible resources in the period, a third location of the UL communication resources in the period, a fourth location of the sensing resources in the period, or a fifth location of the reserved resources in the period.

[0094] In embodiments where the flexible order is used, the resource allocation comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the sensing resources, and the sensing resources are followed by the reserved resources.

[0095] Alternatively, in some embodiments, the resource allocation comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the reserved resources, the reserved resources are followed by the sensing resources, and the sensing resources are followed by the UL communication resources.

[0096] Alternatively, in some embodiments, the resource allocation comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the sensing resources, the sensing resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the reserved resources.

[0097] Alternatively, in some embodiments, the resource allocation comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the sensing resources, the sensing resources are followed by the UL communication resources.

[0098] Alternatively, in some embodiments, the resource allocation comprises the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the sensing resources.

[0099] In embodiments where the flexible order is used, the number of time units for each

type of resource may be configured independently.

[00100] In embodiments where the flexible order is used, for each type of resources, one or more subsets of the resources may be allocated within a period. One subset of the resources comprises a plurality of continuous resources in time domain. For example, one subset of the resources may comprise n slots or m millisecond.

[00101] In some embodiments, the DL communication resources comprise a first subset of the DL communication resources and a second subset of the DL communication resources.

[00102] Alternatively, or additionally, in some embodiments, the flexible resources comprise a third subset of the flexible resources and a fourth subset of the flexible resources.

[00103] Alternatively, or additionally, in some embodiments, the UL communication resources comprise a fifth subset of the UL communication resources and a sixth subset of the UL communication resources.

[00104] Alternatively, or additionally, in some embodiments, the sensing resources comprise a seventh subset of the sensing resources and an eighth subset of the sensing resources.

[00105] Alternatively, or additionally, in some embodiments, the reserved resources comprise a ninth subset of the reserved resources and a tenth subset of the reserved resources.

[00106] In some embodiments, the resource allocation indicates at least one of the following:

- allocation of the first subset of the DL communication resources and allocation of the second subset of the DL communication resources are not adjacent in time domain;
- allocation of the third subset of the flexible resources and allocation of the fourth subset of the flexible resources are not adjacent in time domain;
- allocation of the fifth subset of the UL communication resources and allocation of the sixth subset of the UL communication resources are not adjacent in time domain;
- allocation of the seventh subset of the sensing resources and allocation of the eighth subset of the sensing resources are not adjacent in time domain; or
- allocation of the ninth subset of the reserved resources and allocation of the tenth subset of the reserved resources are not adjacent in time domain.

[00107] In some embodiments, a location of the first subset of the DL communication resources is independent from a location of the second subset of the DL communication resources in the period.

[00108] Alternatively, or additionally, in some embodiments, a location of the third subset of

the flexible resources is independent from a location of the fourth subset of the flexible resources.

[00109] Alternatively, or additionally, in some embodiments, a location of the fifth subset of the UL communication resources is independent from a location of the sixth subset of the UL communication resources.

[00110] Alternatively, or additionally, in some embodiments, a location of the seventh subset of the sensing resources is independent from a location of the eighth subset of the sensing resources.

[00111] Alternatively, or additionally, in some embodiments, a location of the ninth subset of the reserved resources is independent from a location of the tenth subset of the reserved resources.

[00112] The flexible order of all types of resources may provide more flexibility for each type of resources. In addition, the flexible order may support suitable resource allocation for diverse scenarios and requirements.

[00113] Figs. 5A and 5B illustrate an example of a resource allocation in accordance with some embodiments of the present disclosure, respectively.

[00114] In the examples of Figs. 5A and 5B, the flexible order is used and the resource allocation comprises a location of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources, or the reserved resources in the period.

[00115] In the example of Fig. 5A, time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots. The flexible order of types of resources in a period is implicitly indicated through the resource allocation.

[00116] In the example of Fig. 5A, the resource allocation is system configured. For example, the resource allocation is indicated by the control node 130. The resource allocation comprises the following: the period, allocation of two subsets of the DL communication resources, allocation of the UL communication resources, and allocation of two subsets of the sensing resources. The allocation of the flexible resources is determined based on allocation of the DL communication resources, the UL communication resources, and the sensing resources.

[00117] Specifically, the period is equal to 10 slots. The two subsets of the DL communication resources comprise a first subset and a second subset. The first subset comprises slots #0 and #1. The second subset comprises slots #8 and #9. The UL

communication resources comprises slots #5 and #6. The two subsets of the sensing resources comprise a seventh subset and an eighth subset. The seventh subset comprises slots #2 and #3. The eighth subset comprises slot #7. According to the resource allocation, the flexible resources within a period should be implicitly determined, i.e., the flexible resources comprise slot #4.

[00118] In the example of Fig. 5B, time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are milliseconds. The flexible order of types of resources in a period is implicitly indicated through the resource allocation.

[00119] In the example of Fig. 5B, the sensing resources comprise a seventh subset (represented by S1) and an eighth subset (represented by S2). The seventh subset is used for a first sensing signal to be transmitted by a network device (such as the control node 130), and the eighth subset of the sensing resources is used for a second sensing signal to be transmitted by the terminal device 110.

[00120] In the example of Fig. 5B, the resource allocation is indicated by the control node 130 through a new information element (IE). For example, the new IE "TDD-ResourcePattern" may be provided as below:

- TDD-ResourcePattern ::= SEQUENCE {
  - Periodicity
  - pattern
  - nrofDownlink
  - nrofUplink
  - nrofDownlinkSensing
  - nrofUplinkSensing }

[00121] In the new IE "TDD-ResourcePattern",

- Periodicity represents the period of the resource allocation which is equal to m millisecond;
- pattern indicates an order of types of resources (for example, the order is D-S1-F-S2-U as shown in Fig. 5B), or pattern indicates a resource allocation index which will be described later;
- nrofDownlink (N_d) represents the number of time units of the DL communication resources;
- nrofUplink (N_u) represents the number of time units of the UL

communication resources;

- nrofDownlinkSendsing (N_s1) represents the number of time units of the sensing resources in the subset S1;
- nrofUplinkSensing (N_s2) represents the number of time units of the sensing resources in the subset S2;
- the allocation of the flexible resources is implicitly determined based on the allocation of the DL communication resources, the UL communication resources, the subset S1 and the subset S2.

[00122] Hereinafter, some embodiments of an indication scheme for the resource allocation for at least one type of resources will be described.

[00123] In some embodiments, the resource allocation indicates at least one of the following: a first location of the DL communication resources in the period, a second location of the flexible resources in the period, a third location of the UL communication resources in the period, a fourth location of the sensing resources in the period, or a fifth location of the reserved resources in the period.

[00124] Alternatively, or additionally, in some embodiments, the resource allocation indicates at least one of the following: the first number of time units of the DL communication resources in the period, the second number of time units of the flexible resources in the period, the third number of time units of the UL communication resources in the period, the fourth number of time units of the sensing resources in the period, or the fifth number of time units of the reserved resources in the period.

[00125] In some embodiments, the time units comprise at least one of the following: seconds, milliseconds, frames, slots, or symbols.

[00126] In some embodiments, any one of the period and the number of time units may be implicitly determined according to other parameters.

[00127] In some embodiments, the indication scheme for the resource allocation may comprise one of the following: at least one bitmap; at least one resource allocation index based on resource allocation table; or the number of time units of each type of resources.

[00128] In embodiments where the indication scheme for the resource allocation comprises at least one bitmap, allocation of types of resources is assigned by bitmap for each type of resources. The terminal device 110 may determine the resource allocation based on the at least one bitmap. Each of the at least one bitmap indicates one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources

and the reserved resources in the period. A bit in each of the at least one bitmap indicates one of the time units.

[00129] In embodiments where the indication scheme for the resource allocation comprises at least one bitmap, each type of resource is independently allocated. The period may be explicitly indicated or implicitly determined based on one of the at least one bitmap. The flexible order and the number of time units for each type of resources may be indicated.

[00130] Fig. 6A illustrates an example of an indication scheme for a resource allocation in accordance with some embodiments of the present disclosure. In the example of Fig. 6A, the indication scheme for the resource allocation comprises three bitmaps for D, U and S. Time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots. The flexible order of types of resources in a period is indicated through the bitmaps for D, U and S.

[00131] In the example of Fig. 6A, the resource allocation is indicated by the control node 130. A length of one of the three bitmaps is equal to 10 slots. The terminal device 110 determines the period as the length of one of the three bitmaps. That is, the period is equal to 10 slots. The terminal device 110 determines the resource allocation based on the three bitmaps.

[00132] Among the three bitmaps, a first bitmap "11011 00000" indicates the DL communication resources, i.e., slots #0, #1, #3, #4 in the period. The DL communication resources comprise a first subset and a second subset. The first subset comprises slots #0 and 1 and the second subset comprises slots #3 and 4.

[00133] Among the three bitmaps, a second bitmap "00100 10011" indicates the sensing resources, i.e., slots #2, #5, #8, #9 in the period. The sensing resources comprises a seventh subset, an eighth subset and a ninth subset. The seventh subset comprises slot #2, the eighth subset comprises slot #5 and the ninth subset comprises slots #8 and #9.

[00134] Among the three bitmaps, a third bitmap "00000 01100" indicates the UL communication resource, i.e., slots #6, #7 in the period.

[00135] The flexible resources and the reserved resource are absent from the resource allocation, or are indicated with a fourth bitmap and a fifth bitmap of all "0".

[00136] The example of Fig. 6A may provide independent and flexible resource allocation for sensing and communication.

[00137] As described above, in some embodiments, the indication scheme for the resource allocation may comprise at least one resource allocation index based on a resource allocation

table. In such embodiments, allocation of types of resources is assigned based on the resource allocation table. The resource allocation table is defined in system. The resource allocation table comprises at least one entry. Each of the at least one entry is associated with a row in the table. Each of the at least one entry is assigned or associated with a resource allocation index. Each of the at least one entry assigns allocation of types of resources in a period. The terminal device 110 may determine the resource allocation based on at least one resource allocation index.

[00138] In some embodiments, the terminal device 110 may determine the resource allocation based on multiple resource allocation indexes associated with multiple entries in the resource allocation table. In such embodiments, the multiple entries are arranged in the order as indicated.

[00139] In such embodiments, the period is determined based on items comprised in the entry.

[00140] Fig. 6B illustrates an example of an indication scheme for a resource allocation in accordance with some embodiments of the present disclosure. In the example of Fig. 6B, the indication scheme for the resource allocation comprises at least one resource allocation index based on a resource allocation table 600. The resource allocation table 600 is defined in system. Time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots.

[00141] In the example of Fig. 6B, the resource allocation is indicated by the control node 130. The control node 130 may indicate the resource allocation by indicating at least one of the following: SCS of 15kHz, period of 10 slots, or a resource allocation index #3, i.e., within a period, the resource allocation comprises 10 slots, and the slots are assigned in the order of D, S, F, U, R, D, S, F, U, R (index #3). Alternatively, the control node 130 may indicate the resource allocation by indicating at least one of the following: SCS of 30kHz, period of 10 ms, or resource allocation indexes #0 and #1, i.e., within a period, the resource allocation comprises 20 slots, and the slots are assigned as D, D, F, F, U, U, U, U, U, U (index #0), and D, D, F, S, S, S, U, U, U, U (index #1).

[00142] As described above, in some embodiments, the indication scheme for the resource allocation may comprise the number of time units of each type of resources. In such embodiments, allocation of types of resources is assigned by indicating the number of time units of each type of resources.

[00143] In some embodiments, the time units comprise at least one of the following:

seconds, milliseconds, frames, slots, or symbols.

[00144] In some embodiments, more than one types of time units can be combined to indicate one type of resources.

[00145] In some embodiments, slots are used as one type of time unit and symbols are used as another type of time unit.

[00146] In some embodiments, N_x represents the number of the first type of time unit (slot) and n_x represents the number of another type of times unit (symbol). For example, N_d, N_f, N_u, and n_d, n_f, n_u represent the number of time units of DL resources, flexible resources, UL resources, respectively, where each of N_d, N_f and N_u >=0, and each of n_d, n_f and n_u >=0. N_s and n_s represent the number of time units of sensing resources, where each of N_s and n_s >=0. N_r and n_r represent the number of time units of reserved resource, where each of N_r and n_r >=0.

[00147] Fig. 6C illustrates an example of an indication scheme for a resource allocation in accordance with some embodiments of the present disclosure. In the example of Fig. 6C, the indication scheme for the resource allocation comprises the number of time units of each type of resources. Time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots.

[00148] In the example of Fig. 6C, the resource allocation is indicated by the control node 130. The control node 130 may indicate the resource allocation by indicating the period of N slots. In addition, the control node 130 may indicate the resource allocation by indicating the following: the DL communication resources occupy the first number (N_d) of time units in the period starting from a starting boundary of the period, the DL communication resources are followed by the second number (N_f) of time units of the flexible resources, the flexible resources are followed by the fourth number (N_s) of time units of the sensing resources, and the sensing resources are followed by the reserved resources, and the reserved resources are followed by the third number (N_u) of time units of the UL communication resources. The fifth number of time units of the reserved resources is implicitly determined as below: $N\_r = P - (N\_d + N\_f + N\_u + N\_s)$.

[00149] In the example of Fig. 6C, the sensing resources are used for sensing signals to be transmitted by a network device and the terminal device 110.

[00150] The example of Fig. 6C may provide independent and flexible resource allocation for sensing and communication.

[00151] Fig. 6D illustrates an example of an indication scheme for a resource allocation in

accordance with some embodiments of the present disclosure. In the example of Fig. 6D, the indication scheme for the resource allocation comprises the number of time units of each type of resources. Time units of at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period are slots and symbols.

[00152] In the example of Fig. 6D, the resource allocation is indicated by the control node 130. The control node 130 may indicate the resource allocation by indicating the period of N slots. In addition, the control node 130 may indicate the resource allocation by indicating from the starting of the period, the following types of resources are included in turn:

- the DL communication resources occupy N_d slots and n_d symbols;
- the sensing resources occupy N_s slots and n_s symbols;
- allocation of the flexible resources are determined according to allocation of other types of resources;
- the UL communication resources occupy N_u slots and n_u symbols; and
- the reserved resources occupy N_r slots.

[00153] The example of Fig. 6D may provide independent and flexible resource allocation for sensing and communication.

[00154] As described above, the sensing resources comprise a seventh subset (represented by S1) and an eighth subset (represented by S2). The seventh subset is used for a first sensing signal to be transmitted by a network device (such as the control node 130), and the eighth subset of the sensing resources is used for a second sensing signal to be transmitted by the terminal device 110. In other words, the seventh subset is used for at least one of the following: sensing mode 1, sensing mode 2, or sensing mode 3; and the eighth subset of the sensing resources is used for at least one of the following: sensing mode 4, sensing mode 5, or sensing mode 6.

[00155] In some embodiments, the schemes for the resource allocation may be used for allocation of types of resource with sensing resources comprising S1 and S2. This will be described with reference to Fig. 7.

[00156] Fig. 7 illustrates an example of a resource allocation in accordance with some embodiments of the present disclosure. In the example of Fig. 7, the resource type order may be system pre-defined, system configured, or system pre-configured. The resource type order is a fixed order. Time units of the at least one of the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources

in the period are slots.

[00157] In the example of Fig. 7, the resource type order comprises: the DL communication resources start from a start boundary of the period, the DL communication resources are followed by the seventh subset of the sensing resources, the seventh subset of the sensing resources are followed by the flexible resources, the flexible resources are followed by the UL communication resources, the UL communication resources are followed by the eighth subset of the sensing resources. In other words, there is a fixed order of D-S1-F-U-S2 in the period.

[00158] In the example of Fig. 7, the resource allocation comprises: the period, the first number (N_d), the number (N_s1) of time units of sensing resources in the seventh subset, the third number (N_u), and the number (N_s2) of time units of sensing resources in the eighth subset. The period is N slots. The allocation of the flexible resources is determined based on allocation of the DL communication resources, the sensing resources, and the UL communication resources. The reserved resources are absent from the resource allocation.

[00159] The example of Fig. 7 may provide independent sensing resource allocation for sensing signal transmission from a control node and sensing signal transmission from a terminal device.

[00160] In some embodiments, at least one gap may exist between two types of resources adjacent in time domain among the DL communication resources, the flexible resources, the UL communication resources, the sensing resources and the reserved resources in the period.

[00161] In some embodiments, the at least one gap may be used for at least one of the following:

- switching between transmission of a sensing signal and transmission of a communication signal;
- switching between transmission of the sensing signal and reception of the communication signal;
- switching between reception of the sensing signal and reception of the communication signal; or
- switching between reception of the sensing signal and transmission of the communication signal.

[00162] In some embodiments, a duration of the at least one gap comprises at least one time unit.

[00163] In some embodiments, the duration of the at least one gap is system pre-defined,

system configured, or system pre-configured.

[00164] In some embodiments, the two types of resources adjacent in time domain are system pre-defined, system configured, or system pre-configured. In some embodiments, not all types of resources adjacent in time domain needs the at least one gap.

[00165] In some embodiments, the number of the at least one gap in the period is equal to or less than a threshold number (represented by K).

[00166] In some embodiments, the terminal device 110 may determine the threshold number based on at least one of the following: system pre-definition, system configuration, system pre-configuration, or capability of the terminal device 110.

[00167] In some embodiments, the at least one gap comprises at least one of the following: a first gap between the DL communication resources and the sensing resources; or a second gap between the UL communication resources and the sensing resources.

[00168] Fig. 8 illustrates examples of gaps between two types of resources adjacent in time domain in accordance with some embodiments of the present disclosure.

[00169] In an example (a) of Fig. 8, based on the system pre-definition, a first gap is set between the DL communication resources and the sensing resources and a second gap is set between the UL communication resources and the sensing resources.

[00170] In an example (a) of Fig. 8, the time units for the duration of each of the first and second gaps are slots. There is no limitation for the number of gaps within a period. The first gap is set between the last slot for the DL communication resources and following slot for the sensing resources, and the second gap is set between the last slot for the UL communication resources and following slot for the sensing resources.

[00171] In an example (b) of Fig. 8, the time units for the duration of each of the first and second gaps are symbols. The duration is pre-defined as 4 symbols. The threshold number (K) is equal to 2. That is, the number of the at least one gap in the period is equal to or less than 2.

[00172] In an example (b) of Fig. 8, after the last slot for the DL communication resources, following 4 symbols are used as the first gap; and before the starting slot for the UL communication resources, 4 symbols are used as the second gap.

[00173] The examples of Fig. 8 may provide necessary gap duration for device switching operation or other purpose between different resource types.

[00174] Fig. 9 is a simplified block diagram of a device 900 that is suitable for implementing embodiments of the present disclosure. The device 900 can be considered as a further example embodiment of the terminal device 110 or the control node 130 as shown in Fig. 1A or 1B. Accordingly, the device 900 can be implemented at or as at least a part of the terminal

device 110 or the control node 130.

[00175] As shown, the device 900 includes a processor 910, a memory 920 coupled to the processor 910, a suitable transceiver 940 coupled to the processor 910, and a communication interface coupled to the transceiver 940. The memory 910 stores at least a part of a program 930. The transceiver 940 may be for bidirectional communications or a unidirectional communication based on requirements. The transceiver 940 may include at least one of a transmitter 942 and a receiver 944. The transmitter 942 and the receiver 944 may be functional modules or physical entities. The transceiver 940 has at least one antenna to facilitate communication, though in practice an Access Node mentioned in this application may have several ones. The communication interface may represent any interface that is necessary for communication with other network elements, such as X2/Xn interface for bidirectional communications between eNBs/gNBs, S1/NG interface for communication between a Mobility Management Entity (MME)/Access and Mobility Management Function (AMF)/SGW/UPF and the eNB/gNB, Un interface for communication between the eNB/gNB and a relay node (RN), or Uu interface for communication between the eNB/gNB and a terminal device.

[00176] In summary, embodiments of the present disclosure may provide the following solutions.

[00177] In an aspect, there is provided a device. The device comprises a processor configured to cause the device to determine a resource allocation and transmit or receive a signal based on the resource allocation. The resource allocation comprises at least one of the following: a period of the resource allocation, allocation of downlink communication resources in the period, allocation of flexible resources in the period, allocation of uplink communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period.

[00178] In some embodiments, the device is further caused to determine the allocation of sensing resources based on the resource allocation; and the device is caused to transmit or receive the signal by transmitting or receiving a sensing signal on at least one of the sensing resources.

[00179] In some embodiments, the device is further caused to determine the allocation of reserved resources based on the resource allocation; and the device is caused to transmit or receive the signal by transmitting or receiving at least one of the following on at least one of the reserved resources: a sensing signal, or a communication signal.

[00180] In some embodiments, the device is further caused to determine the allocation of

reserved resources based on the resource allocation; and the device is caused to use at least one of the reserved resources for at least one of follows: transmitting or receiving no signal; a gap between the sensing resources and the downlink communication resources or the uplink communication resources; switching between transmission of a sensing signal and transmission of a communication signal; switching between transmission of the sensing signal and reception of the communication signal; switching between reception of the sensing signal and reception of the communication signal; or switching between reception of the sensing signal and transmission of the communication signal.

[00181] In some embodiments, the device is caused to determine the resource allocation based on at least one of the following: system pre-definition, system configuration, or system pre-configuration.

[00182] In some embodiments, the resource allocation is per one of the following: a carrier, a resource block set, or a bandwidth part.

[00183] In some embodiments, the resource allocation is periodically repeated in time domain based on the period.

[00184] In some embodiments, the resource allocation indicates the period; or the period is determined based on a sum of at least one of the following: a first number of time units of the downlink communication resources in the period, a second number of time units of the flexible resources in the period, a third number of time units of the uplink communication resources in the period, a fourth number of time units of the sensing resources in the period, or a fifth number of time units of the reserved resources in the period.

[00185] In some embodiments, the device is further caused to determine the resource allocation based on a resource type order. The resource type order indicates an order of the at least one of the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period.

[00186] In some embodiments, the resource type order is system pre-defined, system configured, or system pre-configured.

[00187] In some embodiments, the resource allocation comprises at least one of the following: a first location of the downlink communication resources in the period, a second location of the flexible resources in the period, a third location of the uplink communication resources in the period, a fourth location of the sensing resources in the period, or a fifth location of the reserved resources in the period.

[00188] In some embodiments, the resource type order or the resource allocation comprises at least one of the following: the downlink communication resources start from a start

boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the sensing resources, and the sensing resources are followed by the reserved resources; the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the reserved resources, the reserved resources are followed by the sensing resources, and the sensing resources are followed by the uplink communication resources; the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the sensing resources, the sensing resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the reserved resources; the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the sensing resources, the sensing resources are followed by the uplink communication resources; or the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the sensing resources.

[00189] In some embodiments, the downlink communication resources comprise a first subset of the downlink communication resources and a second subset of the downlink communication resources; and/or the flexible resources comprise a third subset of the flexible resources and a fourth subset of the flexible resources; and/or the uplink communication resources comprise a fifth subset of the uplink communication resources and a sixth subset of the uplink communication resources; and/or the sensing resources comprise a seventh subset of the sensing resources and an eighth subset of the sensing resources; and/or the reserved resources comprise a ninth subset of the reserved resources and a tenth subset of the reserved resources.

[00190] In some embodiments, the resource allocation indicates at least one of the following: allocation of the first subset of the downlink communication resources and allocation of the second subset of the downlink communication resources are not adjacent in time domain; allocation of the third subset of the flexible resources and allocation of the fourth subset of the flexible resources are not adjacent in time domain; allocation of the fifth subset of the uplink communication resources and allocation of the sixth subset of the uplink

communication resources are not adjacent in time domain; allocation of the seventh subset of the sensing resources and allocation of the eighth subset of the sensing resources are not adjacent in time domain; or allocation of the ninth subset of the reserved resources and allocation of the tenth subset of the reserved resources are not adjacent in time domain.

[00191] In some embodiments, a location of the first subset of the downlink communication resources is independent from a location of the second subset of the downlink communication resources in the period; and/or a location of the third subset of the flexible resources is independent from a location of the fourth subset of the flexible resources; and/or a location of the fifth subset of the uplink communication resources is independent from a location of the sixth subset of the uplink communication resources; and/or a location of the seventh subset of the sensing resources is independent from a location of the eighth subset of the sensing resources; and/or a location of the ninth subset of the sensing resources is independent from a location of the tenth subset of the sensing resources.

[00192] In some embodiments, the seventh subset of the sensing resources are used for a first sensing signal to be transmitted by a network device, and the eighth subset of the sensing resources are used for a second sensing signal to be transmitted by a terminal device.

[00193] In some embodiments, the resource allocation indicates at least one of the following: a first location of the downlink communication resources in the period, a second location of the flexible resources in the period, a third location of the uplink communication resources in the period, a fourth location of the sensing resources in the period, a fifth location of the reserved resources in the period, a first number of time units of the downlink communication resources in the period, a second number of time units of the flexible resources in the period, a third number of time units of the uplink communication resources in the period, a fourth number of time units of the sensing resources in the period, or a fifth number of time units of the reserved resources in the period.

[00194] In some embodiments, the device is caused to determine the resource allocation based on at least one bitmap, each of the at least one bitmap indicates one of the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period, and a bit in each of the at least one bitmap indicates one of the time units.

[00195] In some embodiments, the resource allocation indicates the period; or the device is further caused to determine the period as a length of one of the at least one bitmap.

[00196] In some embodiments, the device is caused to determine the resource allocation based on at least one resource allocation index, and each of the at least one resource

allocation index is associated with an entry comprised in a resource allocation table.

[00197] In some embodiments, the period is determined based on items comprised in the entry.

[00198] In some embodiments, the time units comprise at least one of the following: seconds, milliseconds, frames, slots, or symbols.

[00199] In some embodiments, at least one gap exists between two types of resources adjacent in time domain among the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period.

[00200] In some embodiments, a duration of the at least one gap comprises at least one time unit.

[00201] In some embodiments, the two types of resources adjacent in time domain are system pre-defined, system configured, or system pre-configured.

[00202] In some embodiments, the number of the at least one gap in the period is equal to or less than a threshold number.

[00203] In some embodiments, the device is further caused to determine the threshold number based on at least one of the following: system pre-definition, system configuration, system pre-configuration, or capability of the device.

[00204] In some embodiments, the at least one gap comprises at least one of the following: a first gap between the downlink communication resources and the sensing resources; or a second gap between the uplink communication resources and the sensing resources.

[00205] The components included in the apparatuses and/or devices of the present disclosure may be implemented in various manners, including software, hardware, firmware, or any combination thereof. In one embodiment, one or more units may be implemented using software and/or firmware, for example, machine-executable instructions stored on the storage medium. In addition to or instead of machine-executable instructions, parts or all of the units in the apparatuses and/or devices may be implemented, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (ASICs), Application-specific Standard Products (ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), and the like.

WHAT IS CLAIMED IS:

1. A device, comprising:

a processor configured to cause the device to:

determine a resource allocation, wherein the resource allocation comprises at least one of the following:

a period of the resource allocation,

allocation of downlink communication resources in the period,

allocation of flexible resources in the period,

allocation of uplink communication resources in the period,

allocation of sensing resources in the period, or

allocation of reserved resources in the period; and

transmit or receive a signal based on the resource allocation.

2. The device of claim 1, wherein:

the device is further caused to:

determine the allocation of sensing resources based on the resource allocation; and

the device is caused to transmit or receive the signal by:

transmitting or receiving a sensing signal on at least one of the sensing resources.

3. The device of claim 1, wherein:

the device is further caused to:

determine the allocation of reserved resources based on the resource allocation; and

the device is caused to transmit or receive the signal by:

transmitting or receiving at least one of the following on at least one of the reserved resources:

a sensing signal, or

a communication signal.

4. The device of claim 1, wherein

the device is further caused to:

determine the allocation of reserved resources based on the resource allocation; and

the device is caused to use at least one of the reserved resources for at least one of the following:

transmitting or receiving no signal;

a gap between the sensing resources and the downlink communication resources or the uplink communication resources;

switching between transmission of a sensing signal and transmission of a communication signal;

switching between transmission of the sensing signal and reception of the communication signal;

switching between reception of the sensing signal and reception of the communication signal; or

switching between reception of the sensing signal and transmission of the communication signal.

5. The device of claim 1, wherein the device is caused to determine the resource allocation based on at least one of the following:

system pre-definition,

system configuration, or

system pre-configuration.

6. The device of claim 1, wherein the resource allocation indicates the period; or

the period is determined based on a sum of at least one of the following:

a first number of time units of the downlink communication resources in the period,

a second number of time units of the flexible resources in the period,

a third number of time units of the uplink communication resources in the period,

a fourth number of time units of the sensing resources in the period, or

a fifth number of time units of the reserved resources in the period.

7. The device of claim 1, wherein the device is further caused to:

determine the resource allocation based on a resource type order, wherein the

resource type order indicating an order of the at least one of the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period.

8. The device of claim 7, wherein the resource type order is system pre-defined, system configured, or system pre-configured.

9. The device of claim 1, wherein the resource allocation comprises at least one of the following:

a first location of the downlink communication resources in the period,

a second location of the flexible resources in the period,

a third location of the uplink communication resources in the period,

a fourth location of the sensing resources in the period,

a fifth location of the reserved resources in the period,

a first number of time units of the downlink communication resources in the period,

a second number of time units of the flexible resources in the period,

a third number of time units of the uplink communication resources in the period,

a fourth number of time units of the sensing resources in the period, or

a fifth number of time units of the reserved resources in the period.

10. The device of claim 7 or 9, wherein the resource type order or the resource allocation comprises at least one of the following:

the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the sensing resources, and the sensing resources are followed by the reserved resources;

the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the reserved resources, the reserved resources are followed by the sensing resources, and the sensing resources are followed by the uplink communication resources;

the downlink communication resources start from a start boundary of the period, the

downlink communication resources are followed by the sensing resources, the sensing resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the reserved resources;

the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the sensing resources, the sensing resources are followed by the uplink communication resources; or

the downlink communication resources start from a start boundary of the period, the downlink communication resources are followed by the flexible resources, the flexible resources are followed by the uplink communication resources, the uplink communication resources are followed by the sensing resources.

11. The device of claim 9, wherein:

the downlink communication resources comprise a first subset of the downlink communication resources and a second subset of the downlink communication resources; and/or

the flexible resources comprise a third subset of the flexible resources and a fourth subset of the flexible resources; and/or

the uplink communication resources comprise a fifth subset of the uplink communication resources and a sixth subset of the uplink communication resources; and/or

the sensing resources comprise a seventh subset of the sensing resources and an eighth subset of the sensing resources; and/or

the reserved resources comprise a ninth subset of the reserved resources and a tenth subset of the reserved resources.

12. The device of claim 11, wherein the resource allocation indicates at least one of the following:

allocation of the first subset of the downlink communication resources and allocation of the second subset of the downlink communication resources are not adjacent in time domain;

allocation of the third subset of the flexible resources and allocation of the fourth subset of the flexible resources are not adjacent in time domain;

allocation of the fifth subset of the uplink communication resources and allocation of

the sixth subset of the uplink communication resources are not adjacent in time domain;

allocation of the seventh subset of the sensing resources and allocation of the eighth subset of the sensing resources are not adjacent in time domain; or

allocation of the ninth subset of the reserved resources and allocation of the tenth subset of the reserved resources are not adjacent in time domain.

13. The device of claim 11, wherein:

a location of the first subset of the downlink communication resources is independent from a location of the second subset of the downlink communication resources in the period; and/or

a location of the third subset of the flexible resources is independent from a location of the fourth subset of the flexible resources; and/or

a location of the fifth subset of the uplink communication resources is independent from a location of the sixth subset of the uplink communication resources; and/or

a location of the seventh subset of the sensing resources is independent from a location of the eighth subset of the sensing resources; and/or

a location of the ninth subset of the sensing resources is independent from a location of the tenth subset of the sensing resources.

14. The device of claim 11, wherein the seventh subset of the sensing resources are used for a first sensing signal to be transmitted by a network device, and the eighth subset of the sensing resources are used for a second sensing signal to be transmitted by a terminal device.

15. The device of claim 9, wherein the device is caused to determine the resource allocation based on at least one bitmap, each of the at least one bitmap indicates one of the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period, and a bit in each of the at least one bitmap indicates one of the time units.

16. The device of claim 15, wherein the resource allocation indicates the period; or

the device is further caused to determine the period as a length of one of the at least one bitmap.

17. The device of claim 9, wherein the device is caused to determine the resource allocation based on at least one resource allocation index, and each of the at least one resource allocation index is associated with an entry comprised in a resource allocation table.

18. The device of claim 1, wherein at least one gap exists between two types of resources adjacent in time domain among the downlink communication resources, the flexible resources, the uplink communication resources, the sensing resources and the reserved resources in the period.

19. The device of claim 18, wherein a duration of the at least one gap comprises at least one time unit.

20. The device of claim 18, wherein the at least one gap comprises at least one of the following:

a first gap between the downlink communication resources and the sensing resources; or

a second gap between the uplink communication resources and the sensing resources.

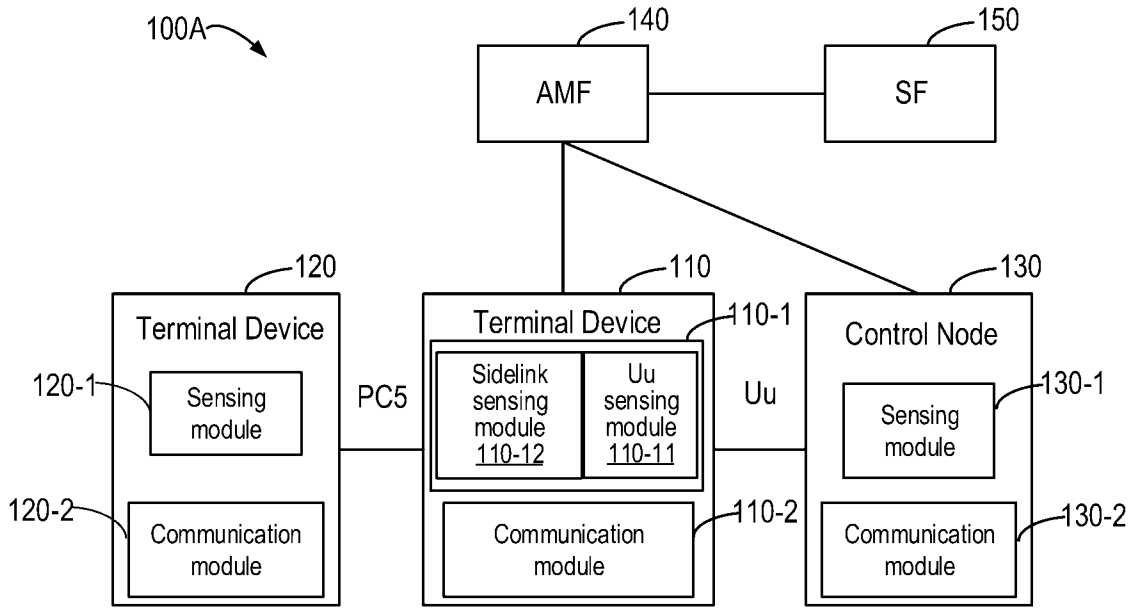
100A
140
AMF
150
SF
120
Terminal Device
120-1
Sensing module
120-2
Communication module
PC5
110
Terminal Device
110-1
Sidelink sensing module 110-12
Uu sensing module 110-11
110-2
Communication module
Uu
130
Control Node
130-1
Sensing module
130-2
Communication module

Fig. 1A

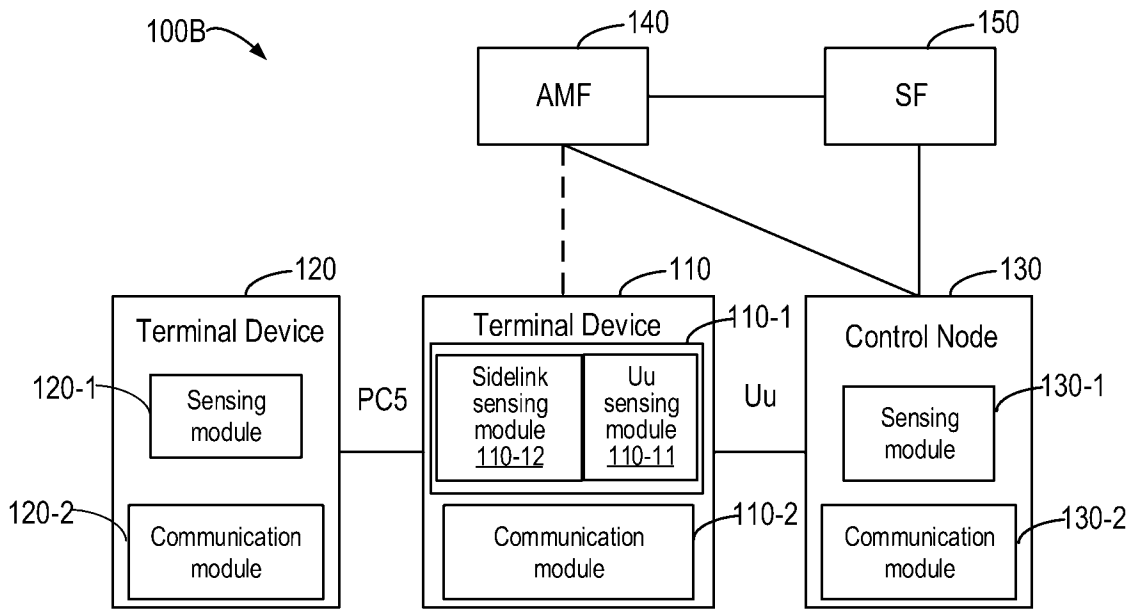
100B
140
AMF
150
SF
120
Terminal Device
120-1
Sensing module
120-2
Communication module
PC5
110
Terminal Device
110-1
Sidelink sensing module 110-12
Uu sensing module 110-11
110-2
Communication module
Uu
130
Control Node
130-1
Sensing module
130-2
Communication module

Fig. 1B

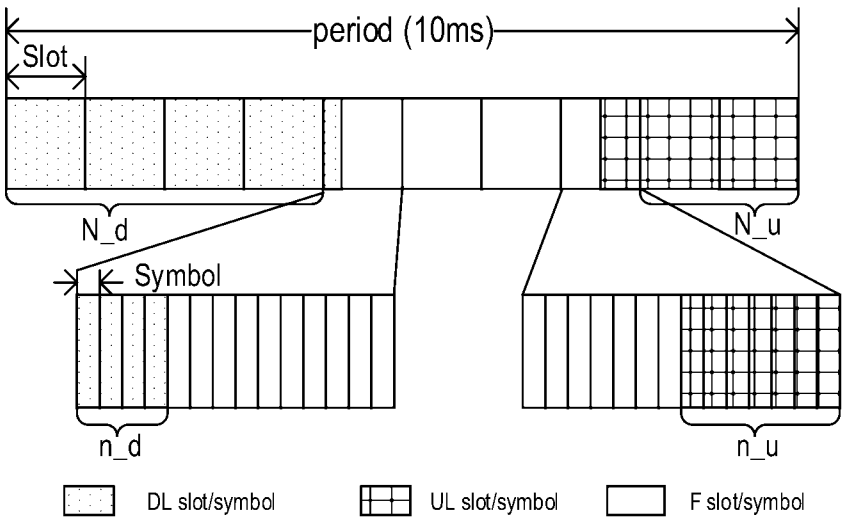
period (10ms)
Slot
N_d
N_u
Symbol
n_d
n_u
DL slot/symbol
UL slot/symbol
F slot/symbol

Fig. 2A

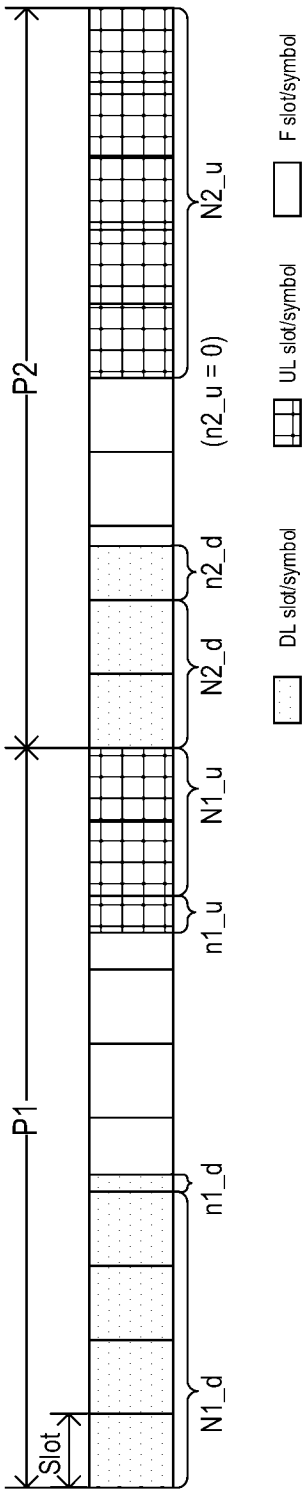
P2
P1
Slot
N1_d
n1_d
n1_u
N1_u
N2_d
n2_d
(n2_u = 0)
N2_u
DL slot/symbol
UL slot/symbol
F slot/symbol

Fig. 2B

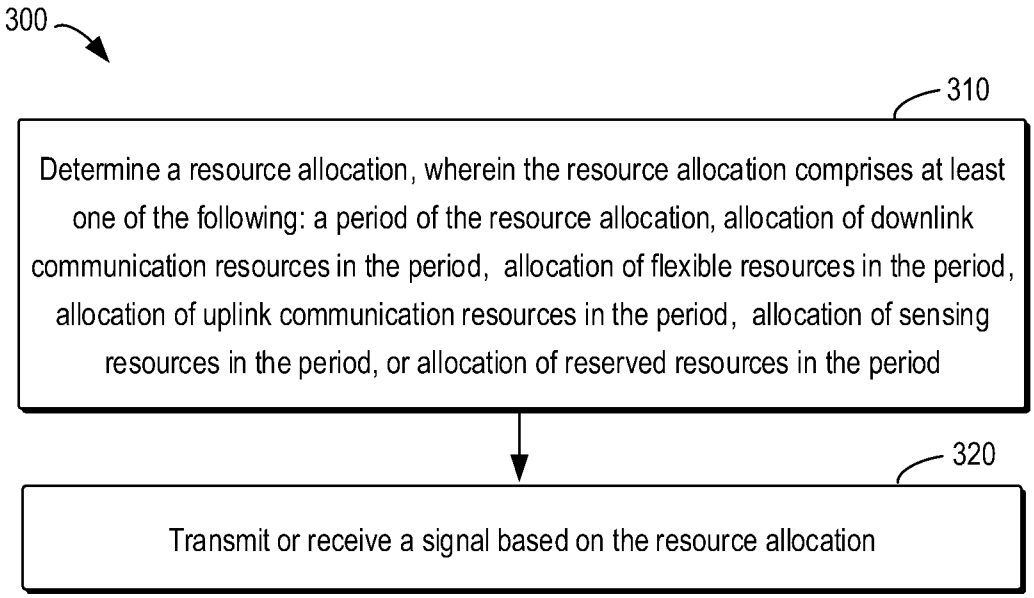
300
310
Determine a resource allocation, wherein the resource allocation comprises at least one of the following: a period of the resource allocation, allocation of downlink communication resources in the period, allocation of flexible resources in the period, allocation of uplink communication resources in the period, allocation of sensing resources in the period, or allocation of reserved resources in the period
320
Transmit or receive a signal based on the resource allocation

Fig. 3

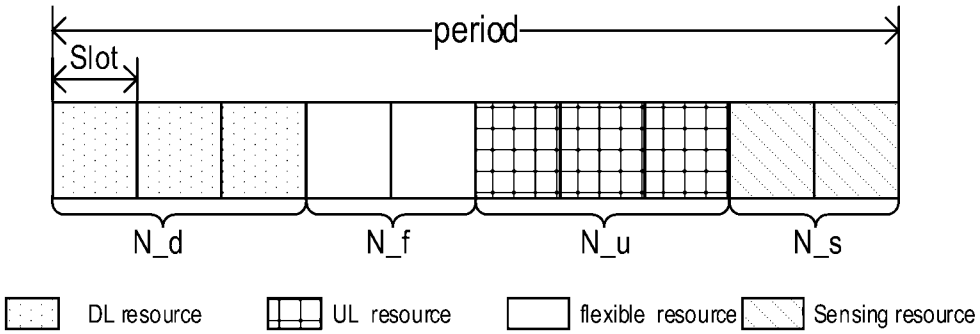
period
Slot
N_d
N_f
N_u
N_s
DL resource
UL resource
flexible resource
Sensing resource

Fig. 4A

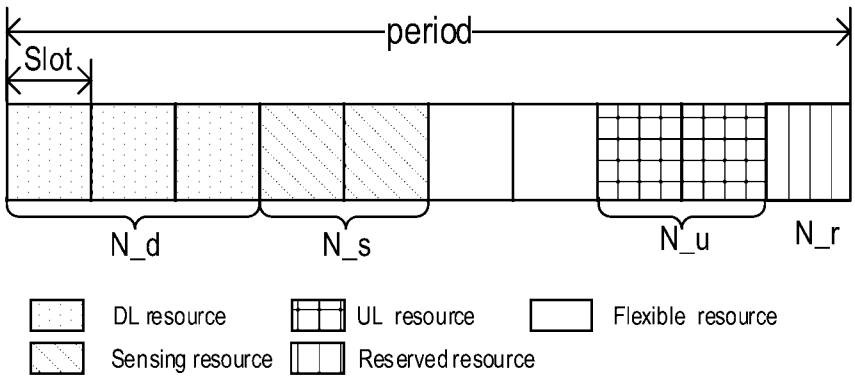
period
Slot
N_d
N_s
N_u
N_r
DL resource
UL resource
Flexible resource
Sensing resource
Reserved resource

Fig. 4B

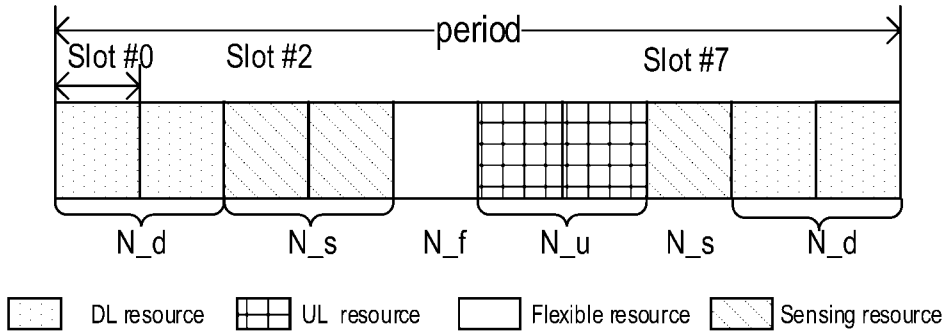

Fig. 5A

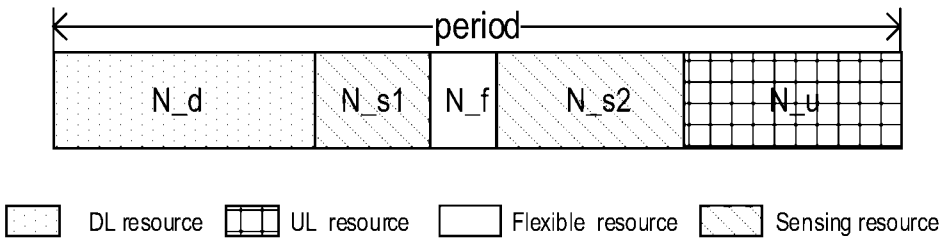

Fig. 5B

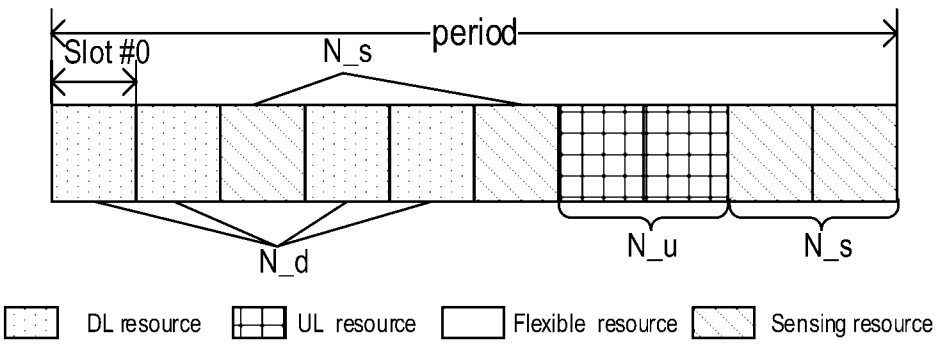

Fig. 6A

600

index	time unit									
	#0	#1	#2	#3	#4	#5	#6	#7	#8	#9
0	D	D	F	F	U	U	U	U	U	U
1	D	D	F	S	S	S	U	U	U	U
2	D	D	D	D	S	U	U	U	S	S
3	D	S	F	U	R	D	S	F	U	R
4	D	D	F	U	U	S	S	S	S	R
5	D	D	D	D	D	D	D	S	U	U
6	D	S	D	S	F	U	S	U	S	U
7	D	F	S	S	S	U	U	R	R	R

Fig. 6B

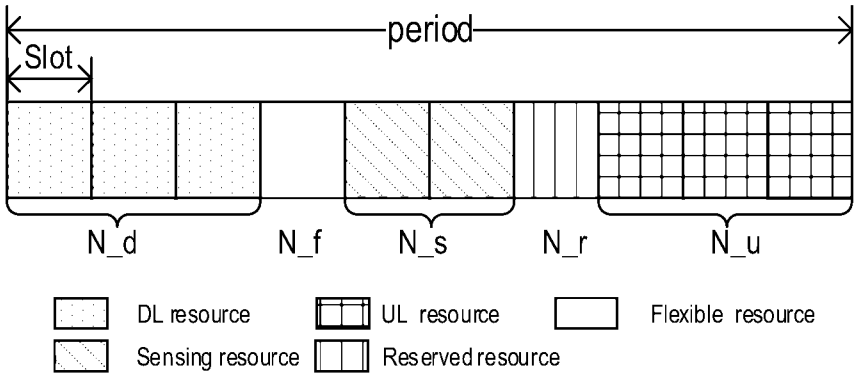
period
Slot
N_d
N_f
N_s
N_r
N_u
DL resource
UL resource
Flexible resource
Sensing resource
Reserved resource

Fig. 6C

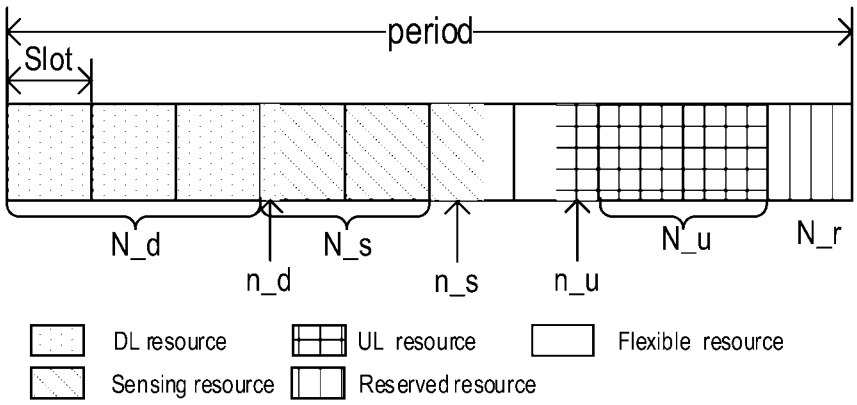
period
Slot
N_d
N_s
N_u
N_r
n_d
n_s
n_u
DL resource
UL resource
Flexible resource
Sensing resource
Reserved resource

Fig. 6D

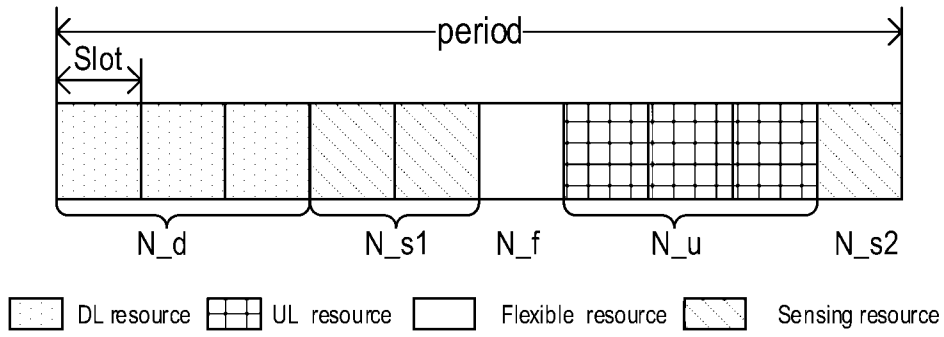
period
Slot
N_d
N_s1
N_f
N_u
N_s2
DL resource
UL resource
Flexible resource
Sensing resource

Fig. 7

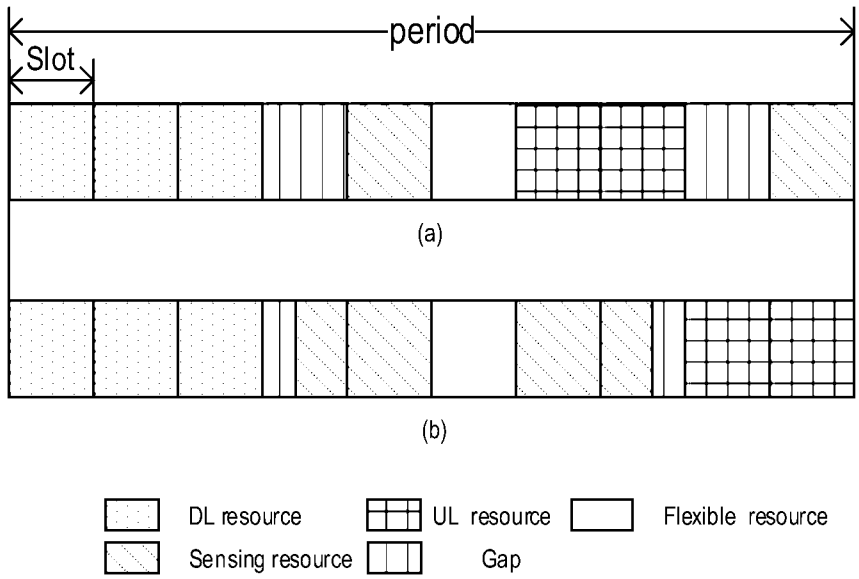
period
Slot
(a)
(b)
DL resource
UL resource
Flexible resource
Sensing resource
Gap

Fig. 8

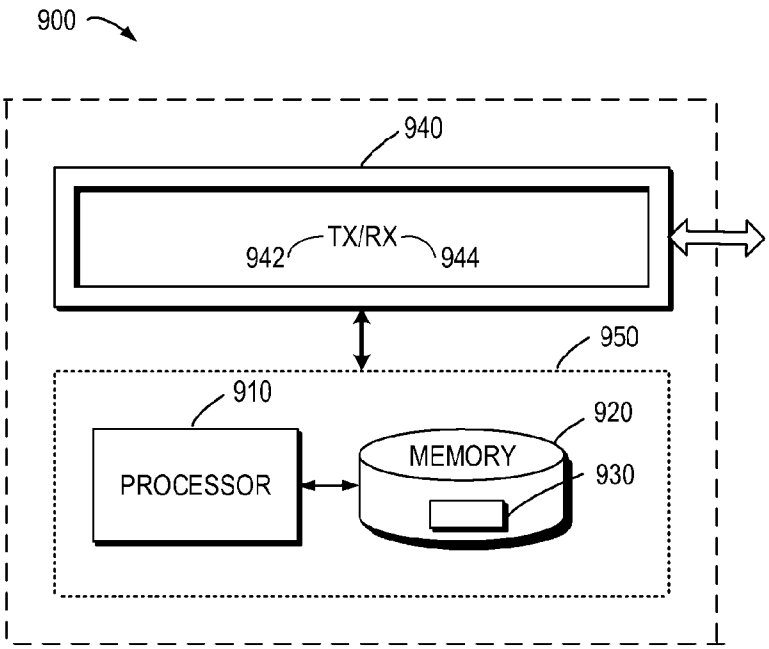

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/100854

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/26(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT,ENTXT,ENTXTC,CNABS,WPABS,DWPI,IEEE,3GPP:sens+, determine, configu+, set,integrat+, flex, up link, UL, down link, DL, communication, ISAC,Integrated Sensing, period, slot, frame, number, amount

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2022133951 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 30 June 2022 (2022-06-30) description, paragraphs [0183]-[0194], [0261], [0375]-[0385],figures 19, 20A-20C	1-20
A	CN 115280176 A (HUAWEI TECHNOLOGIES CO., LTD.) 01 November 2022 (2022-11-01) the whole document	1-20
A	CN 115413407 A (IDAC HOLDINGS, INC.) 29 November 2022 (2022-11-29) the whole document	1-20
A	WO 2022100499 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 19 May 2022 (2022-05-19) the whole document	1-20
A	WO 2022156997 A1 (VESTEL ELEKTRONIK SANAYI VE TICARET A.S.) 28 July 2022 (2022-07-28) the whole document	1-20

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
06 December 2023	**14 December 2023**
Name and mailing address of the ISA/CN **CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	Authorized officer **LU,Xia** Telephone No. **(+86) 010-53961568**

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/100854

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2022133951	A1	30 June 2022	US	2023309144	A1	28 September 2023
				EP	4248696	A1	27 September 2023
				CN	116548002	A	04 August 2023
CN	115280176	A	01 November 2022	EP	4107542	A1	28 December 2022
				WO	2021180210	A1	16 September 2021
				US	2021286045	A1	16 September 2021
				US	2023112477	A1	13 April 2023
CN	115413407	A	29 November 2022	EP	4115558	A1	11 January 2023
				BR	112022017798	A2	29 November 2022
				US	2023086144	A1	23 March 2023
				KR	20220150383	A	10 November 2022
				WO	2021178941	A1	10 September 2021
WO	2022100499	A1	19 May 2022	CN	114501346	A	13 May 2022
WO	2022156997	A1	28 July 2022	KR	20230131923	A	14 September 2023
				EP	4030847	A1	20 July 2022