COMMUNICATION METHOD AND COMMUNICATION APPARATUS

[0001] This application claims priority to United States of America Patent Application No. 63/565,377, filed on March 14, 2024, and entitled “Method, Apparatus, and System for Multiple Hybrid Automatic Repeat Request”, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to wireless communications. Particularly, it relates to a method, apparatus and system for multiple hybrid automatic repeat request.

BACKGROUND

[0003] For tera-bits multiple input and multiple output (T-MIMO) scenario, both base station (BS) side and user equipment (UE) side are equipped with large number of antennas, so communication system performance will be improved in spatial dimension. In such scenario, abundant applications with different quality of service (QoS) will emerge.

[0004] A single hybrid automatic repeat request HARQ process is used and indicated a single scheduling of a data channel carrying data with the same QoS. At present, different data with different QoS will be transmitted in different data channels which are scheduled by different control channels. Thus, when different data blocks with different QoS arrived at the same time, they will be scheduled sequentially in separate control channel and transmitted in different data channels. It will cause more transmission latency and waste resources in the T-MIMO scenario.

[0005] Therefore, there is a need to reduce transmission latency and fully utilize the resources in the T-MIMO scenario.

SUMMARY

[0006] This present disclosure provides a communication method and a communication apparatus used to reduce transmission latency and fully utilize resources.

[0007] According to a first aspect, a communication method is described. The method may be applied at a first device, for example, a first device or a module in a first device, a circuit or a chip (for example, a modem (modem) chip, also referred to as a baseband (baseband) chip, or a system on chip (system on chip, SoC) chip or a system in package (system in package, SIP) chip that includes a modem core) that is responsible for a communication function in a first device. For example, the method is applied to a first device.

[0008] In this method, the first device transmits scheduling information for scheduling a first data transmission and a second data transmission, where the first data transmission is assigned with a first hybrid automatic repeat request (HARQ) process; and the second data transmission is assigned with a second HARQ process. The first device communicates the first data transmission and the second data transmission on a data channel.

[0009] The foregoing method can communicate different data transmissions with different HARQ processes on the same data channel. When different data blocks arrive at the same time, the different data transmissions can be scheduled together and carried on the same data channel. The foregoing method relative to that a single HARQ process is just used and indicated a single scheduling of a data channel gives rise to reduction in transmission latency. Moreover, in the scenario with rich resources like a T-MIMO scenario, the resources can be fully utilized.

[0010] In a possible design, both the first data transmission and the second data transmission are transmitted on one of uplink (UL), downlink (DL) and sidelink (SL).

[0011] In a possible design, the first data transmission and the second data transmission are with different quality of service (QoS).

[0012] In other words, the first data transmission and the second data transmission are with different applications.

[0013] In some implementations, the first data transmission and the second data transmission are with same QoS.

[0014] In a possible design, the first device further transmits first information for indicating the first HARQ process, and the second HARQ process.

[0015] As such, the first information can support different data transmissions with multiple HARQ processes on the same data channel. And, it is helpful to determine the HARQ process corresponding to the data transmission.

[0016] In a possible design, the first information includes a bit map, where a first bit in the bit map is for indicating the first HARQ process and a second bit in the bit map is for indicating the second HARQ process.

[0017] As such, the different HARQ processes will be indicated by the bit map. This method is easy to conduct and will save signaling overhead.

[0018] In a possible design, the first information includes two bit strings, where a first bit string is for indicating the first HARQ process and a second bit string is for indicating the second HARQ process.

[0019] As such, the different HARQ processes will be indicated by the bit strings.

[0020] In a possible design, the first device further transmits second information for indicating the first HARQ process, and the second HARQ process is determined according to the first HARQ process and a pre-configured mapping relationship between the first HARQ process and the second HARQ process.

[0021] As such, more signaling overhead will be saved by virtue of using second information just for indicating one HARQ process. And, other HARQ processes can be determined according to the indicated HARQ process and a pre-configured mapping relationship.

[0022] In a possible design, the first device further transmits third information for indicating first redundancy version associated with the first HARQ process, and second redundancy version associated with the second HARQ process.

[0023] As such, the third information can support different redundancy version corresponding to multiple HARQ processes.

[0024] In a possible design, one or more of the first information, the second information and the third information are carried on a control channel scheduling the data channel.

[0025] In a possible design, the first device further transmits forth information for indicating a first mapping relationship, where the first mapping relation includes a mapping relationship between the first HARQ process and one or more associated codewords for the first data transmission, and a mapping relationship between the second HARQ process and one or more associated codewords for the second data transmission.

[0026] As such, the forth information can indicate a mapping relationship between different HARQ processes and different associated codewords. And, one or more codewords associated with the HARQ process can be determined.

[0027] In a possible design, the first device further transmits fifth information for indicating a second mapping relationship, where the second mapping relationship includes a mapping relationship between the first HARQ process and one or more associated transmission layers, and a mapping relationship between the second HARQ process and one or more associated transmission layers.

[0028] As such, the fifth information can indicate a mapping relationship between different HARQ processes and different associated transmission layers. And, one or more transmission layers associated with the HARQ process can be determined.

[0029] In a possible design, the first device further transmits sixth information for indicating a third mapping relationship, where the third relationship includes a mapping relationship between one or more codewords for the first data transmission and one or more associated transmission layers, and a mapping relationship between one or more codewords for the second data

transmission and one or more associated transmission layers.

[0030] As such, the sixth information can indicate a mapping relationship between different codewords for different data transmissions and different associated transmission layers.

[0031] In some implementations, the relationship between different HARQ processes, different associated codewords and different transmission layers can be determined according to any two of the forth information, the fifth information and the sixth information.

[0032] In a possible design, one or more of the first mapping relationship, the second mapping relationship, and the third mapping relationship are based on a priority of the first data transmission and the second data transmission.

[0033] In a possible design, a radio resource control RRC message includes at least one of the forth information, the fifth information and the sixth information.

[0034] According to a second aspect, a communication method is described. The method may be applied at a second device, for example, a second device or a module in a second device, a circuit or a chip (for example, a modem (modem) chip, also referred to as a baseband (baseband) chip, or a system on chip (system on chip, SoC) chip or a system in package (system in package, SIP) chip that includes a modem core) that is responsible for a communication function in a second device. For example, the method is applied to a second device.

[0035] In this method, the second device receives scheduling information for scheduling a first data transmission and a second data transmission, where the first data transmission is assigned with a first hybrid automatic repeat request (HARQ) process, and the second data transmission is assigned with a second HARQ process. The second device communicates the first data transmission and the second data transmission on a data channel.

[0036] The foregoing method can communicate different data transmissions with different HARQ processes on the same data channel. When different data blocks arrive at the same time, the different data transmission can be scheduled together and carried on the same data channel. The foregoing method relative to that a single HARQ process is just used and indicated a single scheduling of a data channel gives rise to reduction in transmission latency. Moreover, in the scenario with rich resources like a T-MIMO scenario, the resources can be fully utilized.

[0037] In a possible design, both the first data transmission and the second data transmission are transmitted on one of uplink (UL), downlink (DL) and sidelink (SL).

[0038] In a possible design, the first data transmission and the second data transmission are with different quality of service (QoS).

[0039] In other words, the first data transmission and the second data transmission are with different applications.

[0040] In some implementations, the first data transmission and the second data transmission are with same QoS.

[0041] In a possible design, the second device further receives first information for indicating the first HARQ process, and the second HARQ process.

[0042] As such, the first information can support different data transmissions with multiple HARQ processes on the same data channel. And, it is helpful to determine the HARQ process corresponding to the data transmission.

[0043] In a possible design, the first information includes a bit map, where a first bit in the bit map is for indicating the first HARQ process and a second bit in the bit map is for indicating the second HARQ process.

[0044] As such, the different HARQ processes will be indicated by the bit map. This method is easy to conduct and will save signaling overhead.

[0045] In a possible design, the first information includes two bit strings, where a first bit string is for indicating the first HARQ process and a second bit string is for indicating the second HARQ process.

[0046] As such, the different HARQ processes will be indicated by the bit strings.

[0047] In a possible design, the second device further receives second information for indicating the first HARQ process. The second device determines the first HARQ process according to the second information, and the second device determines the

second HARQ process according to the first HARQ process and a pre-configured mapping relationship between the first HARQ process and the second HARQ process.

[0048] As such, more signaling overhead will be saved by virtue of second information just for indicating one HARQ process. And, other HARQ processes can be determined according to the indicated HARQ process and a pre-configured mapping relationship.

[0049] In a possible design, the second device further receives third information for indicating first redundancy version associated with the first HARQ process, and second redundancy version associated with the second HARQ process.

[0050] As such, the third information can support different redundancy version corresponding to multiple HARQ processes.

[0051] In a possible design, one or more of the first information, the second information and the third information are carried on a control channel scheduling the data channel.

[0052] In a possible design, the second device further receives forth information for indicating a first mapping relationship, where the first mapping relation includes a mapping relationship between the first HARQ process and one or more associated codewords for the first data transmission, and a mapping relationship between the second HARQ process and one or more associated codewords for the second data transmission.

[0053] As such, the forth information can indicate a mapping relationship between different HARQ processes and different associated codewords. And, one or more codewords associated with the HARQ process can be easily determined.

[0054] In a possible design, the second device further receives fifth information for indicating a second mapping relationship, where the second mapping relationship includes a mapping relationship between the first HARQ process and one or more associated transmission layers, and a mapping relationship between the second HARQ process and one or more associated transmission layers.

[0055] As such, the fifth information can indicate a mapping relationship between different HARQ processes and different associated transmission layers. And, one or more transmission layers associated with the HARQ process can be easily determined.

[0056] In a possible design, the second device further receives sixth information for indicating a third mapping relationship, where the third relationship includes a mapping relationship between one or more codewords for the first data transmission and one or more associated transmission layers, and a mapping relationship between one or more codewords for the second data transmission and one or more associated transmission layers.

[0057] As such, the sixth information can indicate a mapping relationship between different codewords for different data transmissions and different associated transmission layers.

[0058] In some implementations, the relationship between different HARQ processes, different associated codewords and different transmission layers can be determined according to any two of the forth information, the fifth information and the sixth information.

[0059] In a possible design, one or more of the first mapping relationship, the second mapping relationship, and the third mapping relationship are based on a priority of the first data transmission and the second data transmission.

[0060] In a possible design, radio resource control RRC message includes at least one of the forth information, the fifth information and the sixth information.

[0061] According to a third aspect, a communication apparatus is described. The communication apparatus has a function of implementing the first aspect. For example, the communication apparatus includes a corresponding module, unit, or means (means) for performing operations in the first aspect. The module, unit, or means may be specifically implemented by using software, may be implemented by using hardware, or may be implemented by using software in combination with hardware.

[0062] According to a fourth aspect, a communication apparatus is described. The communication apparatus has a function of implementing the second aspect. For example, the communication apparatus includes a corresponding module, unit, or means (means) for performing operations in the second aspect. The module, unit, or means may be specifically implemented by using software, may be implemented by using hardware, or may be implemented by using software in combination with hardware.

[0063] According to a fifth aspect, another communication apparatus is described. The communication apparatus includes a memory and one or more processors. The memory is configured to store a part or all of a necessary computer program or instructions for implementing a function in the first aspect. The one or more processors may execute the computer program or the instructions, and when the computer program or the instructions is/are executed, the communication apparatus is enabled to implement the method in any possible design or implementation of the first aspect.

[0064] In some implementations, the communication apparatus may further include an interface circuit, and the processor is configured to communicate with another apparatus or component through the interface circuit.

[0065] In some implementations, the communication apparatus may further include the memory.

[0066] The communication apparatus may be a base station, a module in a base station, or a chip responsible for a communication function in a base station, for example, a modem chip (also referred to as a baseband chip) or an SoC chip or an SIP chip that includes a modem module.

[0067] According to a sixth aspect, another communication apparatus is described. The communication apparatus includes a memory and one or more processors. The memory is configured to store a part or all of a necessary computer program or instructions for implementing a function in the second aspect. The one or more processors may execute the computer program or the instructions, and when the computer program or the instructions is/are executed, the communication apparatus is enabled to implement the method in any possible design or implementation of the second aspect.

[0068] In some implementations, the communication apparatus may further include an interface circuit, and the processor is configured to communicate with another apparatus or component through the interface circuit.

[0069] In some implementations, the communication apparatus may further include the memory.

[0070] The communication apparatus may be a user equipment (UE), a module in a UE, or a chip responsible for a communication function in a UE, for example, a modem chip (also referred to as a baseband chip) or an SoC chip or an SIP chip that includes a modem module.

[0071] According to a seventh aspect, a communication system is described. The system includes a first apparatus which is enabled to implement the method in any possible design or implementation of the first aspect, and a second apparatus which is enabled to implement the method in any possible design or implementation of the second aspect.

[0072] According to an eighth aspect, a computer-readable storage medium is described. The computer-readable storage medium stores computer-readable instructions, and when a computer reads and executes the computer-readable instructions, the computer is enabled to perform the method in any one of the possible designs of the first aspect to the second aspect.

[0073] According to a ninth aspect, this application provides a computer program product. When a computer reads and executes the computer program product, the computer is enabled to perform the method in any one of the possible designs of the first aspect to the second aspect.

DESCRIPTION OF DRAWINGS

[0074] FIG. 1 is a schematic diagram of an application scenario according to this application;

[0075] FIG. 2 illustrates an example communication system 100;

[0076] FIG. 3 illustrates an example of an apparatus 310, an apparatus 320a and an apparatus 320b;

[0077] FIG. 4 illustrates units or modules in a device or apparatus;

[0078] FIG. 5 is an example of a channel model of a multiple-input multiple-output (MIMO) system;

[0079] FIG. 6 illustrates data with different QoS multiplexed and transmitted in one data channel.

[0080] FIG. 7 is a schematic flowchart of a communication method 700 according to an implementation of this application;

[0081] FIG. 8 is a schematic flowchart of another communication method 800 according to an implementation of this

application;

[0082] FIG. 9 is a schematic flowchart of another communication method 900 according to an implementation of this application;

[0083] FIG. 10 illustrates a scheme of data transmission with different QoS managed by different HARQ processes;

[0084] FIG. 11 illustrates a scheme of a mapping between different CWs and associated HARQ processes;

[0085] FIG. 12 illustrates a scheme of a mapping between different CWs and associated transmission layers;

[0086] FIG. 13 is a schematic block diagram of a communication apparatus 1300 according to some implementations of the present application; and

[0087] FIG. 14 is a schematic block diagram of a communication apparatus according to some implementations of the present application.

DESCRIPTION OF EMBODIMENTS

[0088] The following describes technical solutions of the present application with reference to the accompanying drawings.

[0089] Wireless communications system such as fourth generation (4G) system (for example, Long-Term Evolution (LTE) system), fifth generation (5G) system (for example, New Radio (NR) system) have been deployed to provide various types of applications, such as message, voice, video and other data.

[0090] The technical solutions in implementations of this application may be applied to multiple-input multiple-output (MIMO) technology. The technical solutions in implementations of this application may be applied to various communication systems, such as a fifth generation (5G) wireless communication system, a new ratio (NR) wireless communication system, a Long Term Evolution (LTE) system, an LTE frequency division duplex (FDD) system, an LTE time division duplex (TDD) system, a wireless local area network (WLAN), a satellite communication system, or other evolving communication systems, such as future wireless communication system.

[0091] For ease of understanding of the implementations of this application, a communication system shown in FIG. 1-FIG. 4 is used as an example to describe in detail a communication system to which the implementations of this application are applicable.

[0092] Referring to FIG. 1, as an illustrative example without limitation, a simplified schematic illustration of a communication system is provided. The communication system 100 (which may be a wireless system) includes a radio access network 120. The radio access network (RAN) 120 may be a future radio access network, or a legacy (e.g. 5G, 4G, 3G or 2nd generation (2G)) radio access network. One or more communication electronic device (ED) 110a, 110b, 110c, 110d, 110e, 110f, 110g, 110h, 110i, 110j (generically referred to as 110) may be interconnected to one another or connected to one or more network nodes (170a, 170b, generically referred to as 170) in the radio access network 120. A core network 130 may be a part of the communication system and may be dependent or independent of the radio access technology used in the communication system 100. The communication system 100 may also include a public switched telephone network (PSTN) 140, the Internet 150, and other networks 160.

[0093] Referring to FIG. 2, an example communication system 100 is illustrated. In general, the communication system 100 enables multiple wireless or wired elements to communicate data and other content. The communication system 100 may provide content, such as voice, data, video, and/or text, via broadcast, multicast, groupcast, unicast, etc. And the communication system 100 may provide a wide range of communication services and applications (such as earth monitoring, remote sensing, passive sensing and positioning, navigation and tracking, autonomous delivery and mobility, etc.) The services and/or applications may be mobile broadband (MBB) services, ultra-reliable low-latency communication (URLLC) services, or machine type communication (MTC) services.

[0094] The communication system 100 may operate by sharing resources, such as carrier spectrum bandwidth, between its constituent elements.

[0095] The communication system 100 may include a terrestrial communication system and/or a non-terrestrial communication system. The communication system 100 may provide a high degree of availability and robustness through a joint operation of a terrestrial communication system and a non-terrestrial communication system. For example, integrating a non-terrestrial communication system (or components thereof) into a terrestrial communication system can result in what may be considered a heterogeneous network including multiple layers. The heterogeneous network may achieve better overall performance through efficient multi-link joint operation, more flexible functionality sharing, and faster physical layer link switching between terrestrial networks and non- terrestrial networks.

[0096] The terrestrial communication system and the non-terrestrial communication system could be considered sub-systems of the communication system.

[0097] Same as in the example shown in FIG. 1, in the example shown in FIG. 2, the communication system 100 may include ED 110a, 110b, 110c, 110d (generically referred to as ED 110), and RAN 120a, 120b. In addition, the communication system 100 may also include a non-terrestrial communication network 120c. The communication system 100 may also include one or more of a core network 130, a public switched telephone network (PSTN) 140, the Internet 150, and other networks 160. The RANs 120a, 120b include respective RAN nodes such as base stations (BSs) 170a, 170b, which may be generically referred to as terrestrial transmit and receive points (T-TRPs) 170a, 170b. In one implementation, the non-terrestrial communication network 120c includes a RAN node such as an access node (or base station) 172, which may be generically referred to as a non-terrestrial transmit and receive point (NT-TRP) 172. As may be surmised on the basis of similarity in reference numerals, the non-terrestrial communication network 120c may be considered to be a radio access network, with operational aspects in common with the RANs 120a, 120b. In another implementations, the non-terrestrial communication network 120c may include at least one non-terrestrial network (NTN) device and at least one corresponding terrestrial network device, where the at least one non-terrestrial network device works as a transport layer device and the at least one corresponding terrestrial network device works as a RAN node, which communicates with the ED via the non-terrestrial network device. In addition, there may be a NTN gateway in the ground (i.e., referred as a terrestrial network device) also as a transport layer device to communication with both the NTN device, and the RAN node communicates with the ED via the NTN device and the NTN gateway. In some implementations, the NTN gateway and the RAN node may be located in the same device.

[0098] Any ED 110 may be alternatively or additionally configured to interface, access, or communicate with any T-TRP 170a,170b and NT-TRP 172, the Internet 150, the core network 130, the PSTN 140, the other networks 160, or any combination of the preceding. In some examples, ED 110a may communicate an uplink (UL) and/or downlink (DL) transmission over a terrestrial air interface 190a with T-TRP 170a. In some examples, the EDs 110a, 110b, 110c, and 110d may also communicate directly with one another via one or more sidelink (SL) air interfaces 190b. In some examples, ED 110d may communicate an uplink and/or downlink transmission over a non-terrestrial air interface 190c with NT-TRP 172.

[0099] The air interfaces 190a and 190b may use similar communication technology, such as any suitable radio access technology. For example, the communication system 100 may implement one or more channel access methods, such as code division multiple access (CDMA), space division multiple access (SDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), or single-carrier FDMA (SC-FDMA, also known as discrete Fourier transform spread OFDMA, DFT-s-OFDMA) in the air interfaces 190a and 190b. The air interfaces 190a and 190b may utilize other higher dimension signal spaces, which may involve a combination of orthogonal and/or non-orthogonal dimensions.

[0100] The non-terrestrial air interface 190c can enable communication between the ED 110d and one or multiple NT-TRPs 172 via a wireless link or simply a link. For some examples, the link is a dedicated connection for unicast transmission, a connection for broadcast transmission, or a connection between a group of EDs 110 and one or multiple NT-TRPs 172 for multicast transmission.

[0101] The RANs 120a and 120b are in communication with the core network 130 to provide the EDs 110a 110b, and 110c with various services such as voice, data, and other services. The RANs 120a and 120b and/or the core network 130 may be in direct or indirect communication with one or more other RANs (not shown), which may or may not be directly served by core network 130, and may or may not employ the same radio access technology as RAN 120a, RAN 120b or both. The core network

130 may also serve as a gateway access between (i) the RANs 120a and 120b or EDs 110a 110b, and 110c or both, and (ii) other networks (such as the PSTN 140, the Internet 150, and the other networks 160). In addition, some or all of the EDs 110a 110b, and 110c may include functionality for communicating with different wireless networks over different wireless links using different wireless technologies and/or protocols. Instead of wireless communication (or in addition thereto), the EDs 110a 110b, and 110c may communicate via wired communication channels to a service provider or switch (not shown), and to the Internet 150. PSTN 140 may include circuit switched telephone networks for providing plain old telephone service (POTS). Internet 150 may include a network of computers and subnets (intranets) or both, and incorporate protocols, such as Internet Protocol (IP), Transmission Control Protocol (TCP), User Datagram Protocol (UDP). EDs 110a 110b, and 110c may be multimode devices capable of operation according to multiple radio access technologies, and incorporate multiple transceivers necessary to support such.

[0102] In addition, the communication system 100 may include a sensing agent (not shown in the figure) to manage the sensed data from ED110 and or the T-TRP 170 and/or NT-TRP 172. In one implementation, the sensing agent is located in the T-TRP 170 and/or NT-TRP 172. In another implementation, the sensing agent is a separate node which has interface to communicate with the core network 130 and/or the RAN 120 (e.g., the T-TRP 170 and/or NT-TRP 172).

[0103] Referring to FIG. 3, an example of apparatus is illustrated. FIG. 3 illustrates example of an Apparatus 310 wirelessly communicating with at least one of two apparatuses (e.g., Apparatus 320a and Apparatus 320b, referred as Apparatus 320) in a communication system, e.g., the communication system 100, according to one implementation. The Apparatus 310 may be a UE (e.g., ED 110 as shown in FIG. 1 or FIG. 2). The Apparatus 320a may be a terrestrial network device (e.g., T-TRP 170 as shown in FIG. 1 or FIG. 2), and Apparatus 320b may be a non-terrestrial network device (e.g., NT-TRP 172 as shown in FIG. 2). However, this is not necessary. For example, Apparatus 320a may be a NT-TRP, and 320b may be a T-TRP, both Apparatus 320a and 320b may be T-TRPs or NT-TRPs, according to present disclosure. In the following, the ED 110 as an example of the Apparatus 310 is described, and T-TRP 170 as an example of Apparatus 320a is described, and NT-TRP 172 as an example of Apparatus 320a is described. Although only one Apparatus 310, one Apparatus 320a and one Apparatus 320b are shown in FIG. 3. Please note that the number of Apparatus 310 (e.g. ED 110) could be one or more, and the number of Apparatus 320a and/or 320b could be one or more. For example, one ED110 may be served by only one T-TRP 170 (or one NT-TRP172), by more than one T-TRP 170, by more than one NT-TRP 172, or by one or more T-TRP 170 and one or more NT-TRP172.

[0104] The ED 110 is used to connect persons, objects, machines, etc. The ED 110 may be widely used in various scenarios including, for example, cellular communications, device-to-device (D2D), vehicle to everything (V2X), peer-to-peer (P2P), machine-to-machine (M2M), MTC, internet of things (IoT), virtual reality (VR), augmented reality (AR), mixed reality (MR), metaverse, digital twin, industrial control, self-driving, remote medical, smart grid, smart furniture, smart office, smart wearable, smart transportation, smart city, drones, robots, remote sensing, passive sensing, positioning, navigation and tracking, autonomous delivery and mobility, etc.

[0105] Each ED 110 represents any suitable end user device for wireless operation and may include such devices (or may be referred to but not limited to) as a user equipment(UE)/ terminal device, a wireless transmit/receive unit (WTRU), a mobile station, a fixed or mobile subscriber unit, a cellular telephone, a station (STA), a MTC device, a personal digital assistant (PDA), a smartphone, a laptop, a computer, a tablet, a wireless sensor, a consumer electronics device, a smart book, a vehicle, a car, a truck, a bus, a train, or an IoT device, a wearable device (such as a watch, a pair of glasses, head mounted equipment, etc.), an industrial device, or an apparatus in (e.g. communication module, modem, or chip) or including the forgoing devices, among other possibilities. Future generation EDs 110 may be referred to using other terms. The base station 170a and 170b are T-TRPs and will hereafter be referred to as T-TRP 170. Also shown in FIG. 3, a non-terrestrial (NT) device will hereafter be referred to as NT-TRP 172. Each ED 110 connected to T-TRP 170 and/or NT-TRP 172 can be dynamically or semi-statically turned-on (i.e., established, activated, or enabled), turned-off (i.e., released, deactivated, or disabled) and/or configured in response to one of more of: connection availability and connection necessity.

[0106] As shown in FIG. 3, the apparatus 310 may be a ED 110 in FIG. 1 or FIG. 2. The ED 110 includes at least one processor 210. Only one processor 210 is illustrated to avoid congestion in the drawing. The ED 110 may further include a transmitter 201 and a receiver 203 coupled to one or more antennas 204. Only one antenna 204 is illustrated to avoid congestion in

the drawing. One, some, or all of the antennas 204 may alternatively be panels. The transmitter 201 and the receiver 203 may be integrated, e.g. as a transceiver. The transceiver is configured to modulate data or other content for transmission by at least one antenna 204 or network interface controller (NIC). The transceiver is also configured to demodulate data or other content received by the at least one antenna 204. Each transceiver includes any suitable structure for generating signals for wireless or wired transmission and/or processing signals received wirelessly or by wire. Each antenna 204 includes any suitable structure for transmitting and/or receiving wireless or wired signals. The ED 110 may include at least one memory 208. Only the transmitter 201, receiver 203, processor 210, memory 208, and antenna 204 are illustrated for simplicity, but the ED 110 may include one or more other components.

[0107] The memory 208 stores instructions. The memory 208 may also store data used, generated, or collected by the ED 110. For example, the memory 208 could store software instructions or modules configured to implement some or all of the functionality and/or implementations described herein and that are executed by one or more processing unit(s) (e.g., a processor 210). Each memory 208 includes any suitable volatile and/or non-volatile storage and retrieval device(s). Any suitable type of memory may be used, such as random access memory (RAM), read only memory (ROM), hard disk, optical disc, subscriber identity module (SIM) card, memory stick, secure digital (SD) memory card, on-processor cache, and the like.

[0108] The ED 110 may further include one or more input/output devices (not shown) or interfaces (such as a wired interface to the Internet 150 in FIG. 1). The input/output devices or interfaces permit interaction with a user or other devices in the network. Each input/output device or interface includes any suitable structure for providing information to or receiving information from a user, and/or for network interface communications. Suitable structures include, for example, a speaker, microphone, keypad, keyboard, display, touch screen, etc.

[0109] The processor 210 performs (or controls the ED 110 to perform) operations described herein as being performed by the ED 110, as illustrated below and elsewhere in the present disclosure. For example, the processor 210 performs or controls the ED110 to perform receiving transport blocks (TBs), using a resource for decoding of one of the received TBs, releasing the resource for decoding of another of the received TBs, and/or receiving configuration information configuring a resource. In details, the operation may include those operations related to preparing a transmission for uplink transmission to the NT-TRP 172 and/or the T-TRP 170; those operations related to processing downlink transmissions received from the NT-TRP 172 and/or the T-TRP 170; and those operations related to processing sidelink transmission to and from another ED 110. Processing operations related to preparing a transmission for uplink transmission may include operations such as encoding, modulating, transmiting beamforming, and generating symbols for transmission. Processing operations related to processing downlink transmissions may include operations such as receive beamforming, demodulating and decoding received symbols. Processing operations related to processing sidelink transmissions may include operations such as transmit/receive beamforming, modulating/demodulating and encoding/decoding symbols. Depending upon the implementation, a downlink transmission may be received by the receiver 203, possibly using receive beamforming, and the processor 210 may extract signaling from the downlink transmission (e.g. by detecting and/or decoding the signaling). An example of signaling may be a reference signal transmitted by the NT-TRP 172 and/or by the T-TRP 170. In some implementations, the processor 210 implements the transmit beamforming and/or the receive beamforming based on the indication of beam direction, e.g. beam angle information (BAI), received from the T-TRP 170. In some implementations, the processor 210 may perform operations relating to network access (e.g. initial access) and/or downlink synchronization, such as operations relating to detecting a synchronization sequence, decoding and obtaining the system information, etc. In some implementations, the processor 210 may perform channel estimation, e.g. using a reference signal received from the NT-TRP 172 and/or from the T-TRP 170.

[0110] Although not illustrated, the processor 210 may form part of the transmitter 201 and/or part of the receiver 203. Although not illustrated, the memory 208 may form part of the processor 210.

[0111] The processor 210, the processing components of the transmitter 201, and the processing components of the receiver 203 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory (e.g. in the memory 208). Alternatively, some or all of the processor 210, the processing components of the transmitter 201, and the processing components of the receiver 203 may each be implemented using dedicated circuitry, such as a programmed

field-programmable gate array (FPGA), an application-specific integrated circuit (ASIC), or a hardware accelerator such as a graphics processing unit (GPU) or an artificial intelligence (AI) accelerator.

[0112] In some implementations, the ED 110 may be an apparatus (also called component) for example, communication module, modem, chip, or chipset, and it includes at least one processor 210, and an interface or at least one pin. In this scenario, the transmitter 201 and receiver 203 may be replaced by the interface or at least one pin, where the interface or at least one pin is to connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 may be referred as transmitting information to the interface or at least one pin, or as transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 via the interface or at least one pin, and receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 may be referred as receiving information from the interface or at least one pin, or as receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or another ED 110 via the interface or at least one pin. The information may include control signaling and/or data.

[0113] As shown in FIG. 3, the Apparatus 320a may be a T-TRP 170 as shown in FIG. 1 or FIG. 2. The T-TRP 170 includes at least one processor 260. Only one processor 260 is illustrated to avoid congestion in the drawing. The T-TRP 170 may further include at least one transmitter 252 and at least one receiver 254 coupled to one or more antennas 256. Only one antenna 256 is illustrated to avoid congestion in the drawing. One, some, or all of the antennas 256 may alternatively be panels. The transmitter 252 and the receiver 254 may be integrated as a transceiver. The T-TRP 170 may further include at least one memory 258. The T-TRP 170 may further include scheduler 253. Only the transmitter 252, receiver 254, processor 260, memory 258, antenna 256 and scheduler 253 are illustrated for simplicity, but the T-TRP may include one or more other components.

[0114] The T-TRP 170 may be known by other names in some implementations, such as a base station, a base transceiver station (BTS), a radio base station, a network node, a network device, a device on the network side, a transmit/receive node, a Node B, an evolved NodeB (eNodeB or eNB), a Home eNodeB, a next Generation NodeB (gNB), a transmission point (TP), a site controller, an access point (AP), a wireless router, a relay station, a terrestrial node, a terrestrial network device, a terrestrial base station, a base band unit (BBU), a remote radio unit (RRU), an active antenna unit (AAU), a remote radio head (RRH), a central unit (CU), a distributed unit (DU), a positioning node, among other possibilities. The T-TRP 170 may be a macro base station (BS), a pico BS, a relay node, a donor node, or the like, or combinations thereof. The T-TRP 170 may refer to the forgoing devices or refer to apparatus (e.g. a communication module, a modem, or a chip) in the forgoing devices.

[0115] The CU (or CU-control plane (CP) and CU-user plane (UP)), DU or RU may be known by other names in some implementations. For example, in an open RAN (ORAN) system, the CU may also be referred to as open CU (O-CU), DU may also be referred to as open DU (O-DU), CU-CP may also be referred to open CU-CP (O-CU-CP), CU-UP may also be referred to as open CU-UP (O-CU-CP), and RU may also be referred to open RU (O-RU). Any one of the CU (or CU-CP, CU-UP), DU, or RU may be implemented through a software module, a hardware module, or a combination of software and hardware modules.

[0116] In some implementations, the parts of the T-TRP 170 may be distributed. For example, some of the modules of the T-TRP 170 may be located remote from the equipment that houses the antennas 256 for the T-TRP 170, and may be coupled to the equipment that houses the antennas 256 over a communication link (not shown) sometimes known as front haul, such as common public radio interface (CPRI). Therefore, in some implementations, the term T-TRP 170 may also refer to modules on the network side that perform processing operations, such as determining the location of the ED 110, resource allocation (scheduling), message generation, and encoding/decoding, and that are not necessarily part of the equipment that houses the antennas 256 of the T-TRP 170. The modules may also be coupled to other T-TRPs. In some implementations, the T-TRP 170 may actually be a plurality of T-TRPs that are operating together to serve the ED 110, e.g. through the use of coordinated multipoint transmissions.

[0117] The processor 260 performs operations including those related to: preparing a transmission for downlink transmission to the ED 110, processing an uplink transmission received from the ED 110, preparing a transmission for backhaul transmission to the T-TRP 170 and/or NT-TRP 172, and processing a transmission received over backhaul from the T-TRP 170 and/or NT-TRP 172. Processing operations related to preparing a transmission for downlink or backhaul transmission may include operations such as encoding, modulating, precoding (e.g. multiple input multiple output (MIMO) precoding), transmit beamforming, and generating symbols for transmission. Processing operations related to processing received transmissions in the

uplink or over backhaul may include operations such as receive beamforming, demodulating received symbols, and decoding received symbols. The processor 260 may also perform operations relating to network access (e.g. initial access) and/or downlink synchronization, such as generating the content of synchronization signal blocks (SSBs), generating the system information, etc. In some implementations, the processor 260 also generates an indication of beam direction, e.g. BAI, which may be scheduled for transmission by a scheduler 253. The processor 260 performs other network-side processing operations described herein, such as determining the location of the ED 110, determining where to deploy the NT-TRP 172, etc. In some implementations, the processor 260 may generate signaling, e.g. to configure one or more parameters of the ED 110 and/or one or more parameters of the NT-TRP 172. Any signaling generated by the processor 260 is sent by the transmitter 252.

[0118] The scheduler 253 may be coupled to the processor 260 or integrated in the processor 260. The scheduler 253 may be included within or operated separately from the T-TRP 170. The scheduler 253 may schedule uplink, downlink, sidelink, and/or backhaul transmissions, including issuing scheduling grants and/or configuring scheduling-free (e.g., “configured grant”) resources.

[0119] The memory 258 is configured to store information, and optionally data. The memory 258 stores instructions and data used, generated, or collected by the T-TRP 170. For example, the memory 258 could store software instructions or modules configured to implement some or all of the functionality and/or implementations described herein and that are executed by the processor 260.

[0120] Although not illustrated, the processor 260 may form part of the transmitter 252 and/or part of the receiver 254. Also, although not illustrated, the processor 260 may implement the scheduler 253. Although not illustrated, the memory 258 may form part of the processor 260.

[0121] The processor 260, the scheduler 253, the processing components of the transmitter 252, and the processing components of the receiver 254 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory, e.g. in the memory 258. Alternatively, some or all of the processor 260, the scheduler 253, the processing components of the transmitter 252, and the processing components of the receiver 254 may be implemented using dedicated circuitry, such as a programmed FPGA, a hardware accelerator (e.g., a GPU or AI accelerator), or an ASIC.

[0122] When the T-TRP 170 is an apparatus (also called as component, for example, communication module, modem, chip, or chipset in a device), it includes at least one processor, and an interface or at least one pin. In this scenario, the transmitter 252 and receiver 254 may be replaced by the interface or at least one pin, where the interface or at least one pin is to connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the NT-TRP 172 and/or the T-TRP 170 and/or ED 110 may be referred as transmitting information to the interface or at least one pin, and receiving information from the NT-TRP 172 and/or the T-TRP 170 and/or ED 110 may be referred as receiving information from the interface or at least one pin. The information may include control signaling and/or data.

[0123] Although the NT-TRP 172 is illustrated as a drone only as an example, the NT-TRP 172 may be implemented in any suitable non-terrestrial form, such as satellites and high altitude platforms, including international mobile telecommunication base stations and unmanned aerial vehicles, for example. Also, the NT-TRP 172 may be known by other names in some implementations, such as a non-terrestrial node, a non-terrestrial network device, or a non-terrestrial base station.

[0124] The T-TRP 170 may further include at least one transmitter 252 and at least one receiver 254 coupled to one or more antennas 256. Only one antenna 256 is illustrated to avoid congestion in the drawing. One, some, or all of the antennas 256 may alternatively be panels. The transmitter 252 and the receiver 254 may be integrated as a transceiver. The T-TRP 170 may further include at least one memory 258. The T-TRP 170 may further include scheduler 253. Only the transmitter 252, receiver 254, processor 260, memory 258, antenna 256 and scheduler 253 are illustrated for simplicity, but the T-TRP may include one or more other components.

[0125] As shown in FIG. 3, the Apparatus 320b may be a NT-TRP 172 as shown in FIG. 2. The NT-TRP 172 includes at least one processor 276. Only one processor 276 is illustrated to avoid congestion in the drawing. The NT-TRP 172 may include a transmitter 272 and a receiver 274 coupled to one or more antennas 280. Only one antenna 280 is illustrated to avoid congestion in the drawing. One, some, or all of the antennas may alternatively be panels. The transmitter 272 and the receiver 274 may be integrated as a transceiver. The NT-TRP 172 may further include at least one memory 278. The NT-TRP 172 may further include

a scheduler. Only the transmitter 272, receiver 274, processor 276, memory 278, antenna 280 are illustrated for simplicity, but the NT-TRP may include one or more other components.

[0126] The NT-TRP 172 includes a processor 276 for performing operations including those related to: preparing a transmission for downlink transmission to the ED 110, processing an uplink transmission received from the ED 110, preparing a transmission for backhaul transmission to T-TRP 170 and/or another NT-TRP 172, and processing a transmission received over backhaul from the T-TRP 170 and/or another NT-TRP 172. Processing operations related to preparing a transmission for downlink or backhaul transmission may include operations such as encoding, modulating, precoding (e.g. MIMO precoding), transmit beamforming, and generating symbols for transmission. Processing operations related to processing received transmissions in the uplink or over backhaul may include operations such as receive beamforming, demodulating received symbols, and decoding received symbols. In some implementations, the processor 276 implements the transmit beamforming and/or receive beamforming based on beam direction information (e.g. BAI) received from the T-TRP 170. In some implementations, the processor 276 may generate signaling, e.g. to configure one or more parameters of the ED 110. In some implementations, the NT-TRP 172 implements physical layer processing, but does not implement higher layer functions such as functions at the medium access control (MAC) or radio link control (RLC) layer. As this is only an example, more generally, the NT-TRP 172 may implement higher layer functions in addition to physical layer processing.

[0127] The memory 278 is configured to store information and optionally data. The memory 258 stores instructions and data used, generated, or collected by the NT-TRP 172. For example, the memory 278 could store software instructions or modules configured to implement some or all of the functionality and/or implementations described herein and that are executed by the processor 276.

[0128] Although not illustrated, the processor 276 may form part of the transmitter 272 and/or part of the receiver 274. Although not illustrated, the memory 278 may form part of the processor 276.

[0129] The processor 276, the processing components of the transmitter 272, and the processing components of the receiver 274 may each be implemented by the same or different one or more processors that are configured to execute instructions stored in a memory, e.g. in the memory 278. Alternatively, some or all of the processor 276, the processing components of the transmitter 272, and the processing components of the receiver 274 may be implemented using dedicated circuitry, such as a programmed FPGA, a hardware accelerator (e.g., a GPU or AI accelerator), or an ASIC. In some implementations, the NT-TRP 172 may actually be a plurality of NT-TRPs that are operating together to serve the ED 110, e.g. through coordinated multipoint transmissions.

[0130] When the NT-TRP 172 is an apparatus (e.g. communication module, modem, chip, or chipset) in a device, it includes at least one processor, and an interface or at least one pin. In this scenario, the transmitter 272 and receiver 257 may be replaced by the interface or at least one pin, where the interface or at least one pin is to connect the apparatus (e.g., chip) and other apparatus (e.g., chip, memory, or bus). Accordingly, the transmitting information to the T-TRP 170 and/or another NT-TRP 172 and/or ED 110 may be referred as transmitting information to the interface or at least one pin, and receiving information from the T-TRP 170 and/or another NT-TRP 172 and/or ED 110 may be referred as receiving information from the interface or at least one pin. The information may include control signaling and/or data.

[0131] Note that “transmit/receive point (TRP)”, as used herein, may refer to a T-TRP or a NT-TRP. A T-TRP may alternatively be called a terrestrial network TRP (“TN TRP”) and a NT-TRP may alternatively be called a non-terrestrial network TRP (“NTN TRP”). The T-TRP 170, the NT-TRP 172, and/or the ED 110 may include other components, but these have been omitted for the sake of clarity.

[0132] Note that “signaling”, as used herein, may alternatively be called control signaling, control message, control information, or message for simplicity. Signaling between a BS (e.g., the network node 170) and a terminal or sensing device (e.g., ED 110), or signaling between different terminal or sensing device (e.g., between ED 110i and ED110j) may be carried in physical layer signaling (also called as dynamic signaling), which is transmitted in a physical layer control channel. For downlink, the physical layer signaling may be known as downlink control information (DCI) which is transmitted in a physical downlink control channel (PDCCH). For uplink, the physical layer signaling may be known as uplink control information (UCI) which is transmitted in a physical uplink control channel (PUCCH). For sidelink, signaling between different terminals or sensing devices (e.g., between

ED 110i and ED110j) may be known as sidelink control information (SCI) which is transmitted in a physical sidlink control channel (PSCCH). Signaling may be carried in higher-layer (e.g., higher than physical layer) signaling, which is transmitted in a physical layer data channel, e.g. in a physical downlink shared channel (PDSCH) for downlink signaling, in a physical uplink shared channel (PUSCH) for uplink signaling, and in a physical slidelink shared channel (PSSCH) for sidelink signaling. Higher-layer signaling may also called static signaling, or semi-static signaling. Higher-layer signaling may be radio resource control (RRC) protocol signaling or media access control – control element (MAC-CE) signaling. Signaling may be included in a combination of physical layer signaling and higher layer signaling.

[0133] It should be noted that in present disclosure, “information”, when different from “message”, may be carried in one single message, or be carried in more than one separate message.

[0134] One or more steps of the methods provided in this disclosure herein may be performed by corresponding units or modules, according to FIG. 4. FIG. 4 illustrates units or modules in a device or apparatus, such as in the ED 110, in the T-TRP 170, or in the NT-TRP 172. For example, a signal may be transmitted by a transmitting unit or by a transmitting module. A signal may be received by a receiving unit or by a receiving module. A signal may be processed by a processing unit or a processing module. Other steps may be performed by an artificial intelligence (AI) or machine learning (ML) module. The respective units or modules may be implemented using hardware, one or more components or devices that execute software, or a combination thereof. For instance, one or more of the units or modules may be a circuit such as an integrated circuit. Examples of an integrated circuit include a programmed FPGA, a GPU, or an ASIC. For instance, one or more of the units or modules may be logical such as a logical function performed by a circuit, by a portion of an integrated circuit, or by software instructions executed by a processor. It will be appreciated that where the modules are implemented using software for execution by a processor for example, the modules may be retrieved by a processor, in whole or part as needed, individually or together for processing, in single or multiple instances, and that the modules themselves may include instructions for further deployment and instantiation.

[0135] Additional details regarding the EDs 110, the T-TRP 170, and the NT-TRP 172 are known to those of skill in the art. As such, these details are omitted here.

[0136] The present disclosure is aimed at devices such as UEs, IoT devices, cars, etc. The type of network scenarios envisioned may include terrestrial TRPs such as base-stations and/or non-terrestrial TRPs such as drones, balloons, high-altitude platform stations (HAPS), satellites, and any such devices that support radio access technologies such as 5G NR, future network or other technologies.

[0137] For illustrative purposes, specific example implementations will now be explained in greater detail in conjunction with the figures and above mentioned system, ED and TRP.

[0138] The implementations set forth herein represent information sufficient to practice the claimed subject matter and illustrate ways of practicing such subject matter. Upon reading the following description in light of the accompanying figures, those of skill in the art will understand the concepts of the claimed subject matter and will recognize applications of these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the disclosure and the accompanying claims.

[0139] For ease of understanding of the implementations of this application, the following briefly describes several terms used in this application.

[0140] 1)MIMO

[0141] MIMO is a core technology of existing 5G NR systems, which uses multiple antennas respectively at the transmit end and the receive end to transmit signals and receive signals. The MIMO technology can make full use of space resources and multiplies the channel capacity of the system without increasing spectrum resources or antenna transmit power. Therefore, MIMO still has great potential as one of the core technologies of future system.

[0142] MIMO technology allows an antenna array of multiple antennas to perform signal transmissions and receptions to meet high transmission rate requirements. The above ED 110 and T-TRP 170, and/or NT-TRP use MIMO to communicate over wireless resource blocks. MIMO utilizes multiple antennas at the transmitting apparatus and/or receiving apparatus to transmit the

wireless resource blocks over parallel wireless signals. MIMO may beamform parallel wireless signals for reliable multipath transmission of a wireless resource block. MIMO may bond parallel wireless signals that transport different data to increase the data rate of the wireless resource block.

[0143] In recent years, a MIMO (large-scale MIMO) wireless communication system with the above T-TRP 170, and/or NT-TRP 172 configured with a large number of antennas has gained wide attention from the academia and the industry. In the large-scale MIMO system, the T-TRP 170 and/or NT-TRP 172 is generally configured with more than ten antenna units (such as 128 or 256), and serves for dozens of the EDs 110. A large number of antenna units of the T-TRP 170, and NT-TRP 172 can greatly increase the degree of spatial freedom of wireless communication, greatly improve the transmission rate, spectrum efficiency and power efficiency, and eliminate the interference between cells to a large extent. The increase in the number of antennas allows each antenna unit to be made smaller and at a lower cost. Using the degree of spatial freedom provided by the large-scale antenna units, the T-TRP 170 and NT-TRP 172 of each cell can communicate with many EDs 110 in the cell on the same time-frequency resource at the same time, thus greatly increasing the spectrum efficiency. A large number of antenna units of the T-TRP 170 and/or NT-TRP 172 also enable each user to have better spatial directivity for uplink and downlink transmission, so that the transmitting power of the T-TRP 170 and/or NT-TRP 172 and an ED 110 is reduced, and the power efficiency is greatly increased. When the number of antennas of the T-TRP 170 and/or NT-TRP 172 is sufficiently large, random channels between each ED 110 and the T-TRP 170 and/or NT-TRP 172 can be close to be orthogonal, and the interference between the cell and the users and the effect of noises can be eliminated. The plurality of advantages described above enable the large-scale MIMO to have a magnificent application prospect.

[0144] A MIMO system may include a receiving apparatus connected to a receive (Rx) antenna, a transmitting apparatus connected to a transmit (Tx) antenna, and a signal processor connected to the transmitting apparatus and the receiving apparatus. Each of the Rx antenna and the Tx antenna may include a plurality of antennas. For instance, the Rx antenna may have a ULA antenna array in which the plurality of antennas is arranged in a line at even intervals. When a radio frequency (RF) signal is transmitted through the Tx antenna, the Rx antenna may receive a signal reflected and returned from a forward target. The receiving apparatus may be an ED (i.e. ED 110) and the transmitting apparatus may be a T-TRP or NT-TRP (i.e. T-TRP 170 or NT-TRP 172), or the receiving apparatus may be a T-TRP or NT-TRP (i.e. T-TRP 170 or NT-TRP 172) and the transmitting apparatus may be an ED (i.e. ED 110).

[0145] Referring to FIG. 5, as an illustrative example without limitation, a simplified schematic illustration of a communication scenario is provided. Specifically, FIG. 5 is an example of a channel model of a MIMO system. A transmitting apparatus is connected to four Tx antennas, x1 to x4, a receiving apparatus is connected to four Rx antennas, y1 to y4, and a transmission channel may be formed between each Tx antenna and each Rx antenna. For example, an RF signal transmitted through x1 may be received by y2 through channel h21. The RF signal transmitted through x3 may be received by y1 through channel h13.

[0146] Hereafter, a base station is used as an example of T-TRP 170 or NT-TRP 172, and the UE is used as an example of ED 110. A receiving apparatus may be referred to as ED 110 for a downlink transmission, and T-TRP 170 or NT-TRP 172 for an uplink transmission. A transmitting apparatus may be referred to as T-TRP 170 or NT-TRP 172 for a downlink transmission, and ED 110 for an uplink transmission. However, limitation is not made herein.

[0147] 2) PDCCH/PUCCH/PSCCH

[0148] In downlink, control signaling may be transmitted in a control channel which may be called a PDCCH. Specifically, the PDCCH is a type of physical downlink channel used to carry a string of bits (e.g., downlink control information (DCI) bits). For example, the PDCCH may be formed by a string of encoded DCI bits plus cyclic redundancy check (CRC) bits.

[0149] In uplink, control signaling may be transmitted in a control channel which may be called PUCCH. Specifically, the PUCCH is a type of physical downlink channel used to carry a string of bits (e.g., uplink control information (UCI) bits). For example, the PUCCH may be formed by a string of encoded UCI plus CRC bits.

[0150] In sidelink, control signaling may be transmitted in a control channel which may be called PSCCH. Specifically, the PSCCH is a type of physical sidelink channel used to carry a string of bits (e.g., sidelink control information (SCI) bits). For example, the PSCCH may be formed by a string of encoded SCI plus CRC bits.

[0151] In some implementations, a signal carried on the PDCCH can also be called PDCCH. Specifically, transmitting/receiving a PDCCH means transmitting/receiving a signal carried by the PDCCH. Similarly, a signal carried on the PUCCH can also be called a PUCCH. Specifically, transmitting/receiving a PUCCH means transmitting/receiving a signal carried by the PUCCH. A signal carried on the PSCCH can also be called a PSCCH. Specifically, transmitting/receiving a PSCCH means transmitting/receiving a signal carried by the PSCCH.

[0152] 3) DCI

[0153] The DCI may be used for scheduling a data transmission or feedback of a data transmission. For example, the DCI may include information for scheduling the data transmission (e.g., for a downlink/uplink data transmission or a sidelink (SL) data transmission) and/or power control (e.g., uplink power control, or sidelink power control, or downlink power control).

[0154] 4) PDSCH/PUSCH/PSSCH

[0155] The downlink data is scheduled by the DCI carried in the PDCCH and transmitted in a data channel which may be called a PDSCH. Similarly, the uplink data is transmitted in a data channel which may be called a PUSCH. The sidelink data is transmitted in a data channel which may be called PSSCH.

[0156] 5) HARQ

[0157] In wireless communication, for a data channel, a HARQ process is implemented to support re-transmission and hybrid combining of original and re-transmission of the same data to counterattack the channel impairment and improve the robustness of the system performance.

[0158] 6) QoS

[0159] Quality of service (QoS) is the description or measurement of the overall performance requirement of a service. And QoS is the requirement to guarantee a certain level of performance to a data flow and also lead to different priorities to different applications for different users and data flows. For example, a required bit rate, delay, delay variation, packet loss or bit error rates may be guaranteed.

[0160] Different data could have the same QoS but from different applications. Or different applications will respond to data with different QoS. For example, data with different QoS may include one or more following characters: data with different required bit rates, data with different delays, data with different delay variations, data with different packet loss, or data with different bit error rates.

[0161] A 400 MHz system bandwidth in the 10~13GHz range is envisioned as a promising mid-band for wide-area coverage and capacity improvement in future network systems. In 10~13GHz with 400MHz, it is possible to deploy a ~1000 transmit/receive (Tx/Rx) antenna array at the base station (BS) side and a ~30 Tx/Rx antenna array at the user equipment (UE) side, which is far larger than the existing 5G antenna array scale. MIMO will be a key technology for 10~13GHz to improve single user-MIMO (SU-MIMO) peak rate with ~20 layers transmission and network peak throughput with ~300 layers multiple-user MIMO (MU-MIMO) layer transmission, and can reach a Tera-bits level system throughput, thus it could also be referred as Tera-bits MIMO (T-MIMO).

[0162] Such super large scale of antennas at both the base station and UE sides would result in rich multiple transmission layers, the multiple transmission layers may be referred to as multi-spatial layers or multi layers. These multiple transmission layers would not only improve the performance of a data transmission but also be used to improve a control signal transmission in both the downlink and uplink directions between the base station and the UE. These multiple transmission layers may also be used in other links such as sidelink between a UE and another UE wherever applicable.

[0163] Specifically, in some scenarios (e.g., T-MIMO scenario), as larger number of antennas will be used in both BS and NE side, more spatial layers with good channel quality could be present, which opens a new dimension (spatial) to improve the performance. For T-MIMO, there are rich spatial layers due to a large number of transmit antennas and receiver. Therefore, to fully utilize those rich spatial resources would really improve the system performance such as reliability and throughput. For future wireless communication, for example, abundant applications would also emerge which could have different QoS. For example, some application/service may have a stricter requirement on latency while others may have more requirement on reliability. That would lead to more requirements to transmit data from different QoS together to fully utilize the MIMO channel capacity as well

as meet the different QoS requirements.

[0164] This above information is provided to reveal information believed by the applicant to be of possible relevance to the present disclosure. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present disclosure.

[0165] In traditional cellular systems such as 5G NR, the UE can receive, detect and measure reference signals such as synchronization signals (SS)/physical broadcast channel (PBCH) blocks and non-zero-power channel state information reference signal (NZP-CSI-RS). Such reference signals are based on pseudo random noise (PRN) binary sequences such as Gold sequences and those sequences may be initialized using common or UE-specific scrambling identities. As an example, primary synchronization signal (PSS)and secondary synchronization signal (SSS) sequences are initialized using the physical cell identity (PCI) value, which is a common scrambling identity. NZP-CSI-RS sequences are initialized using UE-specific scrambling identities, which are configured by the network to the UE.

[0166] 5G NR Rel-17 introduces support for non-terrestrial networks by introducing several enhancements on the timing relationships for the Timing Advance, the reference timing for channel state information (CSI) resources, the transmission timing of DCIs scheduling PUSCH, the transmission timing of Random Access response carried by a PUSCH, the transmission timing of hybrid automatic repeat request acknowledge (HARQ-ACK) on a PUCCH.

[0167] In 5G NR Rel-17, non-terrestrial network (NTN) support was introduced allowing UEs to support DL/UL communication with satellites using the so-called "bent-pipe" scenario, where a ground station transmits signals towards satellites in space, and satellites reflect signals back to UEs on the ground. Dedicating signaling related to NTN was introduced in order to assist UEs with NTN operation. Higher-layer signaling such as RRC introduces signaling satellite ephemeris, satellite position, satellite signal polarization, timing advance offsets, satellite System Information Block (SIB), satellite epochs in order to support NTN operation. Other features that were introduced were the extension of HARQ processes to 32 in order to accommodate for large propagation delay scenarios and the disabling of HARQ-ACK feedback.

[0168] In 5G NR, a single HARQ process is used and indicated in a single scheduling (e.g., by PDCCH/PSCCH) for a transmission in PDSCH/PUSCH/PSSCH respectively. That can only support data of the same QoS.

[0169] In 5G NR, data for different QoS could be scheduled using different control channels (e.g., PDCCH/PSCCH(s)) and transmitted in different data channels (e.g., PDSCH/PUSCH/PSSCH(s)), and one HARQ process is used for the data carried in the same data channel (e.g., PDSCH/PUSCH/PSSCH). In future wireless communication, for example if T-MIMO is used or abundant spatial layers are available, there may be a need to transmit data with different QoS in the same data channel (e.g., PDSCH/PUSCH/PSSCH) scheduled by the same control channel (e.g., PDCCH/PSCCH). Or there may be a need to transmit data with different applications in the same data channel scheduled by the same control channel. For example, there may be a need to transmit data with different QoS (or with different applications) in the same PDSCH or PUSCH scheduled by the same PDCCH. There may be a need to transmit data with different QoS (or with different applications) in the same PSSCH scheduled by the same PSCCH. In general, even without T-MIMO, there could be a need to schedule data with different QoS (or with different applications) in the same control channel and transmit it in the same data channel, and thus require different HARQ processes to handle the re-transmission of these data respectively.

[0170] In many application and deployment scenarios, data with different QoS (or with different applications) needs to be scheduled and transmitted on a same data channel (e.g., PDSCH/PUSCH/PSSCH) and therefore multiple HARQ processes are needed to manage the re-transmission of different data of different QoS (or the re-transmission of different data of different applications). For example, when a chunk of enhanced mobile broadband (eMBB) data and a chunk of ultra reliable low latency communications (URLLC) data arrive at the same time at media access control (MAC) layers to be transmitted, according to prior art, they need to be scheduled sequentially in separate control channels (e.g., PDCCH/PSCCH) and transmitted in different data channels (e.g., PDSCH/PUSCH/PSSCH(s)). That could cause more latency and also may not fully utilize available resources (e.g., available large number of spatial layers in T-MIMO scenario).

[0171] In general, it is a challenge to support multiple HARQ processes for data with different QoS (or with different applications) transmitted in the same data channel.

[0172] Accordingly, a method is provided in the disclosure. In the method, supporting multiple HARQ processes for data transmission in the same data channel (e.g., PDSCH/PUSCH/PSSCH) to accommodate the need of transmission/re-transmission data with different QoS (or with different applications) is provided. The corresponding configuration and indication to support multiple HARQ processes are also provided.

[0173] In the following specific example implementations of this disclosure will now be explained with reference to the accompanying drawings.

[0174] In the implementations of this application, a transmission layer may be referred to as a spatial layer that is used for carrying information (control information or data) for transmission, or may be referred to as a layer for the same purpose. Information carried on a transmission layer may be mapped to time-frequency resources with a corresponding antenna port before being transmitted. Multiple transmission layers would allow multiple independent information streams (one stream on one layer) to be transmitted in the air simultaneously from a transmitter (e.g., a base station, or a UE) to a receiver (e.g., a UE), and thus improving the throughput or reliability. However, limitation is not made herein. The transmission layer is only named for description and does not limit the scope of protection of the implementations of this application. For example, transmission layers may be shown in the form of beams, and thus the implementations may be applied to beams.

[0175] In the implementations of this application, a resource can cover at least one of time domain, frequency domain or spatial domain.

[0176] In the implementations of this application, a time-frequency resource may be referred to as any one of: a time-frequency domain resource, a time-frequency resource set, or a time-frequency resource block.

[0177] In the implementations of this application, "and/or" describes an association relationship between associated objects and represents that three relationships may exist. For example, A and/or B may represent the following three cases: only A exists, both A and B exist, and only B exists. The character "/" generally indicates an "or" relationship between the associated objects. "At least one" means one or more. "At least one of A and B", similar to "A and/or B", describes an association relationship between associated objects and represents that three relationships may exist. For example, at least one of A and B may represent the following three cases: only A exists, both A and B exist, and only B exists.

[0178] FIG. 6 illustrates data with different QoS multiplexed and transmitted in one data channel. For example, a data channel may be a PDSCH, PUSCH or PSSCH. As shown in FIG. 6, for an example, data streams with different QoS could be multiplexed and enter an encoder. The encoder could apply channel encoding to data with different QoS respectively and result in different codewords (CW(s)) such as CW#0, CW#1, etc. Here a CW in general could refer to a stream of bits after channel encoding with CRC bits appended but they could be in more general formats. Modulation operation could then be applied to different CW(s). For data from different QoS, different modulation and coding schemes (MCS(s)) could be applied to encoding and modulation operations. The modulated symbols from each CW could then be mapped to different spatial transmission layers for transmission. It should be noted that the multiplexing operation is optional. Here the multiplexing operation is just for illustration purpose, and whether this operation is needed or not depends on implementation. For example, data from different QoS could be sent to the physical (PHY) layer from MAC layer in different transport blocks (TB) and each TB could be the input to a channel encoder respectively. In essential, data from different QoS are encoded and modulated separately to form different CWs. It should be noted that different CWs (after modulation) to different transmission layers mapping may not be one-to-one, for example the modulated symbols from the same CW could be mapped to one or more transmission layer(s).

[0179] With data from different QoS (or from different applications) multiplexed and transmitted on the same data channel (e.g., PDSCH), the transmission layer mapping could follow different priorities, for example, the data with higher QoS requirement (higher reliability and lower latency) could be mapped to transmission layer(s) with better channel quality while data with lower QoS requirement could be mapped to transmission layer(s) with lower channel quality.

[0180] Data with different QoS requirements could have different requirement on latency and reliability, therefore different HARQ processes could be needed for HARQ processing data with different QoS (or with different applications) to meet different requirements, for example, the re-transmission latency and HARQ-ACK reliability etc.

[0181] FIG. 7 is a schematic flowchart of a communication method 700 according to an implementation of this application. The communication method 700 may be performed by two communication devices (for example, a first device and a second device shown in FIG. 7), or performed by a chip, a circuit, or a processing system configured in the two communication devices. As one example, the first device could be a base station and a second device could be a UE. As another example, both the first device and the second device could be UEs. Limitation is not made here. The following implementations will be described in combination with the communication method 700 performed by the first device and the second device as an example.

[0182] At step 710, the first device transmits, and accordingly the second device receives scheduling information for scheduling a first data transmission and a second data transmission, where the first data transmission is assigned with a first HARQ process, and the second data transmission is assigned with a second HARQ process.

[0183] In some implementations, the first data transmission and the second data transmission could be with different applications.

[0184] In some implementations, the first data transmission and the second data transmission could be with the same or different quality of service QoS.

[0185] The first data with first QoS and the second data with second QoS represents the data with different QoS generated from different applications or different services. For example, data with different QoS may include one or more following characters: data with different required bit rates, data with different delay, data with different delay variations, data with different packet loss, or data with different bit error rates. The first data and the second data could be with the same QoS but from different applications. It should be noted that the implementations of this application do not limit the number of data streams with different QoS.

[0186] In some implementations of this application, the step 710 can be conducted by the first device and the second device shown in FIG.7. And in some implementations of this application, the step 710 can be conducted by a chip, a circuit, or a processing system configured in the first device or the second device. As such, for example, the transmitting action in the step 710 can also be described as an outputting action, and the receiving action in the step 710 can also be described as an inputting action.

[0187] In a downlink or an uplink scenario, the first device can be a base station, the second device can be a UE. The scheduling information can be carried in a control channel (e.g. PDCCH) on Uu link.

[0188] In a sidelink scenario, both the first device and the second device can be different UEs. The scheduling information can be carried in a control channel (e.g. PSCCH) on sidelink.

[0189] At step 720，the first device and the second device communicate the first data transmission and the second data transmission on a data channel.

[0190] In some implementations of this application, both the first data transmission and the second data transmission are transmitted on one of uplink (UL), downlink (DL) and sidelink (SL).

[0191] It should be noted that the first data transmission and second data transmission with the same or different QoS are carried in the same data channel scheduled together. The same data channel may be one of PUSCH, PDSCH or PSSCH.

[0192] As an example, in a downlink scenario, the first device can be a base station, and the second device can be a UE. The base station can obtain original data from the higher layer and generate the first data and the second data according to the original data. In an uplink scenario, the first device can be a base station, and the second device can be a UE. The first data and the second data can be generated by the UE.

[0193] For example, in a downlink scenario, the first device transmits, accordingly the second device receives the first data transmission and the second data transmission with the same or different QoS on a PDSCH.

[0194] For example, in an uplink scenario, the second device transmits, accordingly the first device receives the first data transmission and the second data transmission with the same different QoS on a PUSCH.

[0195] As another example, in a sidelink scenario, both the first device and the second device are UEs. The first data and the second data can be generated by the first device or the second device.

[0196] For example, in the sidelink scenario, the first device may be a first UE, and the second device may be a second UE.

The first UE and the second UE communicate a PSSCH carrying the first data and the second data with the same or different QoS.

[0197] This application does not limit the count of data transmission and HARQ process. The first data transmission and the second data transmission are just examples. And the corresponding first HARQ process and the corresponding second HARQ process are just examples too.

[0198] To support data transmission in a single data channel (e.g., PDSCH/PUSCH/PSSCH) with multiple HARQ processes, the indication of corresponding HARQ processes and their respective attributes are required. There are a number of ways to do so, and some examples are provided below. The details will be described with FIG. 8 and FIG. 9.

[0199] FIG. 8 is a schematic flowchart of another communication method 800 according to an implementation of this application. FIG. 8 is a communication method in a downlink scenario.

[0200] At step 810, the base station generates first data and second data.

[0201] For example, the base station can receive original data from a higher layer (or application) and generate the first data and the second data according to the original data.

[0202] The first data and the second data are generated for different QoS(s) or different applications. For example, the first data is generated in TB#1 and the second data is generated in TB#2.

[0203] At step 820, the base station transmits, and accordingly the UE receives scheduling information for scheduling a first data transmission and a second data transmission.

[0204] The specific description of step 820can refer to step 710, and it is not repeated here.

[0205] At step 830, the base station transmits, and accordingly the UE receives first information for indicating the first HARQ process and the second HARQ process.

[0206] In some implementations of this application, the first information is used for indicating the different HARQ process ID(s) corresponding to the first and second data transmission respectively.

[0207] Accordingly, at step 840, the UE determines the first HARQ process and the second HARQ process. This step could be optional if the information regarding the HARQ processes are already explicitly transmitted in step 830.

[0208] In some implementations, the first information may be carried as control information in a control channel. For example, the control information may be DCI, and the control channel may be a PDCCH.

[0209] In some implementations of this application, the first information includes a bit map, where a first bit in the bit map is used to indicate the first HARQ process and a second bit in the bit map is used to indicate the second HARQ process.

[0210] Accordingly, the UE determines the first HARQ process according to a first bit in the bit map, and the second HARQ process according to a second bit in the bit map.

[0211] A bit map could be used to indicate which HARQ processes are used in this data channel (e.g., PDSCH/PUSCH/PSSCH). For example, if total 16 HARQ processes are supported, a bit map field of 16 can be carried in control information (e.g., DCI or SCI). For example, with each bit corresponding to one HARQ process, a bit value “1’ of a particular bit indicates that a HARQ process is assigned for the data transmission, while a bit value “0” of a particular bit indicates that a HARQ process is not employed. To be more specific, a bit map filed “0001100000000000” could indicate HARQ process #3 and HARQ process #4 (assuming HARQ process index starting from #0, and the lowest bit of the bit field is on the left of the bit field) are assigned for data transmission respectively in current data channel (e.g., PDSCH/PUSCH/PSSCH).

[0212] In some implementations of this application, the first information includes two bit strings, where a first bit string is used to indicate the first HARQ process and a second bit string is used to indicate the second HARQ process.

[0213] The first information can include two or more bit strings for indicating two or more HARQ processes. The first HARQ process and the second HARQ process are example in the implementation of this application. This application does not limit the number of the bit string.

[0214] Alternatively, two or more separate bit strings can be used to indicate two or more separate HARQ processes. For example, if total 16 HARQ process are supported. 4-bit bit strings can be used, and each value of the 4-bit bit strings indicates the

employed HARQ process. To be more specific, two 4-bit bit strings of “0010” and “0011” could indicate HARQ process #2 and HARQ process #3 are assigned for two data stream transmission respectively to schedule the data transmission in data channel (e.g., PDSCH/PUSCH/PSSCH).

[0215] Accordingly, the second device determines the first HARQ process according to a first bit string, and the second HARQ process according to a second bit string or according to some relationship pre-configured as described below.

[0216] The different HARQ processes used can be indirectly indicated.

[0217] As an alternative step of step 820, the base station transmits, accordingly the UE receives second information for indicating the first HARQ process, where the second HARQ process is determined according to the first HARQ process and a pre-configured mapping relationship between the first HARQ process and the second HARQ process.

[0218] For example, if the first HARQ process in a series of HARQ processes is indicated with HARQ process ID of “n”, the other HARQ processes assigned could be with HARQ process ID of n+1, n+2, …, so that other HARQ processes do not have to be explicitly indicated in DCI. That is to say the first HARQ process ID could be included in the second information and the second HARQ process can be determined according to the first HARQ process ID and the pre-configured mapping relationship. In other words, one of the series of HARQ processes is regarded as the reference one. Thus, other HARQ processes can be determined according to the reference one and the pre-configured mapping relationship or HARQ ID numbering relationship between the reference HARQ process and the other HARQ processes.

[0219] At step 850, the base station transmits, and accordingly the UE receives the first data transmission and the second data transmission on a PDSCH.

[0220] The specific explanation of step 850 can refer to the step 720, and it is not repeated here.

[0221] At step 860, the UE can decode the first data transmission and the second data transmission.

[0222] At step 870, the UE transmits, and accordingly the base station receives first HARQ feedback and second HARQ feedback, where the first HARQ feedback corresponds to the first HARQ process and the second HARQ feedback corresponds to the second HARQ process.

[0223] In some implementations of this application, different HARQ feedback can be carried in one control channel (e.g. PUCCH) or one data channel (e.g. PUSCH).

[0224] In some implementations of this application, different HARQ feedback can be carried in different control channels (e.g. PUCCH(s)) or different data channels (e.g. PUSCH(s)).

[0225] The following FIG.9 is just an example for different data with different HARQ processes scheduled in one data channel and transmitted in one control channel. And different HARQ feedback will be sent back in different channels.

[0226] FIG. 9 is a schematic flowchart of another communication method 900 according to an implementation of this application. FIG. 9 is communication method in an uplink scenario.

[0227] At step 910, the base station transmits, and accordingly the UE receives scheduling information for scheduling a first data transmission and a second data transmission.

[0228] The specific description of step 910can refer to step 710, and it is not repeated here.

[0229] At step 920, the base station transmits, and accordingly the UE receives first information for indicating the first HARQ process and the second HARQ process.

[0230] The specific description of step 920 can refer to step 830, and it is not repeated here.

[0231] Accordingly, at step 930, the UE determines the first HARQ process and the second HARQ process.

[0232] The specific description of step 930 can refer to step 840, and it is not repeated here.

[0233] At step 940, the UE generates first data and second data.

[0234] The first data and the second data are generated for different QoS(s) or different applications. For example, the first data is generated in TB#1 and the second data is generated in TB#2.

[0235] The execution sequence from steps 910 to 940 shown in FIG. 9 is just an example, and is not limited in this application. For example, the execution sequence of steps 910, 920, 930 and 940 may also be steps 940, 910, 920 and 930.

[0236] At step 950, the UE transmits, and accordingly the base station receives the first data transmission and the second data transmission on a PUSCH.

[0237] The specific explanation of step 950 can refer to step 720, and it is not repeated here.

[0238] At step 960, the base station can decode the first data transmission and the second data transmission.

[0239] Optionally, at step 970, the base station transmits, and accordingly the UE receives first HARQ feedback and second HARQ feedback, where the first HARQ feedback corresponds to the first HARQ process and the second HARQ feedback corresponds to the second HARQ process.

[0240] If the step is conducted, the specific explanation of step 970 can refer to step 870, and it is not repeated here.

[0241] If the step isn't conducted, the base station can schedule the further data re-transmission or new data transmission.

[0242] For a sidelink scenario, the first device may be a first UE, and the second device may be a second UE. The multiple HARQ processes corresponding to the different data transmission are executed between the first UE and the second UE. Therefore, steps 810, 850 and 860 can be conducted in both sides of the first UE and the second UE depending on which UE is transmitting and which UE is receiving. However, in the sidelink scenario, the first data transmission and the second data transmission are carried in a PSSCH. In addition, the first UE and the second UE may receive the first information from a base station. Or the first information can be pre-configured in the first UE and the second UE. Or the first UE and the second UE can negotiate the first information with each other.

[0243] FIG. 10 illustrates a scheme of data transmission with different QoS managed by different HARQ processes. As shown in FIG.10, for an example, two HARQ process are assigned to different data with different QoS. For different HARQ processes, their HARQ-ACK feedback timing could be different and their control channels (e.g., PUCCH(s)/PSCCH(s)) carrying HARQ-ACK feedback could be different (e.g., resources and formats). It should be noted that different HARQ-ACK feedback shown in FIG.10 are just examples, and whether the feedback in the HARQ process is HARQ acknowledgement (HARQ-ACK) or HARQ negative- acknowledgement (HARQ-NACK) is not limited in this implementation. In the example, data with QoS#0 are assigned with HARQ process #0 and its HARQ-ACK feedback latency is larger (e.g, it is eMBB traffic). In comparison, data with QoS#1 is assigned with HARQ process #1 and its HARQ-ACK feedback latency is shorter (e.g., it is URLLC traffic).

[0244] The multiplexing of data from different QoS into the same data channel (e.g., PDSCH/PUSCH/PSSCH) may not happen all the time. As shown in FIG. 10, for example, the multiplexing of data from different QoS only happen in some transmission instances (or transmission opportunity), while in other instances, maybe only data with the same QoS is scheduled and transmitted. It should be mentioned for some air interface, for example, for Uu uplink (UL), there may not be HARQ-ACK feedback for the UL PUSCH transmission, the network would instead directly schedule the re-transmission if PUSCH transmission fails. However, supporting multiple HARQ processes is still needed if data from different QoS are transmitted together in the same data channel (e.g., PUSCH/PSSCH).

[0245] In addition to HARQ process number indication, associated redundancy version (RV) should also be indicated for each HARQ process.

[0246] The first device transmits, and accordingly the second device receives third information for indicating first redundancy version associated with the first HARQ process, and second redundancy version associated with the second HARQ process.

[0247] For example, in control information (e.g., DCI (carried by PDCCH) or SCI (carried by PSCCH)), the following example of parameters could be included to indicate a HARQ process ID and the associated RV: HARQ process number (or ID) #0 and redundancy version for HARQ process #0; HARQ process number (or ID) #1 and redundancy version for HARQ process #1.

[0248] In some implementations, the third information may be included by the control information in a control channel.

For example, the control information may be DCI or SCI, and the control channel may be PDCCH or PSCCH.

[0249] In addition, the first device transmits, and accordingly the second device receives forth information for indicating a first mapping relationship, where the first mapping relationship includes a mapping relationship between the first HARQ process and one or more associated codewords for the first data transmission, and a mapping relationship between the second HARQ process and one or more codewords for the second data transmission.

[0250] It should be noted that the number of codeword is not limited here.

[0251] The mapping of CWs to different HARQ processes also need to be configured/indicated. FIG. 11 illustrates a scheme of a mapping between different CWs and associated HARQ processes. For example, if there are total 4 CWs shown in FIG. 11, the first one or more CW(s) could be configured for HARQ process#0 and the rest of CW(s) would be configured for HARQ process #1. As shown in FIG. 11, total of 4 CW, CW#0 and CW#1 are configured for HARQ process #0, while CW#2 and CW#3 are configured for HARQ process #1.

[0252] In some implementations, the forth information can be transmitted by a radio resource control RRC configuration.

[0253] Moreover, the first device transmits, and accordingly the second device receives fifth information for indicating a second mapping relationship, where the second mapping relationship includes a mapping relationship between the first HARQ process and one or more associated transmission layers, and a mapping relationship between the second HARQ process and one or more associated transmission layers.

[0254] In some implementations, the fifth information can be transmitted by radio resource control RRC configuration.

[0255] In addition, the first device transmits, and accordingly the second device receives sixth information for indicating a third mapping relationship, where the third mapping relationship includes a mapping relationship between one or more codewords for the first data transmission and one or more associated transmission layers, and a mapping relationship between one or more codewords for the second data transmission and one or more associated transmission layers.

[0256] It should be noted that the number of the transmission layer is not limited here.

[0257] In some implementations of this application, one or more of the first mapping relationship, a second mapping relationship and a third mapping relationship are based on the priority of first data transmission and the second data transmission.

[0258] As mentioned earlier, the CW(s) to transmission layer(s) mapping could also be configured/indicated and priority could be used to configure mapping different CW(s) to different transmission layer(s) to better support different data of different QoS. In general, the relation of following attributes could all be configured/indicated among CW-layer HARQ processes. FIG. 12 illustrates a scheme of a mapping between different CWs and associated transmission layers. For example, as shown in FIG. 12, for HARQ process #0, it could manage HARQ for CW#0 and #1, which are mapped to layer#0 and layer#1 respectively. While HARQ process #1 could manage HARQ for CW#2, CW#3, where CW# 2 is mapped to layer#2 and layer#3, and CW#3 is mapped to layers#4.

[0259] In some implementations, the sixth information can be transmitted by radio resource control RRC configuration.

[0260] In some implementations, the RRC configuration can include at least one of the forth information, the fifth information and the sixth information.

[0261] For example, if the UE receives any two of the forth information, the fifth information and the sixth information, the mapping relationship between different HARQ processes, codewords and transmission layers is determined.

[0262] In the RRC configuration, the relation can be configured between different HARQ processes, CWs and transmission layers. For example, for each HARQ process with {HARQ proc ID}, and it manages a number of CW(s) with {CW_index}, and for each CW {CW_index}, the transmission layers(s) {layer_index} it is mapped for transmission.

[0263] The description of multiple HARQ processes used in a single PDSCH/PUSCH can also be extended to sidelink transmission where multiple HARQ processes can be used to support data transmission scheduled by a PSCCH in a single PSSCH transmission on sidelink.

[0264] Moreover, the control channel (e.g., PUCCH/PSCCH) resources for each HARQ process could also be

configured/indicated.

[0265] The communication method proposed in the implementations of the present application is described in detail above, and a communication apparatus provided by the present application will be described below.

[0266] FIG. 13 is a schematic block diagram of a communication apparatus 1300 according to some implementations of the present application. The apparatus may be a communication device or an apparatus implemented in a communication device and capable of realizing corresponding functions of any one of the implementations of the present application. For example, the apparatus implemented in a communication device may be an integrated circuit, which in some contexts may be known by other colloquial names, such as chip, modem, modem chip, baseband chip, or baseband processor. In some implementations, one or more integrated circuits can be packaged into a system-on-chip, a system- in-package, or a multi-chip module. The apparatus may include one or more integrated circuits or include one or more integrated circuits and other discrete components. The communication device may be a signal transmitter, a signal receiver, or an apparatus implemented in any one of these communication devices.

[0267] The communication apparatus 1300 includes a communication module 1302. The communication module 1302 is configured to implement a transmitting action and/or a receiving action. The communication module 1302 also may be called as transceiver module, a transceiver, or a transceiver device, or the like, and is configured to implement operations of receiving (which may be referred to as inputting) and/or transmitting (which may be referred to as outputting).

[0268] The communication apparatus 1300 may further include a processing module 1301. The processing module 1301 may be a processor, a processing circuit, a processing board, a processing unit, or a processing device, or the like. The processing module 1301 is configured to implement processing and/or operations implemented inside the communication apparatus except transmitting actions and/or receiving actions.

[0269] For example, if the communication apparatus 1300 corresponds to the first device in FIG. 7, the communication module 1302 is configured to transmit scheduling information for scheduling a first data transmission and a second data transmission, where the first data transmission is assigned with a first hybrid automatic repeat request (HARQ) process, and the second data transmission is assigned with a second HARQ process. The communication module 1302 is further configured to communicate the first data transmission and the second data transmission on a data channel.

[0270] For example, if the communication apparatus 1300 corresponds to the second device in FIG. 7, the communication module 1302 is configured to receive scheduling information for scheduling a first data transmission and a second data transmission, where the first data transmission is assigned with a first hybrid automatic repeat request (HARQ) process, and the second data transmission is assigned with a second HARQ process. The communication module 1302 is further configured to communicate the first data transmission and the second data transmission on a data channel.

[0271] Briefly, the operations and/or functions of the communication apparatus 1300 are intended to implement corresponding steps of the foregoing method implementations.

[0272] FIG. 14 is a schematic block diagram of a communication apparatus according to some implementations of the present application. The communication apparatus 1400 includes at least one communication interface 1403, and the at least one communication interface 1403 is configured to input and/or output information or data. Optionally, the apparatus 140 may further include at least one processor 1401. The at least one processor 1401 is coupled to at least one memory 1402. The at least one memory 1402 is configured to store one or more instructions and/or executable computer code. The at least one processor 1401 is configured to invoke the one or more instructions and/or executable computer code, so that the communication apparatus 1400 implements the method provided in the implementations of the present application. Optionally, the apparatus 1400 may further include the at least one memory 1402.

[0273] In an implementation, the communication apparatus 1400 may be any one of the communication devices in the method implementations. For example, the communication apparatus 1400 may be the first device (for example, a base station) or the second device (for example, a UE). In this implementation, the processor 1401 may be a baseband apparatus, and the communication interface 1403 may be a radio frequency apparatus.

[0274] In another implementation, the communication apparatus 1400 may be implemented in a communication device

such as the transmitter sensing node and the receiver sensing node. In this case, the apparatus may be an integrated circuit, which in some contexts may be known by other colloquial names, such as chip, modem, modem chip, baseband chip, or baseband processor. In some implementations, one or more integrated circuits can be packaged into a system-on-chip, a system-in-package, or a multi-chip module. The apparatus may include one or more integrated circuits or include one or more integrated circuits and other discrete components. In this implementation, the processor 1401 may be a logical module or circuit that is part of the integrated circuit. The communication interface 1403 may be a transceiver, an interface circuit, an input/output interface, a bus, a module, a pin, or other types of interfaces.

[0275] An implementation of the present application further provides a communication system. The communication system may include the first device and the second device introduced in the above implementations. For example, as shown in FIG. 8 or FIG. 9, the communication system may include a base station and a UE.

[0276] An implementation of the present application further provides a computer storage medium, and the computer storage medium may store one or more instructions for executing any of the foregoing methods.

[0277] An implementation of the present application further provides a computer program product, and the computer program product may store one or more instructions for executing any of the foregoing methods.

[0278] In the implementations of this application, "and/or" describes an association relationship between associated objects and represents that three relationships may exist. For example, A and/or B may represent the following three cases: Only A exists, both A and B exist, and only B exists. The character "/" generally indicates an "or" relationship between the associated objects. "At least one" means one or more. "At least one of A and B", similar to "A and/or B", describes an association relationship between associated objects and represents that three relationships may exist. For example, at least one of A and B may represent the following three cases: Only A exists, both A and B exist, and only B exists.

[0279] Besides, the use of a singular form of "a", "an" and "the" in the implementations of the present application and the claims appended hereto is also intended to include a plural form, unless otherwise clearly indicated herein by context.

[0280] A person of ordinary skill in the art will be aware that, in combination with the examples described in the implementations disclosed in this specification, units and algorithm steps may be implemented by using electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by using hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of this application.

[0281] It would be understood by a person skilled in the art that, for the purpose of convenience and brevity, in a detailed working process of the foregoing system, apparatus, and unit, reference may be made to a corresponding process in the foregoing method implementations, and details are not described herein again.

[0282] In the several implementations provided in this application, the disclosed system, apparatus, and method may be implemented in other manners. For example, the described apparatus implementation is merely an example. For example, the unit division is a logical function division and other methods of division may be used in an actual implementation. For example, a plurality of units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented using various communication interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

[0283] In addition, function units in the implementations of this application may be integrated into one processing unit, each of the units may exist alone physically, or two or more units may be integrated into one unit.

[0284] When the functions are implemented in the form of a software functional unit and sold or used as an independent product, the functions may be stored in a computer-readable storage medium. The technical solutions of this application may be implemented in the form of a software product. The software product is stored in a storage medium, and includes several instructions for instructing a computer device (which may be a personal computer, a server, a network device, or the like) to perform

all or some of the steps of the methods described in the implementations of this application. The foregoing storage medium includes any medium that can store program code, such as a USB flash drive, a removable hard disk, a ROM, a RAM, a magnetic disk, an optical disc or the like.

[0285] The units described as separate parts may be or may not be physically separate, and parts displayed as units may be or may not be physical units, may be located in one position, or may be distributed on a plurality of network units. Some or all of the units may be selected based on actual requirements to achieve the objectives of the solutions of the implementations. In addition, functional units in the implementations of this application may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units are integrated into one unit.

[0286] The foregoing descriptions are merely specific implementations of this application, but are not intended to limit the protection scope of this application. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in this application shall fall within the protection scope of this application. Therefore, the protection scope of this application shall be subject to the protection scope of the claims.

CLAIMS

What is claimed is:

1. A communication method, comprising:

transmitting scheduling information for scheduling a first data transmission and a second data transmission;

wherein the first data transmission is assigned with a first hybrid automatic repeat request (HARQ) process, and the second data transmission is assigned with a second HARQ process; and

communicating the first data transmission and the second data transmission on a data channel.

2. The method according to claim 1, wherein both the first data transmission and the second data transmission are transmitted on one of uplink (UL), downlink (DL) and sidelink (SL).

3. The method according to claim 1 or 2, wherein the first data transmission and the second data transmission are with different quality of service (QoS).

4. The method according to anyone of claims 1 to 3, the method further comprising:

transmitting first information for indicating the first HARQ process, and the second HARQ process.

5. The method according to claim 4, wherein the first information comprises a bit map, wherein a first bit in the bit map is for indicating the first HARQ process and a second bit in the bit map is for indicating the second HARQ process.

6. The method according to claim 4, wherein the first information comprises two bit strings, wherein a first bit string is for indicating the first HARQ process and a second bit string is for indicating the second HARQ process.

7. The method according to anyone of claims 1 to 3, the method further comprising:

transmitting second information for indicating the first HARQ process; wherein the second HARQ process is determined according to the first HARQ process and a pre-configured mapping relationship between the first HARQ process and the second HARQ process.

8. The method according to anyone of claims 1 to 7, the method further comprising:

transmitting third information for indicating first redundancy version associated with the first HARQ process, and second redundancy version associated with the second HARQ process.

9. The method according to anyone of claims 4 to 8, wherein one or more of the first information, the second information and the third information are carried on a control channel scheduling the data channel.

10. The method according to anyone of claims 1 to 9, the method further comprising:

transmitting forth information for indicating a first mapping relationship, wherein the first mapping relation comprises a mapping relationship between the first HARQ process and one or more associated codewords for the first data transmission, and a mapping relationship between the second HARQ process and one or more associated codewords for the second data transmission.

11. The method according to anyone of claims 1 to 9, the method further comprising:

transmitting fifth information for indicating a second mapping relationship, wherein the second mapping relationship comprises a mapping relationship between the first HARQ process and one or more associated transmission layers, and a mapping relationship between the second HARQ process and one or more associated transmission layers.

12. The method according to anyone of claims1 to 9, the method further comprising:

transmitting sixth information for indicating a third mapping relationship, wherein the third relationship comprises a mapping relationship between one or more codewords for the first data transmission and one or more associated transmission layers, and a mapping relationship between one or more codewords for the second data transmission and one or more associated transmission layers.

13. The method according to anyone of claims 10 to 12, wherein radio resource control (RRC) message comprises at least one of the forth information, the fifth information and the sixth information.

14. A communication method, comprising:

receiving scheduling information for scheduling a first data transmission and a second data transmission,

wherein the first data transmission is assigned with a first hybrid automatic repeat request HARQ process, and the second data

transmission is assigned with a second HARQ process;

communicating the first data transmission and the second data transmission on a data channel.

15. The method according to claim 14, wherein both the first data transmission and the second data transmission are transmitted on one of uplink (UL), downlink (DL) and sidelink (SL).

16. The method according to claim 14 or 15, wherein the first data transmission and the second data transmission are with different quality of service QoS.

17. The method according to anyone of claims 14 to 16, the method further comprising:

receiving first information for indicating the first HARQ process, and the second HARQ process.

18. The method according to claim 17, wherein the first information contains a bit map, the method further comprising:

determining the first HARQ process according to a first bit in the bit map, and the second HARQ process according to a second bit in the bit map.

19. The method according to claim 17, wherein the first information contains two bit strings, the method further comprising:

determining the first HARQ process according to a first bit string, and the second HARQ process according to a second bit string.

20. The method according to anyone of claims 14 to 19, the method further comprising:

receiving second information for indicating the first HARQ process;

determining the first HARQ process according to the second information; and,

determining the second HARQ process according to the first HARQ process and a pre-configured mapping relationship between the first HARQ process and the second HARQ process.

21. The method according to anyone of claims 14 to 20, the method further comprising:

receiving third information for indicating first redundancy version associated with the first HARQ process, and second redundancy version associated with the second HARQ process.

22. The method according to anyone of claims 17 to 21, wherein one or more of the first information, the second information and the third information are carried on a control channel scheduling the data channel.

23. The method according to anyone of claims 14 to 22, the method further comprising:

receiving forth information for indicating a first mapping relationship, wherein the first mapping relationship comprises a mapping relationship between the first HARQ process and one or more associated codewords for the first data transmission, and a mapping relationship between the second HARQ process and one or more associated codewords for the second data transmission.

24. The method according to anyone of claims 14 to 22, the method further comprising:

receiving fifth information for indicating a second mapping relationship, wherein the second mapping relationship comprises a mapping relationship between the first HARQ process and one or more associated transmission layers, and a mapping relationship between the second HARQ process and one or more associated transmission layers.

25. The method according to anyone of claims 14 to 22, the method further comprising:

receiving sixth information for indicating a third mapping relationship, wherein the third mapping relationship comprises a mapping relationship between one or more codewords for the first data transmission and one or more associated transmission layers, and a mapping relationship between one or more codewords for the second data transmission and one or more associated transmission layers.

26. The method according to anyone of claims 23 to 25, wherein radio resource control RRC configuration comprises at least one of the fourth information, the fifth information and the six information.

27. A communication apparatus, configured to perform the method according to any one of claims 1 to 13 or 14 to 26.

28. An apparatus comprising:

one or more processors; and

a memory storing instructions which, when executed by the one or more processors, cause the apparatus to perform the method of any one of claims 1 to 13 or 14 to 26.

29. A computer-readable storage medium having instructions stored thereon which, when executed by an apparatus, cause the apparatus to perform the method of any one of 1 to 13 or 14 to 26.