

DATA TRANSMISSION METHOD AND DEVICE, COMPUTER PROGRAM AND STORAGE MEDIUM

TECHNICAL FIELD

[0001] The disclosure relates to the field of mobile communications technologies, and more particularly to a data transmission method and apparatus, a computer program, and a storage medium.

BACKGROUND

[0002] After several years of version evolution of wireless communication technologies, and with the increase of users' requirements, wireless communication technologies have evolved from the earliest 2G (second Generation) through 3G and 4G to the latest 5G gradually. Major improvements in 5G are made in aspects such as data transmission rate, coverage, delay and capacity.

[0003] Since entry into the 5G stage, it becomes important to satisfy the service requirement of providing flexible service configurations for various services including broadband connection, Internet of Things, Internet of Vehicles, wide area coverage and the like. Current service types of 5G include multiple types such as Enhanced Mobile Broad Band (eMBB), massive Machine Type Transmission (mMTC), and Ultra Reliable Low Latency Communication (URLLC).

[0004] For a URLLC service, an ultra low delay is a design objective for a system. This requires the system to allocate a relatively large bandwidth to a user to perform transmission within a time period as short as possible, and to return an acknowledgement (ACK)/a negative acknowledgement (NACK) feedback within a shortest time period.

SUMMARY

[0005] To resolve the problem in related art, the disclosure provides a data transmission method and apparatus, a computer program, and a storage medium as follows:

[0006] According to a first aspect of embodiments of the disclosure, a data

transmission method is provided. The method includes: determining configuration information of at least one flexible sub-frame included in a Time Division Duplex (TDD) radio frame, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; delivering the determined configuration information of the at least one flexible sub-frame to a user equipment (UE) by using signaling; and according to the determined configuration information of the at least one flexible sub-frame, receiving uplink data in the time slot of the uplink transmission symbol and sending downlink data in the time slot of the downlink transmission symbol.

[0007] In an embodiment, the flexible sub-frame may be configured to further include a Guard Period (GP). The GP may be located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0008] In an embodiment, the GP may be configured to be located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol. Alternatively, the GP may be configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0009] In an embodiment, determining configuration information of at least one flexible sub-frame included in a TDD radio frame may include: for each flexible sub-frame, determining a location and a time length of a sub-timeslot that is occupied by each uplink transmission symbol and a location and a time length of a sub-timeslot that is occupied by each downlink transmission symbol; and when the flexible sub-frame is configured to further include a GP, determining a location and a time length of a sub-timeslot that is occupied by the GP.

[0010] In an embodiment, the at least one flexible sub-frame may include a dynamically configured flexible sub-frame. Determining configuration information of the

dynamically configured flexible sub-frame may include: periodically determining a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

[0011] In an embodiment, the at least one flexible sub-frame may include a semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame may include a fixedly configured timeslot and a flexibly configured timeslot. Determining configuration information of the semi-dynamically configured flexible sub-frame may include: at a first predetermined periodicity, determining a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame; and at a second predetermined periodicity, determining a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame. The first predetermined periodicity may be larger than the second predetermined periodicity.

[0012] In an embodiment, the signaling may include: broadcast signaling, Radio Resource Control (RRC) signaling, and physical layer signaling.

[0013] According to a second aspect of embodiments of the disclosure, another data transmission method is provided. The method includes: receiving, from a base station, configuration information of at least one flexible sub-frame included in a TDD radio frame, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; and according to the configuration information of the at least one flexible sub-frame included in the TDD radio frame, sending uplink data in the time slot of the uplink transmission symbol, and receiving downlink data in the time slot of the downlink transmission symbol.

[0014] In an embodiment, the flexible sub-frame may be configured to further include a GP. The GP may be located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0015] In an embodiment, the GP may be configured to be located between a

downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol. Alternatively, the GP may be configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0016] In an embodiment, the at least one flexible sub-frame may include at least one dynamically configured flexible sub-frame. Receiving configuration information of at least one flexible sub-frame included in a TDD radio frame from a base station may include: periodically receiving, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame. A location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame are periodically and dynamically configured.

[0017] In an embodiment, the at least one flexible sub-frame may include at least one semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame may include a fixedly configured timeslot and a flexibly configured timeslot. Receiving configuration information of at least one flexible sub-frame included in a TDD radio frame from a base station may include: at a first predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame; and at a second predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each flexibly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame. The first predetermined periodicity may be larger than the second predetermined periodicity.

[0018] According to a third aspect of embodiments of the disclosure, a data transmission apparatus is provided. The apparatus includes: a determining module configured to determine configuration information of at least one flexible sub-frame included in a TDD radio frame, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots

occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; a sending module configured to deliver the determined configuration information of the at least one flexible sub-frame to a UE by using signaling; and a transmission module configured to, according to the determined configuration information of the at least one flexible sub-frame, receive uplink data in the time slot of the uplink transmission symbol and send downlink data in the time slot of the downlink transmission symbol.

[0019] In an embodiment, the determining module may include: a first determining sub-module configured to determine configuration information of a GP in the flexible sub-frame. The GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0020] In an embodiment, the first determining sub-module may be configured to determine that the GP is located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or that the GP is located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0021] In an embodiment, the determining module may further include: a second determining sub-module. The second determining sub-module is configured to: for each flexible sub-frame, determine a location and a time length of a sub-timeslot that is occupied by each uplink transmission symbol and a location and a time length of a sub-timeslot that is occupied by each downlink transmission symbol. The first determining sub-module is configured to: when the flexible sub-frame is configured to further include a GP, determine a location and a time length of a sub-timeslot that is occupied by the GP.

[0022] In an embodiment, the at least one flexible sub-frame may include a dynamically configured flexible sub-frame. The determining module is configured to periodically determine a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

[0023] In an embodiment, the at least one flexible sub-frame may include a semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame may include a fixedly configured timeslot and a flexibly configured timeslot. The determining module may be configured to: at a first predetermined periodicity, determine a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame; and at a second predetermined periodicity, determine a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame. The first predetermined periodicity may be larger than the second predetermined periodicity.

[0024] In an embodiment, the signaling may include: broadcast signaling, RRC signaling, and physical layer signaling.

[0025] According to a fourth aspect of an embodiment of the disclosure, another data transmission apparatus is provided. The apparatus includes: a receiving module configured to receive, from a base station, configuration information of at least one flexible sub-frame included in a TDD radio frame, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; and a transmission module configured to, according to the configuration information of the at least one flexible sub-frame included in the TDD radio frame, send uplink data in the time slot of the uplink transmission symbol and receive downlink data in the time slot of the downlink transmission symbol.

[0026] In an embodiment, the receiving module may be configured to receive configuration information of a GP in the flexible sub-frame, where the GP may be located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0027] In an embodiment, the receiving module may be further configured to receive the configuration information of the GP in the flexible sub-frame, indicating one of the following: the GP is located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is

transformed to the uplink transmission symbol; or the GP is located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0028] In an embodiment, the at least one flexible sub-frame may include at least one dynamically configured flexible sub-frame. The receiving module may be configured to periodically receive, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame. A location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame may be periodically and dynamically configured.

[0029] In an embodiment, the at least one flexible sub-frame may include at least one semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame may include a fixedly configured timeslot and a flexibly configured timeslot. The receiving module may be configured to: at a first predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame; and at a second predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each flexibly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame. The first predetermined periodicity may be larger than the second predetermined periodicity.

[0030] According to a fifth aspect of an embodiment of the disclosure, a data transmission apparatus is provided. The apparatus includes: a processor; and a memory configured to store instructions executable by the processor. The processor is configured to perform the data transmission method provided in the first aspect.

[0031] According to a sixth aspect of an embodiment of the disclosure, a storage medium having a computer program recorded thereon is provided. The program includes instructions for performing the data transmission method in the first aspect of the embodiment of the disclosure.

[0032] According to a seventh aspect of an embodiment of the disclosure, a computer

program is provided. The program includes instructions for performing the data transmission method in the first aspect of the embodiment of the disclosure when the computer program is executed by a computer.

[0033] According to an eighth aspect of an embodiment of the disclosure, a data transmission apparatus is provided. The apparatus includes: a processor; and a memory configured to store instructions executable by the processor. The processor is configured to perform the data transmission method provided in the second aspect.

[0034] According to a ninth aspect of an embodiment of the disclosure, a storage medium having a computer program recorded thereon is provided. The program includes instructions for performing the data transmission method of the second aspect of the embodiment of the disclosure.

[0035] According to a tenth aspect of an embodiment of the disclosure, a computer program is provided. The program includes instructions for performing the data transmission method of the second aspect of the embodiment of the disclosure when the computer program is executed by a computer.

[0036] The technical solutions provided in the embodiments of the disclosure may have the following beneficial effects.

[0037] With the data transmission method and apparatus, the computer program, and the storage medium provided in the embodiments of the disclosure, configuration information of at least one flexible sub-frame included in a TDD radio frame is first determined, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; the determined configuration information of the at least one sub-frame is then sent to a UE by using signaling; and uplink data and downlink data are then transmitted according to the configuration information of the flexible sub-frame. In contrary to a sub-frame configuration solution of a TDD radio frame in related art in which one sub-frame (uplink sub-frame or downlink sub-frame) includes only a same type of transmission symbols (an uplink sub-frame includes only an uplink transmission symbol, and a downlink sub-frame includes only a

downlink transmission symbol), configuration of uplink and downlink transmission symbols may be implemented in the same sub-frame, so that feedback of an acknowledgement message such as an ACK/a NACK from a UE can be rapidly performed, and a transmission latency is reduced desirably.

[0038] In this embodiment of the disclosure, the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol. Thus, a GP may be set very flexibly. Moreover, on one hand, setting a GP which is located at transition from downlink to uplink serves to avoid interference with an uplink signal from a downlink signal; on the other hand, due to presence of the GP, when multiple UEs exist, synchronization between the UEs can be ensured, thereby avoiding a blockage during data transmission, and improving the efficiency of data transmission.

[0039] In another aspect, in the data transmission method provided in the embodiments of the disclosure, a flexible sub-frame may be configured fully dynamically or configured semi-dynamically, so that configuration of a TDD sub-frame becomes more flexible, and reconfiguration may be performed according to factors such as service type, network coverage, network capacity, and network interference, thereby fully meeting a requirement of an uplink-downlink asymmetric TDD service.

[0040] Moreover, compared with a dynamically configured flexible sub-frame, a structure of a semi-dynamically configured flexible sub-frame can facilitate saving overheads of control signaling during data transmission, and facilitate determining which symbols may cause interference during interference cancellation.

[0041] It should be understood that the foregoing general description and the following detailed description are merely exemplary, and cannot cause any limitation to the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments consistent with the disclosure and, together with the description, serve to explain the principles of the disclosure.

[0043] Fig. 1 is a flowchart of a data transmission method according to an exemplary embodiment.

[0044] Fig. 2 is a schematic structural diagram of a TDD radio frame in related art.

[0045] Fig. 3 is a schematic structural diagram of two conventional sub-frames in a TDD radio frame in related art.

[0046] Fig. 4 is a schematic structural diagram of an example of a TDD radio frame according to an exemplary embodiment.

[0047] Fig. 5A and Fig. 5B are schematic structural diagrams of examples of a flexible sub-frame according to an exemplary embodiment.

[0048] Fig. 6 is a flowchart of determining configuration information of a semi-dynamically configured flexible sub-frame according to an exemplary embodiment.

[0049] Fig. 7 is a flowchart of another data transmission method according to an exemplary embodiment.

[0050] Fig. 8 is a block diagram of a data transmission apparatus according to an exemplary embodiment.

[0051] Fig. 9 is a block diagram of a determining module according to an exemplary embodiment.

[0052] Fig. 10 is a block diagram of another data transmission apparatus according to an exemplary embodiment.

[0053] Fig. 11 is a block diagram of an apparatus applicable to data transmission according to an exemplary embodiment.

DETAILED DESCRIPTION

[0054] Reference will now be made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings. The following description refers to the

accompanying drawings in which the same numbers in different drawings represent the same or similar elements unless otherwise represented. The implementations set forth in the following description of exemplary embodiments do not represent all implementations consistent with the disclosure. Instead, they are merely examples of apparatuses and methods consistent with aspects related to the disclosure as recited in the appended claims.

[0055] The following description of at least one exemplary embodiment is actually merely descriptive, and should not be construed as any limitation to the disclosure and application or use of the disclosure.

[0056] Technologies, methods, and devices known to a person skilled in the art may be not discussed in detail. However, where appropriate, such technologies, methods, and devices should be considered as a part of the specification.

[0057] In all the examples shown and discussed here, any specific value should be construed as merely illustrative rather than limiting. Therefore, a different value may be used in another example of an exemplary embodiment.

[0058] It should be noted that similar reference numerals and letters represent similar items in the accompanying drawings. Therefore, once an item is defined in one accompanying drawing, the item does not need to be further discussed in the following accompanying drawings.

[0059] A data transmission method provided in the embodiments of the disclosure involves two ends of wireless transmission, which are a base station (for example, a NodeB) and a UE. The base station and the UE communicate with each other in a Time Division Duplexing (TDD) manner. The base station and the UE may transmit uplink data and downlink data in different uplink timeslots and downlink timeslots.

[0060] An embodiment of the disclosure provides a data transmission method. Referring to Fig. 1, the method implemented on a base station side includes the following steps.

[0061] In Step S101, configuration information of at least one flexible sub-frame included in a TDD radio frame is determined. The flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and

sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured.

[0062] In Step S102, the determined configuration information of the at least one flexible sub-frame is delivered to a UE by using signaling.

[0063] In Step S103, uplink data is received in the time slot of the uplink transmission symbol and downlink data is sent in the time slot of the downlink transmission symbol, according to the determined configuration information of the at least one flexible sub-frame.

[0064] In the foregoing data transmission method provided in this embodiment of the disclosure, at least one flexible sub-frame included in a TDD radio frame used for transmission is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured. In contrary to a sub-frame configuration solution of a TDD radio frame in related art in which one sub-frame (uplink sub-frame or downlink sub-frame) includes only a same type of transmission symbols (an uplink sub-frame includes only uplink transmission symbols, and a downlink sub-frame includes only downlink transmission symbols), such a flexible sub-frame enables configuration of uplink and downlink transmission symbols in a same sub-frame, so that feedback of an acknowledgement message from a UE can be rapidly performed, a transmission latency is reduced, and at the same time the number of UEs that can be connected can be increased by several times.

[0065] In an embodiment, in Step S101, the determined structure of the flexible sub-frame may include one or more uplink transmission symbols and one or more downlink transmission symbols, and sub-timeslots occupied by all uplink transmission symbols and downlink transmission symbols are disposed alternately with each other. A flexible sub-frame is a new sub-frame that is different from a TDD sub-frame in related art, and internally includes alternately disposed sub-timeslots that are occupied by the uplink transmission symbols and the downlink transmission symbols.

[0066] To better illustrate the data transmission method provided in this embodiment of the disclosure, a structure of a TDD radio frame in related art is first briefly described

below.

[0067] In related art, a TDD mode refers to a mode in which a same working frequency band is used for uplink and downlink, and an uplink signal and a downlink signal are transmitted at different time periods. Referring to Fig. 2 which illustrates a frame structure of a radio frame in a TDD system, one radio frame has a length of 10 ms, and includes ten sub-frames in total which are classified into two types, that is, special sub-frame and conventional sub-frame. Each sub-frame has a length of 1 ms. The conventional sub-frame includes an uplink sub-frame (represented by using the letter U) and a downlink sub-frame (represented by using the letter D). The special sub-frame (represented by using the letter S) includes three timeslots, that is, a Downlink Pilot Timeslot (DwPTS), a GP, and an Uplink Pilot Timeslot (UpPTS). The uplink sub-frame and the downlink sub-frame are used to transmit uplink and downlink control signaling and service data. Fig. 2 shows seven possible sub-frame ratio schemes.

[0068] In related art, as shown in Fig. 3, one uplink sub-frame or one downlink sub-frame includes only a same type of symbols. For example, a downlink sub-frame in Fig. 3 includes only downlink transmission symbols (represented by the number 1), and an uplink sub-frame in Fig. 3 includes only uplink transmission symbols (represented by the number 0). Because one uplink sub-frame or downlink sub-frame lasts 1 ms according to the structure of the TDD radio frame in related art, a NodeB may wait longer than several milliseconds for a UE to report an ACK message/a NACK message in case the UE reports the ACK message/the NACK message and the NodeB determines, according to the message, a time and a manner of retransmitting data. Taking an example where the second configuration D/D/D/S/U in Fig. 2 is used for performing data transmission (that is, one uplink sub-frame is configured for three downlink sub-frames), the NodeB needs to send three downlink sub-frames in the downlink and wait one timeslot before the NodeB may receive one uplink sub-frame, so that the latency is longer than 4 ms. Therefore, URLLC's requirement for a delay less than 1 ms cannot be met in related art.

[0069] To resolve the foregoing problem and reduce a transmission delay, in the foregoing data transmission method provided in this embodiment of the disclosure, the

structures of the uplink sub-frame and the downlink sub-frame in related art are improved. Configuration of sub-timeslots corresponding to uplink and downlink transmission symbols can be flexibly implemented in one sub-frame. As a result, the UE may perform feedback of an ACK message/a NACK message within a relatively short time (at least shorter than 1 ms), thereby greatly reducing a transmission latency.

[0070] The base station may set locations and lengths of uplink and downlink transmission symbols in a flexible sub-frame of a TDD radio frame, according to service, network capacity, interference and the like. A preset length, for example, 1 ms, can be kept unchanged for a total length of the flexible sub-frame.

[0071] In a specific implementation, all or some of conventional sub-frames (including uplink and downlink sub-frames) in a TDD radio frame in related art may be replaced with the structure of the flexible sub-frame provided in this embodiment of the disclosure. The structure of the special sub-frame in the related art may be kept unchanged. For example, the structure of the sub-frame D or U in Fig. 2 (each sub-frame includes a same type of transmission symbols) continues to be used for some sub-frames, and the structure of the flexible sub-frame provided in this embodiment of the disclosure is used for other sub-frames; or the structures of all conventional sub-frames in the TDD radio frame are replaced with the structure of the flexible sub-frame provided in this embodiment of the disclosure.

[0072] For example, if the second configuration shown in Fig. 2 is used, the foregoing sub-frame structure provided in this embodiment of the disclosure may be used for all the eight sub-frames at the locations U and D, and the structures of the eight sub-frames may be the same or different. Alternatively, as shown in Fig. 4, five of the eight sub-frames have the structure of the flexible sub-frame, and the structures of the rest sub-frames are the same as those in related art.

[0073] In a possible implementation of an exemplary embodiment of the disclosure, determining configuration information of a flexible sub-frame in a TDD radio frame in Step 101 may further include: setting a GP in the flexible sub-frame. The GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink

transmission symbol is transformed to the uplink transmission symbol.

[0074] In an embodiment, for a same flexible sub-frame, a GP may be further set between a downlink transmission symbol and an adjacent uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0075] In a same sub-frame, when a transition from a downlink transmission symbol to an uplink transmission symbol (the uplink transmission symbol immediately follows the downlink transmission symbol) occurs according to a chronological order, it is required to set a GP between the downlink transmission symbol and the uplink transmission symbol that immediately follows the downlink transmission symbol. On one hand, the GP located when the downlink transmission symbol is transformed to the uplink transmission symbol serves to prevent interference with an uplink signal from a downlink signal; on the other hand, due to presence of the GP, when multiple UEs exist, synchronization between the UEs can be ensured, thereby avoiding a blockage during data transmission, and improving the efficiency of data transmission.

[0076] For a structure of a TDD radio frame provided in this embodiment of the disclosure, a structure of a flexible sub-frame enables alternate transition between uplink and downlink, as long as a GP is set at transition from a downlink transmission symbol to an uplink transmission symbol. Locations and lengths of an uplink transmission symbol, a downlink transmission symbol, and a GP in each flexible sub-frame are not limited in this embodiment of the disclosure, and may be determined in a comprehensive manner according to service requirements, network coverage, capacity, interference and the like.

[0077] A structure of an exemplary flexible sub-frame is shown in Fig. 5A. In the example shown in Fig. 5A, the flexible sub-frame includes three GPs, which are respectively located at transitions from three downlink sub-frames into their respective uplink sub-frames.

[0078] In another embodiment, the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0079] For example, in a possible implementation of an exemplary embodiment of the

disclosure, when a downlink transmission symbol exists at the tail of a previous sub-frame of a current flexible sub-frame (the previous sub-frame may be a conventional downlink sub-frame in related art or a flexible sub-frame in this embodiment of the disclosure) and an uplink transmission symbol exists at the head of the current flexible sub-frame, a GP may be set before the uplink transmission symbol at the head of the current flexible sub-frame.

[0080] In this embodiment of the disclosure, in addition to considering setting a GP between transmission symbols in a same flexible sub-frame, it is further required to consider setting a GP between a flexible sub-frame and a flexible sub-frame and setting a GP between a flexible sub-frame and a conventional sub-frame in related art. In this case, if a previous sub-frame is a downlink sub-frame in related art (all symbols are downlink transmission symbols) or if a transmission symbol at the tail of a previous sub-frame is a downlink transmission symbol, it is required to set a GP at the head of a current flexible sub-frame, that is, before an uplink transmission symbol that appears for the first time.

[0081] A structure of an exemplary flexible sub-frame is shown in Fig. 5B. In the example shown in Fig. 5B, a GP exists at the head of a flexible sub-frame, and in addition, two GPs are further included. The case is similar to that in Fig. 5A, and is no longer described here.

[0082] In the data transmission method provided in this embodiment of the disclosure, a structure of the determined flexible sub-frame is not limited to the two structures in Fig. 5A and Fig. 5B, and various forms may be used as long as the configuration principle is met. The structure is not limited in this embodiment of the disclosure.

[0083] Different GPs in a same flexible sub-frame may have the same length or may have different lengths. This is determined according to lengths of uplink and downlink transmission symbols.

[0084] In an embodiment, the at least one flexible sub-frame may include at least one dynamically configured flexible sub-frame. Correspondingly, Step S101 may be implemented as: periodically determining a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

[0085] A dynamically configured flexible sub-frame means that each part of the

flexible sub-frame may be configured and reconfigured at various periodicities.

[0086] For a dynamically configured flexible sub-frame, within various periods, locations, lengths, and ratios of uplink transmission symbols, downlink transmission symbols, and GPs in the flexible sub-frame can be completely changed at various periodicities. The lengths, locations, and ratios of all the uplink transmission symbols, downlink transmission symbols, and GPs can be dynamically changed.

[0087] In an embodiment, the at least one flexible sub-frame may include a semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame includes a fixedly configured timeslot and a flexibly configured timeslot. Correspondingly, as shown in Fig. 6, Step S101 may be implemented as follows.

[0088] In Step S601, a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame are determined at a first predetermined periodicity.

[0089] In Step S602, a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame are determined at a second predetermined periodicity.

[0090] The first predetermined periodicity is larger than the second predetermined periodicity.

[0091] A fixedly configured timeslot and a flexibly configured timeslot have different configuration periodicities. Correspondingly, in Step S102, after a location, occupation information, and a time length of each fixedly configured timeslot are determined, it is required to send information about locations, occupation information, and time lengths of these fixedly configured timeslots to the UE by using preset signaling. Similarly, after a location, occupation information, and a time length of each flexibly configured timeslot are determined, it is required to send information about locations, occupation information, and time lengths of these fixedly configured timeslots to the UE by using preset signaling.

[0092] In an extreme example, a configuration periodicity of a fixedly configured timeslot may be infinitely large. Thus, it is only needed to configure once the fixedly configured timeslot which no longer changes thereafter, but to keep changing the flexibly

configured timeslot at a relatively short periodicity.

[0093] In Step S102, there may be multiple types of preset signaling. For example, the preset signaling may be any one of the following signaling: broadcast signaling, RRC signaling, and physical layer signaling. Certainly, this embodiment of the disclosure is not limited to the several types of signaling in the foregoing.

[0094] The periodicity length may be determined according to a periodicity of used signaling. For example, a periodicity configured for broadcast signaling is relatively long, and is approximately 640 ms. A periodicity configured for RRC signaling is moderate, and is approximately about 100 ms to 200 ms. A periodicity configured for physical layer signaling may be the shortest, and may be 10 ms or even shorter.

[0095] In Steps S601 and S602, at a relatively short periodicity, a location, occupation information, and a time length of a non-fixedly configured timeslot in a flexible sub-frame are changed through configuration. At these periodic times, it is possible to change a structure of only a non-fixedly configured timeslot in the flexible sub-frame, and it is only needed to send the structure information of the changed part to the UE. A location, occupation information, and a time length of a fixedly configured timeslot in a flexible sub-frame are changed only at a relatively long periodicity. Compared with a dynamically configured flexible sub-frame, such a data transmission manner may save overheads of control signaling to a certain degree, and facilitate finding out which symbols may potentially cause interference in an interference cancellation process. However, the flexibility is relatively low.

[0096] The first predetermined periodicity is larger than the second predetermined periodicity. As a result, the signaling used in Step S601 and the signaling used in Step S602 usually have different periodicities. For example, if broadcast signaling is used to send structure information of a fixedly configured timeslot part in a flexible sub-frame, reconfiguration takes place only about every 640 ms. For a non-fixedly configured timeslot part in the flexible sub-frame, signaling having a relatively short periodicity is used to perform configuration. For example, when physical layer signaling is used, configuration may take place every 10 ms or even shorter. The configuration of the non-fixedly configured timeslot part needs shorter-periodicity signaling. Generally speaking, the semi-dynamically

configured flexible sub-frame saves more signaling overheads compared with the dynamically configured flexible sub-frame.

[0097] An embodiment of the disclosure provides another data transmission method. Referring to Fig. 7, the method, implemented on a UE side, includes the following steps.

[0098] In Step S701, configuration information of at least one flexible sub-frame included in a TDD radio frame is received from a base station. The flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured.

[0099] In Step S702, uplink data is sent in the time slot of the uplink transmission symbol and downlink data is received in the time slot of the downlink transmission symbol, according to the configuration information of the at least one flexible sub-frame included in the TDD radio frame.

[0100] In the foregoing data transmission method provided in this embodiment of the disclosure, a UE receives configuration information of a flexible sub-frame included in a TDD radio frame from a base station. The flexible sub-frame includes at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured. In contrary to a sub-frame configuration solution of a TDD radio frame in related art in which one sub-frame (uplink sub-frame or downlink sub-frame) includes only a same type of transmission symbols (an uplink sub-frame includes only uplink transmission symbols, and a downlink sub-frame includes only downlink transmission symbols), such a flexible sub-frame enables configuration of uplink and downlink transmission symbols in a same sub-frame, so that feedback of an acknowledgement message from a UE can be rapidly performed, a transmission latency is reduced, and at the same time the number of UEs that can be connected can be increased by several times.

[0101] In an embodiment, the flexible sub-frame is configured to further include a GP, where the GP is located between a downlink transmission symbol and an uplink

transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0102] Reference may be made to the data transmission method on the base station side for a specific implementation manner of the GP in the flexible sub-frame, which is no longer elaborated here.

[0103] In an embodiment, the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol. Alternatively, the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0104] In an embodiment, the at least one flexible sub-frame include at least one dynamically configured flexible sub-frame. Correspondingly, receiving configuration information of at least one flexible sub-frame included in a TDD radio frame from a base station in S701 may be implemented as: periodically receiving, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame. A location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame are periodically and dynamically configured.

[0105] In an embodiment, the at least one flexible sub-frame includes at least one semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame includes a fixedly configured timeslot and a flexibly configured timeslot. Correspondingly, receiving configuration information of at least one flexible sub-frame included in a TDD radio frame from a base station in S701 may be implemented as: at a first predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame; and at a second predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each flexibly

configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame. The first predetermined periodicity is larger than the second predetermined periodicity.

[0106] Embodiments of apparatuses of the disclosure are provided below. The apparatuses may be configured to perform the foregoing embodiments of the data transmission methods of the disclosure.

[0107] Fig. 8 is a block diagram of a data transmission apparatus according to an exemplary embodiment of the disclosure. The apparatus is used in a base station, and includes the following modules 81, 82 and 83 as shown in Fig. 8.

[0108] The determining module 81 is configured to determine configuration information of at least one flexible sub-frame included in a TDD radio frame. The flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured.

[0109] The sending module 82 is configured to deliver the determined configuration information of the at least one flexible sub-frame to a UE by using signaling.

[0110] The transmission module 83 is configured to: according to the determined configuration information of the at least one flexible sub-frame, receive uplink data in the time slot of the uplink transmission symbol and send downlink data in the time slot of the downlink transmission symbol.

[0111] In an embodiment, as shown in Fig. 9, the determining module 81 includes: a first determining sub-module 811 configured to determine configuration information of a GP in the flexible sub-frame. The GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0112] In an embodiment, the first determining sub-module 811 is configured to determine that the GP is located between a downlink transmission symbol and an uplink transmission symbol in the same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or that the GP is located between a

downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0113] In an embodiment, as shown in Fig. 9, the determining module 81 further includes: a second determining sub-module 812.

[0114] The second determining sub-module 812 is configured to: for each flexible sub-frame, determine a location and a time length of a sub-timeslot that is occupied by each uplink transmission symbol and a location and a time length of a sub-timeslot that is occupied by each downlink transmission symbol.

[0115] The first determining sub-module 811 is configured to: when the flexible sub-frame is configured to further include a GP, determine a location and a time length of a sub-timeslot that is occupied by the GP.

[0116] In an embodiment, the at least one flexible sub-frame includes a dynamically configured flexible sub-frame. Correspondingly, the determining module 81 is configured to periodically determine a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

[0117] In an embodiment, the at least one flexible sub-frame includes a semi-dynamically configured flexible sub-frame, and the semi-dynamically configured flexible sub-frame includes a fixedly configured timeslot and a flexibly configured timeslot. Correspondingly, the determining module 81 is configured to: at a first predetermined periodicity, determine a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame; and at a second predetermined periodicity, determine a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame. The first predetermined periodicity is larger than the second predetermined periodicity.

[0118] In an embodiment, the signaling may include: broadcast signaling, RRC signaling, and physical layer signaling. However, this embodiment of the disclosure is not limited thereto.

[0119] Fig. 10 is a block diagram of another data transmission apparatus according to an exemplary embodiment of the disclosure. The apparatus is used in a UE, and includes the following modules 101 and 102 as shown in Fig. 10.

[0120] The receiving module 101 is configured to receive, from a base station, configuration information of at least one flexible sub-frame included in a TDD radio frame. The flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured.

[0121] The transmission module 102 is configured to: according to the configuration information of the at least one flexible sub-frame included in the TDD radio frame, send uplink data in the time slot of the uplink transmission symbol and receive downlink data in the time slot of the downlink transmission symbol.

[0122] In an embodiment, the receiving module 101 is configured to receive configuration information of a GP in the flexible sub-frame. The GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0123] In an embodiment, the receiving module 101 is further configured to receive the configuration information of the GP in the flexible sub-frame, indicating one of the following: the GP is located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or the GP is located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

[0124] In an embodiment, the at least one flexible sub-frame includes at least one dynamically configured flexible sub-frame. Correspondingly, the receiving module 101 is configured to periodically receive, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame, A location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame are periodically and dynamically configured.

[0125] In an embodiment, the at least one flexible sub-frame includes at least one semi-dynamically configured flexible sub-frame. The semi-dynamically configured flexible sub-frame includes a fixedly configured timeslot and a flexibly configured timeslot. Correspondingly, the receiving module 101 is configured to: at a first predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame; and at a second predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each flexibly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame. The first predetermined periodicity is larger than the second predetermined periodicity.

[0126] Regarding the apparatuses in the foregoing embodiments, specific manners in which various modules perform operations are already described in detail in the embodiments related to the methods, and will no longer be described in detail here.

[0127] With the data transmission method and apparatus, the computer program, and the storage medium provided in the embodiments of the disclosure, configuration information of at least one flexible sub-frame included in a TDD radio frame is first determined, where the flexible sub-frame is configured to include at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; the determined configuration information of the at least one sub-frame is then sent to a UE by using signaling; and uplink data and downlink data are then transmitted according to the configuration information of the flexible sub-frame. In contrary to a sub-frame configuration solution of a TDD radio frame in related art in which one sub-frame (uplink sub-frame or downlink sub-frame) includes only a same type of transmission symbols (an uplink sub-frame includes only uplink transmission symbols, and a downlink sub-frame includes only downlink transmission symbols), configuration of uplink and downlink transmission symbols may be implemented in a same sub-frame, so that feedback of an acknowledgement message

such as an ACK/a NACK from a UE can be rapidly performed, and a transmission latency is reduced desirably.

[0128] In another aspect, in the data transmission method provided in this embodiment of the disclosure, a flexible sub-frame includes a dynamically configured flexible sub-frame and a semi-dynamically configured flexible sub-frame, and a structure of the flexible sub-frame may be configured completely flexibly or configured partially flexibly, so that configuration of a TDD sub-frame becomes more flexible, and reconfiguration may be performed according to factors such as service type, network coverage, network capacity, and network interference, thereby fully meeting a requirement of an uplink-downlink asymmetric TDD service.

[0129] Moreover, compared with a dynamically configured flexible sub-frame, using a structure of a semi-dynamically configured flexible sub-frame to perform data transmission can facilitate saving overheads of control signaling, and facilitate determining which symbols may cause interference during interference cancellation.

[0130] Fig. 11 is a block diagram of an apparatus applicable to data transmission according to an exemplary embodiment. For example, the apparatus 1600 may be a mobile phone, a computer, a digital broadcast terminal, a messaging device, a gaming console, a tablet device, a medical device, exercise equipment, a personal digital assistant, and the like.

[0131] Referring to Fig. 11, the apparatus 1600 may include one or more of the following components: a processing component 1602, a memory 1604, a power component 1606, a multimedia component 1608, an audio component 1610, an Input/Output (I/O) interface 1612, a sensor component 1614, and a communication component 1616.

[0132] The communication component 1616 includes a bluetooth module supporting a standard Bluetooth Low Energy (BLE) protocol. The bluetooth module includes a control chip and a bluetooth chip connected to the control chip.

[0133] The processing component 1602 typically controls overall operations of the apparatus 1600, such as the operations associated with display, telephone calls, data communications, camera operations, and recording operations. The processing component 1602 may include one or more processors 1618 to execute instructions to perform all or part

of the steps in the above described methods. Moreover, the processing component 1602 may include one or more modules which facilitate the interaction between the processing component 1602 and other components. For instance, the processing component 1602 may include a multimedia module to facilitate the interaction between the multimedia component 1608 and the processing component 1602.

[0134] The memory 1604 is configured to store various types of data to support the operation of the apparatus 1600. Examples of such data include instructions for any applications or methods operated on the apparatus 1600, contact data, phonebook data, messages, pictures, video, etc. The memory 1604 may be implemented using any type of volatile or non-volatile memory devices, or a combination thereof, such as a Static Random Access Memory (SRAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), an Erasable Programmable Read-Only Memory (EPROM), a Programmable Read-Only Memory (PROM), a Read-Only Memory (ROM), a magnetic memory, a flash memory, a magnetic or optical disk.

[0135] The power component 1606 provides power to various components of the apparatus 1600. The power component 1606 may include a power management system, one or more power sources, and any other components associated with the generation, management, and distribution of power in the apparatus 1600.

[0136] The multimedia component 1608 includes a screen providing an output interface between the apparatus 1600 and the user. In some embodiments, the screen may include a Liquid Crystal Display (LCD) and a Touch Panel (TP). If the screen includes the touch panel, the screen may be implemented as a touch screen to receive input signals from the user. The touch panel includes one or more touch sensors to sense touches, swipes, and gestures on the touch panel. The touch sensors may not only sense a boundary of a touch or swipe action, but also sense a period of time and a pressure associated with the touch or swipe action. In some embodiments, the multimedia component 1608 includes a front camera and/or a rear camera. The front camera and the rear camera may receive an external multimedia datum while the apparatus 1600 is in an operation mode, such as a photographing

mode or a video mode. Each of the front camera and the rear camera may be a fixed optical lens system or have focus and optical zoom capability.

[0137] The audio component 1610 is configured to output and/or input audio signals. For example, the audio component 1610 includes a microphone ("MIC") configured to receive an external audio signal when the apparatus 1600 is in an operation mode, such as a call mode, a recording mode, and a voice recognition mode. The received audio signal may be further stored in the memory 1604 or transmitted via the communication component 1616. In some embodiments, the audio component 1610 further includes a speaker to output audio signals.

[0138] The I/O interface 1612 provides an interface between the processing component 1602 and peripheral interface modules, such as a keyboard, a click wheel, buttons, and the like. The buttons may include, but are not limited to, a home button, a volume button, a starting button, and a locking button.

[0139] The sensor component 1614 includes one or more sensors to provide status assessments of various aspects of the apparatus 1600. For instance, the sensor component 1614 may detect an open/closed status of the apparatus 1600, relative positioning of components, e.g., the display and the keypad, of the apparatus 1600, a change in position of the apparatus 1600 or a component of the apparatus 1600, a presence or absence of user contact with the apparatus 1600, an orientation or an acceleration/deceleration of the apparatus 1600, and a change in temperature of the apparatus 1600. The sensor component 1614 may include a proximity sensor configured to detect the presence of nearby objects without any physical contact. The sensor component 1614 may also include a light sensor, such as a CMOS or CCD image sensor, for use in imaging applications. In some embodiments, the sensor component 1614 may also include an accelerometer sensor, a gyroscope sensor, a magnetic sensor, a pressure sensor, or a temperature sensor.

[0140] The communication component 1616 is configured to facilitate communication, wired or wirelessly, between the apparatus 1600 and other devices. The apparatus 1600 can access a wireless network based on a communication standard, such as WiFi, 2G, or 3G, or a combination thereof. In one exemplary embodiment, the

communication component 1616 receives a broadcast signal or broadcast associated information from an external broadcast management system via a broadcast channel. In one exemplary embodiment, the communication component 1616 further includes a Near Field Communication (NFC) module to facilitate short-range communications. For example, the NFC module may be implemented based on a Radio Frequency Identification (RFID) technology, an Infrared Data Association (IrDA) technology, an Ultra-wideband (UWB) technology, a Bluetooth (BT) technology, and other technologies.

[0141] In exemplary embodiments, the apparatus 1600 may be implemented with one or more Application Specific Integrated Circuits (ASICs), Digital Signal Processors (DSPs), Digital Signal Processing Devices (DSPDs), Programmable Logic Devices (PLDs), Field Programmable Gate Arrays (FPGAs), controllers, micro-controllers, microprocessors, or other electronic components, for performing the above described methods.

[0142] In exemplary embodiments, there is also provided a non-transitory computer-readable storage medium including instructions, such as included in the memory 1604, executable by the processor 1618 in the apparatus 1600, for performing the above-described methods. For example, the non-transitory computer-readable storage medium may be a ROM, a CD-ROM, a magnetic tape, a floppy disc, an optical data storage device, and the like.

[0143] The disclosure further provides a storage medium having a computer program recorded thereon. The program includes instructions used to perform the data transmission method in the foregoing embodiments of the disclosure.

[0144] The disclosure further provides a computer program, which includes instructions for performing the data transmission method in the foregoing embodiments of the disclosure when the computer program is executed by a computer.

[0145] It should be believed that the specification includes multiple inventions that have independent efficacy. Although each of these inventions is disclosed in a preferred form thereof, as discussed herein, the specific implementation manner thereof should not be considered to be limitative, because there may further be multiple variations. Each example limits an implementation manner limited in the foregoing content, but any example does not

necessarily include all features or combinations that eventually require to be protected. If "one" or "first" component and an equivalent thereof are described in the specification, such description includes one such component or multiple such components, and neither requires nor excludes two or more such components. In addition, sequence numbers (for example, first, second, and third) used to identify components are used to distinguish these components, and neither requires a specified quantity of components or a limited quantity of components, nor indicate locations or an order of these components, unless otherwise particularly described.

[0146] Other implementation solutions of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the disclosure disclosed here. This application is intended to cover any variations, uses, or adaptations of the disclosure following the general principles thereof and including such departures from the disclosure as come within known or customary practice in the art. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the disclosure being indicated by the following claims.

[0147] It will be appreciated that the disclosure is not limited to the exact construction that has been described above and illustrated in the accompanying drawings, and that various modifications and changes can be made without departing from the scope thereof. It is intended that the scope of the disclosure only be limited by the appended claims.

WHAT IS CLAIMED IS:

1. A data transmission method, comprising:

determining configuration information of at least one flexible sub-frame comprised in a Time Division Duplex (TDD) radio frame, wherein the flexible sub-frame is configured to comprise at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured;

delivering the determined configuration information of the at least one flexible sub-frame to a user equipment (UE) by using signaling; and

according to the determined configuration information of the at least one flexible sub-frame, receiving uplink data in the time slot of the uplink transmission symbol and sending downlink data in the time slot of the downlink transmission symbol.

2. The method of claim 1, wherein the flexible sub-frame is configured to further comprise a Guard Period (GP), wherein the GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

3. The method of claim 2, wherein the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or

the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

4. The method of claim 1 or 2, wherein determining configuration information of at least one flexible sub-frame comprised in a TDD radio frame comprises:

for each flexible sub-frame, determining a location and a time length of a sub-timeslot

that is occupied by each uplink transmission symbol and a location and a time length of a sub-timeslot that is occupied by each downlink transmission symbol; and
when the flexible sub-frame is configured to further comprise a GP, determining a location and a time length of a sub-timeslot that is occupied by the GP.

5. The method of claim 1 or 2, wherein the at least one flexible sub-frame comprises a dynamically configured flexible sub-frame, and determining configuration information of the dynamically configured flexible sub-frame comprises:

periodically determining a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

6. The method of claim 1 or 2, wherein the at least one flexible sub-frame comprises a semi-dynamically configured flexible sub-frame, the semi-dynamically configured flexible sub-frame comprises a fixedly configured timeslot and a flexibly configured timeslot, and determining configuration information of the semi-dynamically configured flexible sub-frame comprises:

at a first predetermined periodicity, determining a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame; and

at a second predetermined periodicity, determining a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame, wherein

the first predetermined periodicity is larger than the second predetermined periodicity.

7. The method of claim 1 or 2, wherein the signaling comprises broadcast signaling, Radio Resource Control (RRC) signaling, and physical layer signaling.

8. A data transmission method, comprising:

receiving, from a base station, configuration information of at least one flexible

sub-frame comprised in a Time Division Duplex (TDD) radio frame, wherein the flexible sub-frame is configured to comprise at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; and

according to the configuration information of the at least one flexible sub-frame comprised in the TDD radio frame, sending uplink data in the time slot of the uplink transmission symbol, and receiving downlink data in the time slot of the downlink transmission symbol.

9. The method of claim 8, wherein the flexible sub-frame is configured to further comprise a Guard Period (GP), wherein the GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

10. The method of claim 9, wherein the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or the GP is configured to be located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

11. The method of claim 8 or 9, wherein the at least one flexible sub-frame comprises dynamically configured flexible sub-frame, and receiving configuration information of at least one flexible sub-frame comprised in a TDD radio frame from a base station comprises:

periodically receiving, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame, wherein a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame are periodically and dynamically configured.

12. The method of claim 8 or 9, wherein the at least one flexible sub-frame comprises semi-dynamically configured flexible sub-frame, the semi-dynamically configured flexible sub-frame comprises a fixedly configured timeslot and a flexibly configured timeslot, and receiving configuration information of at least one flexible sub-frame comprised in a TDD radio frame from a base station comprises:

at a first predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame; and

at a second predetermined periodicity, receiving, from the base station, configuration information of a location, occupation information, and a time length of each flexibly configured timeslot in the at least one semi-dynamically configured flexible sub-frame in the radio frame, wherein

the first predetermined periodicity is larger than the second predetermined periodicity.

13. A data transmission apparatus, comprising:

a determining module configured to determine configuration information of at least one flexible sub-frame comprised in a Time Division Duplex (TDD) radio frame, wherein the flexible sub-frame is configured to comprise at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured;

a sending module configured to deliver the determined configuration information of the at least one flexible sub-frame to a user equipment (UE) by using signaling; and

a transmission module configured to, according to the determined configuration information of the at least one flexible sub-frame, receive uplink data in the time slot of the uplink transmission symbol and send downlink data in the time slot of the downlink transmission symbol.

14. The apparatus of claim 13, wherein the determining module comprises:

a first determining sub-module configured to determine configuration information of a Guard Period (GP) in the flexible sub-frame, wherein the GP is located between a downlink transmission symbol and an uplink transmission symbol when the downlink transmission symbol is transformed to the uplink transmission symbol.

15. The apparatus of claim 14, wherein the first determining sub-module is configured to determine that the GP is located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or that the GP is located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

16. The apparatus of claim 13 or 14, wherein the determining module further comprises: a second determining sub-module,

the second determining sub-module is configured to: for each flexible sub-frame, determine a location and a time length of a sub-timeslot that is occupied by each uplink transmission symbol and a location and a time length of a sub-timeslot that is occupied by each downlink transmission symbol, and

the first determining sub-module is configured to, when the flexible sub-frame is configured to further comprise a GP, determine a location and a time length of a sub-timeslot that is occupied by the GP.

17. The apparatus of claim 13 or 14, wherein the at least one flexible sub-frame comprises a dynamically configured flexible sub-frame, and the determining module is configured to periodically determine a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame.

18. The apparatus of claim 13 or 14, wherein the at least one flexible sub-frame comprises a semi-dynamically configured flexible sub-frame, the semi-dynamically configured flexible sub-frame comprises a fixedly configured timeslot and a flexibly configured timeslot, and the determining module is configured to:

at a first predetermined periodicity, determine a location, occupation information, and a time length of each fixedly configured timeslot in the semi-dynamically configured flexible sub-frame; and

at a second predetermined periodicity, determine a location, occupation information, and a time length of each flexibly configured timeslot in the semi-dynamically configured flexible sub-frame, wherein the first predetermined periodicity is larger than the second predetermined periodicity.

19. The apparatus of claim 13 or 14, wherein the signaling comprises broadcast signaling, Radio Resource Control (RRC) signaling, and physical layer signaling.

20. A data transmission apparatus, comprising:

a receiving module configured to receive, from a base station, configuration information of at least one flexible sub-frame comprised in a Time Division Duplex (TDD) radio frame, wherein the flexible sub-frame is configured to comprise at least one uplink transmission symbol and at least one downlink transmission symbol, and sub-timeslots occupied by the uplink transmission symbol and the downlink transmission symbol are alternately configured; and

a transmission module configured to, according to the configuration information of the at least one flexible sub-frame comprised in the TDD radio frame, send uplink data in the time slot of the uplink transmission symbol and receive downlink data in the time slot of the downlink transmission symbol.

21. The apparatus of claim 20, wherein the receiving module is configured to receive configuration information of a Guard Period (GP) in the flexible sub-frame, wherein the GP is located between a downlink transmission symbol and an uplink transmission symbol when

the downlink transmission symbol is transformed to the uplink transmission symbol.

22. The apparatus of claim 21, wherein the receiving module is further configured to receive the configuration information of the GP in the flexible sub-frame wherein the GP is located between a downlink transmission symbol and an uplink transmission symbol in a same flexible sub-frame when the downlink transmission symbol is transformed to the uplink transmission symbol; or the GP is located between a downlink transmission symbol and an uplink transmission symbol in adjacent flexible sub-frames when the downlink transmission symbol is transformed to the uplink transmission symbol.

23. The apparatus of claim 20 or 21, wherein the at least one flexible sub-frame comprises a dynamically configured flexible sub-frame, and the receiving module is configured to periodically receive, from the base station, structure information of the at least one dynamically configured flexible sub-frame in the TDD radio frame, wherein a location, occupation information, and a time length of each sub-timeslot in the dynamically configured flexible sub-frame are periodically and dynamically configured.

24. The apparatus of claim 20 or 21, wherein the at least one flexible sub-frame comprises a semi-dynamically configured flexible sub-frame, wherein the semi-dynamically configured flexible sub-frame comprises a fixedly configured timeslot and a flexibly configured timeslot, and the receiving module is configured to:

at a first predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each fixedly configured timeslot in at least one semi-dynamically configured flexible sub-frame in the radio frame; and

at a second predetermined periodicity, receive, from the base station, configuration information of a location, occupation information, and a time length of each flexibly configured timeslot in at least one semi-dynamically configured flexible sub-frame in the radio frame, wherein the first predetermined periodicity is larger than the second

predetermined periodicity.

25. A data transmission apparatus, comprising:

a processor;

a memory configured to store instructions executable by the processor, wherein the processor is configured to perform the method of any one of claims 1 to 7.

26. A storage medium having a computer program recorded thereon, wherein the program comprises instructions for performing the method of any one of claims 1 to 7.

27. A computer program, comprising instructions for performing the method of any one of claims 1 to 7 when the program is executed by a computer.

28. A data transmission apparatus, comprising:

a processor;

a memory configured to store instructions executable by the processor, wherein the processor is configured to perform the method according to any one of claims 8 to 12.

29. A storage medium having a computer program recorded thereon, wherein the program comprises instructions for performing the method of any one of claims 8 to 12.

30. A computer program, comprising instructions for performing the method of any one of claims 8 to 12 when the program is executed by a computer.