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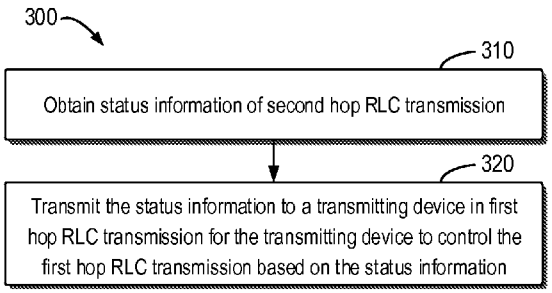

Fig. 3

(57) Abstract: Embodiments of the present disclosure provide a method and device for two-hop packet transmission. The method implemented at a relay device for two-hop packet transmission comprises: at a radio link control (RLC) sub-layer of a radio link layer (L2): obtaining status information of second hop RLC transmission of the two-hop packet transmission; and transmitting the status information to a transmitting device in first hop RLC transmission of the two-hop packet transmission for the transmitting device to control the first hop RLC transmission based on the status information. According to the embodiments of the present disclosure, an effective solution for L2 relay performed at an RLC sub-layer can be provided.

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METHOD AND APPARATUS FOR TWO-HOP PACKET TRANSMISSION

FIELD

[0001] Embodiments of the present disclosure generally relate to the field of wireless communications, and more specifically, to a method, a relay device, a remote device and a base station for two-hop packet transmission.

BACKGROUND

[0002] With the advent of the fifth-generation mobile communication technology (5G), it is expected to further enhance device-to-device (D2D) communication in a third-generation partnership project (3GPP) long term evolution (LTE) system for Internet of Things (IoT) and wearable devices. Particularly, it is desirable to enhance relay from a remote device (such as a wearable device) to a network to support end-to-end (E2E) security through a relay link (such as a smart phone), service continuity, quality of service (QoS), efficient operation with multiple remote devices, and efficient path switching between Uu and D2D air-interfaces.

SUMMARY

[0003] On the whole, embodiments of the present disclosure provide a method, a relay device, a remote device and a base station for two-hop packet transmission.

[0004] In one aspect of the present disclosure, there is provided a method implemented at a relay device for two-hop packet transmission. The method comprises: at a radio link control (RLC) sub-layer of a radio link layer (L2): obtaining status information of second hop RLC transmission for the two-hop packet transmission; and transmitting the status information to a transmitting device in first hop RLC transmission of the two-hop packet transmission for the transmitting device to control the first hop RLC transmission based on the status information.

[0005] In another aspect of the present disclosure, there is provided a method implemented a remote device or a base station for two-hop packet transmission. The method comprises: at a radio link control (RLC) sub-layer of a radio link layer (L2): obtaining, from a relay device, status information of second hop RLC transmission of the two-hop packet transmission; and controlling first hop RLC transmission of the two-hop packet transmission based on the status information.

[0006] In another aspect of the present disclosure, there is provided a relay device for controlling two-hop packet transmission at a radio link control (RLC) sub-layer of a radio link layer (L2). The device comprises a controller configured to obtain status information of second hop RLC transmission and a transceiver configured to transmit the status information to a transmitting device in first hop RLC transmission for the transmitting device to control the first hop RLC transmission based on the status information.

[0007] In another aspect of the present disclosure, there is provided a remote device for controlling, at a radio link control (RLC) sub-layer of a radio link layer (L2), two-hop packet transmission with a base station via a relay device. The remote device comprises a transceiver configured to receive, from the relay device, status information of second hop RLC transmission of the two-hop packet transmission, and a controller configured to control first hop RLC transmission of the two-hop packet transmission based on the status information.

[0008] In another aspect of the present disclosure, there is provided a base station for controlling, at a radio link control (RLC) sub-layer of a radio link layer (L2), two-hop packet transmission with a remote device via a relay device. The base station comprises a transceiver configured to receive, from the relay device, status information of second hop RLC transmission of the two-hop packet transmission, and a controller configured to control first hop RLC transmission of the two-hop packet transmission based on the status information.

[0009] According to the embodiments of the present disclosure, an effective solution for L2 relay performed at an RLC sub-layer can be provided.

[0010] It will be appreciated that the contents described in the Summary does not aim to limit key or vital features of the embodiments of the present disclosure, or to limit scope of the present disclosure. Other features of the present disclosure are easy to understand through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Through the following detailed description with reference to the accompanying drawings, the above and other features, advantages and aspects of embodiments of the present disclosure will become more apparent. In the drawings, identical or similar reference numbers represent the same or similar elements, in which

[0012] FIG. 1 is a schematic diagram illustrating two-hop packet transmission in which embodiments of the present disclosure can be implemented;

[0013] FIG. 2 is a schematic diagram illustrating conventional L2 relay for two-hop packet transmission;

[0014] FIG. 3 is a flow diagram illustrating a method for two-hop packet transmission implemented at a relay device according to the embodiments of the present disclosure;

[0015] FIG. 4 is a flow diagram illustrating a method for two-hop packet transmission implemented at a remote device or a base station according to the embodiments of the present disclosure;

[0016] FIG. 5 is a schematic diagram illustrating L2 relay at an RLC sub-layer for two-hop packet transmission according to the embodiments of the present disclosure;

[0017] FIG. 6 is a schematic diagram illustrating L2 relay at an RLC sub-layer for two-hop packet transmission according to the embodiments of the present disclosure;

[0018] FIG. 7 is a structural block diagram illustrating an apparatus for two-hop packet transmission implemented at a relay device according to the embodiments of the present disclosure;

[0019] FIG. 8 is a structural block diagram illustrating an apparatus for two-hop packet transmission implemented at a remote device or a base station according to the embodiments of the present disclosure; and

[0020] FIG. 9 is a structural block diagram illustrating a device according to the embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] Embodiments of the present disclosure will be described with reference to the drawings in detail. Though some embodiments of the present disclosure are shown in the drawings, it should be appreciated that the present disclosure can be implemented in various manners and should not be interpreted as limited to the embodiments described herein. Conversely, these embodiments are provided for more thorough and complete understanding of the present disclosure. It should be understood that drawings and embodiments of the present disclosure are only exemplary and shall not limit the protection scope of the present disclosure.

[0022] The term "base station" as used herein can represent a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a remote radio unit (RRU), a radio header (RH), a remote

radio head (RRH), a relay, a low power node such as a pico station and a femto station, and the like. In the context of the present disclosure, for the ease of discussion, an eNB is mainly taken as an example of the base station.

[0023] The term "remote device" as used herein refers to any terminal device or user equipment (UE) that can perform wireless communication with base stations or with each other. As an example, the remote device may include a sensor with communication function, a detector, a mobile terminal (MT), a subscriber station (SS), a portable subscriber station (PSS), a mobile station (MS), or an access terminal (AT), and the above devices mounted on a vehicle. In the context of the present disclosure, for the ease of discussion, the terms "remote device," "terminal device" and "user equipment" can be used interchangeably and UE is mainly taken as an example of the remote device (remote UE).

[0024] The term "a relay device" as used herein refers to a network device or a terminal device that can forward data packets between a base station and a remote device. As an example, the relay device can be other entities or nodes having a particular function in the base station or communication network, or any terminal device or user equipment that can perform wireless communication with the bases station or with each other. In the context of the present disclosure, for the ease of discussion, UE is mainly taken as an example for the relay device (relay UE).

[0025] As used herein, the term "includes" and its variants are to be read as open-ended terms that mean "includes, but is not limited to." The term "based on" is to be read as "based at least in part on." The term "one embodiment" and "an embodiment" are to be read as "at least one embodiment"; and the term "another embodiment" is to be read as "at least one another embodiment." Definitions related to other terms will be provided in the following description.

[0026] FIG. 1 is a schematic diagram 100 illustrating two-hop packet transmission in which embodiments of the present disclosure can be implemented, where L2 relay is performed at an RLC sub-layer. As shown in FIG. 1, a remote UE 110 can communicate with an eNB 130 via a relay UE 120. For example, as shown in the figure, the remote UE 110 can transmit, in the form of a protocol data unit (PDU), data packets to the eNB 130 via the relay UE 120 (uplink transmission). It should be understood that the eNB 130 can also transmit data packets to the remote UE 110 via the relay UE 120 (downlink transmission). For the sake of convenience, the embodiments of the present disclosure will be described only with uplink

transmission as an example.

[0027] Communication between the remote UE 110 and the relay UE 120 is shown by 101-104 in FIG. 1. At 101, the remote UE 110 transmits a protocol data unit PDU#1 to the the relay UE 120. At 102, after receiving the PDU#1, the relay UE 120 transmits to the remote UE 110 an acknowledgement ACK#1 for the PDU#1. After the remote UE 110 receives the acknowledgement ACK#1 from the relay UE 120, it releases the PDU#1 from a buffer and at 103, continues to transmit a PDU#2 to the relay UE 120.

[0028] At 104, after receiving the PDU#2, the relay UE 120 transmits to the remote UE 110 an acknowledgement ACK#2 for the PDU#2, and so on. Meanwhile, communication between the relay UE 120 and the eNB 130 is shown by 105-108 shown in FIG. 1. At 105, after receiving the PDU#1 from the remote UE 110, the relay UE 120 forwards it to the eNB 130. At 106, after receiving the forwarded PDU#1, the eNB 130 transmits an acknowledgement ACK#1 for the PDU#1 to the relay UE 120. At 107, after receiving the acknowledgement ACK#1 from the eNB 130, the relay UE 120 continues to forward the PDU#2 received from the remote UE 110 to the eNB 130. At 108, after receiving the forwarded PDU#2, the eNB 130 transmits an acknowledgement ACK#2 for the PDU#2 to the relay UE 120. The above process can be repeated in this fashion.

[0029] Thus, in L2 relay of the current two-hop packet transmission, the first hop packet transmission (such as between the remote UE 110 and the relay UE 120) and the second hop packet transmission (such as between the relay UE 120 and the eNB 130) are independent from each other. In this case, one link cannot be adjusted based on the state of another link, causing the whole transmission to lack flexibility and reducing the efficiency of transmission, which will be described in detail in the following text with reference to FIG. 2.

[0030] FIG. 2 is a schematic diagram 200 illustrating L2 relay for two-hop packet transmission in the prior art. As shown in FIG. 2, the processes 101-104 of first hop packet transmission between the remote UE 110 and the relay UE 120 are similar to that depicted in FIG. 1, thus omitted here. When the link of second hop transmission between the relay UE 120 and the eNB 130 is interrupted or blocked as shown in FIG. 2, the relay UE 120 fails to forward data packets received from the remote UE 110, such as the PDU#1 and PDU#2, to the eNB 130. The remote UE 110 obtains acknowledgements, such as the ACK#1 and ACK#2, from the relay UE 120 and assumes that data packets have been received successfully by the eNB 130, and then releases the transmitted data packets from a buffer. However, as a matter

of fact, these data packets are not received by a receiving device in the second hop packet transmission, namely, the eNB 130. Therefore, these data packets are lost during the whole RLC transmission.

[0031] To solve the above problem, the basic idea of the embodiments of the present disclosure is to establish connection between the first hop packet transmission and the second hop packet transmission at a RLC sub-layer of L2 so that the first hop packet transmission can be adjusted based on status information of the second hop packet transmission. Thereby, the L2 relay at the RLC sub-layer can be implemented to better support the two-hop packet transmission between the remote UE and the eNB. Reference is made to FIGs. 3 and 4 in the following text for depiction in greater detail.

[0032] FIG. 3 is a flow diagram illustrating a method 300 for two-hop packet transmission implemented at a relay device according to the embodiments of the present disclosure. The method 300, for instance, can be implemented at a RLC sub-layer of L2 in the relay UE 120 shown in FIGs. 1 and 2.

[0033] As shown in FIG. 3, at 310, the relay UE 120 can obtain status information of second hop RLC transmission of the two-hop packet transmission. According to an embodiment of the present disclosure, the relay UE 120 can monitor a link condition for the second hop RLC transmission, namely, the condition of the link between the relay UE 120 and the eNB 130.

[0034] For example, the relay UE 120 can monitor deterioration of the link condition for the second hop RLC transmission. Under this condition, according to the embodiments of the present disclosure, monitoring the link condition may at least comprise monitoring at least one of the following: the second hop RLC transmission being blocked for a first predetermined period of time; failing to receive, in the presence of packet transmission, ACK information for the packet transmission within a second predetermined period of time; and a buffer for the second hop RLC transmission being full for a third predetermined period of time.

[0035] Alternatively, for instance, the relay UE 120 can monitor recovery or melioration of the link condition of the second hop RLC transmission. Under this condition, according to the embodiments of the present disclosure, monitoring the link condition may at least comprise monitoring at least one of the following: after the second hop RLC transmission is blocked or ACK information for packet transmission is not received within a predetermined period of time, receiving the ACK information again; and a buffer for the second hop RLC

transmission turning from a full state to a non-full state.

[0036] According to another embodiment of the present disclosure, the relay UE 120 can monitor a packet transmission condition for the second hop RLC transmission. For example, it can monitor whether data packets haven been transmitted successfully between the relay UE 120 and the eNB 130. According to the embodiments of the present disclosure, the relay UE 120 can monitor at least ACK/NACK information for the second hop RLC transmission. For example, the relay UE 120 can establish and maintain a mapping table between a first hop RLC service data unit (SDU) and a second hop RLC SDU to transmit ACK/NACK information for relayed RLC SDUs to a transmitting device in the first hop RLC transmission, thereby notifying which relayed SDUs are successfully received by a receiving device in the second hop RLC transmission.

[0037] At 320, the relay UE 120 can transmit the status information to the transmitting device in the first hop RLC transmission of the two-hop packet transmission for the transmitting device, for the transmitting device to control the first hop RLC transmission based on the status information. In this example, the transmitting device in the first hop RLC transmission is the remote UE 110. The relay UE 120 can transmit to the remote UE 110 at least one of the obtained link condition and packet transmission condition, for instance, as the status information. In this manner, the relay UE 120 feeds, to the transmitting device in the first hop RLC transmission, not only ACK/NACK information for the first hop RLC transmission but also ACK/NACK information for the second hop RLC transmission.

[0038] According to an embodiment of the present disclosure, the relay UE 120 can use an existing or well-defined "STATUS" protocol data unit (PDU) to transmit the status information. For example, the status information can be added to the STATUS PDU for the first hop RLC transmission, for instance, a reserved field in the STATUS PDU, such as 1-bit R1 field or 3-bit CPT field. According to another embodiment of the present disclosure, the relay UE 120 can use a newly-defined PDU to transmit the status information exclusively. For example, a new STATUS PDU can be newly defined so as to contain only the status information.

[0039] After receiving the status information, the transmitting device in the first hop RLC transmission, such as the remote UE 110, can control the first hop RLC transmission based on the status information. Now, reference is made to FIG. 4 for depiction in greater detail. FIG. 4 is a flow diagram illustrating a method 400 for two-hop packet transmission

implemented at a remote device or a base station according to the embodiments of the present disclosure. The method 400 can be implemented at a RLC sub-layer of L2 in the remote UE 110 (uplink transmission) or the eNB 130 (downlink transmission) shown in FIGs. 1 and 2. Here, implementation at the remote UE 110 is taken as an example for depiction.

[0040] As shown in FIG. 4, at 410, the remote UE 110 can receive, from a relay device (such as the relay UE 120), status information of second hop RLC transmission of the two-hop packet transmission. As mentioned above, the relay UE 120 can transmit the status information through an existing or newly-defined PDU. Correspondingly, according to the embodiments of the present disclosure, the remote UE 110 can obtain the status information from a STATUS PDU for the first hop RLC transmission. According to another embodiment of the present disclosure, the remote UE 110 can obtain the status information from a newly defined PDU that is used exclusively for transmitting the status information.

[0041] At 420, the remote UE 110 can control, based on the status information, the first hop RLC transmission of the two-hop packet transmission. As mentioned above, the relay UE 120 can take at least one of the monitored link condition and packet transmission condition of the second hop RLC transmission as status information for delivery. Correspondingly, the remote UE 110 can adjust the first hop RLC transmission based on at least one of the link condition and packet transmission condition of the second hop RLC transmission. Reference can be made to the corresponding depiction of FIG. 3 for knowledge about the link condition and packet transmission condition which are not repeated here. The following text will depict adjustment of the first hop RLC transmission.

[0042] According to the embodiments of the present disclosure, adjusting the first hop RLC transmission at least comprises at least one of the following: ceasing the first hop RLC transmission; changing a size of a data PDU for the first hop RLC transmission; delaying the first hop RLC transmission; and recovering the first hop RLC transmission.

[0043] According to the embodiments of the present disclosure, the first hop RLC transmission can be adjusted based on the link condition of the second hop RLC transmission. For example, when the status information indicates that the link of the second hop RLC transmission deteriorates, for instance, the second hop RLC transmission is blocked for a first predetermined period of time, ACK information for packet transmission is not received within a second predetermined period of time in the presence of the packet transmission, a buffer for the second hop RLC transmission is full for a third predetermined period of time, and so on,

at least one of the following can be adopted to adjust the first hop RLC transmission: ceasing the first hop RLC transmission; changing a size of a data PDU for the first hop RLC transmission (such as reducing the size of the data PDU to slow down the first hop RLC transmission); and delaying the first hop RLC transmission.

[0044] Alternatively, for example, when the status information indicates that the link for the second hop RLC transmission recovers or meliorates, for instance, when the second hop RLC transmission is blocked or ACK information is received again after ACK information for packet transmission is not received within a predetermined period of time, the buffer for the second hop RLC transmission turns from a full state into a non-full state, and so on, at least one of the following can be adopted to adjust the first hop RLC transmission; changing the size of the data PDU for the first hop RLC transmission (such as increasing the size of the data PDU to accelerate the first hop RLC transmission); and recovering (such as restarting or cancelling delaying) the first hop RLC transmission.

[0045] According to the embodiments of the present disclosure, the first hop RLC transmission can be adjusted based on the packet transmission condition of the second hop RLC transmission. For example, the first hop RLC transmission is adjusted based on ACK/NACK information for the second hop RLC transmission. As stated in the preceding text, the relay UE 120 transmits, to the transmitting device in the first hop RLC transmission, ACK/NACK information for the relayed RLC SDU such as the remote UE 110. In an embodiment, the first hop RLC transmission can be adjusted based on the amount of NACK information in the second hop RLC transmission. For example, if the amount of the NACK information in the second hop RLC transmission is larger than a predetermined threshold, then the remote UE 110 can adjust the first hop RLC transmission by means of at least one of the following: ceasing the first hop RLC transmission; changing the size of the data PDU for the first hop RLC transmission (such as reducing the size of the data PDU to slow down the first hop RLC transmission); and delaying the first hop RLC transmission. It shall be appreciated that embodiments of the present disclosure are not limited in this respect, but can have a plurality of other alternative embodiments which will be omitted here. By adjusting the first hop RLC transmission based on the status information of the second hop RLC transmission, the efficiency of the overall transmission and robustness of the link can be improved.

[0046] To facilitate understanding, a specific scenario example for adjusting the first hop RLC transmission based on the status information of the second hop RLC transmission is

depicted with reference to FIG. 5. FIG. 5 is a schematic diagram 500 illustrating L2 relay at a RLC sub-layer for two-hop packet transmission according to the embodiments of the present disclosure. As shown in FIG. 5, the remote UE 110 transmits PDU#1 to the relay UE 120 (similar to 101 shown in FIG. 1) and receives from the relay UE 120 an acknowledgement ACK#1 for PDU#1 (similar to 102 in FIG. 1) . In this example, the remote UE 110 releases PDU#1 from the buffer after receiving ACK#1. The relay UE 120 forwards the PDU#1 to the eNB 130 (similar to 105 in FIG. 1). At this moment, the second hop RLC transmission link is blocked. Unlike that in the embodiment shown in FIG. 1, in the embodiment of FIG. 5, at 510, the relay UE 120 transmits to the remote UE 110 the status information indicating that the second hop RLC transmission link is blocked. At 520, the remote UE 110 delays RLC transmission of PDU#2 based on the status information. It shall be appreciated that FIG. 5 is only an example and does not form any limit to the embodiments of the present disclosure. Apart from the circumstance shown in FIG. 5, there are many other possible alternative embodiments which are omitted here.

[0047] According to the embodiments of the present disclosure, the remote UE 110 can further maintain, based on ACK/NACK information for the second hop RLC transmission, data in the buffer for the first hop RLC transmission. As stated above, the relay UE 120 transmits ACK/NACK information for the relayed RLC SDU to the transmitting device in the first hop RLC transmission, such as the remote UE 110, so that the remote UE 110 can learn which relayed SDUs are received successfully by the receiving device of the second hop RLC transmission. Thereby, the remote UE 110 can release related data in the buffer for the first hop RLC transmission. Conversely, it can learn which relayed SDUs are not received successfully by the receiving device of the second hop RLC transmission, and then the remote UE 110 can continue to store these data in the buffer. In this manner, the contents in the buffer for the first hop RLC transmission can be managed based on the feedback for the second hop RLC transmission, thereby reducing data loss during the whole transmission.

[0048] To facilitate understanding, a specific scenario example for managing the buffer based on the status information of the second hop RLC transmission is depicted with reference to FIG. 6. FIG. 6 is a schematic diagram 600 illustrating L2 relay at an RLC sub-layer for two-hop packet transmission according to the embodiments of the present disclosure. As shown in FIG. 6, the remote UE 110, the relay UE 120 and the eNB 130 perform two-hop packet transmission in a process similar to 101-108 depicted in the preceding text with reference to FIG. 1. Unlike that in FIG. 1, at 610, the relay UE 120

transmits to the remote UE 110 status information containing the respective ACK information for the relayed PDU#1 and PDU#2. At 620, the remote UE 110 releases PDU#1 and PDU#2 from its buffer based on the status information. It should be understood that FIG. 6 is only an example and does not form any limit to the embodiments of the present disclosure. Apart from the circumstance shown in FIG. 6, there are multiple other alternative embodiments which are not enumerated here.

[0049] The above text describes the method for two-hop packet transmission according to the embodiments of the present disclosure. According to the method of the embodiments of the present disclosure, effective link adjustment and enhanced link robustness can be provided, thereby improving efficiency of the overall transmission and reducing loss of data packets. Correspondingly, embodiments of the present disclosure can also provide an apparatus for two-hop packet transmission implemented at a relay device and remote device or base station, which will be described in detail in the following text with reference to FIGs. 7 and 8.

[0050] FIG. 7 is a structural block diagram illustrating an apparatus 700 implemented at a relay device according to the embodiments of the present disclosure. It should be understood that the apparatus 700 can be implemented in the relay UE 120 shown in FIG. 1. Alternatively, the apparatus 700 can be the relay UE *per se*. The apparatus 700 can perform control for two-hop packet transmission at a RLC sub-layer of L2.

[0051] As shown in FIG. 7, the apparatus 700 may comprise an obtaining unit 710 and a transmitting unit 720. The obtaining unit 710 can be configured to obtain status information of second hop RLC transmission. For example, the obtaining unit 710 can be implemented with a controller. The transmitting unit 720 can be configured to transmit the status information to a transmitting device in first hop RLC transmission (such as the remote UE 110 in FIG. 1) for the transmitting device to control the first hop RLC transmission based on the status information. For example, the transmitting unit 720 can be implemented with a transceiver.

[0052] In an embodiment, the obtaining unit 710 may comprise a first monitoring unit (not shown) configured to monitor a link condition of the second hop RLC transmission. In an embodiment, the first monitoring unit is configured to at least monitor at least one of the following: whether the second hop RLC transmission is blocked for a first predetermined period of time; whether, in the presence of packet transmission, ACK information for the packet transmission is received within a second predetermined period of time; whether a

buffer for the second hop RLC transmission is full for a third predetermined period of time; whether, after the second hop RLC transmission is blocked or ACK information for packet transmission is not received within a predetermined period of time, the ACK information is received again; and whether the buffer for the second hop RLC transmission turns from a full state into a non-full state.

[0053] In an embodiment, the obtaining unit 710 may comprise a second monitoring unit (not shown) configured to monitor a packet transmission condition for the second hop RLC transmission. In an embodiment, the second monitoring unit can be configured to monitor at least ACK/NACK information for the second hop RLC transmission.

[0054] In an embodiment, the transmitting unit 720 may comprise a first transmitting unit (not shown) configured to add the status information to a state PDU for the first hop RLC transmission. In another embodiment, the transmitting unit 720 may comprise a second transmitting unit (not shown) configured to transmit the status information in a newly defined PDU that is used exclusively for transmitting the status information.

[0055] It should be understood that each unit recited in the apparatus 700 corresponds to each action in the method 300 depicted with reference to FIG. 3. Besides, operations and features of the apparatus 700 and the units contained therein all correspond to those depicted with reference to FIG. 3 in the preceding text and achieve the same effect. Thus the details are omitted here.

[0056] FIG. 8 is a structural block diagram illustrating an apparatus 800 for two-hop packet transmission implemented at a remote device or a base station according to the embodiments of the present disclosure. It shall be appreciated that the apparatus 800 can be implemented in the remote UE 120 shown in FIG. 1, for instance, or in the eNB 130 shown in FIG.1. Alternatively, the apparatus 800 can be the remote UE *per se* or the eNB *per se*. The apparatus 800 can perform control for the two-hop packet transmission at a RLC sub-layer of L2.

[0057] As shown in FIG. 8, the apparatus 800 may comprise a receiving unit 810 and a controlling unit 820. The receiving unit 810 can be configured to receive, from a relay device (such as the relay UE 120 shown in FIG. 1), status information of second hop RLC transmission of the two-hop packet transmission. The receiving unit 810 can be implemented with a transceiver. The controlling unit 820 is configured to control first hop RLC transmission of the two-hop packet transmission based on the status information. The

controlling unit 820 can be implemented with a controller.

[0058] In an embodiment, the receiving unit 810 may comprise a first receiving unit (not shown) configured to obtain the status information from a status PDU for the first hop RLC transmission. In another embodiment, the receiving unit 810 may comprise a second receiving unit (not shown) configured to obtain the status information from a newly defined PDU that is used exclusively for transmitting the status information.

[0059] In an embodiment, the controlling unit 820 may comprise a first adjusting unit (not shown) configured to adjust the first hop RLC transmission based on a link condition of the second hop RLC transmission. The first adjusting unit is configured to adjust the first hop RLC transmission at least based on at least one of the following: whether the second hop RLC transmission is blocked for a first predetermined period of time; whether, in the presence of packet transmission, ACK information for the packet transmission is received within a second predetermined period of time; whether a buffer for the second hop RLC transmission is full for a third predetermined period of time; whether, after the second hop RLC transmission is blocked or ACK information for packet transmission is not received within a predetermined period of time, the ACK information is received again; and whether the buffer for the second hop RLC transmission turns from a full state into a non-full state.

[0060] In an embodiment, the controlling unit 820 may comprise a second adjusting unit (not shown) configured to adjust the first hop RLC transmission based on a packet transmission condition of the second hop RLC transmission. In an embodiment, the second adjusting unit is configured to adjust the first hop RLC transmission based on the ACK/NACK information for the second hop RLC transmission.

[0061] According to the embodiments of the present disclosure, adjusting the first hop RLC transmission at least comprises at least one of the following: ceasing the first hop RLC transmission; changing a size of a data PDU for the first hop RLC transmission; delaying the first hop RLC transmission; and recovering the first hop RLC transmission.

[0062] In an embodiment, the apparatus 800 may further comprise a maintaining unit (not shown) configured to maintain, based on the ACK/NACK information for the second hop RLC transmission, data in the buffer for the first hop RLC transmission.

[0063] It shall be appreciated that each unit recited in the apparatus 800 corresponds to each action in the method 400 depicted with reference to FIG. 4. Besides, operations and features of the apparatus 800 and the units contained therein all correspond to those depicted with

reference to FIG. 4 in the preceding text and achieve the same effect. Thus the details are omitted here.

[0064] FIG. 9 is a structural block diagram illustrating a device 900 according to the embodiments of the present disclosure. The device 900 may comprise a controller 910 which controls the operations and functions of the device 900. For example, in some embodiments, the controller 910 can implement various operations by means of instructions 930 stored in a memory 920 coupled thereto. The memory 920 can be any proper type adapted to the local technical environment and can be implemented with any proper data storage technology, including but not limited to a semiconductor storage device, a magnetic storage device and system, and an optical storage device and system. Although FIG. 9 only illustrates one memory unit, multiple physically different memory units may exist in the device 900.

[0065] The controller 910 can be any appropriate type suitable for the local technical environment and can comprise but not limited to one or more of a universal computer, a dedicated computer, a microcontroller, a digital signal controller (DSP) and a controller-based multi-core controller architecture. The device 900 can also comprise a plurality of controllers 910.

[0066] The device 900 can be used to implement the relay UE 120. When the device 900 serves as the relay UE 120, the controller 910 and the memory 920 can operate in cooperation to implement the method 300 depicted with reference to FIG. 3 in the above text. All the features described above with reference to FIG. 3 apply to the device 900, thus omitted here.

[0067] The device 900 can be used to implement the remote UE 110 or the eNB 130. When the device 900 serves as the remote UE 110 or the eNB 130, the controller 910 and the memory 920 can operate in cooperation to implement the method 400 depicted with reference to FIG. 4 in the above text. All the features described above with reference to FIG. 4 apply to the device 900, thus omitted here.

[0068] It should be understood that the device 900 may further comprise other necessary devices/elements, such as a transmitter, a receiver, a transceiver, an antenna and so on to implement the corresponding actions, which are not shown in the figures for the sake of clarity.

[0069] Generally speaking, the various exemplary embodiments of the present disclosure may be implemented in hardware or application-specific circuit, software, logic, or in any

combination thereof. Some aspects may be implemented in hardware, while the other aspects may be implemented in firmware or software executed by a controller, a microprocessor or other computing devices. When various aspects of the embodiments of the present disclosure are illustrated or described into block diagrams, flow charts, or other graphical representations, it would be understood that the block diagrams, apparatus, system, technique or method described here may be implemented, as non-restrictive examples, in hardware, software, firmware, dedicated circuit or logic, common software or controller or other computing devices, or some combinations thereof. Illustrative types of the hardware components that can be used to implement the embodiments of the present disclosure comprise but are not limited to: a field programmable gate array (FPGA), an application specific integrated circuit (ASIC), application specific standard parts (ASSP), a system on chip (SOC), and a complex programmable logic device (CPLD) and so on.

[0070] As an example, the embodiments of the present disclosure can be described in a context of machine-executable instructions which are included, for instance, in the program module executed in the device on a target real or virtual processer. Generally, a program module includes routine, program, bank, object, class, component and data structure and so on and performs a particular task or implements a particular abstract data structure. In the embodiments, the functions of the program modules can be combined or divided among the described program modules. The machine executable instructions for the program module can be executed in a local or distributed device. In the distributed device, the program module can be located between the local and remote storage mediums.

[0071] The computer program code for implementing the method of the present disclosure may be complied with one or more programming languages. These computer program codes may be provided to a general-purpose computer, a dedicated computer or a processor of other programmable data processing apparatus, such that when the program codes are executed by the computer or other programmable data processing apparatus, the functions/operations prescribed in the flowchart and/or block diagram are caused to be implemented. The program code may be executed completely on a computer, partially on a computer, partially on a computer as an independent software packet and partially on a remote computer, or completely on a remote computer or server.

[0072] In the context of the present disclosure, the machine-readable medium may be any tangible medium including or storing a program for or about an instruction executing system, apparatus or device. The machine-readable medium may be a machine-readable signal

medium or machine-readable storage medium. The machine-readable medium may include, but not limited to, electronic, magnetic, optical, electro-magnetic, infrared, or semiconductor system, apparatus or device, or any appropriate combination thereof. More specific examples of the machine readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[0073] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[0074] Although the present disclosure has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter specified in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

I/We Claim:

1. A method implemented at a relay device for two-hop packet transmission, comprising:

at a radio link control (RLC) sub-layer of a radio link layer (L2):

obtaining status information of second hop RLC transmission of the two-hop packet transmission; and

transmitting the status information to a transmitting device in first hop RLC transmission of the two-hop packet transmission for the transmitting device to control the first hop RLC transmission based on the status information.

2. The method according to Claim 1, wherein obtaining the status information comprises:

monitoring a link condition for the second hop RLC transmission.

3. The method according to Claim 2, wherein monitoring the link condition at least comprises monitoring at least one of:

whether the second hop RLC transmission is blocked for a first predetermined period of time,

whether ACK information for the second hop RLC transmission is received within a second predetermined period of time if there is the second hop RLC transmission,

whether a buffer for the second hop RLC transmission is in a full state for a third predetermined period of time,

whether the ACK information is received again after the second hop RLC transmission is blocked or the ACK information is not received within a predetermined period of time, and

whether the buffer for the second hop RLC transmission is changed from the full state to a non-full state.

4. The method according to Claim 1, wherein obtaining the status information comprises:

monitoring a packet transmission condition for the second hop RLC transmission.

5. The method according to Claim 4, wherein monitoring the packet transmission condition comprises monitoring at least ACK/NACK information for the second hop RLC

transmission.

6. The method according to Claim 1, wherein transmitting the status information comprises:

adding the status information to a "STATUS" protocol data unit (PDU) for the first hop RLC transmission.

7. The method according to Claim 1, wherein transmitting the status information comprises:

transmitting the status information in a newly defined PDU that is used exclusively for transmitting the status information.

8. A method implemented at a remote device or base station for two-hop packet transmission, comprising:

at a radio link control (RLC) sub-layer of a radio link layer (L2):

receiving, from a relay device, status information for second hop RLC transmission of the two-hop packet transmission; and

controlling first hop RLC transmission of the two-hop packet transmission based on the status information.

9. The method according to Claim 8, wherein receiving the status information comprises:

obtaining the status information from a "STATUS" protocol data unit (PDU) for the first hop RLC transmission.

10. The method according to Claim 8, wherein receiving the status information comprises:

obtaining the status information from a newly defined PDU that is used exclusively for transmitting the status information.

11. The method according to Claim 8, wherein controlling the first hop RLC transmission comprises:

adjusting the first hop RLC transmission based on a link condition of the second hop RLC transmission.

12. The method according to Claim 11, wherein the adjusting comprises adjusting the first hop RLC transmission based on at least one of:

whether the second hop RLC transmission is blocked for a first predetermined period of time,

whether ACK information for the second hop RLC transmission is received within a second predetermined period of time if there is the second hop RLC transmission,

whether a buffer for the second hop RLC transmission is in a full state for a third predetermined period of time,

whether the ACK information is received again after the second hop RLC transmission is blocked or the ACK information is not received within a predetermined period of time, and

whether the buffer for the second hop RLC transmission is changed from the full state to a non-full state.

13. The method according to Claim 8, wherein controlling the first hop RLC transmission comprises:

adjusting the first hop RLC transmission based on a packet transmission condition of the second hop RLC transmission.

14. The method according to Claim 13, wherein adjusting the first hop RLC transmission comprises:

adjusting the first hop RLC transmission based on ACK/NACK information for the second hop RLC transmission.

15. The method according to Claim 14, further comprising:

maintaining data in a buffer for the first hop RLC transmission based on the ACK/NACK information for the second hop RLC transmission.

16. The method according to any of Claims 11-14, wherein adjusting the first hop RLC transmission comprises at least one of:

ceasing the first hop RLC transmission,

changing a size of a data PDU for the first hop RLC transmission,

delaying the first hop RLC transmission, and

recovering the first hop RLC transmission.

17. A relay device for controlling two-hop packet transmission at a radio link control (RLC) sub-layer of a radio link layer (L2), comprising:

a controller configured to obtain status information of second hop RLC transmission of the two-hop packet transmission; and

a transceiver configured to transmit the status information to a transmitting device in first hop RLC transmission of the two-hop packet transmission for the transmitting device to control the first hop RLC transmission based on the status information.

18. The device according to Claim 17, wherein the controller is configured to monitor a link condition for the second hop RLC transmission.

19. The device according to Claim 18, wherein the controller is configured to at least monitor at least one of:

whether the second hop RLC transmission is blocked for a first predetermined period of time,

whether ACK information for the second hop RLC transmission is received within a second predetermined period of time if there is the second hop RLC transmission,

whether a buffer for the second hop RLC transmission is in a full state for a third predetermined period of time,

whether the ACK information is received again after the second hop RLC transmission is blocked or the ACK information is not received within a predetermined period of time, and

whether the buffer for the second hop RLC transmission is changed from the full state to a non-full state.

20. The device according to Claim 17, wherein the controller is configured to monitor a packet transmission condition for the second hop RLC transmission.

21. The device according to Claim 20, wherein the controller is configured to monitor at least ACK/NACK information for the second hop RLC transmission.

22. The device according to Claim 17, wherein the transceiver is configured to add the status information to a “STATUS” protocol data unit (PDU) for the first hop RLC transmission.

23. The device according to Claim 17, wherein the transceiver is configured to transmit the status information in a newly defined PDU that is used exclusively for transmitting the status information.

24. A remote device for controlling, at a radio link control (RLC) sub-layer of a radio link layer (L2), two-hop packet transmission with a base station via a relay device, comprising:

a transceiver configured to receive, from the relay device, status information for second hop RLC transmission of the two-hop packet transmission; and

a controller configured to control first hop RLC transmission of the two-hop packet transmission based on the status information.

25. The device according to Claim 24, wherein the transceiver is configured to obtain the status information from a "STATUS" protocol data unit (PDU) for the first hop RLC transmission.

26. The device according to Claim 24, wherein the transceiver is configured to obtain the status information from a newly defined PDU that is used exclusively for transmitting the status information.

27. The device according to Claim 24, wherein the controller is configured to adjust the first hop RLC transmission based on a link condition of the second hop RLC transmission.

28. The device according to Claim 27, wherein the controller is configured to adjust the first hop RLC transmission at least based on at least one of:

whether the second hop RLC transmission is blocked for a first predetermined period of time,

whether ACK information for the second hop RLC transmission is received within a second predetermined period of time if there is the second hop RLC transmission,

whether a buffer for the second hop RLC transmission is in a full state for a third predetermined period of time,

whether the ACK information is received again after the second hop RLC transmission is blocked or the ACK information is not received within a predetermined period of time, and

whether the buffer for the second hop RLC transmission is changed from the full state to a non-full state.

29. The device according to Claim 24, wherein the controller is configured to adjust the first hop RLC transmission based on a packet transmission condition of the second hop RLC transmission.

30. The device according to Claim 29, wherein the controller is configured to adjust the first RLC transmission based on ACK/NACK information for the second hop RLC transmission.

31. The device according to Claim 30, wherein the controller is further configured to maintain data in a buffer for the first hop RLC transmission based on the ACK/NACK information for the second hop RLC transmission.

32. The device according to any of Claims 27-30, wherein adjusting the first hop RLC transmission comprises at least one of:

ceasing the first hop RLC transmission,

changing a size of a data PDU for the first hop RLC transmission,

delaying the first hop RLC transmission, and

recovering the first hop RLC transmission.

33. A base station for controlling, at a radio link control (RLC) sub-layer of a radio link layer (L2), two-hop packet transmission with a remote device via a relay device, comprising:

a transceiver configured to receive, from the relay device, status information for second hop RLC transmission of the two-hop packet transmission; and

a controller configured to control first hop RLC transmission of the two-hop packet transmission based on the status information.

34. The base station according to Claim 33, wherein the transceiver is configured to obtain the status information from a “STATUS” protocol data unit (PDU) for the first hop RLC transmission.

35. The base station according to Claim 33, wherein the transceiver is configured to obtain the status information from a newly defined PDU that is used exclusively for transmitting the status information.

36. The base station according to Claim 33, wherein the controller is configured to adjust the first hop RLC transmission based on a link condition of the second hop RLC transmission.

37. The base station according to Claim 36, wherein the controller is configured to adjust the first hop RLC transmission at least based on at least one of:

whether the second hop RLC transmission is blocked for a first predetermined period of time;

whether ACK information for the second hop RLC transmission is received within a second predetermined period of time if there is the second hop RLC transmission;

whether a buffer for the second hop RLC transmission is in a full state for a third predetermined period of time;

whether the ACK information is received again after the second hop RLC transmission is blocked or the ACK information is not received within a predetermined period of time; and

whether the buffer for the second hop RLC transmission is changed from the full state to a non-full state.

38. The base station according to Claim 33, wherein the controller is configured to adjust the first hop RLC transmission based on a packet transmission condition of the second hop RLC transmission.

39. The base station according to Claim 38, wherein the controller is configured to adjust the first RLC transmission based on ACK/NACK information for the second hop RLC transmission.

40. The base station according to Claim 39, wherein the controller is further configured to maintain data in a buffer for the first hop RLC transmission based on the ACK/NACK information for the second hop RLC transmission.

41. The base station according to any of Claims 36-39, wherein adjusting the first hop

RLC transmission comprises at least one of:

ceasing the first hop RLC transmission,

changing a size of a data PDU for the first hop RLC transmission,

delaying the first hop RLC transmission, and

recovering the first hop RLC transmission.

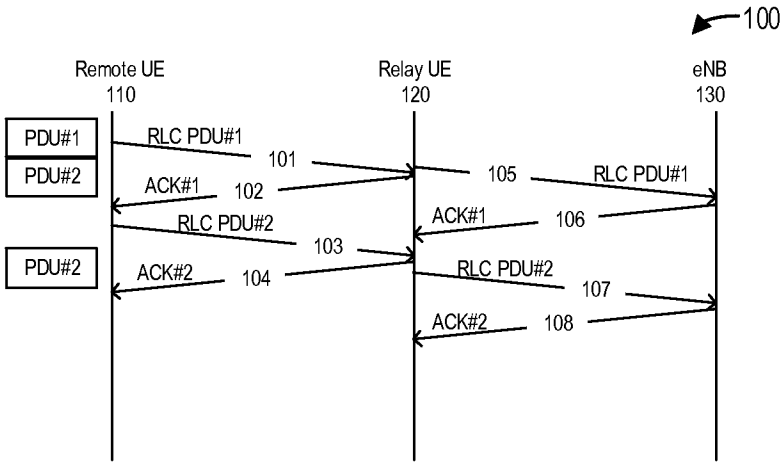
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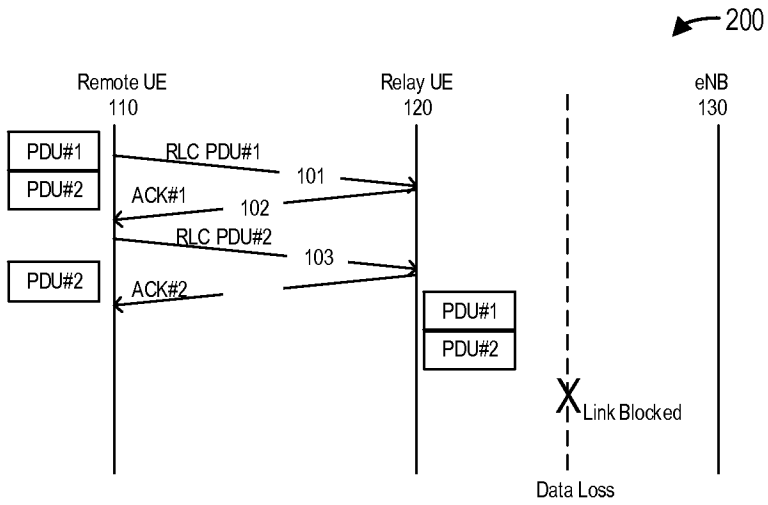
Fig. 1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Link Blocked
Data Loss

Fig. 2

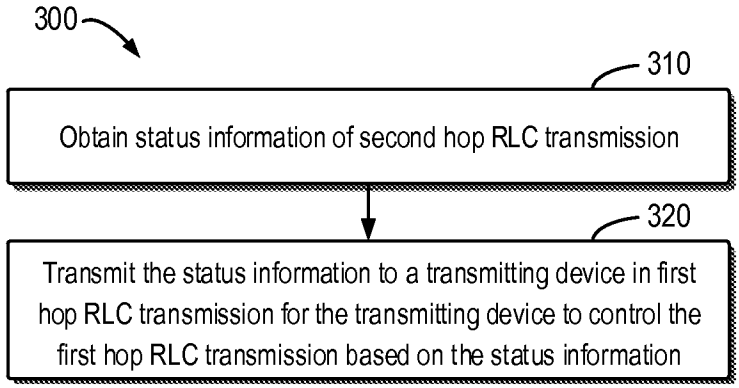

Fig. 3

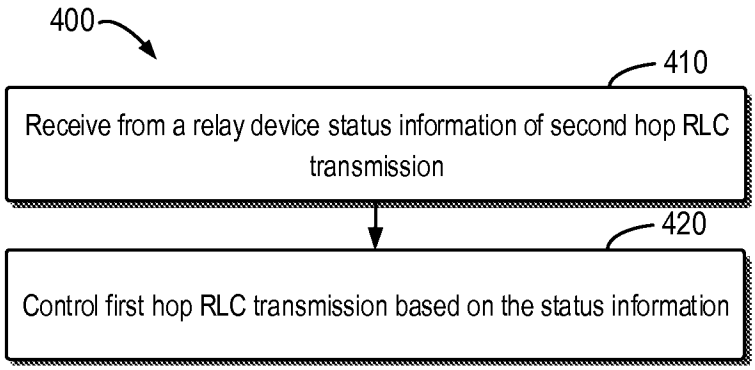

Fig. 4

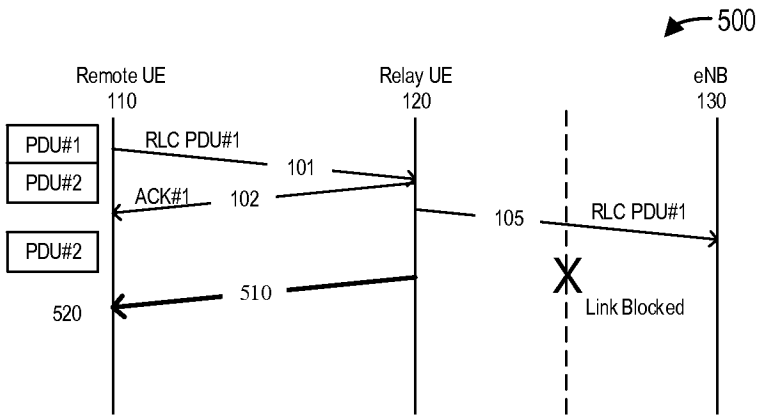

Fig. 5

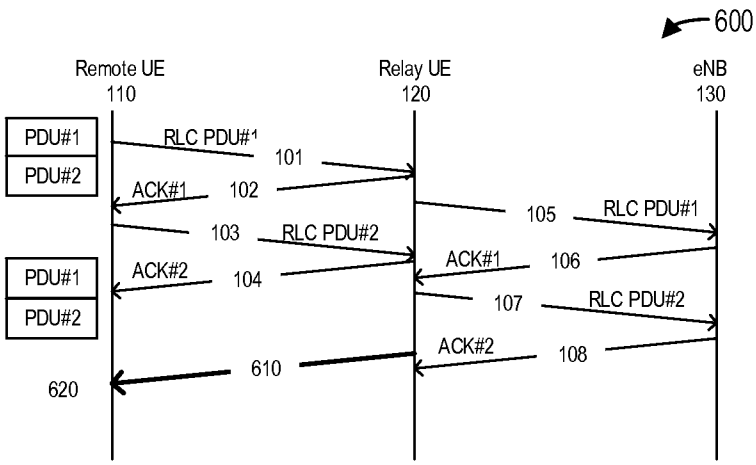

Fig. 6

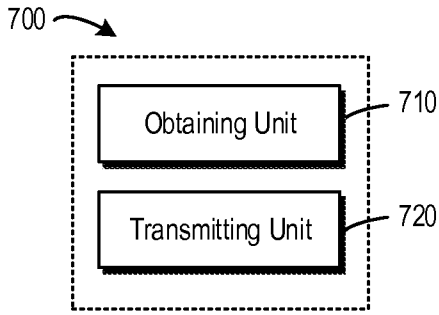

Fig. 7

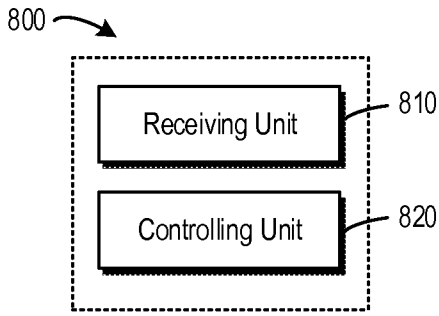

Fig. 8

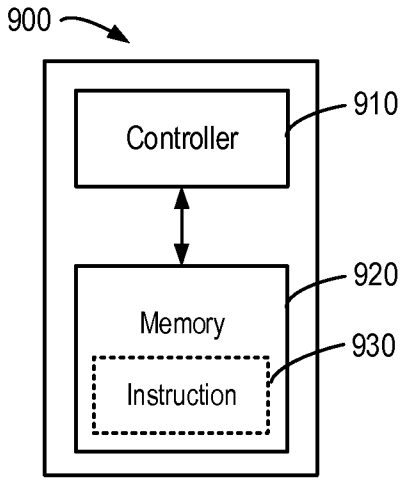

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/001414

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/18 H04L1/00 H04L1/16
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 214 435 A1 (PANASONIC CORP [JP]) 4 August 2010 (2010-08-04) abstract figure 11 paragraph [0135] - paragraph [0159] -----	1-41
X	US 2011/038376 A1 (WIEMANN HENNING [US] ET AL) 17 February 2011 (2011-02-17) figures 6-8, 12-14c paragraph [0122] - paragraph [0128] -----	1-41

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 February 2018	14/03/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borges, Pedro

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/001414

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2214435 A1	04-08-2010	EP 2214435 A1	04-08-2010
		WO 2010086156 A1	05-08-2010
US 2011038376 A1	17-02-2011	CN 101069378 A	07-11-2007
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