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(54) Title: METHOD OF TRANSMITTING SIGNALING OF DEVICE-TO-DEVICE COMMUNICATION IN CELLULAR NETWORK

(57) Abstract: The invention provides a method of transmitting signaling of device-to-device communication in a cellular network. Particularly the invention provides a method of transmitting an HARQ of device-to-device communication in a cellular network. With the HARQ transmission solution of the invention, HARQ transmission can be performed effectively while maintaining backward compatibility.

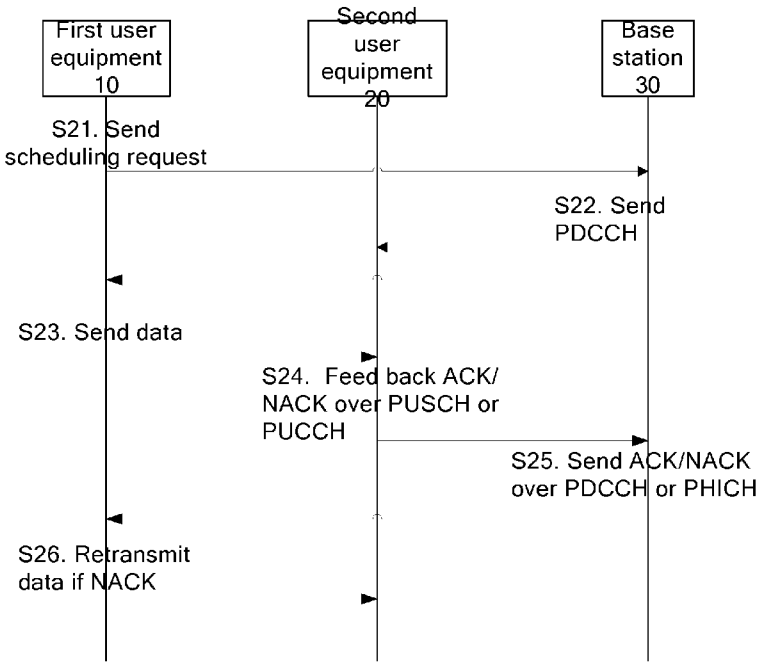



Fig.2

WO 2014/076552 A2

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# Method of Transmitting Signaling of Device-to-Device Communication in Cellular Network

## Field of the invention

The present disclosure relates to a communication system and particularly to device-to-device communication in a cellular network.

## Background of the invention

In recent years, a communication mode of Device-to-Device (D2D) has been proposed. The communication mode of Device-to-Device is a short-range service different from a conventional cellular communication mode. For a conventional cellular communication system, communication between user equipments has to be processed by an RAN and core network nodes (including an eNB, etc) even though they are close to each other. In order to save cellular resources and lower a communication delay, a cellular controlled D2D communication system has been introduced as a potential short-range technology for the LTE-A. Now the 3GPP has initiated a new study item to develop a D2D technology-related standard for a proximity service.

For the conventional cellular communication system, communication between user equipments in the same cell has to be scheduled and transmitted/received by the eNB. In D2D communication, two user equipments can communicate directly with each other. Obviously the existing HARQ transmission mechanism cannot support D2D communication properly. Thus it is necessary to introduce an efficient HARQ mechanism applicable to D2D communication in the cellular infrastructure while keeping backward compatibility.

## Summary of the invention

In conventional cellular communication, if a user equipment A wants to send data to a user equipment B, then firstly the user equipment A sends data to a base station in the uplink, and then the base station forwards the data to the user equipment B in the downlink. Thus there are two independent HARQ processes in the uplink and the downlink respectively.

Steps of the conventional HARQ mechanism in cellular communication are as follows:

For uplink HARQ transmission:

Step 1: The user equipment A sends a scheduling request to the base station.

Step 2: The base station sends a Physical Downlink Control Channel (PDCCH) to the user equipment A in the n1-th sub-frame.

Step 3: The user equipment A sends data to the base station over an allocated frequency resource in the (n1+k1)-th sub-frame.

Step 4: The base station sends an HARQ ACK/NACK to the user equipment A on a Physical HARQ Indicator Channel (PHICH) in the (n1+k1+k2)-th sub-frame for a non-adaptive HARQ; and the base station sends an HARQ ACK/NACK to the user equipment A over the PDCCH in the (n1+k1+k2)-th sub-frame for an adaptive HARQ.

Step 5: The user equipment A receives the HARQ ACK/NACK over the PHICH or the PDCCH. If the user equipment A receives the NACK over the PDCCH, then the user equipment A retransmits the data to the base station over a newly allocated frequency resource in the (n1+k1+k2+k3)-th sub-frame; or if the user equipment A receives the NACK over the PHICH, then the user equipment A retransmits the data to the base station over an original frequency resource in the (n1+k1+k2+k3)-th sub-frame.

Step 6: The foregoing steps 4 to 5 are repeated until the data is decoded correctly by the base station.

For downlink HARQ transmission:

Step 1: The base station forwards the data to the user equipment B in the n2-th sub-frame.

Step 2: If the user equipment B has data to be transmitted over a Physical Uplink Shared Channel (PUSCH), then the user equipment B sends an HARQ ACK/NACK to the base station over the PUSCH in the (n2+k4)-th sub-frame; or if the user equipment has no data to be transmitted over the PUSCH, then the user equipment B sends an HARQ ACK/NACK to the base station over a Physical Uplink Control Channel (PUCCH) in the (n2+k4)-th sub-frame.

Step 3: The base station receives the HARQ ACK/NACK. If the HARQ feedback is an NACK, then the base station retransmits the data to the user equipment B in the (n2+k4+k5)-th sub-frame.

Step 4: The foregoing steps 2 to 3 are repeated until the data is decoded correctly by the user equipment B.

In conventional cellular communication, an HARQ feedback is designed only between the user equipment and the base station. In D2D communication, since the user equipment A can communicate directly with the user equipment B, the main challenge is how to utilize an existing data channel or control channel to feed back an HARQ ACK/NACK between the user equipment A and the user equipment B with a limited impact on the existing HARQ mechanism in cellular communication.

In view of the foregoing, the invention proposes a method of transmitting an HARQ of D2D communication in a cellular network and other methods of transmitting signaling.

According to an embodiment of an aspect of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: a. the first user equipment sending data to the

second user equipment over an allocated resource; b. the first user equipment receiving an HARQ feedback forwarded by the base station over a PDCCH or a PHICH; and c. if the HARQ feedback is NACK signaling and the NACK signaling is received over the PDCCH, then the first user equipment retransmitting the data over the newly allocated resource; or if the HARQ feedback is NACK signaling and the NACK signaling is received over the PHICH, then the first user equipment retransmitting the data over an originally allocated resource.

Advantageously the step b further includes: the first user equipment receiving device-to-device communication indicator information provided by the base station, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

According to another embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: A. the second user equipment receiving data from the first user equipment and decoding the data; and B. if the second user equipment currently has data to be transmitted over a PUSCH, then the second user equipment sending an HARQ feedback to the base station over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then the second user equipment sending the HARQ feedback to the base station over a PUCCH.

Advantageously the step B further includes: the second user equipment providing device-to-device communication indicator information to the base station, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device communication

According to a further embodiment of the invention, there is proposed

a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: i. the base station receiving an HARQ feedback from the second user equipment; ii. if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then the base station forwarding the HARQ feedback to the first user equipment over a PDCCH; or if the HARQ feedback is NACK signaling and corresponds to a non-adaptive HARQ and a semi-static HARQ, then the base station forwarding the HARQ feedback to the first user equipment over a PHICH; and iii. if the HARQ feedback is ACK signaling, then the base station forwarding the HARQ feedback to the first user equipment over the PHICH.

Advantageously the step i further includes: the base station receiving device-to-device communication indicator information provided by the second user equipment; the step ii further includes: the base station providing the device-to-device communication indicator information to the first user equipment; and the step iii further includes: the base station providing the device-to-device communication indicator information to the first user equipment, and wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: I. the first user equipment sending data to the second user equipment over an allocated resource; II. the first user equipment receiving an HARQ feedback from the second user equipment over a PUSCH or a PDCCH; III. if the HARQ feedback is NACK signaling, then the first user equipment

retransmitting the data over an originally allocated resource; and IV. if the HARQ feedback is ACK signaling, then the first user equipment instructing the base station to release the allocated resource.

Advantageously the step II further includes: the first user equipment receiving device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: m. the second user equipment receiving data from the first user equipment and decoding the data; and n. if the second user equipment currently has data to be transmitted over a PUSCH, then the second user equipment sending an HARQ feedback to the first user equipment over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then the second user equipment sending the HARQ feedback to the first user equipment over a PUCCH.

Advantageously the step n further includes: the second user equipment providing device-to-device communication indicator information to the first user equipment, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: x. the first user equipment sending data to the second user equipment over

an allocated resource; y. the first user equipment receiving an HARQ feedback from the second user equipment; and z. if the HARQ feedback is NACK signaling and the first user equipment obtains a newly allocated resource from the base station, then the first user equipment retransmitting the data over the newly allocated resource; or if the HARQ feedback is NACK signaling and the first user equipment does not obtain the newly allocated resource from the base station, then the first user equipment retransmitting the data over the originally allocated resource.

Advantageously the step y further includes: the first user equipment receiving device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: M. the second user equipment receiving data from the first user equipment and decoding the data; and N. if the second user equipment currently has data to be transmitted over a PUSCH, then the second user equipment sending an HARQ feedback to the base station and the first user equipment over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then the second user equipment sending the HARQ feedback to the base station and the first user equipment over a PUCCH.

Advantageously the step N further includes: the second user equipment providing device-to-device communication indicator information to the base station and the first user equipment, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device

communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the steps of: X. the base station receiving an HARQ feedback from the second user equipment; and Y. if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then the base station providing the first user equipment with a newly allocated resource; or if the HARQ feedback is NACK signaling and corresponds to a non-adaptive HARQ and a semi-static HARQ, then the base station providing the first user equipment without the newly allocated resource.

Advantageously the step X further includes: the base station receiving device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

According to a further embodiment of the invention, there is proposed a method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method includes the step of: - the second user equipment sending signaling to the base station, and wherein the signaling includes any of a CQI, a CSI, a PMI, a rank indicator, a buffer status report and RRC signaling.

The respective aspects of the invention will become more apparent from the following description of particular embodiments.

## Brief description of drawings

The foregoing and other features of the invention will become more

apparent upon review of the following detailed description of non-limiting embodiments taken with reference to the drawings in which:

Fig.1 illustrates a network topology diagram of D2D communication in a cellular network according to an embodiment of the invention;

Fig.2 illustrates a flow chart of a method of transmitting an HARQ according to an embodiment of the invention;

Fig.3 illustrates a flow chart of a method of transmitting an HARQ according to another embodiment of the invention; and

Fig.4 illustrates a flow chart of a method of transmitting an HARQ according to a further embodiment of the invention.

Identical or similar reference numerals denote identical or similar components in the drawings.

## Detailed description of embodiments

Respective embodiments of the invention will be described below in details with reference to the drawings.

For D2D communication in a cellular network, in order to realize correct communication between user equipments, extra indicator information needs to be defined to indicate whether current HARQ transmission is for device-to-device communication or for cellular communication. This can be done in the following two ways:

(1) Defining the explicit indicator bits by using reserved bits in an existing PDCCH, PUCCH, PHICH and PUSCH as an indicator bit. For example, one of the bits can be used to indicate whether current HARQ transmission is HARQ transmission for device-to-device communication or HARQ transmission for cellular communication.

(2) They can be distinguished by sub-frames/frequencies/antenna ports/sequences. For example, a sub-frame 1 can be defined to be dedicated to HARQ transmission of device-to-device communication while having other sub-frames used for HARQ transmission of cellular communication. In another example, some dedicated frequency resource

can be defined for HARQ transmission of device-to-device communication while having other frequency resources used for HARQ transmission of cellular communication. In still another example, HARQ transmission for device-to-device communication and HARQ transmission for cellular communication can be distinguished by different sequence offsets.

Respective embodiments of the invention will be described below in connection with the network topology diagram in Fig.1 by way of an example in which reserved bits in the existing PDCCH, PUCCH, PHICH and PUSCH are used to indicate whether current HARQ transmission is HARQ transmission for device-to-device communication or HARQ transmission for cellular communication.

The network topology in Fig.1 includes a base station 30, a first user equipment 10 and a second user equipment 20 based upon D2D communication, and a third user equipment 40 and a fourth user equipment 50.

First Embodiment

In this embodiment, an HARQ feedback is made in two steps: from the second user equipment 20 to the base station 30 and from the base station 30 to the first user equipment 10.

Referring to Fig.2, in the step S21, the first user equipment 10 sends a scheduling request to the base station 30.

After the base station 30 receives the scheduling request from the first user equipment 10, in the step S22, the base station 30 sends a PDCCH to the first user equipment 10 and the second user equipment 20 in the n1-th sub-frame to indicate a resource allocated for the first user equipment 10.

In the step S23, the first user equipment 10 sends data to the second user equipment 20 over the allocated resource in the (n1+k1)-th sub-frame.

After the second user equipment 20 receives the data from the first user equipment 10, in the step S24, the second user equipment 20 decodes

the data and sends an HARQ feedback and provides device-to-device communication indicator information to the base station 30 in the (n1+k1+k2)-th sub-frame. Specifically if the second user equipment 20 currently has data to be transmitted over a PUSCH, then the second user equipment 20 sends the HARQ feedback to the base station 30 over the PUSCH and sets an indicator bit in the PUSCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication; or if the second user equipment 20 currently has no data to be transmitted over the PUSCH, then the second user equipment 20 sends the HARQ feedback to the base station 30 over a PUCCH and sets an indicator bit in the PUCCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication.

After the base station 30 receives the HARQ feedback and the device-to-device communication indicator information from the second user equipment 20, in the step S25, if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then the base station 30 forwards the HARQ feedback to the first user equipment 10 over the PDCCH in the (n1+k1+k2+k3)-th sub-frame and sets an indicator bit in the PDCCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication; or if the HARQ feedback is NACK signaling and corresponds to a non-adaptive HARQ and a semi-static HARQ, then the base station 30 forwards the HARQ feedback to the first user equipment 10 over a PHICH in the (n1+k1+k2+k3)-th sub-frame and sets an indicator bit in the PHICH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication; or if the HARQ feedback is ACK signaling, then the base station 30 forwards the HARQ feedback to the first user equipment 10 over the PHICH in the (n1+k1+k2+k3)-th sub-frame and sets the indicator bit in the PHICH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for

device-to-device communication.

After the first user equipment 10 receives the HARQ feedback forwarded by the base station 30 and the device-to-device communication indicator information provided by the base station 30 over the PDCCH or the PHICH, in the step S26, if the HARQ feedback is NACK signaling and the first user equipment 10 receives the NACK signaling over the PDCCH, then the first user equipment 10 retransmits the data over the newly allocated resource indicated in the PDCCH in the (n1+k1+k2+k3+k4)-th sub-frame; or if the HARQ feedback is NACK signaling and the first user equipment 10 receives the NACK signaling over the PHICH, then the first user equipment 10 retransmits the data over an originally allocated resource in the (n1+k1+k2+k3+k4)-th sub-frame.

The foregoing steps S24 to S26 are repeated until the second user equipment 20 decodes correctly the data.

In this embodiment, for a link from the second user equipment 20 to the base station 30, the HARQ ACK/NACK is fed back over the uplink channel PUCCH or PUSCH; and for a link from the base station 30 to the first user equipment 10, the HARQ ACK/NACK is fed back over the downlink channel PHICH or PDCCH. That is, the technical solution of this embodiment reuses the existing control channel or data channel to feed back the HARQ ACK/NACK without any extra channel overhead.

Second Embodiment

In some application scenario, for example, semi-static scheduling, a base station will allocate a fixed frequency resource the whole HARQ process, that is, the base station will not reallocate a scheduled resource in each retransmission. Moreover since the D2D transmission architecture has not been determined, the base station may not control or only partly control a scheduled resource for D2D transmission. In view of this, there is proposed in this embodiment a mechanism of a direct HARQ feedback from the second user equipment 20 to the first user equipment 10.

Referring to Fig.3, in the step S31, the first user equipment 10 sends a

scheduling request to the base station 30.

After the base station 30 receives the scheduling request from the first user equipment 10, in the step S32, the base station 30 sends a PDCCH to the first user equipment 10 and the second user equipment 20 in the n1-th sub-frame to indicate a resource allocated for the first user equipment 10.

In the step S33, the first user equipment 10 sends data to the second user equipment 20 over the allocated resource in the (n1+k1)-th sub-frame.

After the second user equipment 20 receives the data from the first user equipment 10, in the step S34, the second user equipment 20 decodes the data and sends an HARQ feedback and provides device-to-device communication indicator information to the first user equipment 10 in the (n1+k1+k2)-th sub-frame. Specifically if the second user equipment 20 currently has data to be transmitted over a PUSCH, then the second user equipment 20 sends the HARQ feedback to the first user equipment 10 over the PUSCH and sets an indicator bit in the PUSCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication; or if the second user equipment 20 currently has no data to be transmitted over the PUSCH, then the second user equipment 20 sends the HARQ feedback to the first user equipment 10 over a PUCCH and sets an indicator bit in the PUCCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication.

After the first user equipment 10 receives the HARQ feedback and the device-to-device communication indicator information from the second user equipment 20 over the PUSCH or the PDCCH, in the step S35, if the HARQ feedback is NACK signaling, then the first user equipment 10 retransmits the data over an originally allocated resource in the (n1+k1+k2+k3)-th sub-frame; or if the HARQ feedback is ACK signaling, then the first user equipment 10 instructs the base station 30 to release the allocated resource.

The foregoing steps S34 to S35 are repeated until the second user equipment 20 decodes the data correctly.

In this embodiment, the HARQ ACK/NACK is sent directly from the second user equipment 20 to the first user equipment 10, and the first user equipment 10 retransmits without waiting for scheduling information from the base station 30, so the HARQ transmission mechanism in this embodiment has a lower delay as compared with the HARQ transmission mechanism in the foregoing first embodiment. However the HARQ transmission mechanism in this embodiment has some modifications to HARQ transmission in the existing cellular network, where in cellular communication, the first user equipment receives the HARQ ACK/NACK over the PDCCH or the PHICH, and in the HARQ mechanism of this embodiment, the first user equipment 10 receives the HARQ ACK/NACK over the PUSCH or the PUCCH.

Third Embodiment

In this embodiment, the second user equipment 20 broadcasts an HARQ feedback to the first user equipment 10 and the base station 30.

Referring to Fig.4, in the step S41, the first user equipment 10 sends a scheduling request to the base station 30.

After the base station 30 receives the scheduling request from the first user equipment 10, in the step S42, the base station 30 sends a PDCCH to the first user equipment 10 and the second user equipment 20 in the n1-th sub-frame to indicate a resource allocated for the first user equipment 10.

In the step S43, the first user equipment 10 sends data to the second user equipment 20 over the allocated resource in the (n1+k1)-th sub-frame.

After the second user equipment 20 receives the data from the first user equipment 10, in the step S44, the second user equipment 20 decodes the data and broadcasts an HARQ feedback and provides device-to-device communication indicator information to the base station 30 and the first user equipment 10 in the (n1+k1+k2)-th sub-frame. Specifically if the

second user equipment 20 currently has data to be transmitted over a PUSCH, then the second user equipment 20 sends the HARQ feedback to the base station 30 and the first user equipment 10 over the PUSCH and sets an indicator bit in the PUSCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication; or if the second user equipment currently has no data to be transmitted over the PUSCH, then the second user equipment 20 sends the HARQ feedback to the base station 30 and the first user equipment 10 over a PUCCH and sets an indicator bit in the PUCCH (for example, sets the indicator bit to 0) to indicate that the HARQ feedback is for device-to-device communication.

After the base station 30 receives the HARQ feedback and the device-to-device communication indicator information from the second user equipment 20, in the step S45, if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then the base station 30 sends the PDCCH to the first user equipment 10 in the (n1+k1+k2+k3)-th sub-frame to provide the first user equipment 10 with the newly allocated resource; or if the HARQ feedback is NACK signaling and corresponds to a non-adaptive HARQ and a semi-static HARQ, then the base station 30 does not send the PDCCH to the first user equipment 10, that is, does not provide the first user equipment 10 with the newly allocated resource.

After the first user equipment 10 receives the HARQ feedback and the device-to-device communication indicator information from the second user equipment 20, in the step S46, if the HARQ feedback is NACK signaling and the first user equipment 10 receives the PDCCH from the base station 30 (that is, the first user equipment 10 obtains the newly allocated resource from the base station 30), then the first user equipment 10 retransmits the data over the newly allocated resource in the (n1+k1+k2+k3+k4)-th sub-frame; or if the HARQ feedback is NACK signaling and the first user equipment 10 does not receive the PDCCH from the base station 30 (that is, the first user equipment 10 does not

obtain the newly allocated resource from the base station 30), then the first user equipment 10 retransmits the data over an originally allocated resource in the (n1+k1+k2+k3+k4)-th sub-frame.

The foregoing steps S44 to S46 are repeated until the second user equipment 20 decodes the data correctly.

In this embodiment, the second user equipment 20 broadcasts the HARQ ACK/NACK to the base station 30 and the first user equipment 10, so it is not necessary for the base station 30 to forward the HARQ ACK/NACK to the first user equipment 10. This embodiment saves a control channel resource as compared with the HARQ transmission mechanism in the foregoing first embodiment. However the HARQ transmission mechanism in this embodiment has some modifications to HARQ transmission in the existing cellular network, where in cellular communication, the first user equipment receives the HARQ ACK/NACK over the PDCCH or the PHICH, and in the HARQ mechanism of this embodiment, the first user equipment 10 receives the HARQ ACK/NACK over the PUSCH or the PUCCH.

According to another aspect, there is further provided a method of transmitting signaling of device-to-device communication in cellular network. This method includes the steps of: the second user equipment 20 transmitting the signaling to the base station 30, wherein the signaling includes any of a CQI, a CSI, a PMI, a rank indicator, a buffer status report, RRC signaling etc. Such signaling being known to the base station 30 can be beneficial to enhanced performance of the system.

Those skilled in the art shall appreciate that the invention apparently will not be limited to the foregoing exemplary embodiments and can be embodied in other specific forms without departing from the spirit or essence of the invention. Accordingly the embodiments shall be construed anyway to be exemplary and non-limiting. Any reference numerals in the claims shall not be construed as limiting the claims in question. Moreover apparently the term “comprising” will not preclude another element(s) or

step(s), and the term “a” or “an” will not preclude plural. A plurality of elements stated in an apparatus claim can alternatively be embodied as a single element in software or hardware. The terms “first”, “second”, etc., are intended to designate a name but not to suggest any specific order.

5

# CLAIMS

1. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

a. sending, by the first user equipment, data to the second user equipment over an allocated resource;

b. receiving, by the first user equipment, an HARQ feedback forwarded by the base station over a PDCCH or a PHICH; and

c. if the HARQ feedback is NACK signaling and the NACK signaling is received over the PDCCH, then retransmitting, by the first user equipment, the data over the newly allocated resource; or if the HARQ feedback is NACK signaling and the NACK signaling is received over the PHICH, then retransmitting, by the first user equipment, the data over an originally allocated resource.

2. The method according to claim 1, wherein the step b further comprises: receiving, by the first user equipment, device-to-device communication indicator information provided by the base station, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

3. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

A. receiving, by the second user equipment, data from the first user equipment and decoding the data; and

B. if the second user equipment currently has data to be transmitted over a PUSCH, then sending, by the second user equipment, an HARQ

feedback to the base station over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then sending, by the second user equipment, the HARQ feedback to the base station over a PUCCH.

4. The method according to claim 3, wherein the step B further comprises: providing, by the second user equipment, device-to-device communication indicator information to the base station, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device communication.

5. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

i. receiving, by the base station, an HARQ feedback from the second user equipment;

ii. if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then forwarding, by the base station, the HARQ feedback to the first user equipment over a PDCCH; or if the HARQ feedback is NACK signaling and corresponds to a non-adaptive HARQ and a semi-static HARQ, then forwarding, by the base station, the HARQ feedback to the first user equipment over a PHICH; and

iii. if the HARQ feedback is ACK signaling, then forwarding, by the base station, the HARQ feedback to the first user equipment over the PHICH.

6. The method according to claim 5, wherein the step i further comprises: receiving, by the base station, device-to-device communication indicator information provided by the second user equipment;

the step ii further comprises: providing, by the base station, the device-to-device communication indicator information to the first user equipment; and

the step iii further comprises: providing, by the base station, the

device-to-device communication indicator information to the first user equipment, and

wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

7. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

I. sending, by the first user equipment, data to the second user equipment over an allocated resource;

II. receiving, by the first user equipment, an HARQ feedback from the second user equipment over a PUSCH or a PDCCH;

III. if the HARQ feedback is NACK signaling, then retransmitting, by the first user equipment, the data over an originally allocated resource; and

IV. if the HARQ feedback is ACK signaling, then instructing, by the first user equipment, the base station to release the allocated resource.

8. The method according to claim 7, wherein the step II further comprises: receiving, by the first user equipment, device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

9. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

m. receiving, by the second user equipment, data from the first user equipment and decoding the data; and

n. if the second user equipment currently has data to be transmitted over a PUSCH, then sending, by the second user equipment, an HARQ feedback to the first user equipment over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then sending, by the second user equipment, the HARQ feedback to the first user equipment over a PUCCH.

10. The method according to claim 9, wherein the step n further comprises: providing, by the second user equipment, device-to-device communication indicator information to the first user equipment, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device communication.

11. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

x. sending, by the first user equipment, data to the second user equipment over an allocated resource;

y. receiving, by the first user equipment, an HARQ feedback from the second user equipment; and

z. if the HARQ feedback is NACK signaling and the first user equipment obtains a newly allocated resource from the base station, then retransmitting, by the first user equipment, the data over the newly allocated resource; or if the HARQ feedback is NACK signaling and the first user equipment does not obtain the newly allocated resource from the base station, then retransmitting, by the first user equipment, the data over the originally allocated resource

12. The method according to claim 11, wherein the step y further comprises: receiving, by the first user equipment, device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used

for indicating that the HARQ feedback is for device-to-device communication.

13. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

M. receiving, by the second user equipment, data from the first user equipment and decoding the data; and

N. if the second user equipment currently has data to be transmitted over a PUSCH, then sending, by the second user equipment, an HARQ feedback to the base station and the first user equipment over the PUSCH; or if the second user equipment currently has no data to be transmitted over the PUSCH, then sending, by the second user equipment, the HARQ feedback to the base station and the first user equipment over a PUCCH.

14. The method according to claim 13, wherein the step N further comprises: providing, by the second user equipment, device-to-device communication indicator information to the base station and the first user equipment, the device-to-device communication indicator information being used for indicating that the HARQ feedback is for device-to-device communication.

15. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the steps of:

X. receiving, by the base station, an HARQ feedback from the second user equipment;

Y. if the HARQ feedback is NACK signaling and corresponds to an adaptive HARQ, then providing, by the base station, the first user equipment with a newly allocated resource; or if the HARQ feedback is NACK signaling

and corresponds to a non-adaptive HARQ and a semi-static HARQ, then providing. by the base station, the first user equipment without the newly allocated resource.

16. The method according to claim 15, wherein the step X further comprises: receiving, by the base station, device-to-device communication indicator information provided by the second user equipment, wherein the device-to-device communication indicator information is used for indicating that the HARQ feedback is for device-to-device communication.

17. A method of transmitting an HARQ of device-to-device communication in a cellular network, wherein the cellular network includes a base station, and a first user equipment and a second user equipment based upon device-to-device communication, and the method comprises the step of:

- sending, by the second user equipment, signaling to the base station, and

wherein the signaling includes any of a CQI, a CSI, a PMI, a rank indicator, a buffer status report and RRC signaling.

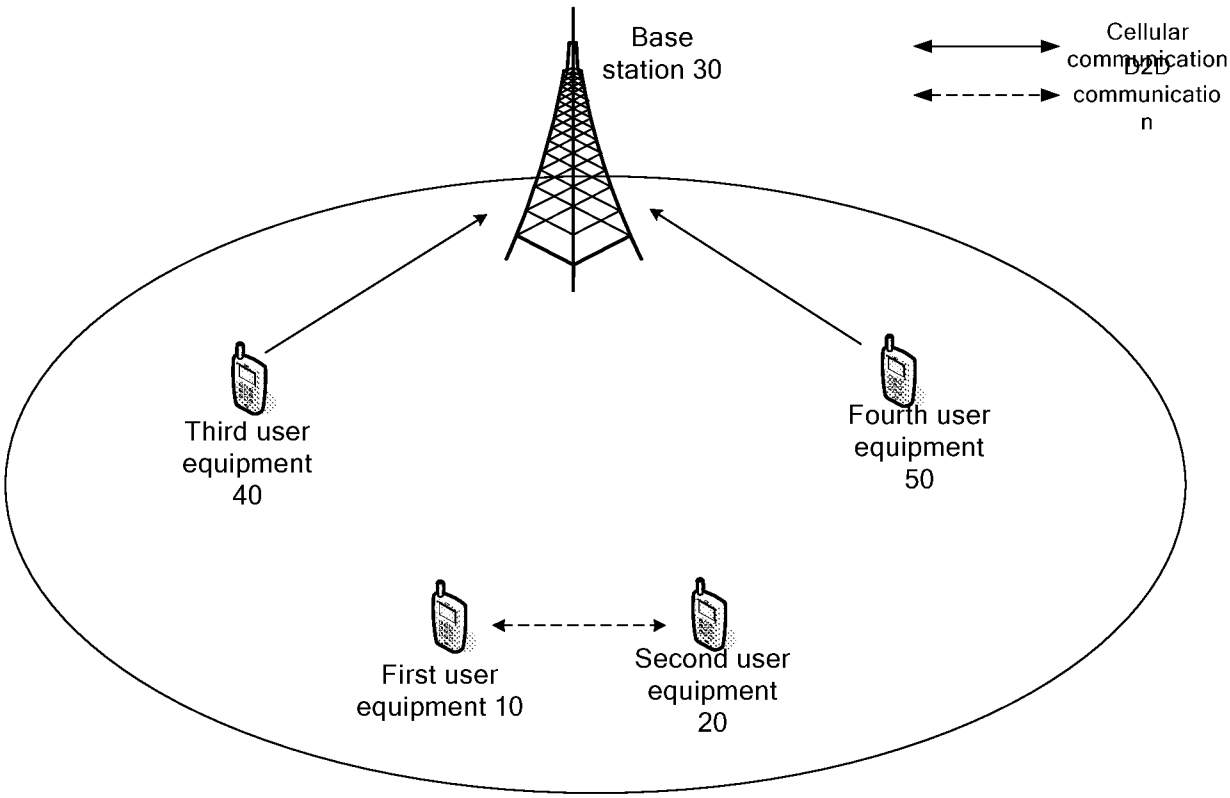

Base station 30
Cellular communication
D2D communication
Third user equipment 40
Fourth user equipment 50
First user equipment 10
Second user equipment 20

Fig.1

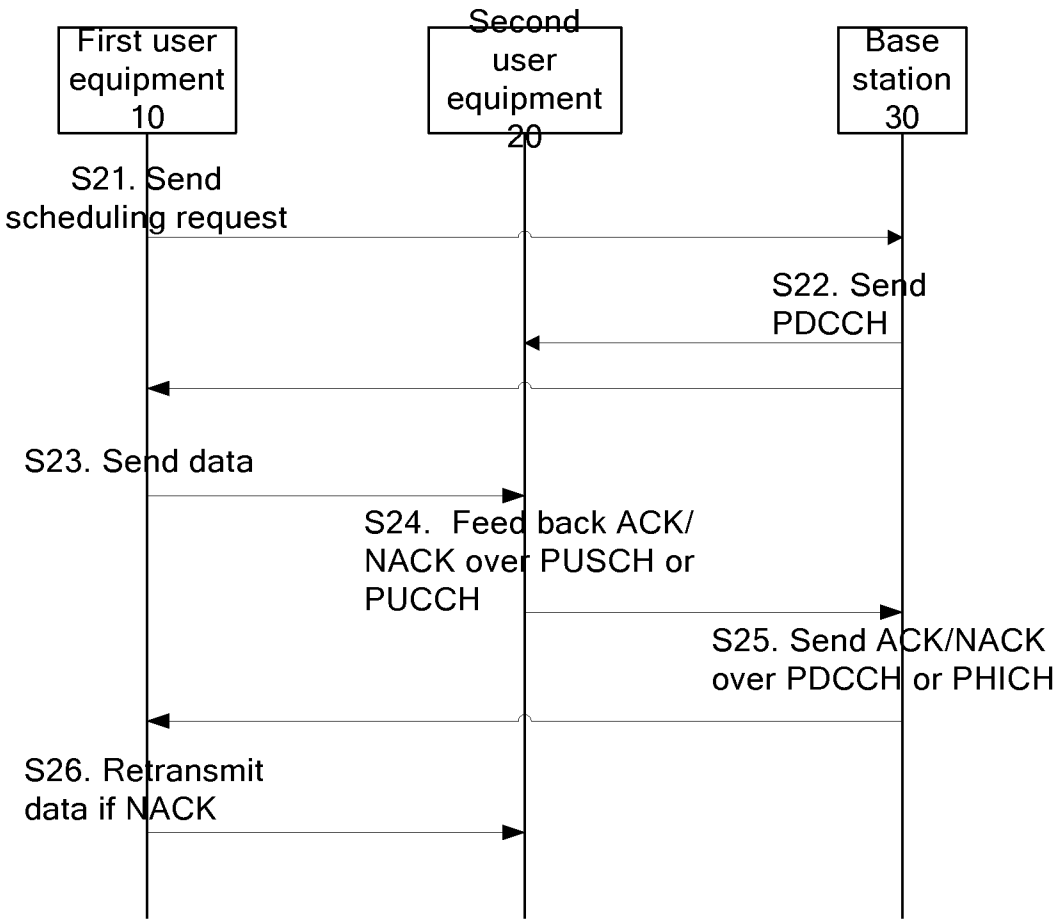

First user equipment 10
Second user equipment 20
Base station 30
S21. Send scheduling request
S22. Send PDCCH
S23. Send data
S24. Feed back ACK/ NACK over PUSCH or PUCCH
S25. Send ACK/NACK over PDCCH or PHICH
S26. Retransmit data if NACK

Fig.2

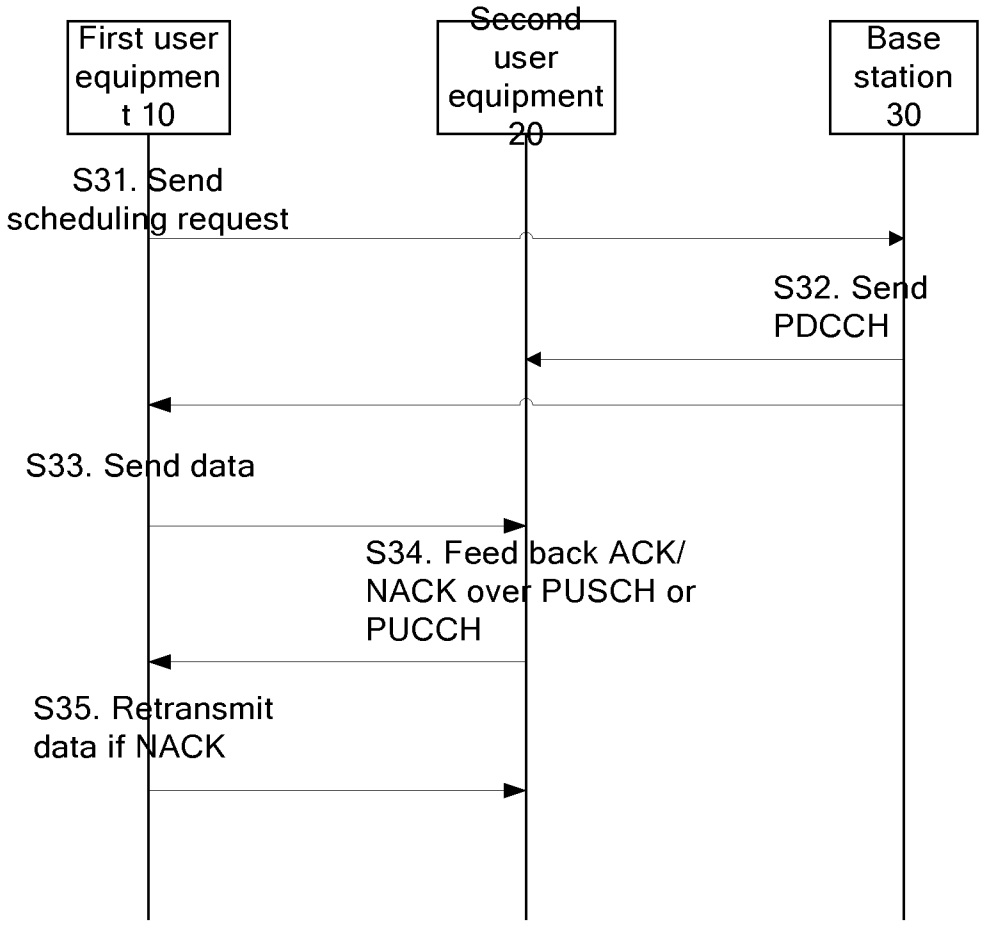

First user equipmen t 10
Second user equipment 20
Base station 30
S31. Send scheduling request
S32. Send PDCCH
S33. Send data
S34. Feed back ACK/ NACK over PUSCH or PUCCH
S35. Retransmit data if NACK

Fig.3

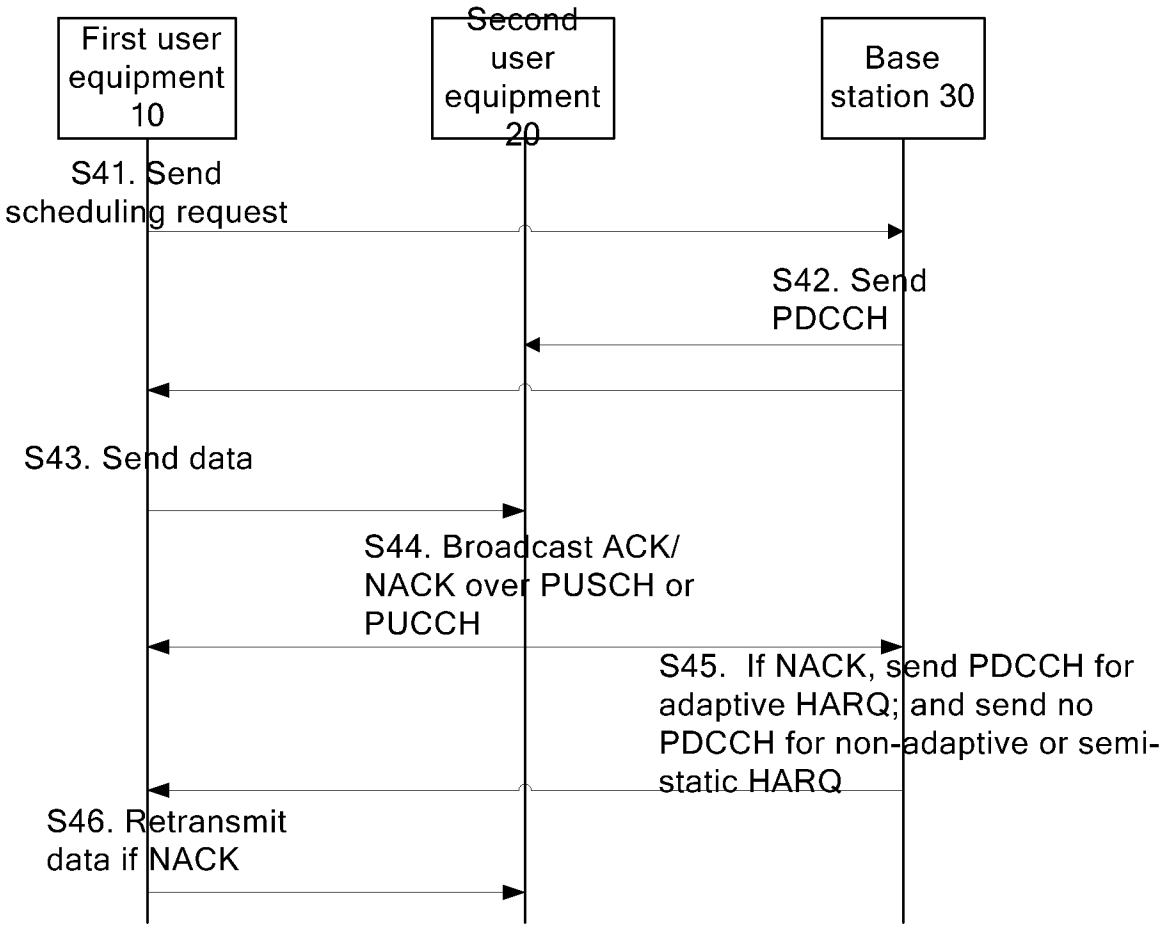

First user equipment 10
Second user equipment 20
Base station 30
S41. Send scheduling request
S42. Send PDCCH
S43. Send data
S44. Broadcast ACK/ NACK over PUSCH or PUCCH
S45. If NACK, send PDCCH for adaptive HARQ; and send no PDCCH for non-adaptive or semi-static HARQ
S46. Retransmit data if NACK

Fig.4