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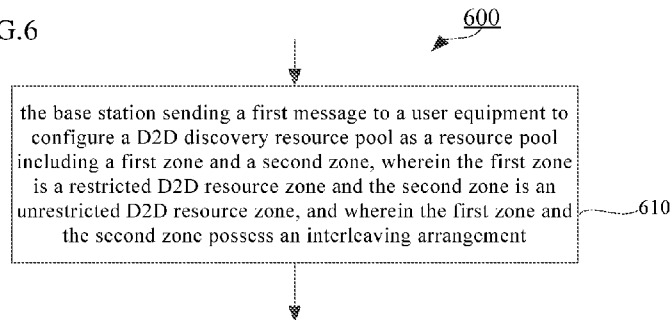
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(54) Title: METHOD OF REDUCING IMPACT OF D2D IN-BAND INTERFERENCE ON CELLULAR TRANSMISSION

FIG.6



(57) Abstract: The invention relates to a method implemented in a base station of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, the method comprising the following step of: - the base station sending a first message to a user equipment to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein the first zone and the second zone possess an interleaving arrangement.. In the method according to the present invention, the first zone and the second zone possess an interleaving arrangement and thus loss in downlink throughput is reduced and the impact of D2D in-band interference on cellular transmission is reduced.



# **Method of reducing Impact of D2D In-Band Interference on Cellular Transmission**

## **Field of the invention**

5           The present invention relates to the technology field of wireless communication, and particularly to a method of reducing impact of D2D in-band interference on cellular transmission in base station or user equipment.

## **Background of the invention**

10           In LTE D2D study, it was decided that the D2D signals occupy part of uplink cellular resources (i.e., uplink carriers for FDD and uplink subframes for TDD), as shown in Figure 2 for the case of FDD. In particular, the D2D signals will occupy some periodical uplink subframes.  
15           In order to support the normal downlink cellular transmissions, the uplink cellular control signals (i.e., PUCCH) still have to be transmitted. That is to say in the D2D subframes the cellular PUCCH signals have to be multiplexed with D2D signals through FDM, as shown in Figure 2. On the other hand, according to the in-band emission interference modeling as  
20           described in 3GPP TR38.843 V12.0.1, "Study on LTE Device to Device Proximity Services – radio aspects", the cellular PUCCH signals suffer from the in-band interference from the D2D signals. Figure 1 shows an example of in-band emission interference model.

25           Since the uplink PUCCH signals (e.g., ACK/NACK, CQI feedback etc. depending on the PUCCH format) play an important role in supporting the downlink data transmission, the in-band emission interference from D2D signals to the cellular control signals has to be solved. This invention aims to address this technical problem.

          Figure 1 illustrates an example of in-band interference, based on the

modeling method described in 3GPP TR38.843 V12.0.1, "Study on LTE Device to Device Proximity Services – radio aspects" with updated parameters  $\{W,X,Y,Z\}=\{3,6,3,3\}$ .

Up to now, the best existing solution of this problem is through usage of power control for the D2D signal. Such a technical solution is disclosed by the application with the application number 201410041266.0 titled "method of controlling transmission power" and the application with the application number 201410192499.0 titled "method of reducing Impact of D2D In-Band Interference on Cellular Transmission".

In the first patent application, namely for the power control method, the solution works well in controlling the in-band emission interference to uplink cellular signals. However, it has some disadvantages. The main disadvantage is that by using power control, the D2D signal transmission powers are not uniform for different D2D users (the closer to base station, the lower the D2D signal transmission power is), thus the D2D transmission range is not uniform. This is not a desirable property for D2D transmissions.

For the restricted resource selection method proposed in the second patent application, the configured D2D subframes are divided into two groups, each group constitutes a number of contiguous subframes, as per the configuration of base station. The D2D users near the base station can only select D2D resources for transmission from one group (say group 1) while the D2D users far from the base station can only select D2D transmission resource from another group (say group 2), such that the in-band interference from the D2D users to the base station is mainly limited to the D2D resource group 1. The main disadvantages of this method are that although the in-band interference to the D2D resource group 2 is largely alleviated, the in-band interference over the D2D resource group 1 is further degraded such that the base station may hardly decode the received PUCCHs over the subframes of D2D resource group 1. Since the uplink PUCCHs may convey the information of ACK/NACK,

CQI feedback, and so on, the collapse of the PUCCH detection will lead to loss in downlink throughput.

### **Summary of the invention**

5           Based on the prior art described in the part background of the invention and the technical understanding of the existing technical problem, the present invention proposes a method, implemented in a base station of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, the method comprises the following step of:

10           - the base station sending a first message to a user equipment to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein the first zone and the second zone possess an interleaving arrangement.

15           In the method according to the present invention, the first zone and the second zone possess an interleaving arrangement and thus loss in downlink throughput is reduced and the impact of D2D in-band interference on cellular transmission is reduced.

20           In one embodiment of the present invention, the first message indicates an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

25           In such a manner the base station could inform the user equipment an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool, for example, 1/1, 2/1 or 1/3 etc..

30           In one embodiment of the present invention, the first message includes a starting position of the first and/or the second zone in the D2D discovery resource pool. Those skilled in the art should understand that

the starting position is optional and it could be not included in case that the specification specifies it.

In one embodiment of the present invention, the method further comprises:

5       - dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the  
10       specification version after release 12;

      - the base station performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool for the user equipments in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone  
15       which is unrestricted D2D resource zone and/or the base station performing normal downlink data scheduling in the timing associated with the configured D2D discovery resource pool for the user equipments in the second group and adjusting the feedback timing of the user equipments, which needs to transmit feedback on the subframe in the first  
20       zone according to normal ACK/NACK feedback sequence, to the subframe in the nearest next second zone to transmit the feedback.

In one embodiment of the present invention, in FDD system the base station induces the downlink data of the user equipments in the first group to be transmitted on the  $n$ th downlink subframe if the  $(n+4)^{\text{th}}$  uplink  
25       subframe is the subframe on which the unrestricted D2D resource zone locates.

In one embodiment of the present invention, user equipment of cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone which is unrestricted D2D resource zone, to  
30       transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

In one embodiment of the present invention, D2D neighbor discovery user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to downlink reference signal measuring result and threshold parameter sent by the base station, wherein

- the resource in the first zone is configured for the first type of user equipment and the first type of user equipment locates at the center of a cell and the first type of user equipment is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

- the resource in the second zone is configured for the second type of user equipment and the second type of user equipment locates at the edge of the cell and the second type of user equipment is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

Those skilled in the art should understand that the first type of user equipment and the second type of user equipment here are not equal to the first group and the second group mentioned above. The first type of user equipment refers to the user equipment locates at the center of a cell namely the user equipment near the base station and the second type of user equipment refers to the user equipment locates at the edge of a cell namely the user equipment far from the base station.

The second aspect of the invention proposes a method, implemented in a user equipment of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, the method comprising:

- receiving a first message from a base station to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein the first zone and the second zone possess an interleaving arrangement.

In one embodiment of the present invention, the first message indicates an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

5 In one embodiment of the present invention, the first message includes a starting position of the first and/or the second zone in the D2D discovery resource pool.

In one embodiment of the present invention, the method further comprises:

10 - dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the specification version after release 12;

15 - performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user equipment is the user equipment in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone which is unrestricted D2D resource zone and/or performing normal downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user equipment is the user equipment in the second group and adjusting the feedback timing for the user equipment, which needs to transmit feedback on the subframe in the first zone according to normal ACK/NACK feedback timing, to the subframe in the nearest next second zone to transmit the feedback.

In one embodiment of the present invention,

20 - if the downlink data of the user equipment belonging to the second group is transmitted on the  $n$ th subframe and the  $(n+4)$ th subframe is the subframe on which the unrestricted D2D resource zone locates, then the feedback timing of the data scheduling is not adjusted in the feedback

30

timing adjustment of the data scheduling; and

- if the downlink data of the user equipment belonging to the second group is transmitted on the  $n$ th subframe and the  $(n+4)$ th subframe is the subframe on which the restricted D2D resource zone locates and the  
5  $(n+5)$ th subframe is the subframe on which the unrestricted D2D resource zone locates, then the  $(n+5)$ th subframe is adjusted to be used for sending the feedback of the data scheduling in the feedback timing adjustment of the data scheduling.

In one embodiment of the present invention, the user equipment of  
10 cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone which is unrestricted D2D resource zone, to transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

In one embodiment of the present invention, D2D neighbor discovery  
15 user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to downlink reference signal measuring result and threshold parameter sent by the base station, wherein

- the resource in the first zone is configured for the first type of user  
20 equipment and the first type of user equipment locates at the center of a cell and the first type of user equipment is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

- the resource in the second zone is configured for the second type of  
25 user equipment and the second type of user equipment locates at the edge of the cell and the second type of user equipment is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

In the method according to the present invention, the first zone and the  
30 second zone possess an interleaving arrangement and thus loss in downlink throughput is reduced and the impact of D2D in-band



interference on cellular transmission is reduced.

### **Brief description of drawings**

Other features, objects and advantages of the invention will become  
5 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 schematic diagram 100 of interference generated  
due to signal power leakage in the prior art;

Fig.2 illustrates a schematic diagram 200 of D2D resource pool  
10 configuration in the prior art;

Fig.3 illustrates another schematic diagram 300 of D2D resource pool  
configuration in the prior art;

Fig.4 illustrates a schematic diagram 400 of D2D resource pool  
configuration according to the present invention;

Fig.5 illustrates another schematic diagram 500 of D2D resource pool  
15 configuration according to the present invention;

Fig.6 illustrates a flow chart 600 of a method, implemented in a base  
station of a wireless communication system, of reducing impact of D2D  
in-band interference on cellular transmission; and

Fig.7 illustrates a flow chart 700 of a method, implemented in a user  
20 equipment of a wireless communication system, of reducing impact of  
D2D in-band interference on cellular transmission.

Identical or similar devices (modules) or steps will be denoted by  
identical or similar reference numerals throughout the drawings.

### **Detailed description of embodiments**

The above described particular description of preferred embodiments  
will be given with reference to the drawings constituting a part of the  
invention. The drawings exemplarily illustrate particular embodiments, in  
30 which the invention can be practiced. The exemplary embodiments are not  
intended to exhaust all the embodiments of the invention. As can be  
appreciated, other embodiments can be possible or structural or logical

modifications can be made without departing from the scope of the invention. Thus the following detailed description is not intended to be limiting, and the scope of the invention will be defined as in the appended claims.

5 Fig.1 illustrates a schematic diagram 100 of interference generated due to signal power leakage in the prior art. Fig.2 illustrates a schematic diagram 200 of D2D resource pool configuration in the prior art. Fig.3 illustrates another schematic diagram 300 of D2D resource pool configuration in the prior art. All these three figures are described in the background of the invention and thus repeated description is here omitted.

10 This invention proposes a scheme to address the in-band interference of D2D signal to cellular signals to a large extent. The following figures 4-7 only illustrate the D2D resource portion in figure 3 and other portions are not shown.

15 Fig.4 illustrates a schematic diagram 400 of D2D resource pool configuration according to the present invention and Fig.5 illustrates another schematic diagram 500 of D2D resource pool configuration according to the present invention. As can be seen from Fig.4 and Fig.5, the first zone and second zone in the D2D resource possess interleaving arrangement and the proportion there between could be 1/1 and 1/3, namely they contains discrete subframe but not continuous subframes as shown in Fig.3.

20 Fig.6 illustrates a flow chart 600 of a method, implemented in a base station of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission. As shown in Fig.6, a method, implemented in a base station of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, comprises the following step 610:

30 - the base station sending a first message to a user equipment to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone,

and wherein the first zone and the second zone possess an interleaving arrangement.

In the method according to the present invention, the first zone and the second zone possess an interleaving arrangement and thus loss in downlink throughput is reduced and the impact of D2D in-band interference on cellular transmission is reduced.

In one embodiment of the present invention, the first message indicates an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

In such a manner the base station could inform the user equipment an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool, for example, 1/1, 2/1 or 1/3 etc..

In one embodiment of the present invention, the first message includes a starting position of the first and/or the second zone in the D2D discovery resource pool. Those skilled in the art should understand that the starting position is optional and it could be not included in case that the specification specifies it.

In one embodiment of the present invention, the method further comprises:

- dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the specification version after release 12;

- the base station performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool for the user equipments in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone which is unrestricted D2D resource zone and/or the base station

performing normal downlink data scheduling in the timing associated with the configured D2D discovery resource pool for the user equipments in the second group and adjusting the feedback timing of the user equipments, which needs to transmit feedback on the subframe in the first zone according to normal ACK/NACK feedback sequence, to the subframe in the nearest next second zone to transmit the feedback.

In one embodiment of the present invention, in FDD system the base station induces the downlink data of the user equipments in the first group to be transmitted on the  $n$ th downlink subframe if the  $(n+4)$ th uplink subframe is the subframe on which the unrestricted D2D resource zone locates.

In one embodiment of the present invention, user equipment of cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone which is unrestricted D2D resource zone, to transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

In one embodiment of the present invention, D2D neighbor discovery user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to downlink reference signal measuring result and threshold parameter sent by the base station, wherein

- the resource in the first zone is configured for the first type of user equipment and the first type of user equipment locates at the center of a cell and the first type of user equipment is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

- the resource in the second zone is configured for the second type of user equipment and the second type of user equipment locates at the edge of the cell and the second type of user equipment is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

Those skilled in the art should understand that the first type of user

equipment and the second type of user equipment here are not equal to the first group and the second group mentioned above. The first type of user equipment refers to the user equipment locates at the center of a cell namely the user equipment near the base station and the second type of user equipment refers to the user equipment locates at the edge of a cell namely the user equipment far from the base station.

Fig.7 illustrates a flow chart 700 of a method, implemented in a user equipment of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission. As shown in Figure 7, a method, implemented in a user equipment of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, comprises the step 710:

- receiving a first message from a base station to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein the first zone and the second zone possess an interleaving arrangement.

In one embodiment of the present invention, the first message indicates an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

In one embodiment of the present invention, the first message includes a starting position of the first and/or the second zone in the D2D discovery resource pool.

In one embodiment of the present invention, the method further comprises:

- dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the specification version after release 12;

- performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user equipment is the user equipment in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone which is unrestricted D2D resource zone and/or performing normal downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user equipment is the user equipment in the second group and adjusting the feedback timing for the user equipment, which needs to transmit feedback on the subframe in the first zone according to normal ACK/NACK feedback timing, to the subframe in the nearest next second zone to transmit the feedback.

In one embodiment of the present invention,

- if the downlink data of the user equipment belonging to the second group is transmitted on the  $n$ th subframe and the  $(n+4)$ th subframe is the subframe on which the unrestricted D2D resource zone locates, then the feedback timing of the data scheduling is not adjusted in the feedback timing adjustment of the data scheduling; and

- if the downlink data of the user equipment belonging to the second group is transmitted on the  $n$ th subframe and the  $(n+4)$ th subframe is the subframe on which the restricted D2D resource zone locates and the  $(n+5)$ th subframe is the subframe on which the unrestricted D2D resource zone locates, then the  $(n+5)$ th subframe is adjusted to be used for sending the feedback of the data scheduling in the feedback timing adjustment of the data scheduling.

In one embodiment of the present invention, the user equipment of cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone which is unrestricted D2D resource zone, to transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

In one embodiment of the present invention, D2D neighbor discovery user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to downlink

reference signal measuring result and threshold parameter sent by the base station, wherein

- the resource in the first zone is configured for the first type of user equipment and the first type of user equipment locates at the center of a cell and the first type of user equipment is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

- the resource in the second zone is configured for the second type of user equipment and the second type of user equipment locates at the edge of the cell and the second type of user equipment is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

In the method according to the present invention, the first zone and the second zone possess an interleaving arrangement and thus loss in downlink throughput is reduced and the impact of D2D in-band interference on cellular transmission is reduced.

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. 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. The terms “first”, “second”, etc., are intended to designate a name but not to suggest any specific order.

## CLAIMS

1. A method, implemented in a base station of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, the method comprising the following step of:

5 - the base station sending a first message to a user equipment to configure a D2D discovery resource pool as a resource pool including a first zone and a second zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein  
10 the first zone and the second zone possess an interleaving arrangement.

2. The method according to claim 1, wherein the first message indicates an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

3. The method according to claim 1, wherein the first message includes  
15 a starting position of the first and/or the second zone in the D2D discovery resource pool.

4. The method according to any of claims 1 to 3, wherein the method further comprises:

20 - dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the specification version after release 12;

25 - the base station performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool for the user equipments in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone which is an unrestricted D2D resource zone and/or the base station performing normal  
30 downlink data scheduling in the timing associated with the configured D2D discovery resource pool for the user equipments in the second group and



adjusting the feedback timing of the user equipments, which needs to transmit feedback on the subframe in the first zone according to normal ACK/NACK feedback sequence, to the subframe in the nearest next second zone to transmit the feedback.

5           5. The method according to claim 4, wherein in FDD system the base station induces the downlink data of the user equipments in the first group to be transmitted on the  $n^{\text{th}}$  downlink subframe if the  $(n+4)^{\text{th}}$  uplink subframe is the subframe on which the unrestricted D2D resource zone locates.

10           6. The method according to claim 4, wherein the user equipment of cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone, which is an unrestricted D2D resource zone, to transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

15           7. The method according to claim 1, wherein D2D neighbor discovery user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to a downlink reference signal measuring result and a threshold parameter sent by the base station, wherein

20           - the resource in the first zone is configured for the first type of user equipment, and the first type of user equipment locates at the center of a cell and is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

25           - the resource in the second zone is configured for the second type of user equipment, and the second type of user equipment locates at the edge of the cell and is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

8. A method, implemented in a user equipment of a wireless communication system, of reducing impact of D2D in-band interference on cellular transmission, the method comprising:

30           - receiving a first message from a base station to configure a D2D discovery resource pool as a resource pool including a first zone and a second

zone, wherein the first zone is a restricted D2D resource zone and the second zone is an unrestricted D2D resource zone, and wherein the first zone and the second zone possess an interleaving arrangement.

9. The method according to claim 8, wherein the first message indicates  
5 an interval and a sum of subframes of the interleaving arrangement of the first zone and/or the second zone in the D2D discovery resource pool.

10. The method according to claim 8, wherein the first message includes a starting position of the first and/or the second zone in the D2D discovery resource pool.

10 11. The method according to any of claim 8 or 9, wherein the method further comprises:

- dividing user equipments communicatively connected to the base station into two groups according to the specification version of the user equipments, wherein a first group is the user equipment using the  
15 specification version before release 12 and a second group is the user equipment using the specification version of release 12 or the specification version after release 12;

- performing restricted downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user  
20 equipment is the user equipment in the first group, such that feedback of the data scheduling can be transmitted on the subframe in the second zone which is an unrestricted D2D resource zone and/or performing normal downlink data scheduling within the timing associated with the configured D2D discovery resource pool if the user equipment is the user equipment in the  
25 second group and adjusting the feedback timing for the user equipment, which needs to transmit feedback on the subframe in the first zone according to normal ACK/NACK feedback timing, to the subframe in the nearest next second zone to transmit the feedback.

12. The method according to claim 11, wherein

30 - if the downlink data of the user equipment belonging to the second group is transmitted on the  $n^{\text{th}}$  subframe and the  $(n+4)^{\text{th}}$  subframe is the

subframe on which the unrestricted D2D resource zone locates, then the feedback timing of the data scheduling is not adjusted in the feedback timing adjustment of the data scheduling; and

- if the downlink data of the user equipment belonging to the second group is transmitted on the  $n^{\text{th}}$  subframe and the  $(n+4)^{\text{th}}$  subframe is the subframe on which the restricted D2D resource zone locates and the  $(n+5)^{\text{th}}$  subframe is the subframe on which the unrestricted D2D resource zone locates, then the  $(n+5)^{\text{th}}$  subframe is adjusted to be used for sending the feedback of the data scheduling in the feedback timing adjustment of the data scheduling.

13. The method according to claim 11, wherein the user equipment of cellular transmission adopts Frequency Division Multiplexing on the subframe in the second zone, which is unrestricted D2D resource zone, to transmit the ACK/NACK feedback of the downlink data scheduling and D2D signal of D2D user equipment.

14. The method according to claim 11, wherein D2D neighbor discovery user equipment determines the user equipments as a first type of user equipment or a second type of user equipment according to a downlink reference signal measuring result and a threshold parameter sent by the base station, wherein

- the resource in the first zone is configured for the first type of user equipment and the first type of user equipment locates at the center of a cell and is configured to be just able to use the resource in the restricted D2D resource zone of the first zone for D2D transmission;

- the resource in the second zone is configured for the second type of user equipment, and the second type of user equipment locates at the edge of the cell and is configured to be just able to use the resource in the unrestricted D2D resource zone of the second zone for D2D transmission.

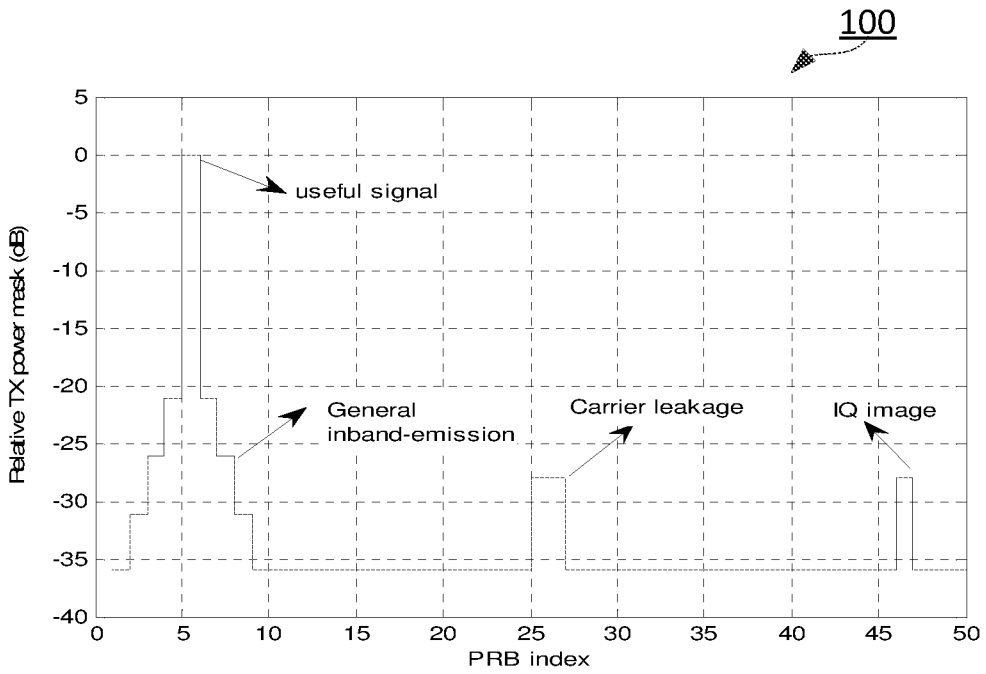


FIG.1

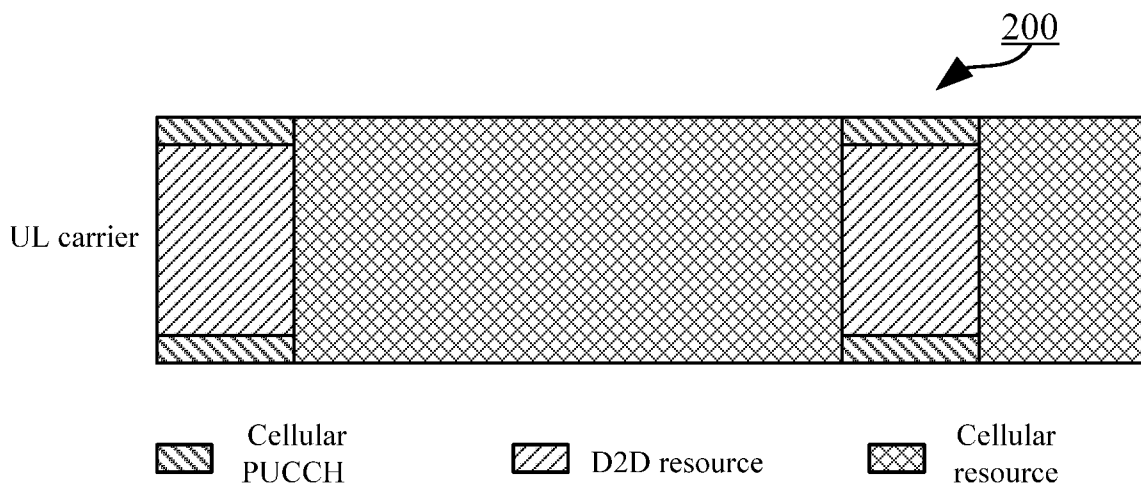


FIG.2

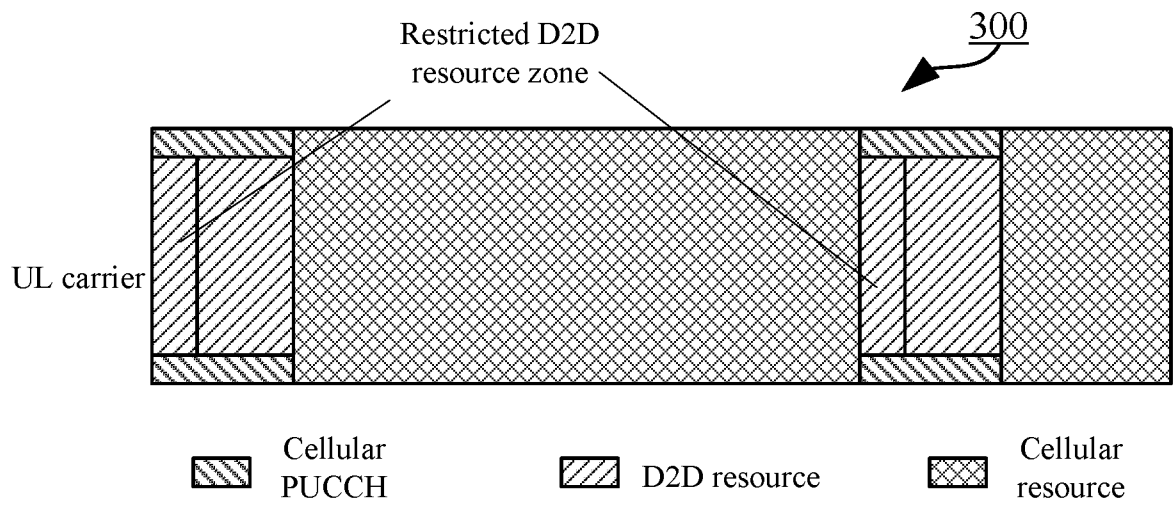


FIG.3

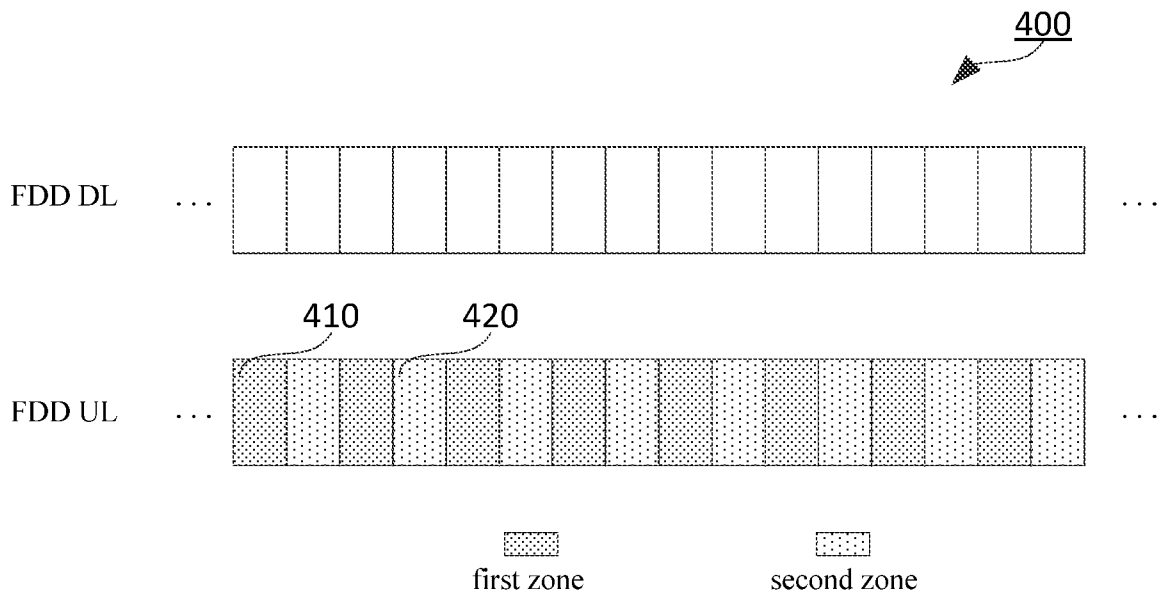


FIG.4

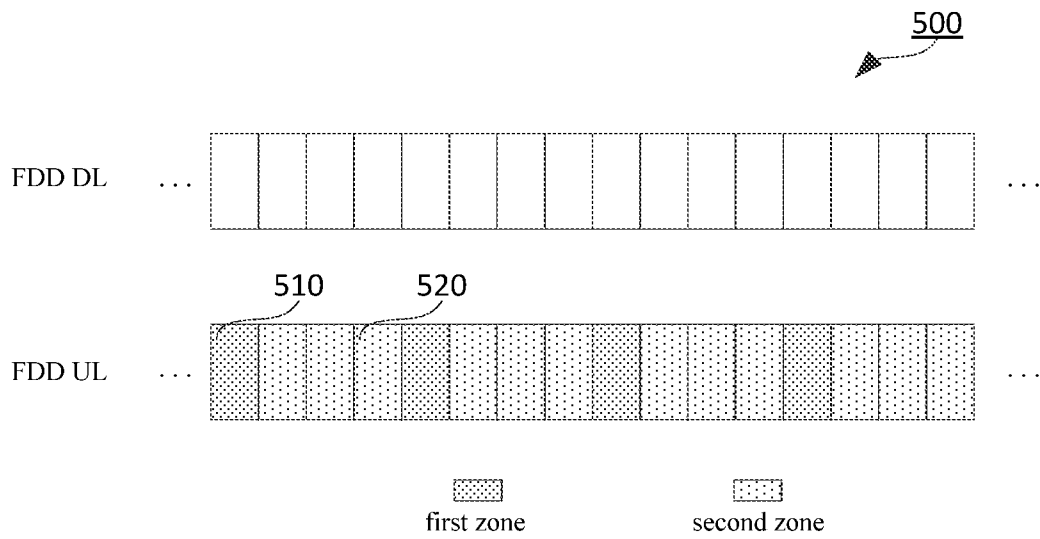


FIG.5

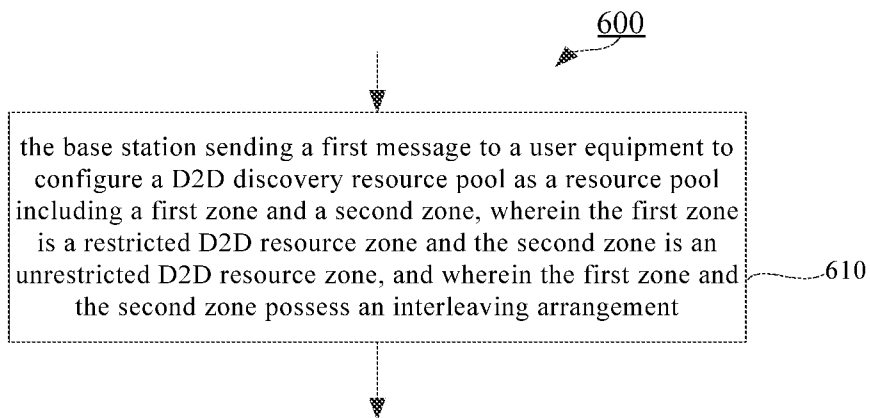


FIG.6

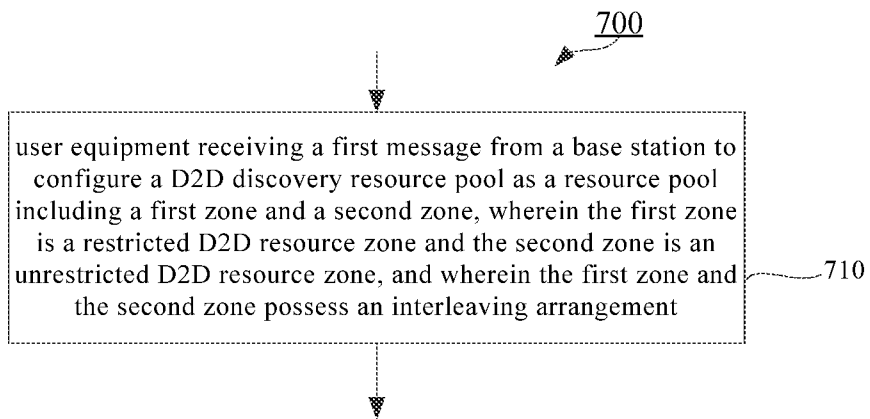


FIG.7

# INTERNATIONAL SEARCH REPORT

International application No <b>PCT/IB2015/001546</b>
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**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. H04W72/08 H04W76/02  
 ADD. H04W72/04 H04W72/02

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)  
**H04W**

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**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2013/288608 A1 (FWU JONG-KAE [US] ET AL) 31 October 2013 (2013-10-31) paragraphs [0029] - [0041] paragraphs [0044], [0052] paragraphs [0054] - [0057] paragraphs [0062] - [0064] figures 2,3  -----  -/--	1,8  2-7,9-13 14

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

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search <b>23 December 2015</b>	Date of mailing of the international search report <b>08/01/2016</b>
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  <p style="text-align: center; font-size: 1.2em;"><b>Papanikolaou, Eleni</b></p>
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## INTERNATIONAL SEARCH REPORT

 International application No  
 PCT/IB2015/001546

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**INTERNATIONAL SEARCH REPORT**

International application No PCT/IB2015/001546
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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