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(54) **Title:** DEVICE AND METHOD FOR PERFORMING A DEVICE-TO-DEVICE BROADCAST COMMUNICATION IN A WIRELESS NETWORK

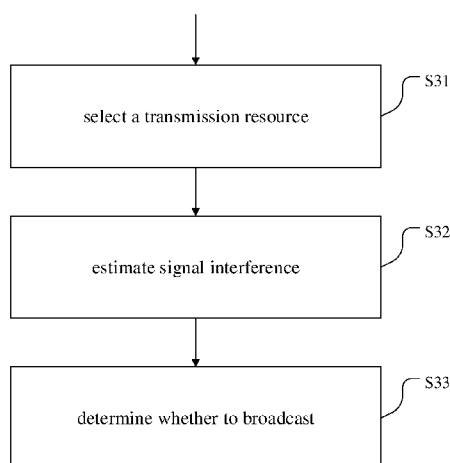


Fig. 3a

(57) **Abstract:** The present invention provides a device and method for performing a device-to-device broadcast communication in a wireless communication network, wherein the method comprises steps of: selecting a transmission resource; estimating signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource; based on the estimated signal interference, determining whether to perform a device-to-device broadcast communication on the selected transmission resource. Compared with the prior art, the present invention needs no much extra overhead, effectively reduces signal interference between user equipments that transmit simultaneously, and thereby achieves a better system performance.



DEVICE AND METHOD FOR PERFORMING A DEVICE-TO-DEVICE BROADCAST COMMUNICATION IN
A WIRELESS NETWORK

FIELD OF THE INVENTION

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The present invention relates to the field of wireless communication, and more specifically to a device and method for performing a device-to-device broadcast communication in a wireless communication network.

10 **BACKGROUND OF THE INVENTION**

Device-to-device communication as a study item in LTE R12 is for studying the performance and standardization of the device-to-device communication in the LTE network. This study item will study neighbor discovery and direct communication techniques. For direct communication techniques, the device-to-device broadcast communication is prioritized. Application scenarios of the device-to-device include a full network coverage, non-network coverage, and partial network coverage. The non-network coverage device-to-device broadcast communication is a current study focus. In the non-network coverage scenario, there are many design concerns towards special characters of network without central control. The method of physical resource allocation is a key aspect, which will affect the overall design of the device-to-device broadcast communication.

Currently, there are two solutions to determine the occupied resources for broadcast transmitters, i.e., centralized and distributed solutions. The centralized solution predefines or elects a control node as the cluster head to manage the resources. However, in this solution, the functionality of the cluster head for device-to-device broadcast is restricted since it cannot have all functionalities of eNodeB. In addition, the interference cannot be well managed due to the mobility of the cluster head. Further, this solution needs some information exchange for resource allocation and cluster head election, which brings extra overheads to the device-to-device broadcast communication. In addition, this method might not improve the system performance since there might not be feedback from receivers, which is different from the traditional centralized resource allocation. On the other hand, in the distributed solution, broadcasting UEs (User Equipment) can decide their resources in a distributed manner and thus do not need a control node. However, some simple distributed solutions, e.g., random distributed solution, might not perform as well as the centralized solutions. Some more complicated distributed solutions, e.g., sense distributed scheme, may perform well, but they need information exchange so as to make their performance comparable with that of the centralized solution, which causes resource consumption for extra overheads.

Therefore, in the device-to-device communication, it needs to be solved how to schedule resources in a distributed manner so as to provide a better performance than a centralized scheme without bring about extra overheads.

SUMMARY OF THE INVENTION

An objective of the present invention is to provide a device and method for a device-to-device broadcast communication in a wireless communication network.

According to one aspect of the present invention, there is disclosed a method for performing a device-to-device broadcast communication in a user equipment of a wireless communication network, the method comprising steps of:

- selecting a transmission resource;
- estimating signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource;
- based on the estimated signal interference, determining whether to perform a device-to-device broadcast communication on the selected transmission resource.

According to a further aspect of the present invention, there is disclosed a user equipment for performing a device-to-device broadcast communication in a user equipment of a wireless communication network, the user equipment comprising:

- a selecting module configured to select a transmission resource;
- a first interference estimating module configured to estimate signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource;
- a first determining module configured to, based on the estimated signal interference, determine whether to perform a device-to-device broadcast communication on the selected transmission resource.

Compared with the prior art, the present invention has the following advantages: through the solution of the present invention, a broadcasting user equipment can select a resource for signal transmission in a distributed manner based on a signal intensity detection result before sending the broadcast signal, which thereby reduces signal interference caused by resource reuse and in-band emission. Compared with the prior centralized solution and distributed solution, the present invention needn't much extra overhead, effectively reduces signal interference between user equipments sending simultaneously, and thereby achieves a better system performance.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Other features, objectives and advantages of the present invention will become more apparent through reading the detailed description of the non-limiting embodiments with reference to the accompanying drawings:

Fig. 1 shows a schematic diagram of a device-to-device broadcast communication in a wireless communication network;

Fig. 2 shows a schematic diagram of a frame structure of a device-to-device broadcast communication in an example of a wireless communication network;

Fig. 3a shows a flow diagram of a method for performing a device-to-device broadcast communication in a user equipment of a wireless communication network according to one embodiment of one aspect of the present invention;

Fig. 3b shows a flow diagram of a method for performing a device-to-device broadcast

communication in a user equipment of a wireless communication network according to another embodiment of one aspect of the present invention;

Fig. 4 shows a schematic diagram of a user equipment for performing a device-to-device broadcast communication in a wireless communication network according to a further aspect of the present invention;

In the accompanying drawings, same or similar reference numerals represent same or similar components.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described in further detail with reference to the accompanying drawings.

Fig. 1 shows a schematic diagram of performing a device-to-device broadcast communication in a wireless communication network. Generally, a wireless communication network may comprise a plurality of user equipments (hereinafter referred to as UE). In Fig. 1, an example of a device-to-device broadcast communication is schematically shown with 6 user equipments UE1, UE2, ..., UE6 therein. In one embodiment, the wireless communication network is one based on the 3GPP (the 3rd Generation Partnership Project) protocol. Preferably, the wireless communication network may be an LTE (Long Term Evolution) network. The user equipment may be any kind of electronic device that can directly or indirectly communicate with other user equipment and/or base station in a wireless manner, including but not limited to, a mobile phone, a PDA, and etc. Preferably, respective user equipments in the LTE network adopts a frequency-division duplexing mode (FDD mode) or a time-division duplexing mode (TDD mode) to transmit and receive information. Those skilled in the art should understand that the wireless communication network and/or user equipments described here are only exemplary, not limitative. The principle of this method is applicable to other existing or future possibly emerging wireless communication networks and/or user equipments without departing from the spirit and scope of the present invention, and is incorporated here by reference.

As shown in Fig. 1, UE1 and UE3 are sending device-to-device broadcast signals to other user equipments. Here, UE2 and UE4 are located within a coverage area common to UE1 and UE3, such that the UE2 and UE4 will receive the broadcast signals from the UE1 and UE3; therefore, signal interference likely exists between the broadcast signals received by UE2 and UE4. Besides, the interference between the received signals at respective user equipments not only comes from the interference between signals from respective user equipments simultaneously sent on the same resource, but also comes from the in-band emission of signals from respective user equipments as sent using orthogonal frequency resources on the same transmission time domain. Therefore, the signal interference received by a user equipment on a certain resource may be expressed as:

$$I_N = \sum_{p \in \Phi_r} I_{pN} + \sum_{q \in \Phi_i} I_{qN} \quad (1)$$

Where I_N denotes signal interference at UE_N; Φ_r denotes a set of user equipments sending signals by reusing the same resource; Φ_i denotes a set of user equipments sending signals using frequency resources orthogonal to the resource on the same sending time domain. I_{p^n} denotes signal interference from the user equipments in the set Φ_r ; I_{p^n} denotes signal interference from the user equipments in the set Φ_i . It would be appreciated that, in order to reduce interference and enhance the probability of successful transmission, both I_{p^n} and I_{p^n} need to be lowered. Therefore, the resource used by the user equipment sending broadcast signals needs to be adaptively scheduled.

Fig. 2 shows a schematic diagram of a frame structure performing a device-to-device broadcast communication in an example of a wireless communication network. As shown in Fig. 2, in this example, the basic resource allocation unit for broadcast communication is N_b resource block pairs in one subframe, called broadcast data channels (as shown in Fig. 2, respective units flagged with UE). One subframe may have a plurality of broadcast data channels, suppose the total number of its resource block pairs is N_f . Broadcast data channels in N_p subframes form a broadcast block (e.g., number of resource block pairs in one broadcast block = N_f resource block pairs * N_p subframes). A plurality of broadcast blocks of a plurality of frames consecutive in time domain form a broadcast period (e.g., number of resource block pairs in one broadcast period = N_f resource blocks * N_t subframes). When a user equipment in the wireless communication network performs a device-to-device broadcast communication, the user equipment will select an available broadcast data channel from the broadcast blocks to send the broadcast signal. For example, when a user equipment is to send a voice signal by broadcast, the user equipment selects from each broadcast block one or more broadcast data channels to send all voice packets within a time not exceeding the maximum delay. Those skilled in the art should understand that the resource and/or frame structure as described here is exemplary, not limitative. There are other resource and/or signal structures for a device-to-device broadcast communication without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Fig. 3a shows a flow diagram of a method for performing a device-to-device broadcast communication in a user equipment of a wireless communication network according to an embodiment of one aspect of the present invention.

First, in step S31, a user equipment selects a transmission resource. Here, the transmission resource is a resource can be used by the user equipment for signal transmission. Preferably, the transmission resource may be broadcast data channel as described above in Fig. 2. Those skilled in the art should understand that the transmission resource described here being a broadcast data channel is only exemplary, not limitative. There are other manners of implementing various

transmission resources without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Specifically, the user equipment may select a transmission resource based on a predetermined rule. For example, the predetermined rule may be selecting an available transmission resource least recently used. The predetermined rule may also be selecting an available transmission resource most recently used. The user equipment may also randomly select from the available transmission resources. Those skilled in the art should understand that the method of selecting a transmission resource as described here is exemplary, not limitative. There are various other manners of selecting transmission resources without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Next, in step S32, the user equipment estimates signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource.

Specifically, the user equipment first detects signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource. Here, the other user equipments simultaneously broadcasting include other user equipments performing signal transmission reusing the selected transmission resource, and other user equipments performing signal transmission using a frequency resource orthogonal to the selected transmission resource on the same sending time domain. Because those skilled in the art already know the technology of how to detect the signal intensity value, it will not be detailed here. Here, we use R_p to indicate the signal intensity value determined by the user equipment. Preferably, the signal intensity value may be a RSRP (Reference Signal Received Power) value.

Next, the user equipment estimates signal interference of broadcasting on the selected transmission resource. As readily appreciated by those skilled in the art, generally, the larger the R_p value is, and the stronger the signal interference from other user equipments might be. Here, I_N is used to indicate the value of the signal interference estimated by UE_N. Here, a value range of signal interference may be preset based on for example the empirical value, e.g., [0-20], wherein the larger the value is, the stronger the signal intensity is. For example, 0 denotes no signal interference, while 20 denotes the strongest signal interference. Besides, a mapping from the R_p value to a value in the value range of the signal interference may be preset based on for example the empirical value, wherein a larger R_p value is mapped to a larger signal interference value, a medium R_p value is mapped to a medium signal interference value, while when the R_p value is 0, it is mapped to the signal interference value 0, etc. In this way, we may obtain the signal interference I_N for broadcasting on the selected transmission resource based on the R_p value.

Besides, preferably, a threshold for a R_p value, denoted as R_p^{th} , may be preset based on such as an empirical value. When the R_p value detected by the user equipment is greater than the R_p^{th} value, it may be deemed that the selected transmission resource has been occupied by other

user equipment; while when the R_p value is not greater than the R_p^{th} value, it may be deemed that the selected transmission resource is not occupied by other user equipment. Besides, a threshold for signal interference may be preset based on for example the empirical value, denoted as I_N^{TH} . When the signal interference I_N estimated by UE_N is greater than the I_N^{TH} value, it may be deemed that the selected transmission resource has been occupied by other user equipment; while when the I_N value is not greater than the I_N^{TH} value, it may be deemed that the selected transmission resource is not occupied by other user equipment. Those skilled in the art should understand that the setting of the threshold of a signal intensity and/or signal interference based on the empirical value as described here is exemplary, not limitative. There are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

In another embodiment, preferably, the value of the signal interference I_N may be calculated based on the R_p value according to the following equation:

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$$I_N = \left\lfloor \frac{R_p}{R_p^{th}} \right\rfloor \quad (2)$$

where $\frac{R_p}{R_p^{th}}$ denotes a ratio between R_p value and the threshold R_p^{th} value, $\left\lfloor \right\rfloor$ denotes downward rounding.

It should be noted that the signal intensity value R_p and the threshold R_p^{th} value are based on the signal intensity value per se, and its unit is generally expressed by milliwatt.

Those skilled in the art should understand that the method of estimating signal interference based on the signal intensity as described here is exemplary, not limitative. There are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Next, in step S33, based on the estimated signal interference, it is determined whether to perform a device-to-device broadcast communication on the selected transmission resource. Specifically, as mentioned above, the estimated signal interference value I_N may be compared with the predetermined threshold I_N^{TH} . When the signal interference I_N value is greater than the I_N^{TH} value, it may be deemed that the selected transmission resource has been occupied by other user equipment, so as to determine not to perform a device-to-device broadcast communication on the transmission resource; while when the I_N value is not greater than the I_N^{TH} value, it may be deemed that the selected transmission resource is not occupied by other user equipment, so as to determine that a device-to-device broadcast communication may be performed on the transmission resource.

Fig. 3b shows a flow diagram of a method for performing a device-to-device broadcast communication in a user equipment of a wireless communication network according to another

embodiment of one aspect of the present invention. First, in step S31 and step S32, according to the method described above, the user equipment selects a transmission resource and estimates signal interference I_N of broadcasting on the transmission resource based on signal intensity value R_p of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource.

Next, in step S331, a transmission probability for sending on the transmission resource is estimated based on the estimated signal interference. Here, the transmission probability is a value between [0-1], which refers to a probability that a signal can be sent on the transmission resource. The probability is related to a probability of successfully sending the signal on the transmission resource, and this transmission probability may be referenced to perform signal sending. Those skilled in the art would easily understand that, generally, the larger the estimated signal interference is, the smaller the transmission probability is; on the contrary, the smaller the estimated signal interference is, the greater the transmission probability is. Therefore, with reference to the transmission probability, the user equipment may adjust a percentage of actually sending of the broadcast signal selecting the transmission resource, i.e., sending the broadcast signal on the transmission resource at a certain probability so as to reduce the possibility of mutual interference with other user equipments being sending signals. For example, if the transmission probability is 0, then with reference to the transmission probability, it may be deemed that all signals having selected the transmission resource can be sent on the transmission resource; if the transmission probability is a medium value between [0, 1], e.g., 0.5, then with reference to this transmission probability, it may be deemed that 50% signals selecting to transmit on the transmission resource can be transmitted on this transmission resource.

In one embodiment, a mapping from the estimated signal interference to the transmission probability value range [0-1] may be predefined for example based on an empirical value. For the scenario in which the estimated signal interference is the strongest, it can be mapped to the transmission probability 0; for the scenario in which the estimated signal interference is of a medium intensity, it can be mapped to a medium value between the transmission probability [0-1]; for the scenario of the estimated non-signal interference, it can be mapped to the transmission probability value 1, etc. In this way, the transmission probability for transmitting on the selected transmission resource is derived based on the estimated signal interference, the transmission probability being indicated by P_t .

In another embodiment, the transmission probability P_t may be estimated based on the following equation:

$$P_t = 1 - \frac{I_N}{I_N + 1} \quad (3)$$

Where I_N is the value of signal interference estimated in step S32.

Those skilled in the art should understand that the method of estimating the sending probability based on the value of the signal interference is exemplary, not limitative, and there

are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Next, in step S332, based on the estimated transmission probability, it is determined whether to perform a device-to-device broadcast communication on the transmission resource. In one embodiment, a threshold P_t^{th} for the transmission probability may be preset based on for example the empirical value. When the estimated transmission probability P_t is higher than the threshold P_t^{th} , it may be determined that the device-to-device broadcast communication can be performed on the selected transmission resource; while when the estimated transmission probability P_t is not higher than the threshold P_t^{th} , it may be determined that the device-to-device broadcast communication will not be performed on the selected transmission resource. The setting the threshold of the transmission probability based on the empirical value as described here is exemplary, not limitative, and there are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference. In another embodiment, whether to perform a device-to-device broadcast communication on the transmission resource may be determined based on the estimated transmission probability P_t and a randomly generated variable denoted as V . Specifically, when the randomly generated variable V is no greater than P_t , it is determined to perform the broadcast communication on the resource; when V is greater than P_t , it is determined not to perform the broadcast communication on the resource. In this way, statistically speaking, the probability of the broadcast signal being transmitted on the resource corresponds to the transmission probability P_t . Those skilled in the art should understand that the method of determining whether to perform broadcast communication on the transmission resource based on the transmission probability as described here is exemplary, not limitative, and there are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Fig. 4 shows schematic diagram of a user equipment for performing a device-to-device broadcast communication in a wireless communication network according to a further aspect of the present invention.

A selecting module 41 is configured to select a transmission resource. Here, the transmission resource is a resource can be used by the user equipment for signal transmission. Preferably, the transmission resource may be broadcast data channel as described above in Fig. 2. Those skilled in the art should understand that the transmission resource described here being a broadcast data channel is only exemplary, not limitative. There are other manners of implementing various transmission resources without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Specifically, the selecting module 41 may select a transmission resource based on a predetermined rule. For example, the predetermined rule may be selecting an available transmission resource least recently used. The predetermined rule may also be selecting an available transmission resource most recently used. The user equipment may also randomly select from the available transmission resources. Those skilled in the art should understand that

the module for selecting a transmission resource as described here is exemplary, not limitative. There are various other implementation manners of module for selecting transmission resources without departing from the spirit and scope of the present invention, which are incorporated here by reference.

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Next, a first interference estimating module 42 estimates signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource.

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Specifically, the a first interference estimating module 42 first detects signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource. Here, the other user equipments simultaneously broadcasting include other user equipments performing signal transmission reusing the selected transmission resource, and other user equipments performing signal transmission using a frequency resource orthogonal to the selected transmission resource on the same sending time domain. Because those skilled in the art already know the technology of how to detect the signal intensity value, it will not be detailed here. Here, we use R_p to indicate the signal intensity value determined by the user equipment. Preferably, the signal intensity value may be a RSRP (Reference Signal Received Power) value.

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Next, the first interference estimating module 42 estimates signal interference of broadcasting on the selected transmission resource. As readily appreciated by those skilled in the art, generally, the larger the R_p value is, the stronger the signal interference from other user equipments might be. Here, I_N is used to indicate the value of the signal interference estimated by UE_N. Here, a value range of signal interference may be preset based on for example the empirical value, e.g., [0-20], wherein the larger the value is, the stronger the signal intensity is. For example, 0 denotes no signal interference, while 20 denotes the strongest signal interference. Besides, a mapping from the R_p value to a value in the value range of the signal interference may be preset based on for example the empirical value, wherein a larger R_p value is mapped to a larger signal interference value, a medium R_p value is mapped to a medium signal interference value, while when the R_p value is 0, it is mapped to the signal interference value 0, etc. In this way, we may obtain the signal interference I_N for broadcasting on the selected transmission resource based on the R_p value.

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Besides, preferably, a threshold for a R_p value, denoted as R_p^{th} , may be preset based on such as an empirical value. When the R_p value detected by the first interference estimating module 42 is greater than the R_p^{th} value, it may be deemed that the selected transmission resource has been occupied by other user equipment; while when the R_p value is not greater than the R_p^{th} value, it may be deemed that the selected transmission resource is not occupied by other user equipment. Besides, a threshold for signal interference may be preset based on for example the empirical value, denoted as I_N^{TH} . When the signal interference I_N estimated by UE_N is greater than the I_N^{TH} value, it may be deemed that the selected transmission resource has been occupied by other user equipment; while when the I_N value is not greater than the I_N^{TH} value, it may be deemed that

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the selected transmission resource is not occupied by other user equipment. Those skilled in the art should understand that the setting of the threshold of a signal intensity and/or signal interference based on the empirical value as described here is exemplary, not limitative. There are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

In another embodiment, preferably, the value of the signal interference I_N may be calculated by a second interference estimating module based on the R_p value according to the following equation:

$$I_N = \left\lfloor \frac{R_p}{R_p^{th}} \right\rfloor \quad (2)$$

where $\frac{R_p}{R_p^{th}}$ denotes a ratio between R_p value and the threshold R_p^{th} value, $\left\lfloor \right\rfloor$ denotes downward rounding.

It should be noted that the signal intensity value R_p and the threshold R_p^{th} value are based on the signal intensity value per se, and its unit is generally expressed by milliwatt.

Those skilled in the art should understand that the module for estimating signal interference based on the signal intensity as described here is exemplary, not limitative. There are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Next, a first determining module based on the estimated signal interference to determine whether to perform a device-to-device broadcast communication on the selected transmission resource. Specifically, as mentioned above, the estimated signal interference value I_N may be compared with the predetermined threshold I_N^{TH} by the first determining module. When the signal interference I_N value is greater than the I_N^{TH} value, it may be deemed that the selected transmission resource has been occupied by other user equipment, so as to determine not to perform a device-to-device broadcast communication on the transmission resource; while when the I_N value is not greater than the I_N^{TH} value, it may be deemed that the selected transmission resource is not occupied by other user equipment, so as to determine that a device-to-device broadcast communication may be performed on the transmission resource.

In another embodiment of the user equipment according to one further aspect of the present invention for performing a device-to-device broadcast communication in a wireless communication network, first, the selecting module 41 and the first interference estimating module 42, according to the method described above, the selecting module 41 selects a transmission resource and the first interference estimating module 42 estimates signal interference I_N of broadcasting on the transmission resource based on signal intensity value R_p of other user equipments that simultaneously transmit signals on the transmission resource or on a

frequency resource orthogonal to the transmission resource.

Next, a first transmission probability estimating module estimates a transmission probability for sending on the transmission resource based on the estimated signal interference. Here, the transmission probability is a value between [0-1], which refers to a probability that a signal can be sent on the transmission resource. The probability is related to a probability of successfully sending the signal on the transmission resource, and this transmission probability may be referenced to perform signal sending. Those skilled in the art would easily understand that, generally, the larger the estimated signal interference is, the smaller the transmission probability is; on the contrary, the smaller the estimated signal interference is, the greater the transmission probability is. Therefore, with reference to the transmission probability, the user equipment may adjust a percentage of actually sending of the broadcast signal selecting the transmission resource, i.e., sending the broadcast signal on the transmission resource at a certain probability so as to reduce the possibility of mutual interference with other user equipments being sending signals. For example, if the transmission probability is 0, then with reference to the transmission probability, it may be deemed that all signals having selected the transmission resource can be sent on the transmission resource; if the transmission probability is a medium value between [0, 1], e.g., 0.5, then with reference to this transmission probability, it may be deemed that 50% signals selecting to transmit on the transmission resource can be transmitted on this transmission resource.

In one embodiment, a mapping from the estimated signal interference to the transmission probability value range [0-1] may be predefined for example based on an empirical value by the first transmission probability estimating module. For the scenario in which the estimated signal interference is the strongest, it can be mapped to the transmission probability 0; for the scenario in which the estimated signal interference is of a medium intensity, it can be mapped to a medium value between the transmission probability [0-1]; for the scenario of the estimated non-signal interference, it can be mapped to the transmission probability value 1, etc. In this way, the transmission probability for transmitting on the selected transmission resource is derived based on the estimated signal interference, the transmission probability being indicated by P_t .

In another embodiment, the transmission probability P_t may be estimated by a second transmission probability estimating module based on the following equation:

$$P_t = 1 - \frac{I_N}{I_N + 1} \quad (3)$$

Where I_N is the value of signal interference estimated in step S32.

Those skilled in the art should understand that the modules for estimating the sending probability based on the value of the signal interference is exemplary, not limitative, and there are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

Next, a second determining module based on the estimated transmission probability to determine whether to perform a device-to-device broadcast communication on the transmission resource. In one embodiment, a threshold P_t^{th} for the transmission probability may be preset based on for example the empirical value by the second determining module. When the estimated transmission probability P_t is higher than the threshold P_t^{th} , it may be determined that the device-to-device broadcast communication can be performed on the selected transmission resource; while when the estimated transmission probability P_t is not higher than the threshold P_t^{th} , it may be determined that the device-to-device broadcast communication will not be performed on the selected transmission resource. The setting the threshold of the transmission probability based on the empirical value as described here is exemplary, not limitative, and there are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference. In another embodiment, whether to perform a device-to-device broadcast communication on the transmission resource may be determined by a third determining module based on the estimated transmission probability P_t and a randomly generated variable denoted as V . Specifically, when the randomly generated variable V is no greater than P_t , it is determined by the third determining module to perform the broadcast communication on the resource; when V is greater than P_t , it is determined by the third determining module not to perform the broadcast communication on the resource. In this way, statistically speaking, the probability of the broadcast signal being transmitted on the resource corresponds to the transmission probability P_t . Those skilled in the art should understand that the module for determining whether to perform broadcast communication on the transmission resource based on the transmission probability as described here is exemplary, not limitative, and there are various other implementation manners without departing from the spirit and scope of the present invention, which are incorporated here by reference.

It should be noted that the present disclosure may be implemented in software or a combination of software and hardware; for example, it may be implemented by a dedicated integrated circuit (ASIC), a general-purpose computer, or any other similar hardware device. In an embodiment, the software program of the present disclosure may be executed by a processor so as to implement the above steps or functions. Likewise, the software program of the present disclosure (including relevant data structure) may be stored in a computer readable recording medium, for example, a RAM memory, a magnetic or optical driver, or a floppy disk, and similar devices. Besides, some steps of functions of the present disclosure may be implemented by hardware, for example, a circuit cooperating with the processor to execute various functions or steps.

Further, a portion of the present disclosure may be applied as a computer program product, for example, a computer program instruction, which, when executed by the computer, may invoke or provide a method and/or technical solution according to the present disclosure through operations of the computer. Further, the program instruction invoking the method of the present disclosure may be stored in a fixed or mobile recording medium, and/or transmitted through broadcast or data flow in other signal bearer media, and/or stored in a working memory of a computer device which operates based on the program instruction. Here, in an embodiment according to the present disclosure, an apparatus comprises a memory for storing a computer

program instruction and a processor for executing the program instruction, wherein when the computer program instruction is executed by the processor, the apparatus is triggered to run the methods and/or technical solutions according to a plurality of embodiments of the present disclosure.

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To those skilled in the art, it is apparent that the present disclosure is not limited to the details of the above exemplary embodiments, and the present disclosure may be implemented with other forms without departing from the spirit or basic features of the present disclosure. Thus, in any way, the embodiments should be regarded as exemplary, not limitative; the scope of the present disclosure is limited by the appended claims, instead of the above depiction. Thus, all variations intended to fall into the meaning and scope of equivalent elements of the claims should be covered within the present disclosure. No reference signs in the claims should be regarded as limiting the involved claims. Besides, it is apparent that the term “comprise/comprising/include/including” does not exclude other units or steps, and singularity does not exclude plurality. A plurality of units or means stated in the apparatus claims may also be implemented by a single unit or means through software or hardware. Terms such as the first and the second are used to indicate names, but do not indicate any particular sequence.

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Claims

1. A method for performing a device-to-device broadcast communication in a user equipment of a wireless communication network, the method comprising steps of:

- 5 - selecting a transmission resource;
 - estimating signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource;
 10 - based on the estimated signal interference, determining whether to perform a device-to-device broadcast communication on the selected transmission resource.

2. The method according to claim 1, wherein the step of estimating signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource
 15 orthogonal to the transmission resource comprises:

 - estimating signal interference of broadcasting on the transmission resource according to the following equation:

$$I_N = \left\lfloor \frac{R_p}{R_p^{th}} \right\rfloor$$

Where R_p denotes a signal intensity value of other user equipments that simultaneously
 20 transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource, R_p^{th} denotes a predetermined threshold, and $\left\lfloor \right\rfloor$ denotes downward rounding.

3. The method according to claim 1 or 2, wherein the step of based on the estimated signal interference, determine whether to perform a device-to-device broadcast communication on the
 25 selected transmission resource comprises:

 - estimating a transmission probability of transmitting on the transmission resource based on the estimated signal interference;
 30 - determining whether to perform the device-to-device broadcast communication on the transmission resource based on the estimated transmission probability.

4. The method according to claim 3, wherein the step of determining whether to perform the device-to-device broadcast communication on the transmission resource based on the
 35 estimated transmission probability comprises:

 - determining whether to perform the device-to-device broadcast communication on the transmission resource based on the estimated transmission probability and a randomly generated variable.

5. The method according to claim 3 or 4, wherein the step of estimating a transmission probability of transmitting on the transmission resource based on the estimated signal

interference comprises:

- estimating the transmission probability based on the following equation:

$$P_t = 1 - \frac{I_N}{I_N + 1}$$

where I_N denotes a value of the estimated signal interference.

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6. The method according to any one of claims 1 to 5, wherein the step of selecting a transmission resource comprises:

- randomly selecting a transmission resource.

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7. The method according to any one of claims 1 to 6, wherein the wireless communication network is a wireless communication network based on a 3GPP protocol.

8. A user equipment for performing a device-to-device broadcast communication in a wireless communication network, the user equipment comprising:

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- a selecting module configured to select a transmission resource;
- a first interference estimating module configured to estimate signal interference of broadcasting on the transmission resource based on signal intensity of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource;

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- a first determining module configured to, based on the estimated signal interference, determine whether to perform a device-to-device broadcast communication on the selected transmission resource.

9. The user equipment according to claim 8, wherein the first interference estimation module comprises:

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- a second interference estimating module configured to estimate signal interference of broadcasting on the transmission resource according to the following equation:

$$I_N = \left\lfloor \frac{R_p}{R_p^{th}} \right\rfloor$$

Where R_p denotes a signal intensity value of other user equipments that simultaneously transmit signals on the transmission resource or on a frequency resource orthogonal to the transmission resource, R_p^{th} denotes a predetermined threshold, and $\left\lfloor \right\rfloor$ denotes downward rounding.

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10. The user equipment according to claim 8 or 9, wherein the first determining module comprises:

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- a first transmission probability estimating module configured to estimate a transmission probability of transmitting on the transmission resource based on the estimated signal interference;

- a second determining module configured to determine whether to perform the device-to-device broadcast communication on the transmission resource based on the estimated transmission probability.

5 11. The user equipment according to claim 10, wherein the second determining module comprises:

- a third determining module configured to determine whether to perform the device-to-device broadcast communication on the transmission resource based on the estimated transmission probability and a randomly generated variable.

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12. The user equipment according to claim 10 or 11, wherein the first transmission probability estimating module comprises:

- a second transmission probability estimating module configured to estimate the transmission probability based on the following equation:

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$$P_t = 1 - \frac{I_N}{I_N + 1}$$

where I_N denotes a value of the estimated signal interference.

13. The user equipment according to any one of claims 8 to 12, wherein the selecting module comprises:

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- a random selection module configured to randomly select a transmission resource.

14. The user equipment according to any one of claims 8 to 13, wherein the wireless communication network is a wireless communication network based on a 3GPP protocol.

Drawings

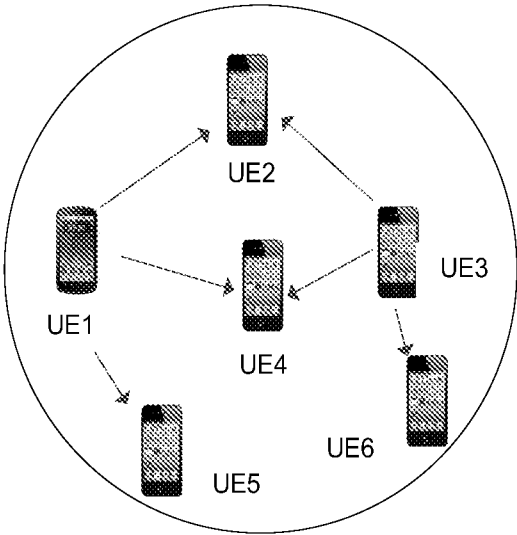


Fig. 1

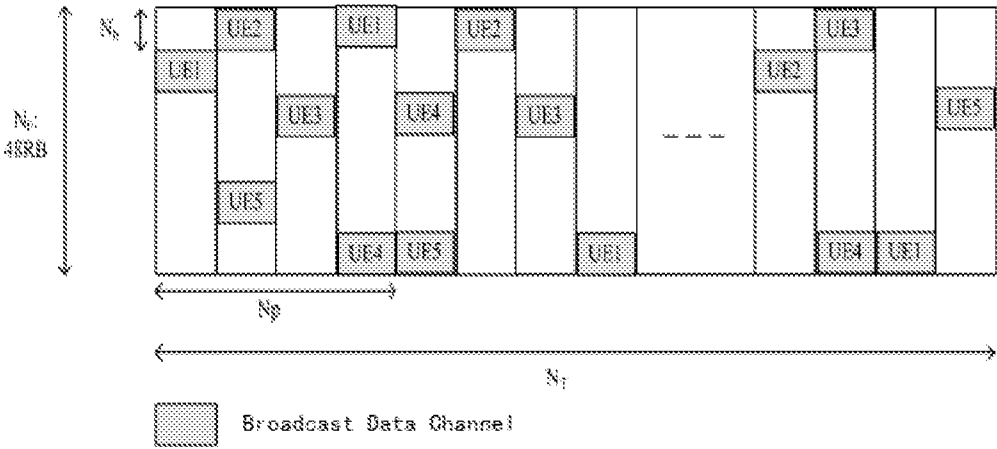


Fig. 2

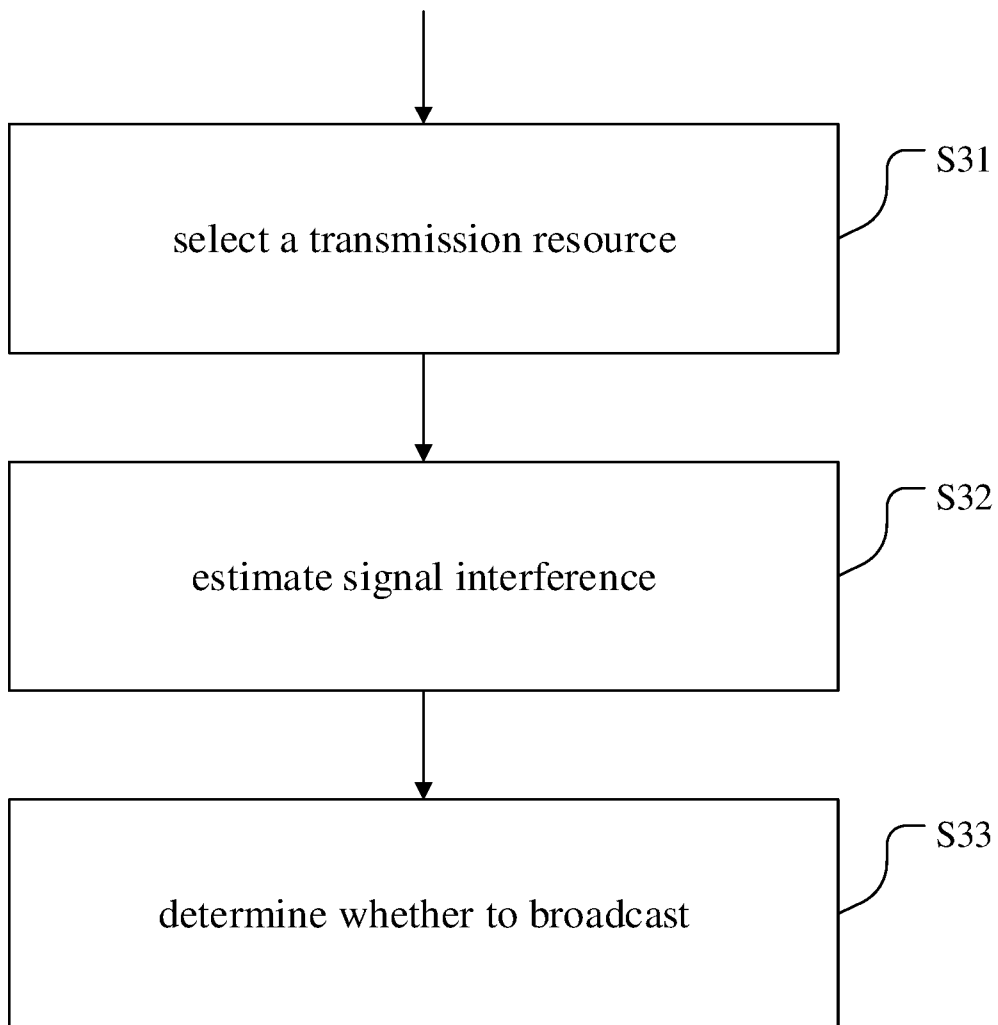


Fig. 3a

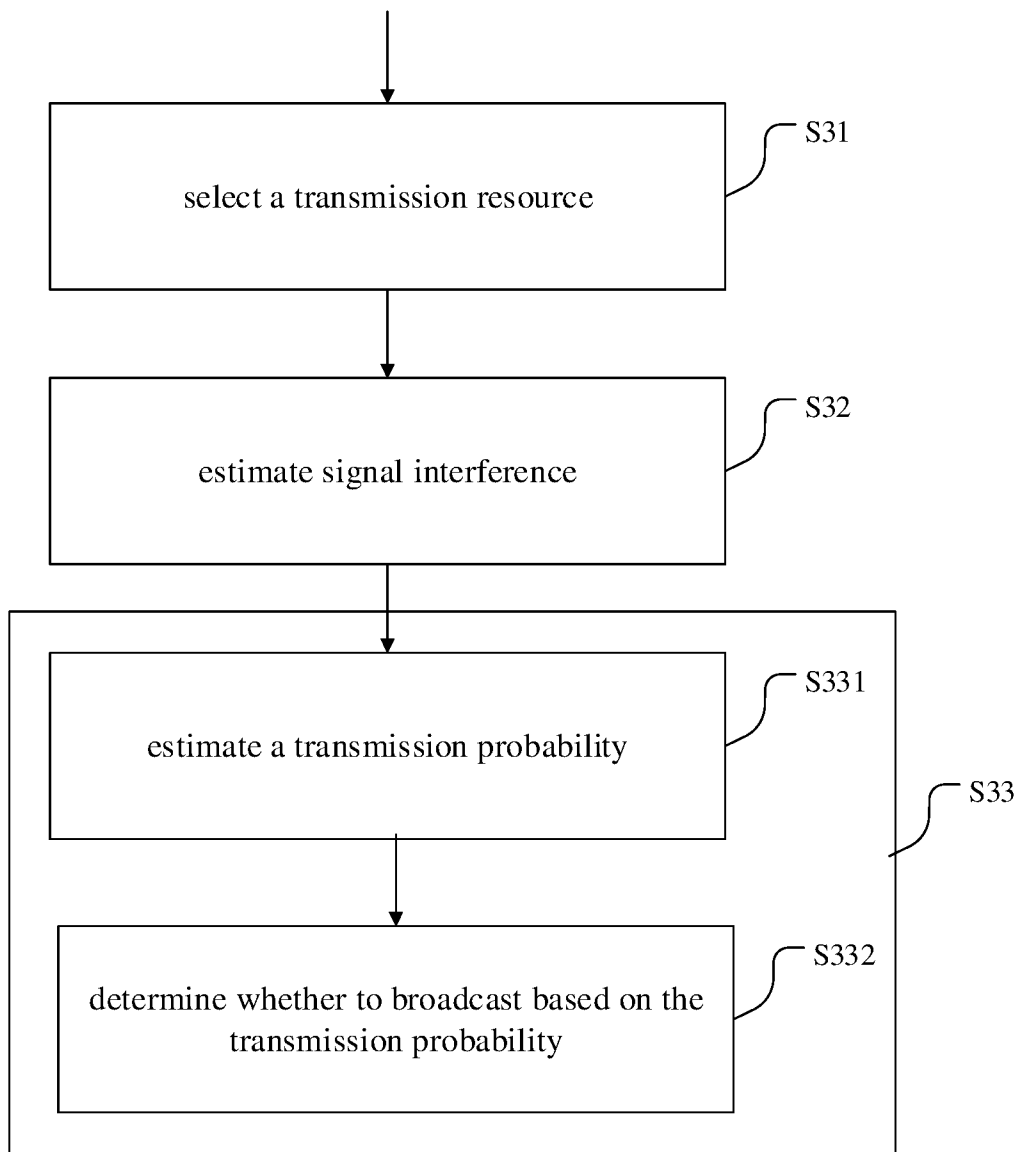


Fig. 3b

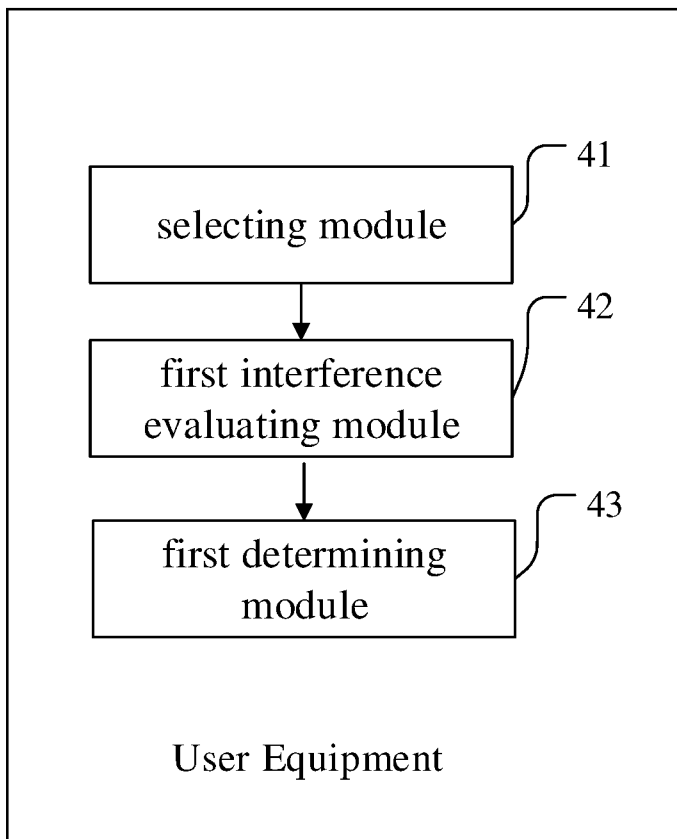


Fig. 4