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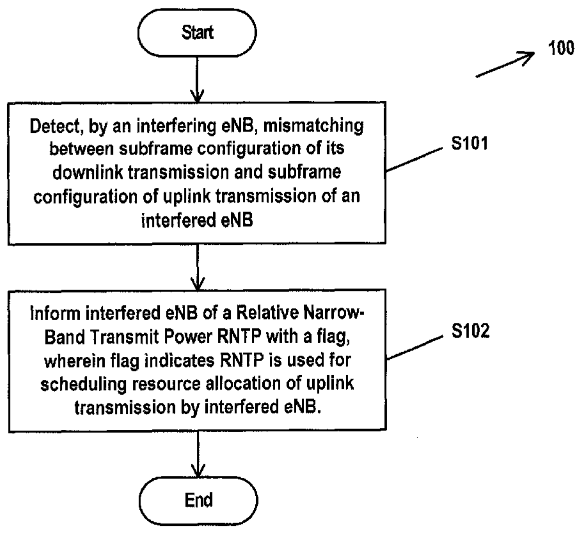

FIG. 1

(57) Abstract: Embodiments of the present invention disclose a method and apparatuses for interference coordination in a wireless communication system. The method comprises: detecting, by an interfering eNB, mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB; and informing the interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB. According to embodiments of the present invention, by adapting the RNTP in Release 8/9, an proactive inter-cell interference coordination (ICIC) for the eNB-to-eNB interference can be implemented. Moreover, the RNTP can be used with a message of the OI-like as previously proposed, so as to achieve a better bi-directional ICIC in the eNB-to-eNB interference case.

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METHOD AND APPARATUS FOR INTERFERENCE COORDINATION IN WIRELESS COMMUNICATION SYSTEM

FIELD OF THE INVENTION

[0001] Embodiments of the present invention relate to the interference coordination in a communications system, and more particularly, to a method and apparatus for interference coordination in a. wireless communication system.

BACKGROUND OF THE INVENTION

[0002] In the LTE time division duplex (TDD) system, the uplink transmission and downlink transmission adopt the time division multiplexing manner to share time division subframe resources over the time domain. Namely, some subframes of TDD are configured for uplink transmission, and some subframes are configured for downlink transmission. Apparently, if the same uplink and downlink subframe configurations are employed between neighboring cells, then like the FDD system, downlink interference of the base station with the user in the neighboring cell and uplink interference of the user with the neighboring cell exist. If the uplink and downlink subframe configurations between neighboring cells are different, then besides the conventional interference between the base station and the user, base station–to–base station and user–to–user interference will also be introduced. Specifically, when allocating different uplink transmission or downlink transmission subframes in different cells of the TDD system, mismatching likely forms between the subframe allocation of downlink transmission of a cell and the subframe allocation of uplink transmission of a neighboring cell, such that interference between the uplink transmission (UL) and the downlink transmission (DL) is generated, i.e., the base station (eNode B, eNB) to base station interference and the user equipment (UE) to user equipment interference.

[0003] In order to avoid the inter-base station interference and inter-user interference incurred due to different subframe configurations, the same uplink and downlink subframe configuration is generally employed between neighboring cells of the LTE TDD network. With the skyrocketing of network traffics, it is hard to improve data capacity and cell edge spectrum efficiency through simple cell splitting. Thus, in the enhanced LTE system, a shared-frequency co-channel heterogeneous network is introduced. The so-called heterogeneous network is to add more different kinds of small base stations/ micro-base stations in a traditional macro-base station cellular system. Because the traffic demands of respective cells in a heterogeneous network are different, it is improper to employ the same subframe configuration. Additionally, the uplink and downlink traffic proportions for respective cells in the heterogeneous network have a strong time variation, it is necessary to dynamically adjust the cell subframe configuration to adapt to the current traffic variation. Such dynamic cell subframe configuration is a natural trend for future network service development, which is a common goal of TDD spectrum operations. Under this background, it becomes an imminent problem how to solve the base station-to-base station and user-to-user interference specific to the TDD system.

[0004] In LTE Release 8/9, there are three kinds of interference coordination signaling, i.e., Relative Narrow-Band Transmit Power (RNTP), high interference indicator (HII), and overload indicator (OI), which are used for performing inter-cell interference coordination (ICIC) over the frequency domain. In Release 10, Almost Blank Subframes (ABS) has been added to perform the inter-cell interference coordination over the time domain. These signaling can be used for reducing the interference of the base station to the user equipment and the interference of the user equipment to the base station.

[0005] However, the above ICIC methods cannot be directly or effectively used for reducing the interference between the uplink transmission and downlink transmission in the TDD system, with the reasons being specified below:

[0006] In Release 8/9, the RNTP is triggered as often as every 200ms, such that the ICIC message is not frequently triggered, which is not suitable for TDD dynamic reconfiguration. Moreover, in Release 8/9, the ICIC message has no time flag to indicate in which TDD colliding subframe the ICIC is used.

[0007] Although the time-domain ICIC message (Almost Blank Subframes, ABS) in Release 10 can also be used to reduce the BS-to-BS interference, its spectrum efficiency is very low, because the BS-to-BS interference level varies over the frequency domain, and not all frequency resources corresponding to uplink transmission of different user equipment need protecting. For example, the user equipment in the cell center has a relatively large range of power rising, and its uplink transmission is not significantly affected by downlink transmission of neighboring cell. As a result, it does not need to be protected specially.

[0008] More importantly, the existing ICIC is mainly used to reduce eNB-to-UE interference and UE-to-eNB interference. Even though they can be utilized in some circumstances to reduce eNB-to-eNB interference and UE-to-UE interference, different values or additional information must be provided to the ICIC, such that the interference between the uplink transmission and downlink transmission can be distinguished from the traditional interference between the uplink transmission and uplink transmission and the interference between downlink transmission and downlink transmission. For example, the RNTP in Release 8/9 is applied for all subframes, including a non-colliding subsframe and colliding subframe. Apparently, the interferences in the two cases are totally different. If the RNTP is used, then the RNTP should have individual values.

[0009] To make up for lack of TDD-specific ICIC methods, the signaling in the existing releases can be adapted, for example, adapted for the signaling in the existing release 8/9, such as the high interference indicator (HII) and the overload indicator (OI), such that they are applied for UE-to-UE interference and BS-to-BS interference, respectively. It is already known that the signaling of the OI-like is a reactive solution, and only when the interference to the uplink transmission of the interfered eNB overloads, the interfered eNB reactively notifies the interfering eNB to request the interfering eNB to make a corresponding adjustment. Because eNB-to-eNB interference would result in catostrophic network failure, only having this reactive approach is not enough. It is therefore crucial and beneficial that prior to interference overload at the interfered eNB, steps are taken to avoid this interference.

SUMMARY OF THE INVENTION

[0010] In view of the drawbacks in the prior art, embodiments of the present invention provide a method and apparatus for interference coordination in a wireless communication system. According to one aspect of the present invention, there is provided a method for interference coordination in a wireless communication system, comprising: detecting, by an interfering eNB, mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB; and informing the interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

[0012] According to another aspect of the present invention, there is further provided a method for interference coordination in a wireless communication system, comprising: receiving, by an interfered eNB, a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB; and scheduling, by the interfered eNB, resource allocation of uplink transmission based on power distribution information over a frequency domain in the RNTP.

[0013] According to a further aspect of the present invention, there is further provided an apparatus for interference coordination in a wireless communication system, comprising: detecting means configured for an interfering eNB to detect mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB; and allocating means configured to inform the interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

[0014] According to a yet further embodiment of the present invention, there is further provided an apparatus for interference coordination in a wireless communication system, comprising: receiving means configured for an interfered eNB to receive a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB; and scheduling means configured for the interfered eNB to schedule resource allocation of uplink transmission based on power distribution information over a frequency domain in the RNTP.

[0015] According to embodiments of the present invention, by adapting the RNTP in Release 8/9, a proactive inter-cell interference coordination (ICIC) for the eNB-to-eNB interference can be implemented. Moreover, the RNTP can be used with a message of the OI-like as previously proposed, thereby achieving a better bi-directional ICIC in the eNB-to-eNB interference case.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The other objectives and effects of the present invention will become more apparent and easily comprehensible with more thorough understanding of the present invention through the following description with reference to the accompanying drawings, wherein:

[0017] Fig. 1 illustrates a flow chart of a method for interference coordination according to one embodiment of the present invention;

[0018] Fig. 2 illustrates a flow chart of a method for interference coordination according to another embodiment of the present invention;

[0019] Fig. 3 illustrates an example of applying RNTP to TDD interference coordination according to one embodiment of the present invention;

[0020] Fig. 4 illustrates a block diagram of an apparatus for interference coordination according to one embodiment of the present invention; and

[0021] Fig. 5 illustrates a block diagram of an apparatus for interference coordination according to another embodiment of the present invention.

[0022] In all of the above figures, like reference numerals indicates the same, similar or corresponding features or functions.

DETAILED DESCRIPTION OF EMBODIMENTS

[0023] Hereinafter, the embodiments of the present invention will be explained and described in more detail with reference to the accompanying drawings. It should be noted that the drawings and embodiments of the present invention are only for exemplary purposes, not for limiting the protection scope of the present invention.

[0024] The flow charts and block diagrams in the figure illustrate the likely implemented architecture, functions, and operations of the system, method, and apparatus according to various embodiments of the present invention. In this point, each block in the flow charts or block diagrams could represent a part of a module, a program segment, or code, where the part of the module, program segment, or code comprises one or more executable instructions for implementing a prescribed logic function. It should also be noted that in some alternative implementations, the functions indicated in the block diagrams could also occur in a sequence different from what is indicated in the figure. For example, two sequentially indicated blocks could be executed substantially in parallel or sometimes in an inversed order, depending on the functions as involved. It should be also noted that each block in a block diagram and/or a flow chart, and a combination of the blocks in the block diagram and/or flow chart could be implemented by a dedicated hardware-based system for performing prescribed functions or operations, or implemented by a combination of the dedicated hardware and a computer instruction.

[0025] In the present invention, the user equipment (UE) can be various kinds of terminals, for example, a mobile phone, a personal digital assistant (PDA), or a portable computer, etc. The eNB can be a macro base station, micro base station, femtocell or relay base station.

[0026] The other features and advantages of the present invention will become more apparent through the following description of the preferred embodiments of the principle of the present invention with reference to the accompanying drawings.

[0027] As previously mentioned, embodiments of the invention may be applied to various wireless communication system where the UE-to-UE or eNB-to-eNB interference may occur. Generally speaking, the UE-to-UE or eNB-to-eNB interference may occur when different uplink and downlink frame allocations are used in neighbour cells, for example, when these neighbour cells are from different operators, or the neighbour cells belong to different network (e.g., one is LTE-FDD, the other is LTE-TDD). The UE-to-UE or eNB-to-eNB interference may also occur in further systems, e.g., device to device communication system. For illustration, in the following description, a wireless communication system that operates according to Time Division Duplex (TDD) is given as an example to detail the exemplary embodiments of the present invention.

[0028] As mentioned above, the prior art only disclosed a reactive method of avoiding eNB-to-eNB interference. Thus, prior to interference overload at the interfered eNB, it needs to adopt measures to prevent such interference, which is crucial and beneficial.

[0029] According to the embodiments of the present invention, by designing a TDD-specific frequency domain power indicator for an interfering eNB that performs downlink transmission so as to reserve certain resources, the eNB-to-eNB interference

ICIC is implemented. The interfered eNB could correspondingly adjust its uplink transmission scheduling, therefore a seriously interfered UE (for example, the UE at the edge of the cell) could be normally served in the case of reserved low interference resource.

[0030] Specifically, in the embodiments of the present invention, a RNTP message in the existing Release 8/9 is adapted and extended by adding a UL-DL information element, so as to enhance the backhaul (i.e., X2) to support faster eNB-to-eNB interference coordination. Further, the new information element (IE) directly enhances the existing RNTP so as to adapt the UL-DL ICIC use case.

[0031] Hereinafter, referring to Fig. 1, which illustrates a flow chart of a method for interference coordination in a wireless communication system according to one embodiment of the present invention. It should be understood that the steps in method 100 as illustrated in Fig. 1 are for illustration purposes. The method 100 can comprise additional and/or alternative steps.

[0032] After the method 100 starts, at step S101, an interfering eNB detects mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB. At step S102, the interfered eNB is informed of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

[0033] It is already known that the RNTPs interact between eNBs through an X2 interface to transmit therebetween their own downlink energy distribution information within a certain period in the future. The RNTP informed by each eNB indicates the relative magnitude of the transmission power of the eNB over each frequency resource within the certain time in the future.

[0034] According to the embodiments of the present invention, the RNTP with the flag is used for reflecting the interference of the downlink transmission of the interfering eNB with the uplink transmission of the interfered eNB. Specifically, in the eNB-to-eNB interference, the RNTP with the flag is valid on the mismatching subframe, but invalid on the matching subframe. On the matching subframe, the existing RNTP can be still used (i.e., RNTP flag is set as “false”).

[0035] According to one embodiment of the present invention, the RNTP further comprises power distribution information over the frequency domain, and the power distribution information is adjusted based on the power distribution of the downlink transmission of the interfering eNB and the uplink transmission of the interfered eNB.

[0036] According to one embodiment of the present invention, the interfering eNB detects, by means of the X2 signaling, the mismatching between the subframe configuration of its downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB, or detects, by means of its interference information, the mismatching between the subframe configuration of its downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB.

[0037] According to one embodiment of the present invention, the flag can be a single bit or a bitmap.

[0038] According to one embodiment of the present invention, the flag is a single bit, which is used for distinguishing the RNTP from existing RNTP; and when the single bit is valid, the RNTP is allocated to all of the mismatching subframes. For example, in case of mismatching, 4 subframes among 10 subframes are mismatching, and then the RNTP with the single-bit flag can be applied to the mismatching of the 4 subframes.

[0039] According to one embodiment of the present invention, the flag is a bitmap, and the bits in the bitmap are allocated to different mismatching subframes so as to indicate the mismatching subframes to which the RNTP with the flag are applied. For example, when 4 subframes among the 10 subframes are mismatching, 2 of the 4 subframes are applicable to one RNTP, and another two subframes are applicable to another RNTP. At this point, the mismatching subframes to which the RNTP with the flag is applied can be indicated in the manner of bitmap.

[0040] It is already known that ABS is a Almost Blank Subframes. On this subframe, the eNB does not work, or work in a low power, or is inactive. The other subframes are subframes that work normally. According to one embodiment of the present invention, the RNTP with a flag is allocated to Non-Zero Tx Power ABS, and the power distribution information in the RNTP is adjusted, such that the interfered eNB schedules the resource allocation of uplink transmission.

[0041] Hereinafter, an example of the specific structure of RNTP according to the present invention will be described.

[0042] Based on the existing definition of RNTP in section 9.2.19 of the standard TS 36.423, the embodiments of the present invention adapt the specific structure of the existing RNTP. The RNTP being adapted as illustrated in Table 1 comprises power distribution information over the frequency domain, i.e., indication of DL power restriction per physical resource block (PRB) in a cell, and indication of other information required by a neighboring eNB for interference aware scheduling. Moreover, the adapted RNTP further comprises "TDD UL-DL mismatch flag" and "non-zero Tx power ABS flag".

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
RNTP Per PRB	M		BIT STRING (6..110, …)	Each position in the bitmap represents an n_{PRB} value (i.e. first bit=PRB 0 and so on), for which the bit value represents *RNTP* (n_{PRB}), defined in TS 36.213 [11]. Value 0 indicates "Tx not exceeding RNTP threshold". Value 1 indicates "no promise on the Tx power is given"	–	–
RNTP Threshold	M		ENUMERATED (-∞, -11, -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, …)	$RNTP_{threshold}$ is defined in TS 36.213 [11]	–	–
Number Of Cell-specific Antenna Ports	M		ENUMERATED (1, 2, 4, …)	*P* (number of antenna ports for cell-specific reference signals) defined in TS 36.211 [10]	–	–
P_B	M		INTEGER (0..3, …)	P_B is defined in TS 36.213 [11]	–	–
PDCCH Interference Impact	M		INTEGER (0..4, …)	Measured by Predicted Number Of Occupied PDCCH OFDM Symbols (see	–	–

				TS 36.211 [10]). Value 0 means "no prediction is available"		
Single Bit Flag List						
>TDD UL-DL Mismatch Flag	O		BOOLEAN: TRUE or FALSE	True is set when the recipient eNB TDD Subframe Assignment is different from the sender eNB TDD Subframe Assignment	–	–
>Non-Zero Tx Power ABS Flag	O		BOOLEAN: TRUE or FALSE	True is set when non-zero Tx power ABS is applied at the sender eNB.	–	–
>Other cases						

[0043] In the above example of the specific structure of the RNTP, enhancement of the RNTP use is described. The interfered eNB2 adapts the existing OI and reports high eNB-to-eNB interference from eNB1. Moreover, upon receiving this OL-like report, the interfering eNB1 could set the adapted RNTP with more suitable and pertinent values.

[0044] Hereinafter, referring to Fig. 2, which illustrates a flow chart of a method for interference coordination in a wireless communication system according to another embodiment of the present invention. It should be understood that the steps in the method 200 as illustrated in Fig. 2 are merely for illustrative purposes. The method 200 could comprise additional and/or alternative steps.

[0045] After start of the method 200, at step S201, the interfered eNB receives a RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB. At step S202, the interfered eNB schedules resource allocation of uplink transmission based on the power distribution information over the frequency domain in the RNTP.

[0046] According to one embodiment of the present invention, the method further comprises the following steps: upon receiving the RNTP with the flag, the inferred eNB requesting the interfering eNB to inform TDD subframe assignment of the interfering eNB.

[0047] Hereinafter, the method for interference coordination in a time division duplex system according to the embodiments of the present invention will be described with a specific application instance. According to adaption for the existing Release 8/9, by enabling the interfering eNB to inform the interfered eNB of the RNTP, the RNTP has a single-bit "flag" for notifying the interfered eNB that the RNTP is associated with the TDD subframe configuration. The added bit "flag" can be used to indicate the mismatching between the uplink and downlink transmission subframe configurations of TDD.

[0048] The adapted RNTP is received at the interfered eNB to schedule the resource allocation of uplink transmission so as to alleviate the eNB-to-eNB interference, for example, allocating the UL resource corresponding to low transmission power as indicated in the RNTP to the UE at the cell edge. According to one embodiment of the present invention, the interfered eNB is informed through the X2 interface of the interfering eNB the TDD Subframe Assignment included in the served Cell Information (for details, please refer to the TDD Subframe Assignment in Section 9.2.8, TS 36.423).

[0049] According to one embodiment of the present invention, the information element structure of the RNTP in Release 8/9 is unchanged, but added with an optional flag bit (i.e., the mismatching flag of TDD UL-DL).

[0050] It is the simplest method which left much to network implementation. In other words, the interfering eNB informs the interfered eNB of the transmission power distribution information over the frequency domain and the mismatching of the TDD subframe allocation (if exist). This mismatching could be due to changes at either of the eNBs. Because the existing TDD subframe allocation IE is signaled by triggering or regularly, this adapted RNTP provides "indirect" IE to signal such mismatching.

[0051] When the single-bit “flag” is valid, the value of the information element in RNTP is changeable, particular for the eNB-to-eNB ICIC. · Moreover, certain high-level wireless resource control (RRC) signaling or L1/L2 signaling can be required.

[0052] If different “R_B” values are used in the TDD UL-DL colliding subframes, then the information element “R_B” in the RNTP message has to be signaled by the RRC to the UE.

[0053] When the number of occupied PDCCH OFDM symbols predicted by the interfering eNB is changed in the TDD UL-DL colliding subframes, PCFICH in these subframes change accordingly.

[0054] According to one embodiment of the present invention, the interfering eNB assigns continuous frequency resources with similar transmission power levels. This is because the UL resources for the UE are allocated in a continuous manner.

[0055] This RNTP with TDD UL-DL Mismatch Flag is only valid in TDD UL-DL colliding subframes and valid until reception of a new LOAD INFORMATION message carrying an updated RNTP or TDD Subframe Assignment of either the interfering eNB or the interfered eNB is changed.

[0056] The proposed method with a single bit “Flag” according to the embodiments of the present invention could also be used in other interference scenarios. For example, there is a coexistence problem of RNTP in non-zero Tx power ABS. And if a single bit “Flag” is added, the RNTP applied for all subframes could be also specially used to indicate RNTP status in non-zero Tx power ABS.

[0057] Hereinafter, an example of applying the RNTP to TDD interference coordination according to one embodiment of the present invention will be described.

[0058] Fig. 3 shows an example of applying the RNTP to TDD interference coordination according to one embodiment of the present invention. As illustrated in Fig. 3, eNB1 performs downlink transmission with reference to the center UE1 and edge UE1’ within its service area, and eNB2 performs uplink transmission with respect to the center UE2 and edge UE2’ within its service area. Mismatching exists between the downlink transmission of eNB1 and the uplink transmission of eNB2. At this point, the interfering eNB1 notifies the existence of colliding DL-UL subframes between eNB2 and itself. In order to avoid potential eNB-to-eNB interference, the eNB1 configures the TDD-specific RNTP, i.e., the RNTP with a flag, and notifies eNB2 of this configuration via the X2 interface. Correspondingly, in the colliding DL subframes, the eNB1 schedules its cell center UE1 at the upper part of the bandwidth at a relatively low transmission power, and schedules its cell edge UE1' at the lower part of the bandwidth at a high power.

[0059] Once the adapted RNTP is received from the eNB1, the interfered eNB2 adaptively adjusts its scheduling in response to the interference coordination. In other words, among the colliding UL subframes, the cell center UE2 is scheduled at the lower part of the bandwidth, and the cell edge UE2' is scheduled at the upper part of the bandwidth.

[0060] By virture of this interference coordination, the UL transmission from the cell edge UE2' to eNB2 will not be subjected to the strong interference from the DL transmission of eNB1. In other words, the eNB-to-eNB interference will be alleviated. Meanwhile, the DL transmission at the cell edge UE1' received from eNB1 will not be subjected to the strong interference from the UL transmission of the cell edge UE2'. In other words, the strong UE-to-UE interference could also be removed.

[0061] Now, referring to Fig. 4, which illustrates a block diagram of an apparatus for interference coordination in a wireless communication system according to one embodiments of the present invention. The apparatus 400 as illustrated in Fig. 4 comprises a detecting means 401 and an allocating means 402. The detecting means 401 is configured for an interfering eNB to detect mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB. The allocating means 402 is configured for the interfered eNB to inform the interfered eNB a RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

[0062] According to one embodiment of the present invention, the RNTP further comprises power distribution information over a frequency domain and the power distribution information is adjusted based on power distribution of the downlink transmission of the interfering eNB and the uplink transmission of the interfered eNB.

[0063] According to one embodiment of the present invention, the interfering eNB detects, by means of an X2 signaling, mismatching between subframe configuration of its downlink transmission and subframeconfiguration of uplink transmission of the interfered eNB, or detects, by means of its interference information, mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of the interfered eNB.

[0064] According to one embodiment of the present invention, the flag is a single bit, which is used for distinguishing the RNTP from existing RNTP; and when the single bit is valid, the RNTP is allocated to all of the mismatching subframes.

[0065] According to one embodiment of the present invention, the flag is a bit map, and the bits in the bitmap are allocated to different mismatching subframes so as to indicate the mismatched frames to which the RNTP with a flag is applied.

[0066] According to one embodiment of the present invention, the distributing means allocates the RNTP with the flag to Non-Zero Tx Power ABS and adjusts the power distribution information in the RNTP, such that the interfered eNB schedules the resource allocation of uplink transmission.

[0067] Hereinafter, referring to Fig. 5, it illustrates a block diagram of an apparatus for interference coordination in a wireless communication system according to an other embodiment of the invention. The apparatus 500 as illustrated in Fig. 5 comprises receiving means 501 and scheduling means 502. The receiving means 501 is configured for the interfered eNB to receive a RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB. The scheduling means 502 is configured for the interfered eNB to schedule the resource allocation of uplink transmission based on the power distribution information over the frequency domain in the RNTP.

[0068] According to one embodiment of the present invention, the apparatus further comprises a requesting means configured for the inferred eNB to request the interfering eNB to inform the interfering eNB of TDD subframe assignment, upon receiving the RNTP with a flag.

[0069] Through the above depiction, it is seen that the methods and apparatuses for interference coordination according to the embodiments of the present invention are proactive ICIC solutions, which could prevent interference overload in advance. Specifically, due to different UL-DL subframe allocations, the embodiments of the present invention provide an proactive frequency domain ICIC method for eNB-to-eNB interference. The signaling messages maintains substantially identical to the existing Release 8/9, with only very limited changes. The adapted RNTP signaling helps to fast control of TDD eNB-to-eNB interference and subframe reconfiguration. Beside, the RNTP-like of signaling as proposed can be easily extended to ICIC in other conditions (for example, RNTP under the non-zero transmission power ABS).

[0070] Although embodiments of the present invention have been set forth with respect to TDD systems, but the embodiments of the present invention may also be used to any wireless communication systems where UE-to-UE or eNB-to-eNB interference may occur, regardless the being developed system or the future systems. The present invention has no limitation in this regard.

[0071] It should be noted that the method as disclosed in the embodiments of the present invention could be implemented in software, hardware, or combination of software and hardware. The hardware part could be implemented utilizing a dedicated logic; the software part could be stored in a memory and executed by a proper instruction executing system, for example, a microprocessor, a personal computer (PC), or a large machine. In some embodiments, the present invention is implemented as software, including, but not limited to, firmware, residing software, or microcode, etc.

[0072] Moreover, the embodiments of the present invention could also assume a form of a computer program product available to the computer or accessible by e computer readable medium. These mediums provide program codes to be used by the computer or any instruction execution system or to be used in combination. For the sake of depiction, the computer available or computer readable mechanism could be any tangible apparatus, which could comprise, store, communicate, propagate, or transmit a program to be used by an instruction executing system, an apparatus or device, or to be used in combination thereof.

[0073] The medium could be an electrical, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of computer readable mediums comprise semiconductor or solid memory, magnetic tape, mobile computer disk, random access memory (RAM), read-only memory (ROM), hard disk, and optical disk. Examples of current optical disks comprise a compact disk-read only memory (CD-ROM), a compression disk- read/write

(CD-R/W) and DVD.

[0074] It should be noted that in order to make the embodiments of the present invention more comprehensible, the above depiction omits some more specific technical details that are known to those skilled in the art but might be essential for implementing the embodiments of the present invention. The description of the present invention is for the purpose of illustration and depiction, not for exhausting or limiting the present invention within the disclosed embodiments. To those normally skilled in the art, various modifications and changes are possible.

[0075] Thus, selecting and describing the embodiments is to better interpret the principle and its practical applications of the present invention and to enable those normally skilled in the art to understand that without departing from the essence of the present invention, all modifications and alterations fall within the protection scope as defined in the appending claims.

What is Claimed is:

1. A method for interference coordination in a wireless communication system, comprising:

detecting, by an interfering eNB, mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB; and

informing the interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

2. The method according to claim 1, wherein the RNTP further comprises power distribution information over the frequency domain, and the power distribution information is adjusted based on the power distribution of the downlink transmission of the interfering eNB and the uplink transmission of the interfered eNB.

3. The method according to claim 1, wherein the interfering eNB detects, by means of X2 signaling, the mismatching between the subframe configuration of its downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB, or detects, by means of its interference information, the mismatching between the subframe configuration of its downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB.

4. The method according to claim 1, wherein the flag is a single bit, which is used for distinguishing the RNTP from existing RNTP; and when the single bit is valid, the RNTP is allocated to all of the mismatching subframes.

5. The method according to claim 1, wherein the flag is a bitmap, and the bits in the bitmap are allocated to different mismatching subframes, so as to indicate the mismatching subframes to which the RNTP with the flag are applied.

6. The method according to claim 1, further comprising:

allocating the RNTP with the flag to a Non-Zero Tx power Almost Blank Subframes ABS and adjusting power distribution information in the RNTP, such that the interfered eNB schedules resource allocation of uplink transmission.

7. A method for interference coordination in a wireless communication system, comprising:

receiving, by an interfered eNB, a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB; and

scheduling, by the interfered eNB, resource allocation of uplink transmission based on power distribution information over a frequency domain in the RNTP.

8. The method according to claim 7, further comprising:

upon receiving the RNTP with the flag, the inferred eNB requesting the interfering eNB to inform TDD subframe assignment of the interfering eNB.

9. An apparatus for interference coordination in a wireless communication system, comprising

detecting means configured for an interfering eNB to detect mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB; and

allocating means configured to inform the interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB.

10. The apparatus according to claim 9, wherein the RNTP further comprises power distribution information over the frequency domain, and the power distribution information is adjusted based on the power distribution of the downlink transmission of the interfering eNB and the uplink transmission of the interfered eNB.

11. The apparatus according to claim 9, wherein the interfering eNB detects, by means of X2 signaling, the mismatching between the subframe configuration of its

downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB, or detects, by means of its interference information, the mismatching between the subframe configuration of its downlink transmission and the subframe configuration of the uplink transmission of the interfered eNB.

12. The apparatus according to claim 9, wherein the flag is a single bit, which is used for distinguishing the RNTP from existing RNTP; and when the single bit is valid, the RNTP is allocated to all of the mismatching subframes.

13. The apparatus according to claim 9, wherein the flag is a bitmap, and the bits in the bitmap are allocated to different mismatching subframes so as to indicate the mismatching subframes to which the RNTP with the flag are applied.

14. The apparatus according to claim 9, wherein the allocating means allocates the RNTP with the flag to a Non-Zero Tx power Almost Blank Subframes ABS and adjusts power distribution information in the RNTP, such that the interfered eNB schedules the resource allocation of uplink transmission.

15. An apparatus for interference coordination in a wireless communication system, comprising:

receiving means configured for an interfered eNB to receive a Relative Narrow-Band Transmit Power RNTP with a flag, wherein the flag indicates the RNTP is used for scheduling resource allocation of uplink transmission by the interfered eNB; and

scheduling means configured for the interfered eNB to schedule resource allocation of uplink transmission based on power distribution information over a frequency domain in the RNTP.

16. The apparatus according to Claim 15, further comprising a requesting means configured for the inferred eNB to request the interfering eNB to inform TDD subframe assignment of the interfering eNB, upon receiving the RNTP with the flag.

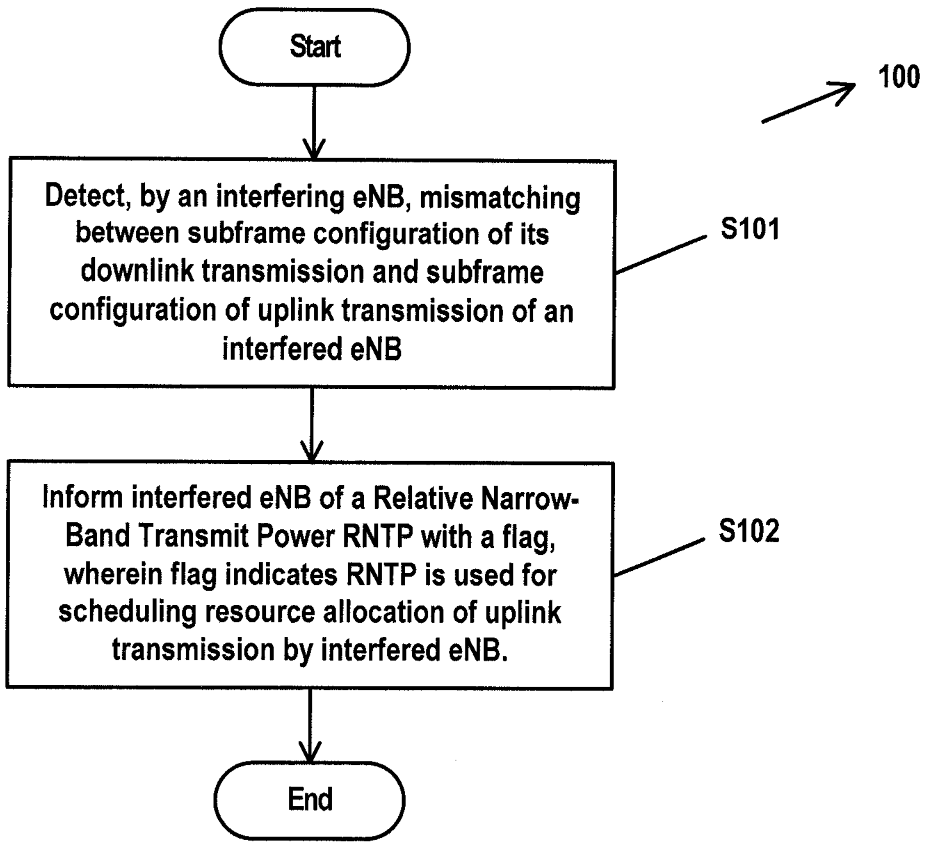
Start
100
Detect, by an interfering eNB, mismatching between subframe configuration of its downlink transmission and subframe configuration of uplink transmission of an interfered eNB
S101
Inform interfered eNB of a Relative Narrow-Band Transmit Power RNTP with a flag, wherein flag indicates RNTP is used for scheduling resource allocation of uplink transmission by interfered eNB.
S102
End

FIG. 1

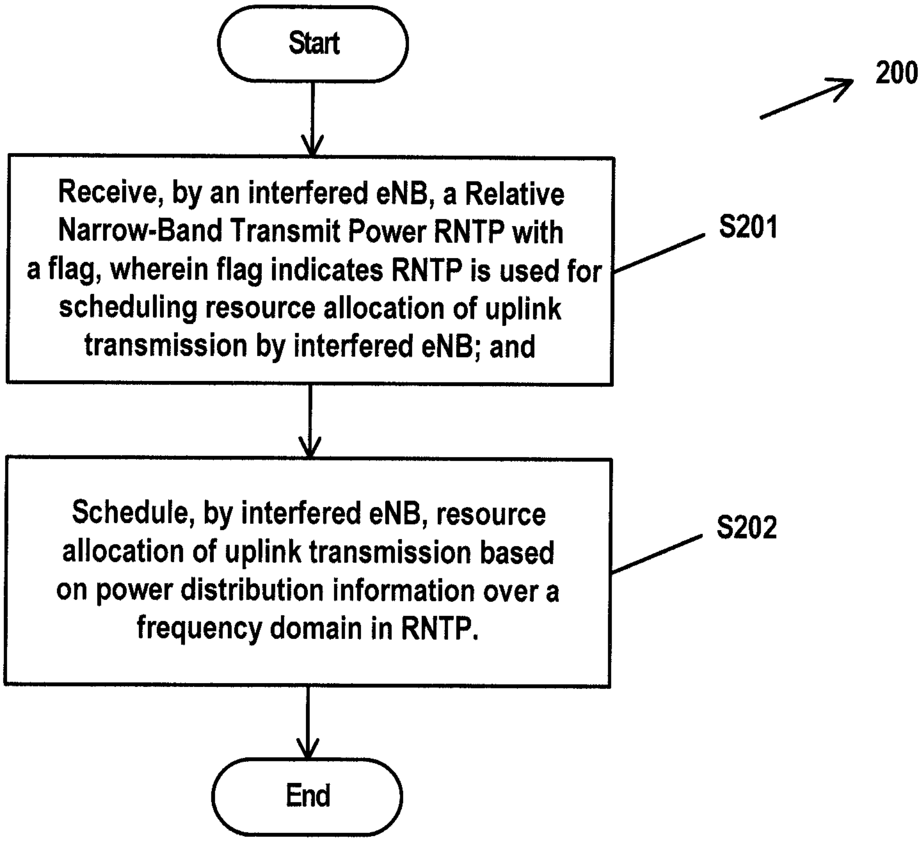
Start
200
Receive, by an interfered eNB, a Relative Narrow-Band Transmit Power RNTP with a flag, wherein flag indicates RNTP is used for scheduling resource allocation of uplink transmission by interfered eNB; and
S201
Schedule, by interfered eNB, resource allocation of uplink transmission based on power distribution information over a frequency domain in RNTP.
S202
End

FIG. 2

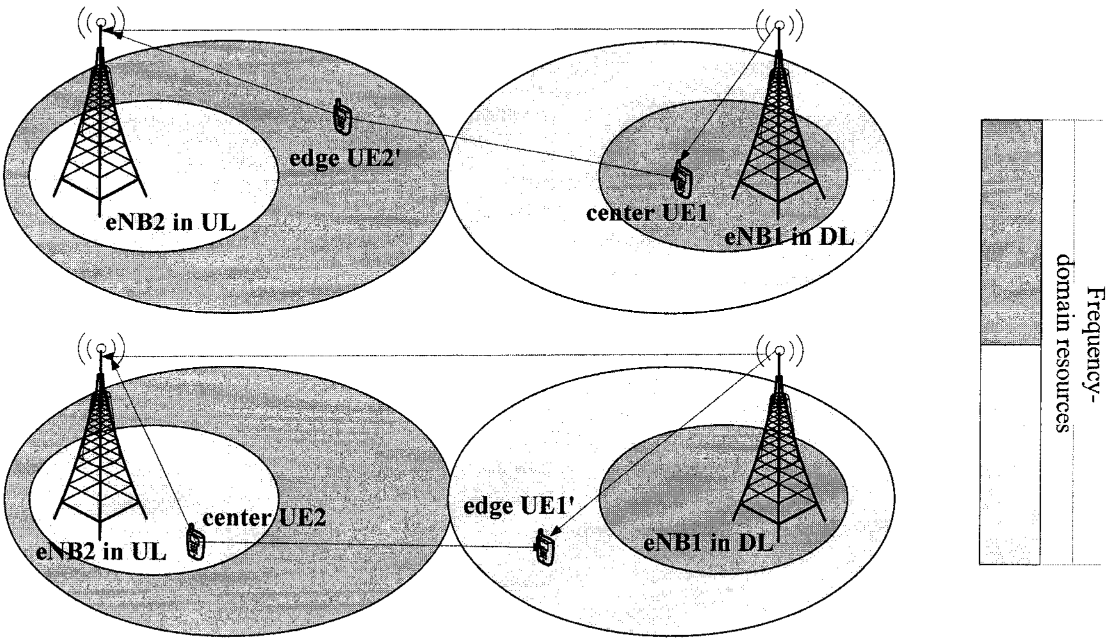
edge UE2'
eNB2 in UL
center UE1
eNB1 in DL
center UE2
edge UE1'
eNB2 in UL
eNB1 in DL
Frequency-
domain resources

FIG. 3

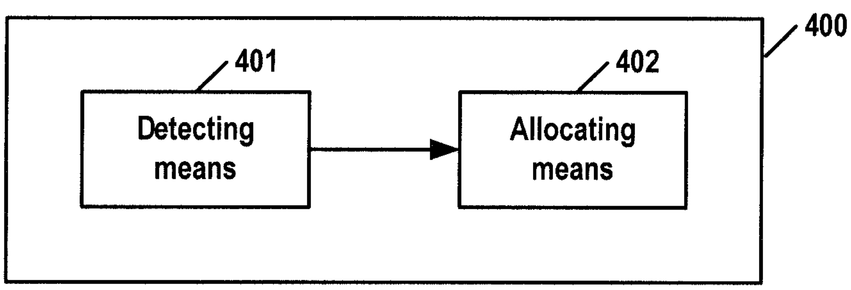
400
401
402
Detecting means
Allocating means

FIG. 4

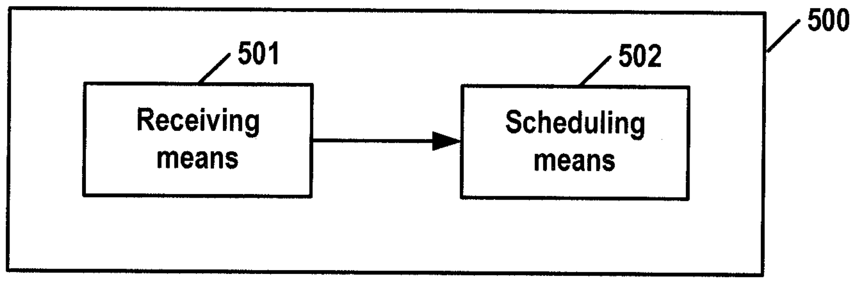

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/072565

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/08 (2009.01) i

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)

IPC: 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)

CNABS; CNTXT; VEN: interfere+, coordinate+, eNB, subframe w configuration, downlink, uplink, RNTP, flag, resource w allocation, X2

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN101877856A(NEW POST COMM. EQUIPMENT CO., LTD.) 03 November 2010(03.11.2010) the whole document	1-16
A	CN102065490A(DATANG MOBILE COMMUNICATION EQUIP. CO., LTD.) 18 May 2011(18.05.2011) the whole document	1-16
A	CN102149099A(INST TELECOM SCI&TECHNOLOGY MIN O) 10 August 2011(10.08.2011) the whole document	1-16
A	CN101932100A(DATANG MOBILE COMMUNICATION EQUIP. CO., LTD.) 29 December 2010(29.12.2010) the whole document	1-16
A	US2010267408A1(SAMSUNG ELECTRONICS CO., LTD.) 21 October 2010(21.10.2010) the whole document	1-16

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

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

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

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

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

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2012(14.12.2012)	**20 Dec. 2012 (20.12.2012)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/072565

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101877856A	03.11.2010	NONE	
CN102065490A	18.05.2011	NONE	
CN102149099A	10.08.2011	WO2012136100A1	11.10.2012
CN101932100A	29.12.2010	NONE	
US2010267408A1	21.10.2010	KR20100115653A	28.10.2010