

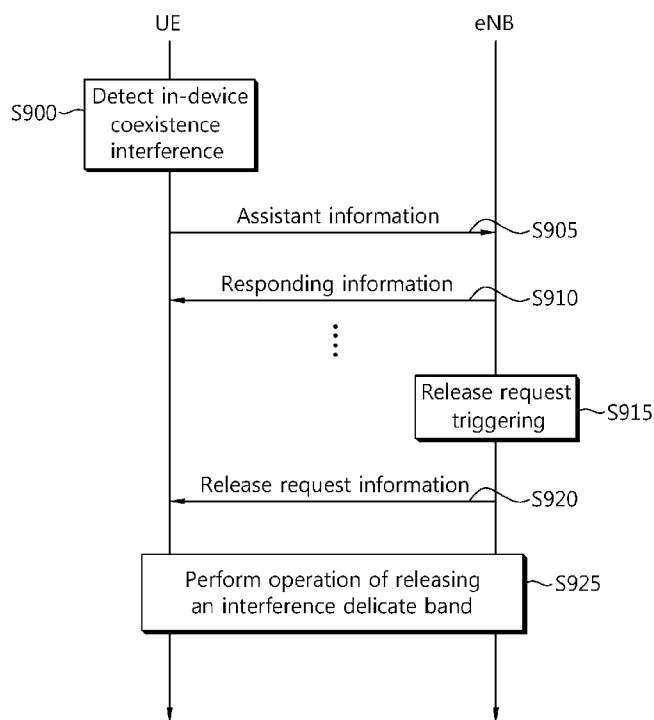


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[Continued on next page]

(54) **Title:** APPARATUS AND METHOD FOR TRANSMITTING CONTROL INFORMATION ON IN-DEVICE COEXISTENCE INTERFERENCE

[Fig. 9]



(57) **Abstract:** The present invention relates to an apparatus and a method for transmitting control information about in-device coexistence interference. The present invention provides a method that a UE generates assistant information indicating occurrence or a probability of occurrence of the interference, and transmits the assistant information to an eNodeB. The eNodeB transmits responding information allowing to enter an avoiding state or release request information indicating releasing the avoiding state corresponding to the assistant information to the UE. The UE releases the avoiding state. According to the present invention, while a UE avoiding an interference delicate frequency band due to in-device coexistence interference, a procedure for re-allocation of an interference delicate frequency band or hand-over to the interference delicate frequency band for the UE is made clear; and a eNodeB can separately release an avoiding state against the interference delicate frequency band without assistance of the UE.



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Description

Title of Invention: APPARATUS AND METHOD FOR TRANSMITTING CONTROL INFORMATION ON IN-DEVICE COEXISTENCE INTERFERENCE

Technical Field

- [1] The present invention relates to wireless communication, more specifically, an apparatus and a method for transmitting control information on in-device coexistence interference.

Background Art

- [2] In general, a wireless communication system occupies a frequency range consisting of single bandwidth. For example, the 2nd generation wireless communication system uses frequency bandwidth ranging from 200 KHz to 1.25 MHz and the 3rd wireless communication system uses bandwidth ranging from 5 MHz to 10 MHz. To support increasing transmission capacity, the recent 3GPP (3rd Generation Partnership Project) LTE (Long Term Evolution) or the IEEE 802.16m is expanding the bandwidth up to 20 MHz or beyond. Extending bandwidth is necessary to accommodate increasing transmission capacity; however, maintaining large bandwidth may cause considerable power consumption in a case where quality of service required is low.
- [3] Therefore, multiple component carrier systems are now emerging, which define a carrier wave with a frequency spectrum consisting of single bandwidth and a center frequency and are capable of transmitting and/or receiving broadband data through a plurality of carrier waves. That is, by using one or more carrier waves, frequency spectrums of narrow and broad bandwidth are supported at the same time. For example, if one carrier wave corresponds to bandwidth of 5 MHz, bandwidth up to 20 MHz can be supported by using four carrier waves.
- [4] Due to ubiquitous access network nowadays, users at different places can access networks different from one another and maintain connectivity continuously regardless of their current locations. In the conventional situation where a user equipment performs communication only with a single network, a user used to carry separate devices supporting the respective network systems. However, as functions provided by a single user equipment become more advanced and complicated, user equipments of today are capable of performing communication with a plurality of networks at the same time, thereby increasing user convenience.
- [5] However, if a user equipment performs communication simultaneously across frequency bands of a plurality of network systems, in-device coexistence interference may occur. The in-device coexistence interference refers to the phenomenon where

transmission through some frequency band causes interference in receiving data through a different frequency band. For example, if a user equipment supports both the Bluetooth and the LTE system, the in-device coexistence interference may occur in the corresponding frequency bands of the Bluetooth and the LTE system. The in-device coexistence interference often occurs when spacing between boundaries of frequency bands of different network systems is not sufficiently secured.

- [6] To avoid the in-device coexistence interference, a frequency division multiplexing (FDM) method and a time division multiplexing (TDM) method may be used. If interference occurs between a first frequency band of a first network system and a second frequency band of a second network system, the FDM method coordinates in-device coexistence interference by moving the frequency band of one of the two network systems. That is, in-device coexistence interference is coordinated by avoiding a frequency band in which the in-device coexistence is generated. Meanwhile, the TDM method coordinates in-device coexistence interference by separating the transmission time of a first network system and the reception time of a second network system.
- [7] To coordinate in-device coexistence interference, control information about the in-device coexistence interference should be communicated between a user equipment and an eNodeB; however, a specific operating procedure for communicating the control information has not been established yet.

Disclosure of Invention

Technical Problem

- [8] One object of the present invention is to provide an apparatus and a method for transmitting control information about in-device coexistence interference.
- [9] Another object of the present invention is to provide an apparatus and a method for requesting a measurement result about an interference delicate frequency band when a particular frequency band is rendered unuseable due to in-device coexistence interference.
- [10] Yet another object of the present invention is to provide an apparatus and a method for releasing an avoiding state of an interference delicate frequency band.
- [11] Still another object of the present invention is to provide an apparatus and a method for triggering to release an avoiding state of an interference delicate frequency band.
- [12] A further object of the present invention is to provide an apparatus and a method for transmitting release request information which releases an avoiding state of an interference delicate frequency band.

Solution to Problem

- [13] According to one aspect of the present invention, a user equipment transmitting

control information about interference in a wireless communication system is provided. The user equipment comprises an interference detection unit detecting interference caused by transmission of a first network system in a first frequency band against reception of a second network system in a second frequency band; an assistant information generation unit generating assistant information indicating occurrence of the interference or a probability of interference occurrence; a transmitter transmitting the generated assistant information to an eNodeB; a receiver receiving responding information allowing the second frequency band to enter an avoiding state or release request information indicating releasing the avoiding state from the eNodeB; and a release operation execution unit carrying out the operation of releasing the avoiding state based on the release request information.

[14] According to another aspect of the present invention, provided is a method for transmitting control information about interference by a user equipment in a wireless communication system. The method comprises a detection step detecting interference caused by transmission through a first frequency band of a first network system against reception through a second frequency band of a second network system; a transmission step transmitting assistant information indicating occurrence of the interference in the second frequency band or a probability of occurrence of the interference to an eNodeB; a reception step receiving responding information allowing the second frequency band to enter an avoiding state; a reception step receiving release request information indicating releasing the avoiding state from the eNodeB; and an execution step carrying out operation of releasing the avoiding state based on the release request information.

[15] According to yet another aspect of the present invention, provided is an eNodeB transmitting control information about interference in a wireless communication system. The eNodeB comprises a receiver receiving assistant information indicating occurrence of interference caused by transmission through a first frequency band of a first network system against reception through a second frequency band of a second network system or a probability of occurrence of interference from a user equipment; a transmitter transmitting responding information allowing the second frequency band to enter an avoiding state or release request information indicating releasing the avoiding state to the user equipment; and a triggering unit triggering release of the avoiding state if triggering conditions for releasing the avoiding state are met.

[16] According to still another aspect of the present invention, provided is a method for transmitting control information about interference by an eNodeB in a wireless communication system. The method comprises a reception step receiving assistant information indicating occurrence of interference caused by transmission through a first frequency band of a first network system against reception through a second frequency band of a second network system or a probability of occurrence of interference from a

user equipment; a transmission step transmitting responding information allowing the second frequency band to enter an avoiding state; a triggering step triggering release of the avoiding state if triggering conditions for releasing the avoiding state are met; and a transmission step transmitting release request information indicating release of the avoiding state.

Advantageous Effects of Invention

- [17] According to the present invention, while a user equipment avoiding an interference delicate frequency band due to in-device coexistence interference, a procedure for re-allocation of an interference delicate frequency band or hand-over to the interference delicate frequency band for the user equipment is made clear; and an eNodeB can separately release an avoiding state against the interference delicate frequency band without assistance of the user equipment.

Brief Description of Drawings

- [18] FIG. 1 illustrates a wireless communication system to which embodiments of the present invention are applied;
- [19] FIG. 2 illustrates in-device coexistence interference;
- [20] FIG. 3 is an example illustrating in-device coexistence interference from an ISM transmitter to an LTE receiver;
- [21] FIG. 4 is an example illustrating a frequency band divided into an ISM band and an LTE band;
- [22] FIG. 5 is an example where in-device coexistence interference is reduced by using the FDM method;
- [23] FIG. 6 is another example where in-device coexistence interference is reduced by using the FDM method;
- [24] FIG. 7 is an example where in-device coexistence interference is reduced by using the TDM method;
- [25] FIG. 8 illustrates a transmission and reception timing along the time axis of the LTE and the ISM band based on the TDM method;
- [26] FIG. 9 is a flow diagram illustrating a method for transmitting control information about in-device coexistence interference according to one example of the present invention;
- [27] FIG. 10 is a flow diagram illustrating a method for transmitting control information about coordination of in-device coexistence interference due to an eNB according to one example of the present invention;
- [28] FIG. 11 is a flow diagram illustrating a method for controlling in-device coexistence interference due to a user equipment according to one example of the present invention; and

- [29] FIG. 12 is a block diagram illustrating a user equipment and an eNB transmitting and receiving control information about in-device coexistence interference according to one example of the present invention.

Mode for the Invention

- [30] In what follows, embodiments of the present invention will be described in detail with reference to illustrative drawings. In assigning reference symbols to constituting elements of each drawing, it should be noted that the same symbols have been assigned to the same constituting elements as possibly as can be even if the elements are used in different drawings. Also, for the sake of describing embodiments of the present invention, if it is regarded that detailed description about related structure or functions already known for the corresponding technical field may lead to misunderstanding of the technical principles of the present invention, the corresponding description will be omitted.
- [31] FIG. 1 illustrates a wireless communication system to which embodiments of the present invention are applied.
- [32] With reference to FIG. 1, a wireless communication system is deployed across a wide area to provide various kinds of communication services such as transmission of voice, packet data, and so on; the wireless communication system includes a user equipment (UE) 10, an evolved NodeB (eNB) 20, a wireless LAN access point (AP) 30, and GPS (Global Positioning System) 40 satellites. At this time, the wireless LAN corresponds to a device supporting the IEEE 802.11 technology which is a standard for wireless communication networks and the IEEE 802.11 may be called interchangeably with a WiFi system.
- [33] The UE 10 can be positioned within the coverage of a plurality of networks such as a cellular network, a wireless LAN, a broadcasting network, a satellite system, etc. To access various networks such as an eNB 20, a wireless LAN AP 30, GPS 40, etc. and use various services, the UE 10 is equipped with a plurality of wireless transceivers. For example, a smart phone is equipped with an LTE, WiFi, Bluetooth transceiver and a GPS receiver. Thus, to incorporate as many transceivers as possible within a single UE 10 while at the same time maintaining high performance, the design for the UE 10 is getting more complicated. As a result, a possibility of occurrence of in-device co-existence interference may become higher.
- [34] In the following, downlink transmission refers to communication from an eNB 20 to a UE 10 while uplink transmission from the UE 10 to the eNB 20. In the downlink transmission, a transmitter may be a part of the eNB 20 in the downlink transmission while a receiver a part of the UE 10. Similarly, in the uplink transmission, the transmitter may be a part of the UE 10 while the receiver a part of the eNB 20.

- [35] The UE 10 may be fixed or mobile and can be called in various ways such as a mobile station (MS), a user terminal (UT), a subscriber station (SS), a mobile terminal (MT), a wireless device, etc. The eNB 20 denotes a fixed station communicating with the UE 10 and can be called in various ways such as a base station (BS), a base transceiver system (BTS), an access point, a Femto BS, a Pico BS, a relay, etc.
- [36] There is no limit on multiple access methods which can be applied for a wireless communication system. Various kinds of multiple access methods can be used: CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), OFDMA (Orthogonal Frequency Division Multiple Access), SC-FDMA (Single Carrier-FDMA), OFDM-FDMA, OFDM-TDMA, OFDM-CDMA, and so on. Uplink and downlink transmission can employ a TDD (Time Division Duplex) method by which transmission is performed by using different time periods or a FDD (Frequency Division Duplex) method by which transmission is performed by using different frequencies.
- [37] Carrier aggregation (CA) supports a plurality of component carriers and alternatively called a spectrum aggregation or bandwidth aggregation. An individual unit carrier grouped by carrier aggregation is called a component carrier (hereinafter, it is called a CC). Each CC is defined by bandwidth and a center frequency. Carrier aggregation is introduced to support increasing throughput and prevent cost increase due to introduction of broadband radio frequency (RF) devices and ensure compatibility with the existing systems. For example, if five CCs are allocated to represent granularity of carrier units having 5 MHz bandwidth, bandwidth with a maximum of 25 MHz can be supported. In what follows, it is assumed that a multiple carrier system denotes a system supporting carrier aggregation. The wireless communication system of FIG. 1 may correspond to a multiple carrier system.
- [38] According to carrier aggregation, system frequency bandwidth is divided into a plurality of carrier frequencies. At this time, carrier frequency denotes the center frequency of a cell. A cell may denote a downlink CC and an uplink CC. Also, a cell may be a combination of a downlink CC and an optional uplink CC. In general, if carrier aggregation is not taken into account, a single cell is always constructed in the form of a pair of an uplink and a downlink CC.
- [39] FIG. 2 illustrates in-device coexistence interference.
- [40] With reference to FIG. 2, a UE 20 includes an LTE RF module 21, a GPS RF module 22, and a Bluetooth/WiFi RF module 23. Each RF module is connected to a transmission and reception antenna 24, 25, 26. In other words, various types of RF modules are installed side by side within a single device platform. At this time, it should be noted that transmission power of an RF module may be significantly larger than the receiving power level of other RF receivers. Therefore, unless frequency

spacing between RF modules is sufficiently large and powerful filtering technique is employed, transmission signals from one RF module may cause considerable interference on the receivers of the other RF modules within the device. For example, "(1)" is an example where transmission signals from the LTE RF module 21 causes in-device coexistence interference on the GPS RF 22 and the Bluetooth/WiFi RF module 23 while "(2)" is an example where transmission signals from the Bluetooth/WiFi RF module 23 causes the in-device coexistence interference on the LTE RF module 21. FIG. 3 illustrates this problem in more detail.

- [41] FIG. 3 is an example illustrating in-device coexistence interference from an ISM transmitter to an LTE receiver. The ISM (Industrial, Scientific and Medical) band denotes the frequency range which is freely available without permission for industrial, scientific, and medical applications.
- [42] FIG. 3 assumes that the frequency band of a signal received by the LTE receiver overlaps the frequency band of a transmission signal of the ISM transmitter. In this case, in-device coexistence interference may occur. As shown in the figure, the frequency band where in-device coexistence interference occurs; a potential probability for occurrence of interference is high; or interference is expected to occur is called an in-device coexistence interference delicate band or an interference delicate band for short. Since the interference delicate band may correspond to a frequency band unavailable for a UE, it may also be called a unusable band. An interference delicate band does not necessarily mean occurrence of in-device coexistence interference; a frequency band with a potential probability of occurrence of interference may also be termed as an interference delicate band.
- [43] FIG. 4 is an example illustrating a frequency band divided into an ISM band and an LTE band.
- [44] With reference to FIG. 4, band 40, band 7, and band 38 are LTE bands. The band 40 occupies a frequency band ranging from 2300 to 2400 MHz in the TDD mode; the band 7 is a uplink in the FDD mode occupying a frequency band ranging from 2500 to 2570 MHz. The band 38 occupies a frequency band ranging from 2570 to 2620 MHz in the TDD mode. Meanwhile, the ISM band is used as a WiFi and Bluetooth channel, occupying a frequency band ranging from 2400 to 2483.5 MHz. These bands are usually classified as interference delicate bands. The following table shows how the in-device coexistence interference is developed for the respective frequency bands.
- [45] Table 1

[Table 1]

Interference frequency band	Interference pattern
Band 40	ISM Tx -> LTE TDD DL Rx
Band 40	LTE TDD UL Tx -> ISM Rx
Band 7	LTE FDD UL Tx -> ISM Rx
Band 7/13/14	LTE FDD UL Tx -> GPS Rx

- [46] With reference to Table 1, the inference pattern in the form of "a->b" represents a situation where transmission of "a" causes in-device coexistence interference against reception of "b". Therefore, for the band 40, transmission through the ISM band causes the in-device coexistence interference against downlink TDD reception of the LTE band (LTE TDD DL Rx). The in-device coexistence interference can be somewhat reduced by employing a filtering scheme but it is far from being satisfactory. If the FDM or TDM method is applied in addition to the filtering scheme, the in-device coexistence interference can be reduced more effectively.
- [47] FIG. 5 is an example where in-device coexistence interference is reduced by using the FDM method.
- [48] With reference to FIG. 5, the LTE band can be moved such that the LTE band does not overlap the ISM band. As a result, handover of the UE from the ISM band is induced. However, to implement the above, a method is required for legacy measurement or new signaling to trigger a mobility procedure or a radio link failure (RLF) procedure precisely.
- [49] FIG. 6 is another example where in-device coexistence interference is reduced by using the FDM method.
- [50] With reference to FIG. 6, the ISM band can be reduced and moved away from the LTE band. However, this may cause a backward compatibility problem. In the case of Bluetooth, the backward compatibility problem may be somewhat reduced owing to a frequency hopping mechanism; however, the backward compatibility problem may not be easily solved for WiFi.
- [51] FIG. 7 is an example where in-device coexistence interference is reduced by using the TDM method.
- [52] With reference to FIG. 7, in-device coexistence interference can be avoided even without avoiding the interference delicate band if reception time in the LTE band is made not to overlap the reception time in the ISM band. For example, it is so structured that if a signal in the ISM band is transmitted at time t_0 , a signal in the LTE band is received at time t_1 . A transmission and reception timing of the LTE and the ISM band along the time axis based on the TDM method may be implemented as il-

illustrated in FIG. 8. By employing the above method, the in-device coexistence interference can be avoided without moving between the LTE and the ISM band. From FIG. 8, a frequency range in each band through which signals are not transmitted is called a blank transmission area.

- [53] As described above, by using the methods illustrated in FIGS. 5 to 7, generation of in-device coexistence interference can be prevented to some degree. When the FDM method is employed, it is highly probable that a UE may be assigned to a different frequency band by avoiding an interference delicate band or the UE may be handed over to a different frequency band. For example, suppose that CCs available for a system are CC1, CC2, and CC3 and an interference delicate band is CC3. A plurality of UEs can be handed over from CC3 to CC1 or CC2. If CC1 and CC2 get a relatively large load and in-device coexistence interference at CC3 is removed, an eNB should be able to carry out handover of the UE to CC3. However, since the in-device coexistence interference is the information which can be known only for the UE, the eNB may not be able to arbitrarily perform handover of the UE to CC3 unless the UE deliberately informs the eNB of the fact that the interference has been removed. If UEs are not handed over to CC3 while in-device coexistence interference is no longer generated or when the probability of occurrence of the interference is low, degradation of system performance is introduced. But at the same time, it is not preferable for the eNB to perform handover of the UE to CC3 for load balancing without proper grounds. Doing so imposes considerable constraints on scheduling the eNB. However, a separate signaling procedure for a UE to be re-allocated an interference delicate band or to perform handover to the interference delicate band has not been established yet.
- [54] FIG. 9 is a flow diagram illustrating a method for transmitting control information about in-device coexistence interference according to one example of the present invention.
- [55] According to FIG. 9, a UE detects in-device coexistence interference in an interference delicate band f_1 , S900. At this time, f_1 may correspond to a CC or a serving cell. In-device coexistence interference corresponds to a case where transmission of signals to nearby devices communicating through Bluetooth or WiFi causes interference against reception of the UE from an eNB of the LTE system. In a situation such as shown in FIG. 2, the UE detects whether a transmission signal of other RF modules develops interference from a reception signal of the LTE RF module. As one example, the UE can detect in-device coexistence interference by using signal-to-interference noise ratio (SINR). As another example, the UE can detect the in-device coexistence interference by using Reference Signal Received Power (RSRP) or Reference Signal Received Quality (RSRQ). For example, suppose the UE transmits a signal y through a different RF module such as WiFi while receiving a signal x from an

eNB through the LTE RF module. At this time, if SINR of the signal y is large more than a predetermined threshold value to exert as interference on the signal x , the UE can detect occurrence of the in-device coexistence interference.

- [56] If in-device coexistence interference is detected or there is a potential chance of detection of the interference, the UE transmits assistant information for reducing, avoiding, or removing the interference to the eNB S905. In what follows, the operation of reducing, avoiding, or removing interference is collectively called interference coordination. The assistant information is the information required for coordinating in-device coexistence interference, which the eNB may regard the assistant information as an interference coordination request from the UE. The assistant information may correspond to a message generated from an Radio Resource Control (RRC) layer or a Medium Access Control (MAC) layer; or signaling originating from a physical layer. The assistant information includes a reactive indicator indicating that in-device coexistence interference has been actually detected and a proactive indicator indicating a potential probability of developing the in-device coexistence interference.
- [57] The proactive indicator is transmitted to indicate potential interference when unacceptably severe interference occurs in the interference delicate band. Potential interference only denotes a possibility of occurrence of in-device coexistence interference after the instant the proactive indicator is transmitted but does not imply actual occurrence.
- [58] An interference delicate band or a unusable band may be defined as a frequency band having potential for interference to develop and may be indicated by the proactive indication. Therefore, handover to the interference delicate band or carrying out RRC configuration or reconfiguration is not unattainable; an UE simply has possibility to be exposed to the in-device coexistence interference. Conversely, a usable frequency band corresponds to the band where the in-device coexistence interference does not occur. However, according to handover or a transmission pattern, the usable frequency band may be changed to a unusable frequency band.
- [59] The eNB transmits responding information S910. The responding information includes handover indication information for an UE to be handed over from an interference delicate band f_1 to another frequency band f_2 or scheduling or reconfiguration information for allocating the UE to a different frequency band f_2 . At this time, the handover includes changing a main serving cell allocated for the UE from a current serving cell to another serving cell.
- [60] The UE carries out operation for avoiding an interference delicate band according to the responding information and maintains an avoiding state until the eNB issues a separate instruction or command (not shown in the figure). Avoiding an interference delicate band includes the UE's carrying out handover from the interference delicate

band f_1 to another frequency band f_2 or carrying out communication by receiving a different frequency band. The avoiding state may be called a unusable state and also be described such that the corresponding interference delicate band stays in a proactive state due to supporting information or proactive indication.

- [61] If triggering conditions are met, the eNB triggers a release request S915. The release request is meant for requesting release of an avoiding state on the UE. In other words, if it is the case that further interference is not anticipated in an interference delicate band avoided by proactive indication or reactive indication or considerable restriction on scheduling due to the avoidance is imposed, the eNB may trigger a release request to efficiently use the interference delicate band. The step S910 subsequent to the step S905 represents a basic process for configuring operation of avoiding in-device co-existence interference. Although it is assumed that the step S915 is performed subsequent to the step S910, it has been introduced only for the sake of illustration; the step S905 may be performed once again after the step S910 or the step S915 may be performed together with the corresponding step S905 or after step the S905; the step S915 may be performed according to a decision made by the eNB itself while the avoiding state of the interference delicate band is maintained after the step S905.
- [62] The eNB transmits release request information to the UE S920. The release request information is the information requesting or indicating release of an avoiding state on the UE. The release request information may be transmitted dedicated to a particular UE or transmitted to a plurality of UEs through broadcasting or multicast. The release request information may correspond to or include at least one of TDM interference co-ordination indication information, measurement result request information about an interference delicate band, a message for handover to the interference delicate band, or an RRC reconfiguration message.
- [63] As one example, the release request information may be TDM interference co-ordination indication information which is interpreted simply as the information requesting interference coordination based on the TDM scheme or the information for recommending a particular TDM scheme. Recommending a particular TDM scheme may involve information in the form of transmitting a TDM pattern used for the TDM scheme.
- [64] As another example, the release request information may be the information requesting a measurement result required to realize mobility or handover of a UE or carry out RRC reconfiguration.
- [65] As yet another example, the release request information may be a message for handover to an interference delicate band or RRC reconfiguration.
- [66] An UE receiving the release request information carries out operation for releasing an avoiding state of the interference delicate band S925. The operation for releasing an

avoiding state of the interference delicate band may include various kinds of operation or meaning depending on the type of release request information.

[67] As one example, in the case of TDM interference coordination indication information, the operation of releasing an avoiding state of an interference delicate band includes operation of carrying out interference coordination based on the TDM scheme. For example, the eNB can coordinate a schedule so that transmission or reception of the UE may occur at different timing from each other. Also, the eNB can perform a discontinuous reception (DRX) procedure. The DRX procedure may be a DRX command or DRX reconfiguration. As another example, interference coordination can be carried out by using a particular TDM pattern determined by the UE. As yet another example, the interference coordination can be carried out by using a TDM pattern requested by the eNB.

[68] As still another example, in the case when the release request information is measurement result request information, the operation of releasing an avoiding state of an interference delicate band includes operation of carrying out measurement in the interference delicate band and transmitting the measurement result. In other words, in an avoiding state of an interference delicate band, the UE does not perform measurement for the interference delicate band but when release request information is received, the UE carries out measurement even for the interference delicate band. At this time, the measurement result of the interference delicate band may be obtained by using measurement at the time of interference coordination based on the TDM scheme or may be obtained based on measurement about in-device coexistence interference itself. In addition, the measurement result may be obtained based on measurement by removing the in-device coexistence interference.

[69] Meanwhile, a method for carrying out measurement based on the TDM scheme can be carried out as follows. For example, measurement may be carried out based on a particular TDM pattern specified previously between a UE and an eNB; the measurement may be carried out based on the TDM pattern specified by the eNB or the TDM pattern specified arbitrarily by the UE. If the TDM pattern specified arbitrarily by the UE is used, the UE may incorporate information about the TDM pattern into the measurement result so that the TDM pattern can be recognized.

[70] As another example, if the release request information is a message for handover to an interference delicate band or RRC reconfiguration, operation for releasing an avoiding state of an interference delicate band includes operation for an UE to carry out handover or generate and transmit an RRC reconfiguration completion message.

[71] FIG. 10 is a flow diagram illustrating a method for transmitting control information about coordination of in-device coexistence interference due to an eNB according to one example of the present invention.

- [72] With reference to FIG. 10, an eNB receives assistant information from a UE S1000. In response to the assistant information, the eNB may or may not transmit responding information. An interference delicate band may be explicitly specified due to the assistant information or the eNB may recognize the interference delicate band through implicit protocol. The assistant information being received, the eNB can know that the interference delicate band stays in an avoiding state. Therefore, the eNB may deactivate the interference delicate band or assign the band as an unusable band.
- [73] While the interference delicate band is in an avoiding state, the eNB determines whether triggering conditions for releasing the avoiding state are met S1005. The triggering conditions are as follows.
- [74] As one example, the triggering conditions can be met if the UE itself instructs release of the avoiding state. The UE instructs release of the avoiding state when a timer started from the initiation of the avoiding state is expired; strength of the interference is smaller than a predetermined level; data transmission rate toward different apparatus is lowered than a predetermined level; in-device coexistence interference no longer occurs as the band through which the UE communicates with different apparatus is moved; or data transmission toward different apparatus is not performed continuously for a predetermined time period. To this end, the UE transmits a release indicator indicating release of the avoiding state to the eNB. Receiving the release indicator, the eNB can trigger a release request or ignore the release indicator according to its own decision.
- [75] As another example, triggering conditions can be met when a load balancing problem occurs in a different frequency band, a serving cell, or a CC. For example, if a frequency band stays in an avoiding state due to a plurality of UEs, the eNB can release the avoiding state to balance the load.
- [76] As yet another example, the triggering conditions can be met when the UE follows a reported measurement result and strength of in-device coexistence interference is smaller than a threshold value. Strength of the in-device coexistence interference may correspond to the strength of a signal measured based on the measurement result (e.g., RSRP or RSRQ) or the strength of the in-device coexistence interference.
- [77] When the triggering conditions are met, the eNB triggers a release request S1010, transmits release request information S1015, and carries out operation for releasing an avoiding state of the interference delicate band S1020. The release request information is the information requesting or instructing release of the avoiding state on the UE. The release request information may be transmitted being dedicated to a single UE or transmitted to a plurality of UEs through broadcasting or multicast. The release request information may correspond to or include at least one of TDM interference coordination indication information, measurement result request information about an in-

interference delicate band, a message for handover to the interference delicate band, or an RRC reconfiguration message.

[78] FIG. 11 is a flow diagram illustrating a method for controlling in-device coexistence interference due to a user equipment according to one example of the present invention.

[79] With reference to FIG. 11, a UE transmits assistant information to an eNB S1100. The assistant information may be transmitted for interference coordination based on the FDM scheme of in the middle of interference coordination based on the FDM scheme. The assistant information includes a reactive indicator indicating that in-device coexistence interference has been actually detected and a proactive indicator indicating a potential probability of occurrence of the in-device coexistence interference. At this time, a frequency delicate band for the UE is maintained to be in the avoiding state.

[80] The UE receives release request information from the eNB S1105. The release request information is the information requesting or instructing release of an avoiding state on the UE. When triggering conditions for release request are met, eNB triggers a release request and transmits release request information to the UE. As one example, the triggering conditions can be met if the UE itself instructs release of the avoiding state. The UE instructs release of the avoiding state when a timer started from the initiation of the avoiding state is expired; strength of the interference is smaller than a predetermined level; data transmission rate toward different apparatus is lowered than a predetermined level; in-device coexistence interference no longer occurs as the band through which the UE communicates with different apparatus is moved; or data transmission toward different apparatus is not performed continuously for a predetermined time period. To this end, the UE transmits a release indicator indicating release of the avoiding state to the eNB. Receiving the release indicator, the eNB can trigger a release request or ignore the release indicator according to its own decision.

[81] The UE carries out operation of releasing the avoiding state of the interference delicate band S1110. The operation for releasing an avoiding state of the interference delicate band may include various kinds of operation or meaning depending on the type of release request information.

[82] As one example, in the case of TDM interference coordination indication information, operation of releasing the avoiding state of the interference delicate band includes operation for the UE to carry out interference coordination based on the TDM scheme.

[83] As another example, in the case when the release request information is measurement result request information, operation of releasing an avoiding state of the interference delicate band includes operation for the UE to perform measurement in the interference

delicate band and transmit a measurement result. At this time, the measurement result of the interference delicate band can be obtained by using measurement at the time of interference coordination based on the TDM scheme or can be obtained based on measurement about in-device coexistence interference itself. In addition, the measurement result may be obtained based on measurement by removing the in-device coexistence interference.

[84] As yet another example, if the release request information is a message for handover to an interference delicate band or RRC reconfiguration, operation for releasing an avoiding state of an interference delicate band includes operation for an UE to carry out handover or transmit an RRC reconfiguration completion message.

[85] FIG. 12 is a block diagram illustrating a UE and a eNB transmitting and receiving control information about in-device coexistence interference according to one example of the present invention.

[86] With reference to FIG. 12, an UE 1200 comprises an interference detection unit 1205, an assistant information generation unit 1210, a transmitter 1215, a release operation execution unit 1220, and a receiver 1225.

[87] The interference detection unit 1205 detects occurrence of in-device coexistence interference caused by transmission of a first network system in a first frequency band against reception of a second network system in a second frequency band. For example, suppose a signal y such as WiFi is transmitted through another RF module while an UE 1200 receiving a signal x from an eNB 1250 through the LTE RF module. . At this time, if Signal to Interference Noise Ratio SINR of the signal y is large more than a predetermined threshold value to exert as interference on the signal x, the interference detection unit 1205 can detect occurrence of the in-device coexistence interference. At this time, the interference detection unit 1205 measures the amount of interference due to the signal y and a measurement result about the interference is transmitted to the assistant information generation unit 1210. In the above, SINR has been introduced as a criterion for the interference detection unit 1205 to detect interference; however, the criterion is not limited to SINR but Reference Signal Received Power (RSRP) or Reference Signal Received Quality (RSRQ) may be used as an alternative.

[88] The assistant information generation unit 1210 generates assistant information based on an interference measurement result obtained from the interference detection unit 1205. As one example, the assistant information includes a reactive indicator indicating that in-device coexistence interference has been actually detected and a proactive indicator indicating a potential probability of developing the in-device coexistence interference. Also, the assistant information includes a measurement result, and the assistant information includes a measurement result such as SINR, RSRP, or

RSRQ. As another example, the assistant information, along with the measurement result, includes an indicator indicating that avoiding in-device coexistence interference is necessary.

- [89] The transmitter 1215 transmits a handover-related message which includes assistant information, an RRC connection reconfiguration completion message, or a measurement result to the eNB 1250 belonging to the second network system. At this time, the transmitter 1215 can transmit the assistant information through an RRC message, a MAC message, or physical layer signaling. The assistant information includes a reactive indicator indicating that in-device coexistence interference has been actually detected and a proactive indicator indicating a potential probability of developing the in-device coexistence interference.
- [90] The transmitter 1215 transmits a release indicator indicating release of the avoiding state to the eNB. Receiving the release indicator, the eNB can trigger a release request or ignore the release indicator according to its own decision.
- [91] The release operation execution unit 1220 carries out operation of releasing an avoiding state of an interference delicate band. Also, the release operation execution unit 1220 checks a release request information which is transmitted dedicated to a particular UE or transmitted to a plurality of UEs through broadcasting or multicast. In other words, the release operation execution unit 1220 checks if it is the case that further interference is not anticipated in an interference delicate band avoided by proactive indication or reactive indication or considerable restriction on scheduling due to the avoidance is imposed, and releases an avoiding state of an interference delicate band.
- [92] For example, the release operation execution unit 1220 may perform interference coordination based on the TDM scheme or operation of performing measurement about the interference delicate band. At this time, the measurement result of the interference delicate band may be obtained based on the measurement at the time of interference coordination according to the TDM scheme or obtained based on the measurement about in-device coexistence interference itself. In addition, the release operation execution unit 1220 may carry out handover or operation of generating an RRC reconfiguration completion message.
- [93] The receiver 1225 receives responding information, release request information, an RRC reconfiguration message, and a handover command message from the eNB 1250.
- [94] The eNB 1250 comprises a receiver 1255, a triggering unit 1260, a release information generation unit 1265, a scheduling unit 1270, and a transmitter 1275.
- [95] The receiver 1255 receives assistant information, a handover-related message, an RRC connection reconfiguration completion message, a release indicator, or a measurement result from the UE 1200.

- [96] The triggering unit 1260 determines whether triggering conditions for releasing an avoiding state while the interference delicate band stays in the avoiding state are met. As one example of the determination, the triggering unit 1260 determines whether the UE 1200 instructs release of the avoiding state. In other words, the triggering unit 1260 determines whether a release indicator has been received from the UE 1200. The UE 1200 instructs release of the avoiding state when a timer started from the initiation of the avoiding state is expired; strength of the interference is smaller than a predetermined level; data transmission rate toward different apparatus is lowered than a predetermined level; in-device coexistence interference no longer occurs as the band through which the UE 1200 communicates with different apparatus is moved; or data transmission toward different apparatus is not performed continuously for a predetermined time period. When the release indicator is received, the triggering unit 1260 determines that the triggering conditions have been met.
- [97] As another example of the determination, the triggering unit 1260 checks whether a load balancing problem occurs in a different frequency band, a serving cell, or a CC. For example, if a frequency band stays in an avoiding state due to a plurality of UEs, the triggering unit 1260 regards that the triggering conditions for balancing the load are met.
- [98] As yet another example of the determination, the triggering unit 1260 considers that the triggering conditions are met if strength of in-device coexistence interference is smaller than a threshold value. Strength of the in-device coexistence interference may correspond to the strength of a signal measured based on the measurement result or the strength of the interference.
- [99] If the triggering conditions are met, the triggering unit 1260 triggers a release request.
- [100] The release information generation unit 1265 generates release request information for releasing the avoiding state when a release request is triggered and transmits the information to the transmitter 1275. The release request information may correspond to a MAC message, an RRC message, or physical layer signaling.
- [101] The scheduling unit 1270 performs scheduling of an interference delicate band. In other words, the scheduling unit 1270 may allocate uplink or downlink resources of the interference delicate band to the UE 1200.
- [102] The transmitter 1275 transmits responding information, release request information, an RRC reconfiguration message, or a handover command message to the UE 1200 belonging to the second network system.
- [103] The above descriptions provides only examples realizing the technical principles of the present invention; it should be understood for those skilled in the art that various modifications and revisions are possible without departing the inherent characteristics

of the present invention. Therefore, the embodiments disclosed in this document are not meant to limit the technical principles of the present invention but to provide descriptions of the present invention; thus, the technical scope of the present invention is not limited by the embodiments. The technical scope of the present invention should be interpreted according to the appended claims; thus, all the technical principles within a scope equivalent to that defined by the claims should be interpreted to belong to the technical scope of the present invention.

Claims

- [Claim 1] An user equipment (UE) transmitting control information about interference in a wireless communication system, comprising:
an interference detection unit detecting interference caused by transmission of a first network system in a first frequency band against reception of a second network system in a second frequency band;
an assistant information generation unit generating assistant information indicating occurrence or a probability of occurrence of the interference;
a transmitter transmitting the generated assistant information to an eNodeB (eNB);
a receiver receiving responding information allowing the second frequency band to enter an avoiding state or release request information indicating releasing the avoiding state from the eNB; and
a release operation execution unit carrying out the operation of releasing the avoiding state based on the release request information.
- [Claim 2] The UE of claim 1, wherein the release operation execution unit includes operation of measuring the second frequency band, and transmits the measurement result with the transmitter to the eNB.
- [Claim 3] The UE of claim 1, wherein the release operation execution unit executing at least one among operation of controlling reception of the second network system and transmission of the first network system to be carried out at a different timing; operation of carrying out interference coordination based on the TDM scheme; operation of carrying out measurement at the time of interference coordination based on the TDM scheme, measurement about in-device coexistence interference, or measurement by removing in-device coexistence interference; operation of carrying out handover; and operation of carrying out generating and transmitting an RRC reconfiguration completion message.
- [Claim 4] The UE of claim 1, wherein the release operation execution unit generates a release indicator for triggering transmission of the release request information, and transmits the release indicator with the transmitter to the eNB.
- [Claim 5] A method for transmitting control information about interference by a user equipment (UE) in a wireless communication system, comprising:
a detection step detecting interference caused by transmission of a first

frequency band of a first network system against reception of a second frequency band of a second network system;
a transmission step transmitting assistant information indicating occurrence or a probability of occurrence of the interference in the second frequency band to an eNodeB (eNB);
a reception step receiving responding information allowing the second frequency band to enter an avoiding state;
a reception step receiving release request information indicating releasing the avoiding state from the eNB; and
an execution step carrying out operation of releasing the avoiding state based on the release request information.

[Claim 6] The method of claim 5, wherein the operation of releasing the avoiding state includes operation for the UE to be handed over to a second frequency band.

[Claim 7] The method of claim 5, further comprising transmitting a release indicator for triggering release of the avoiding state to the eNB.

[Claim 8] The method of claim 7, wherein the release indicator is transmitted when strength of the interference becomes smaller than a predetermined level or data transmission rate of the first network is lowered than a predetermined level.

[Claim 9] The method of claim 5, wherein the release request information indicating carrying out interference coordination based on the TDM scheme; indicating carrying out measurement at the time of interference coordination based on the TDM scheme, measurement about in-device coexistence interference, or measurement by removing in-device coexistence interference; or indicating carrying out handover or generating and transmitting an RRC reconfiguration completion message.

[Claim 10] An eNodeB (eNB) transmitting control information about interference in a wireless communication system, comprising:
a receiver receiving assistant information indicating occurrence or a probability of occurrence of interference caused by transmission of a first frequency band of a first network system against reception of a second frequency band of a second network system from a user equipment (UE);
a transmitter transmitting responding information allowing the second frequency band to enter an avoiding state or release request information indicating releasing the avoiding state to the UE; and

a triggering unit triggering release of the avoiding state if triggering conditions for releasing the avoiding state are met.

[Claim 11]

The eNB of claim 10, wherein the triggering unit considers that the triggering conditions are met when load balancing is required in a different frequency band of the second network system.

[Claim 12]

The eNB of claim 10, wherein the release request information requesting for the UE to release the avoiding state; and indicating carrying out interference coordination based on the TDM scheme; indicating carrying out measurement at the time of interference coordination based on the TDM scheme, measurement about in-device coexistence interference, or measurement by removing in-device coexistence interference; or indicating carrying out handover or generating and transmitting an RRC reconfiguration completion message.

[Claim 13]

A method for transmitting control information about interference by an eNodeB (eNB) in a wireless communication system, comprising:
a reception step receiving assistant information indicating occurrence or a probability of occurrence of interference caused by transmission of a first frequency band of a first network system against reception of a second frequency band of a second network system from a user equipment (UE);
a transmission step transmitting responding information allowing the second frequency band to enter an avoiding state;
a triggering step triggering release of the avoiding state if triggering conditions for releasing the avoiding state are met; and
a transmission step transmitting release request information indicating release of the avoiding state.

[Claim 14]

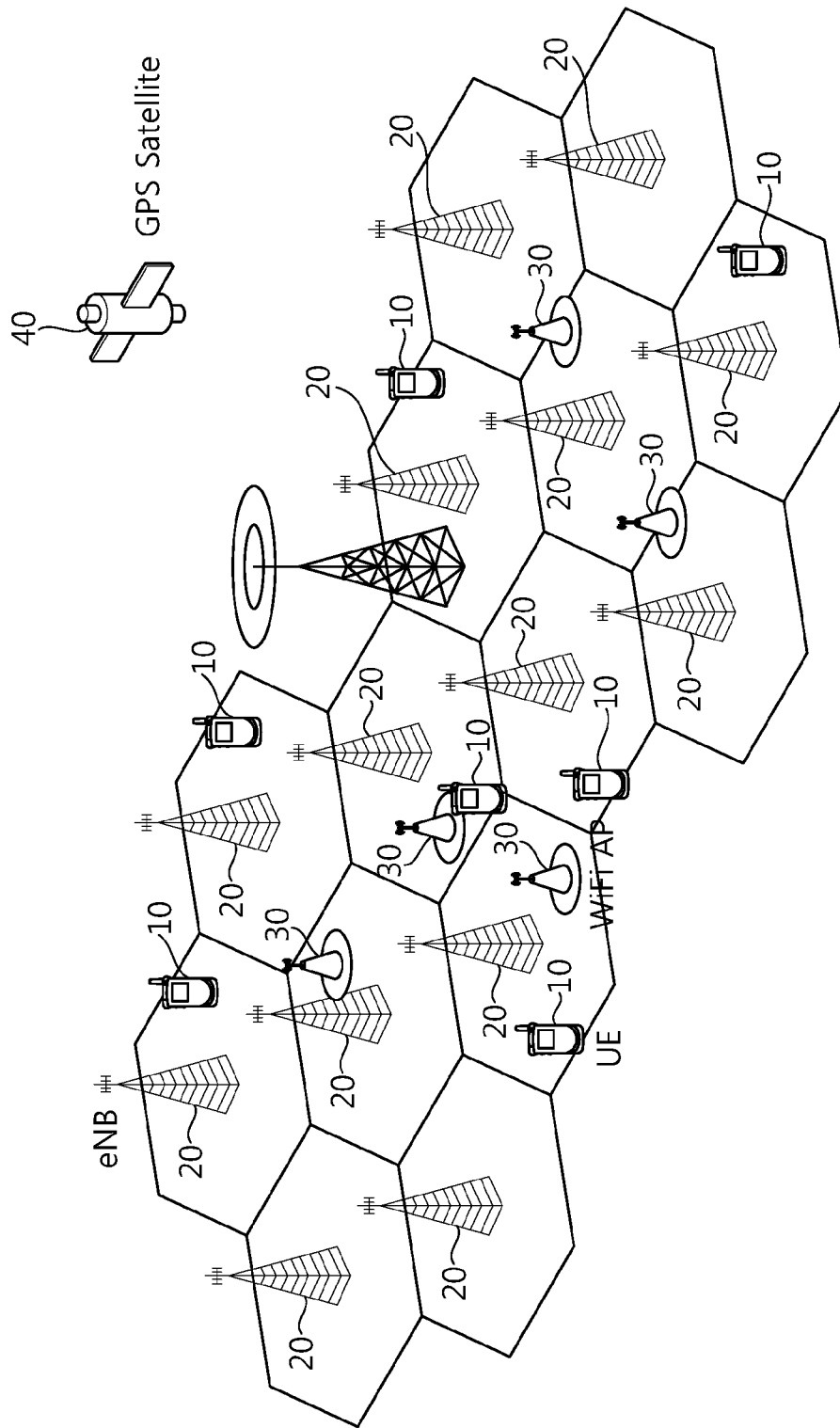
The method of claim 13, wherein the triggering conditions are met when load balancing is required in a different frequency band of the second network system.

[Claim 15]

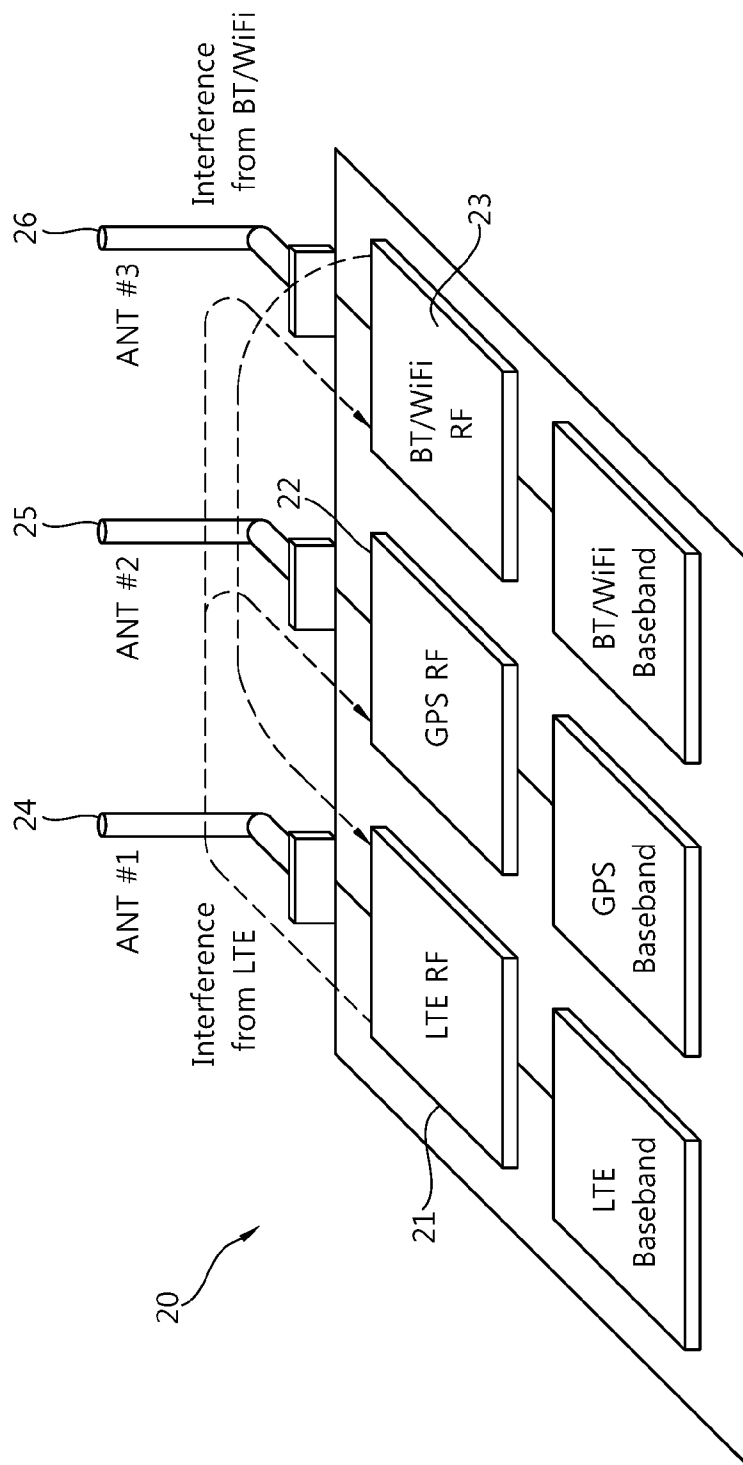
The method of claim 13, wherein the release request information requesting for the UE to release the avoiding state; and indicating carrying out interference coordination based on the TDM scheme; indicating carrying out measurement at the time of interference coordination based on the TDM scheme, measurement about in-device coexistence interference, or measurement by removing in-device coexistence interference; or indicating carrying out handover or generating and transmitting an RRC reconfiguration completion

message.

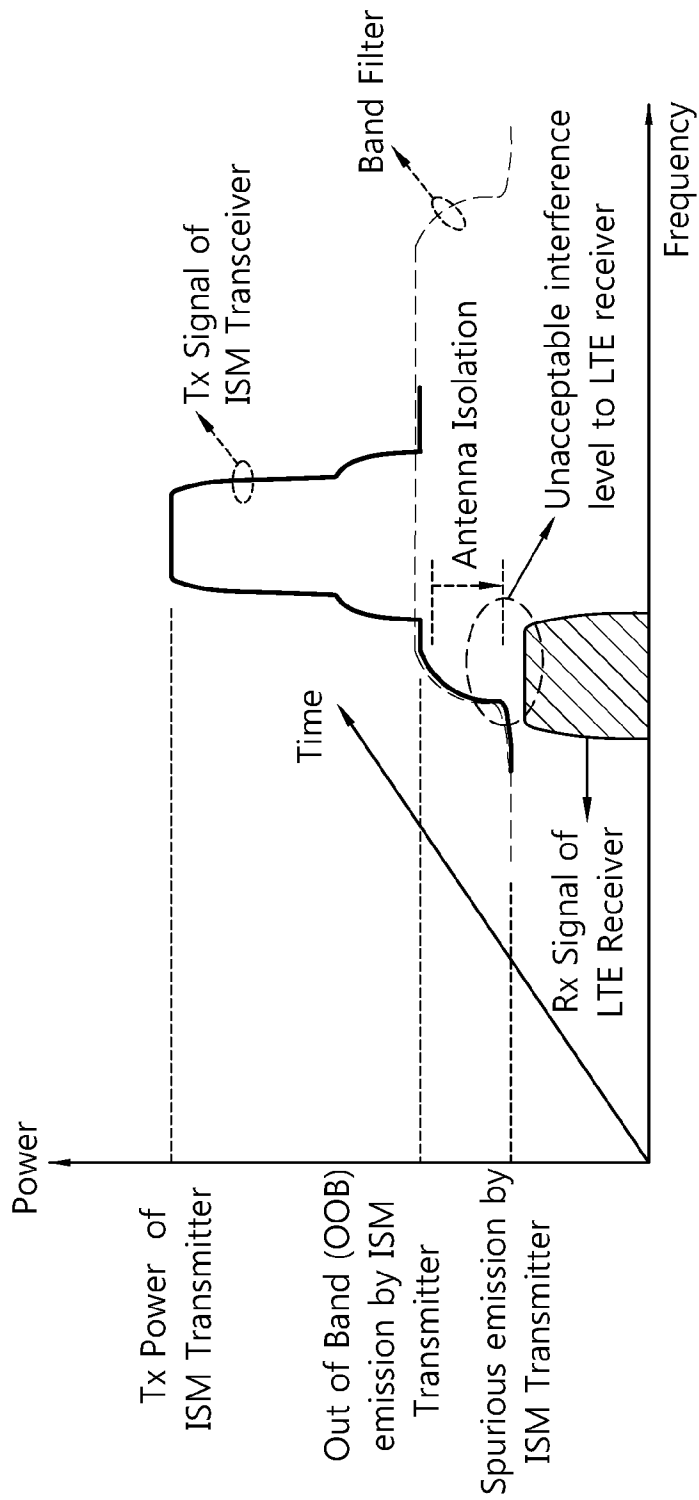
[Fig. 1]



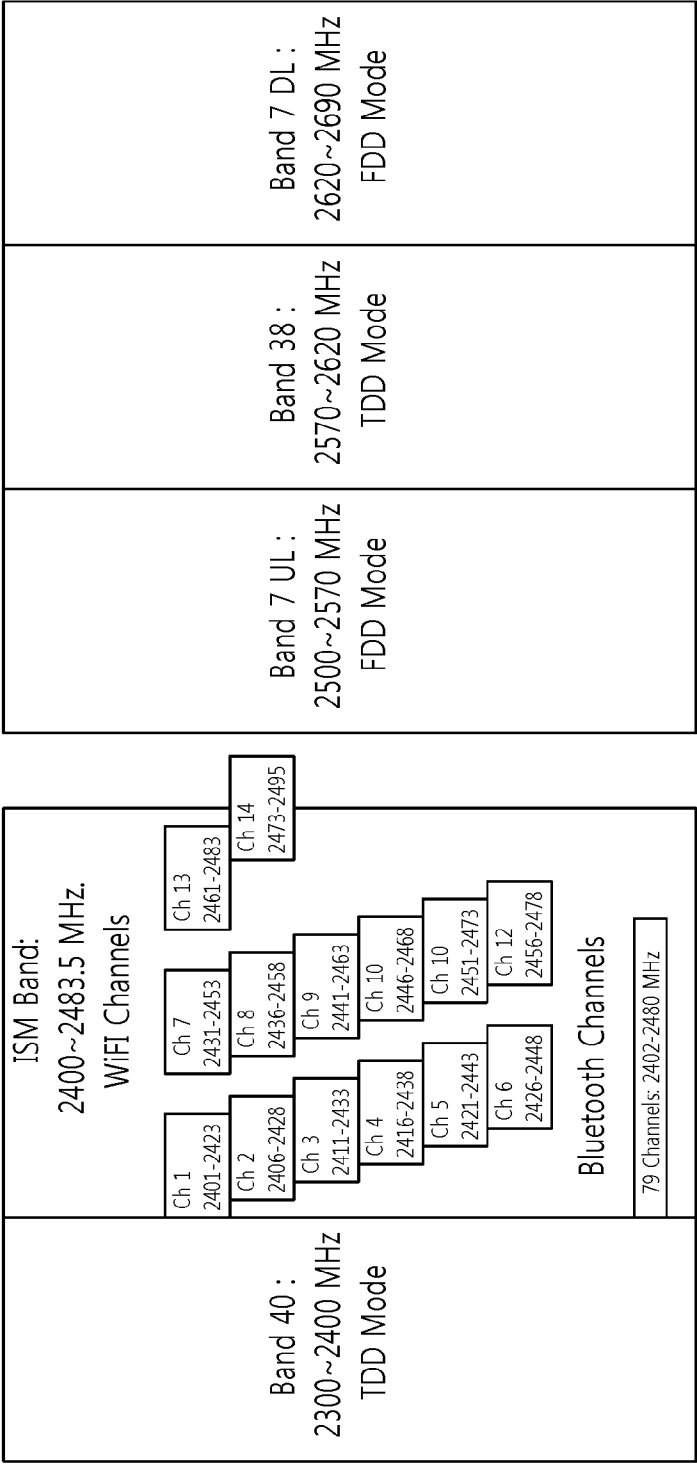
[Fig. 2]



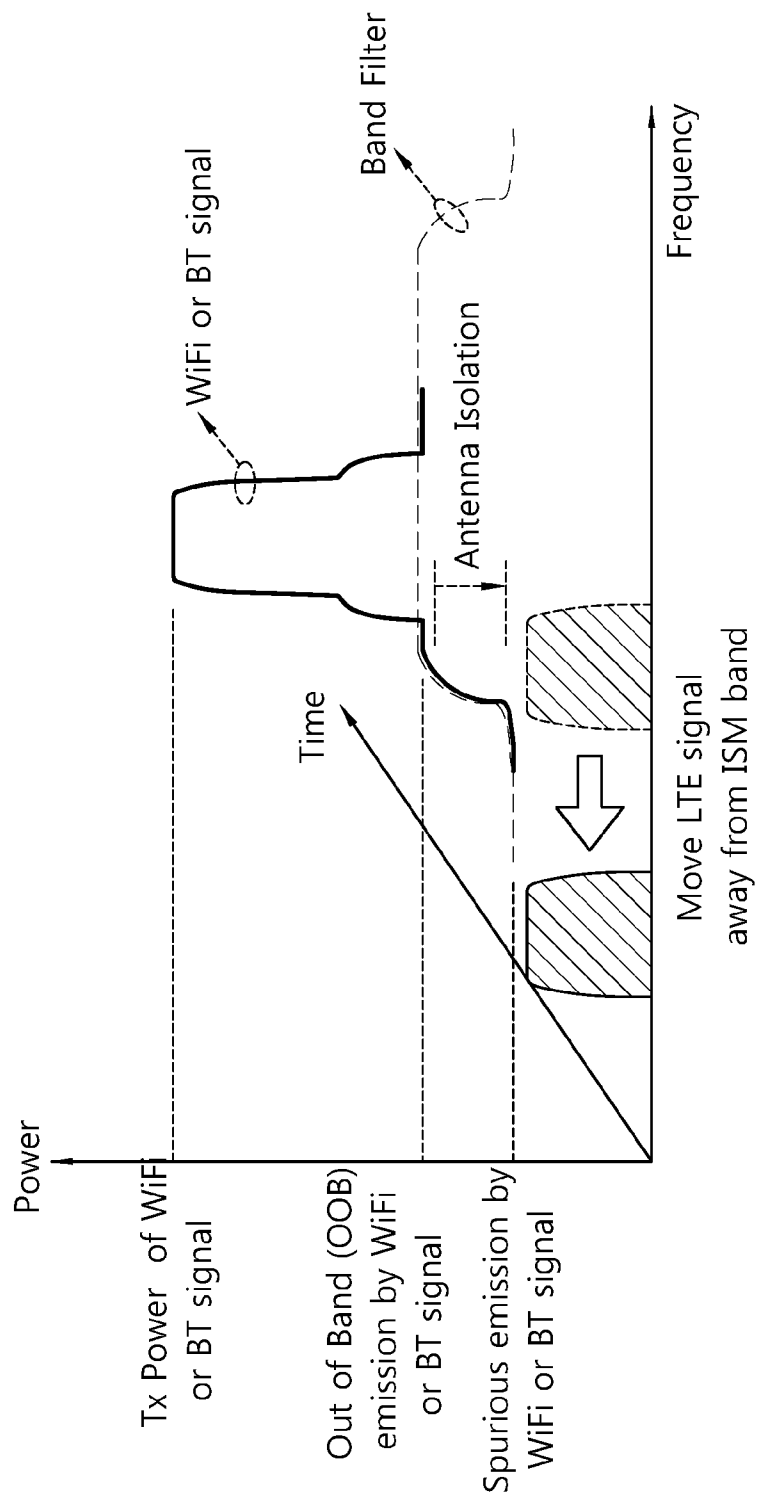
[Fig. 3]



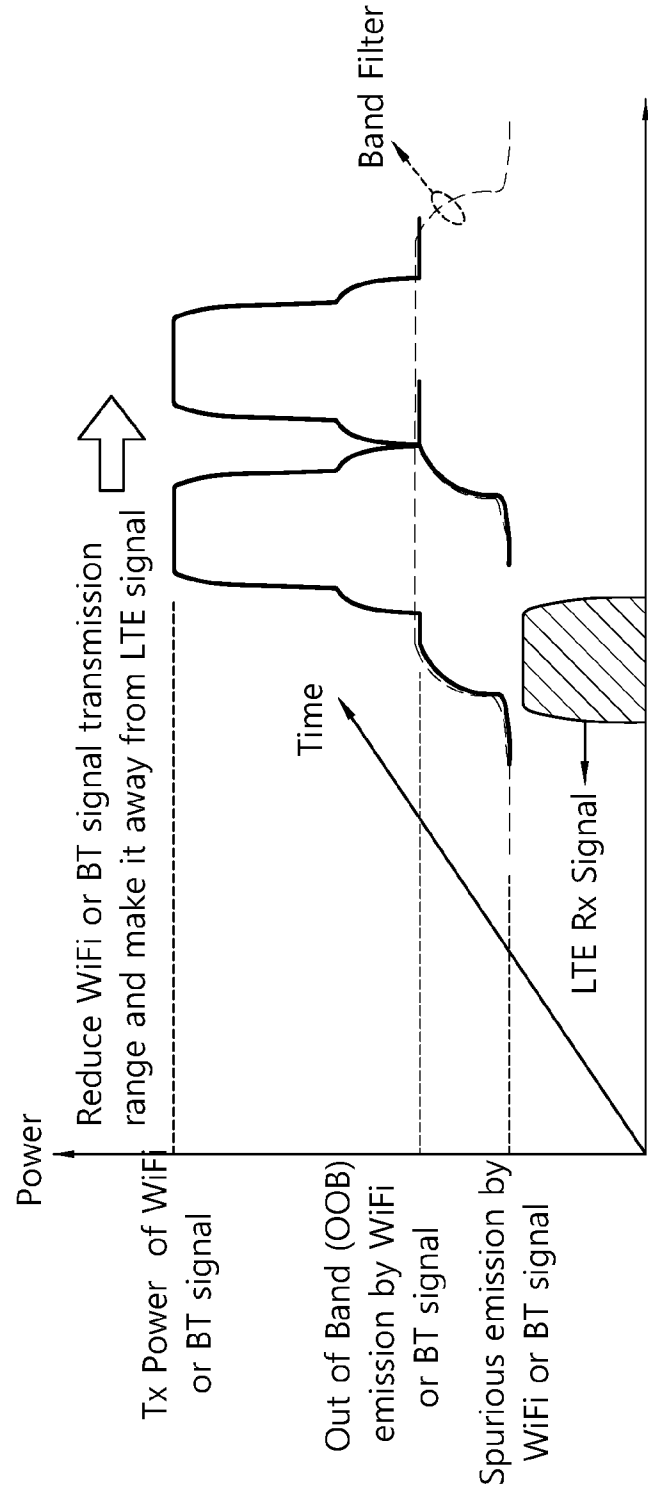
[Fig. 4]



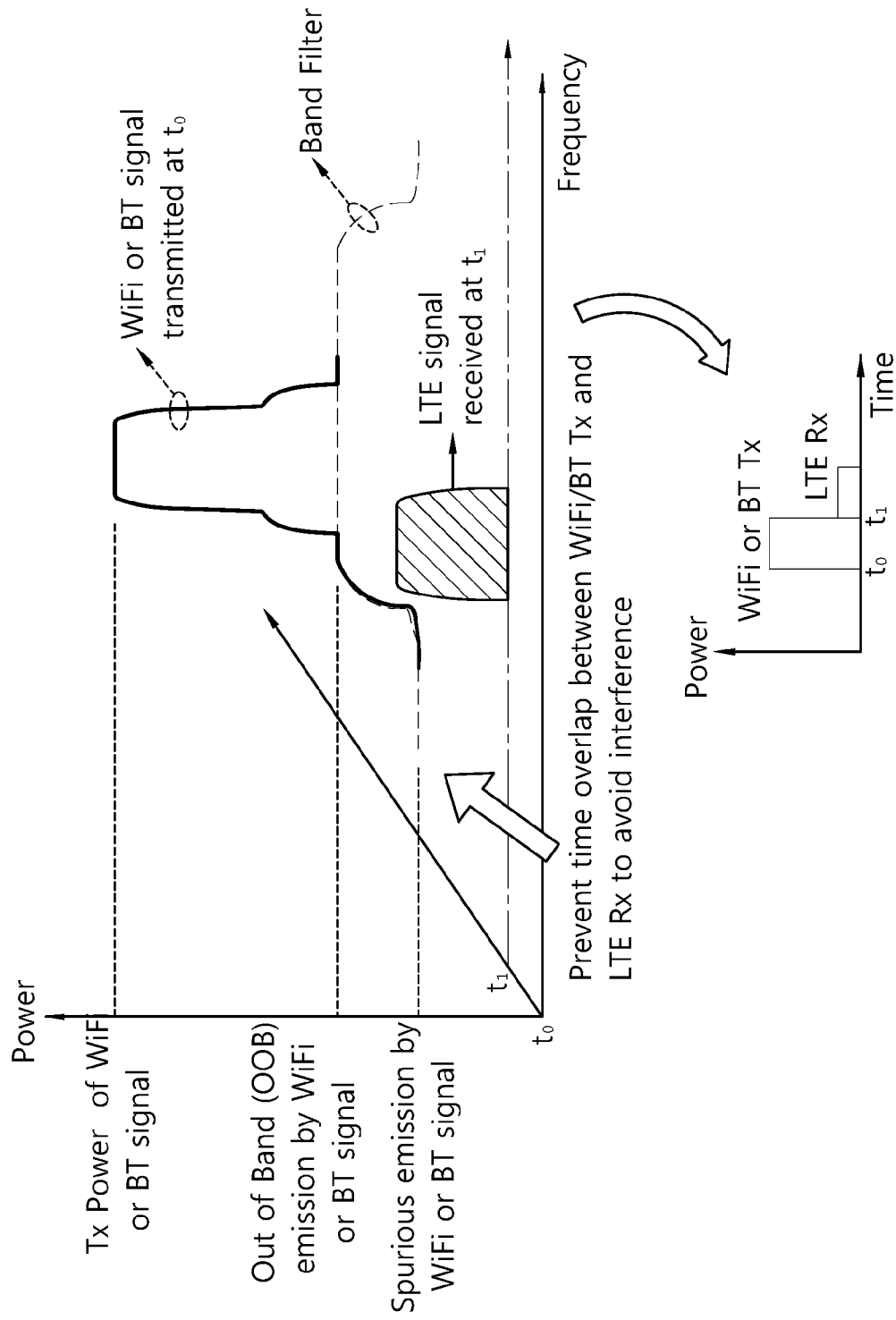
[Fig. 5]



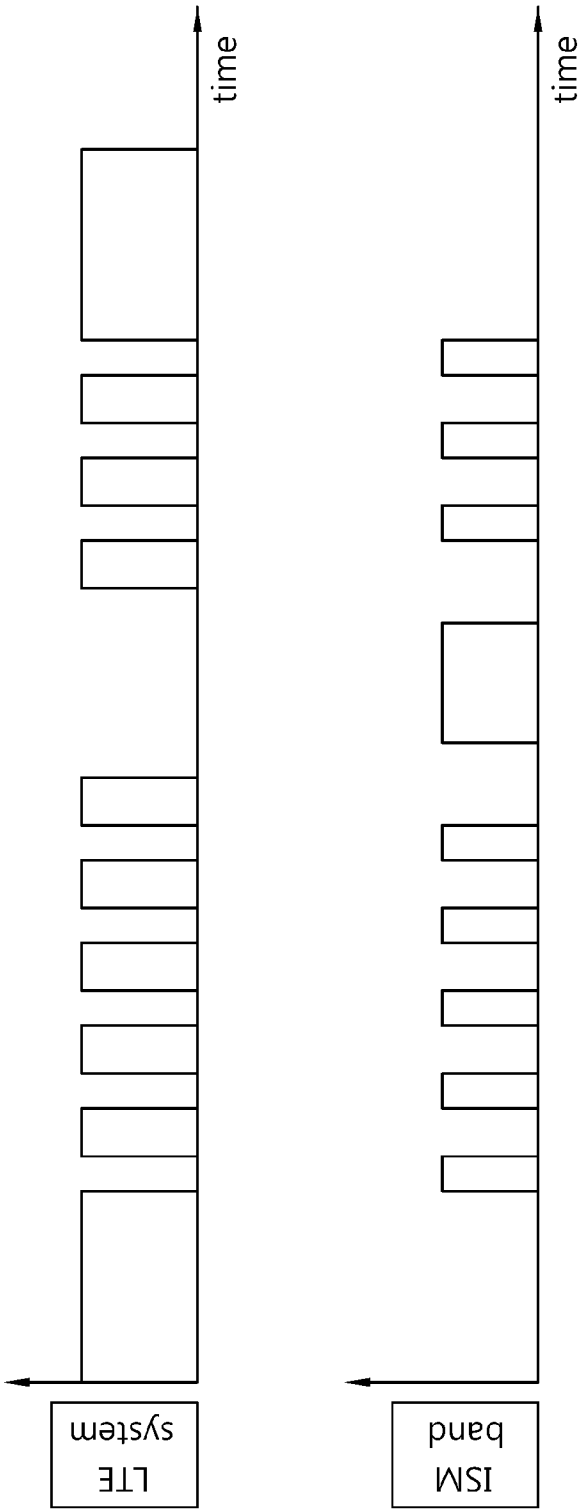
[Fig. 6]



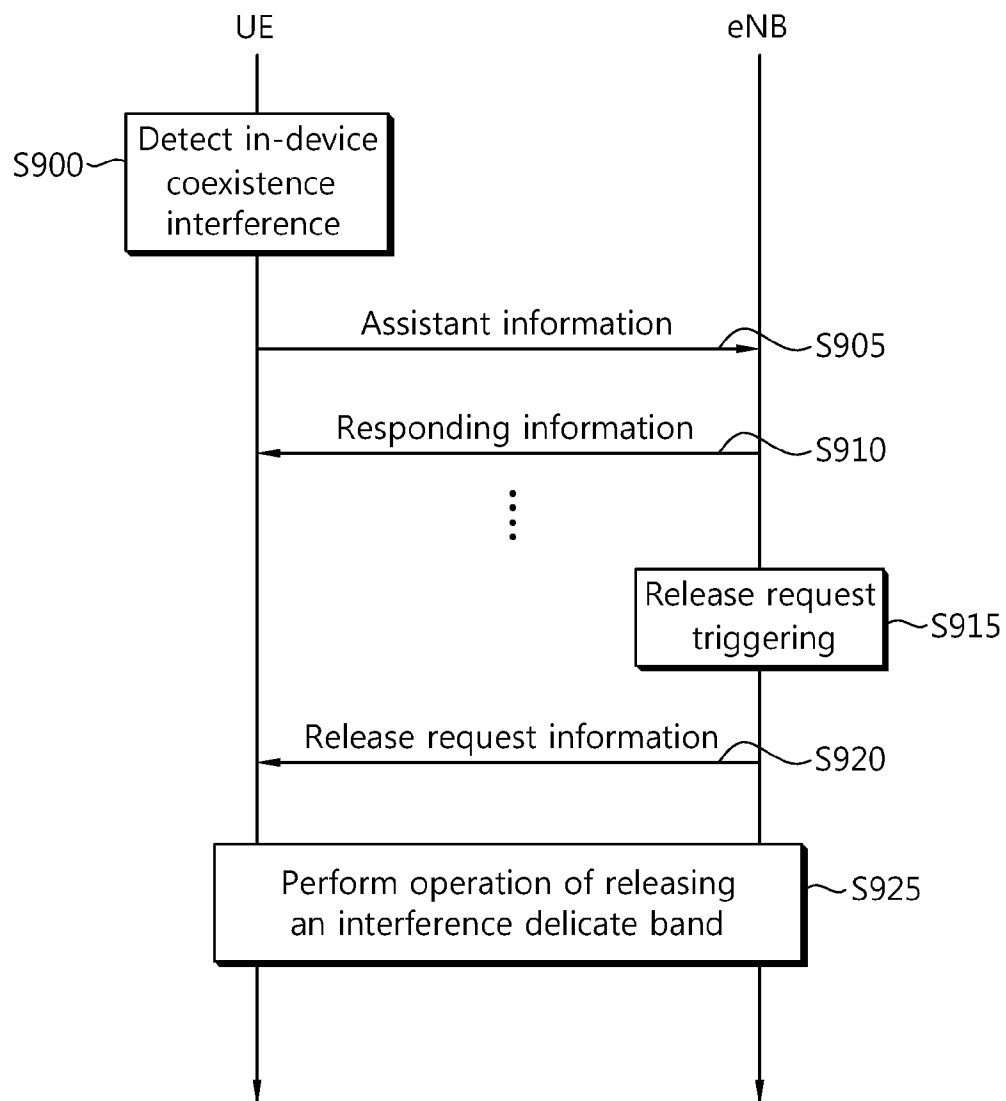
[Fig. 7]



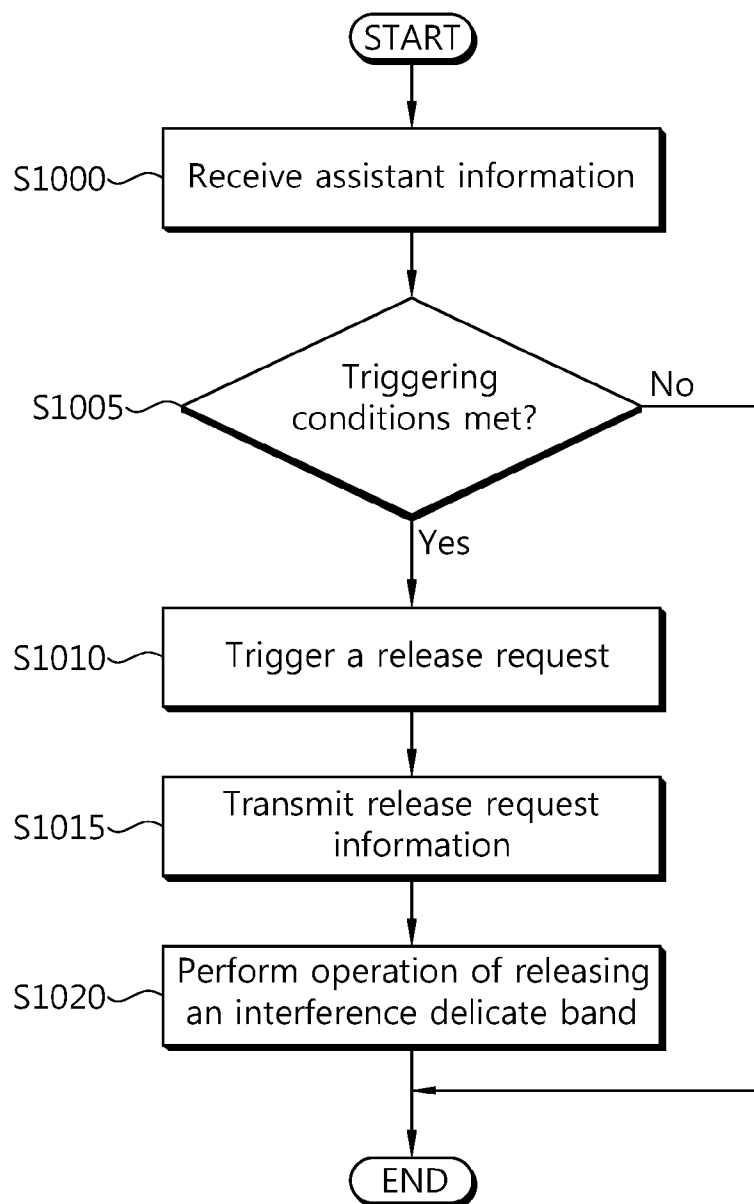
[Fig. 8]



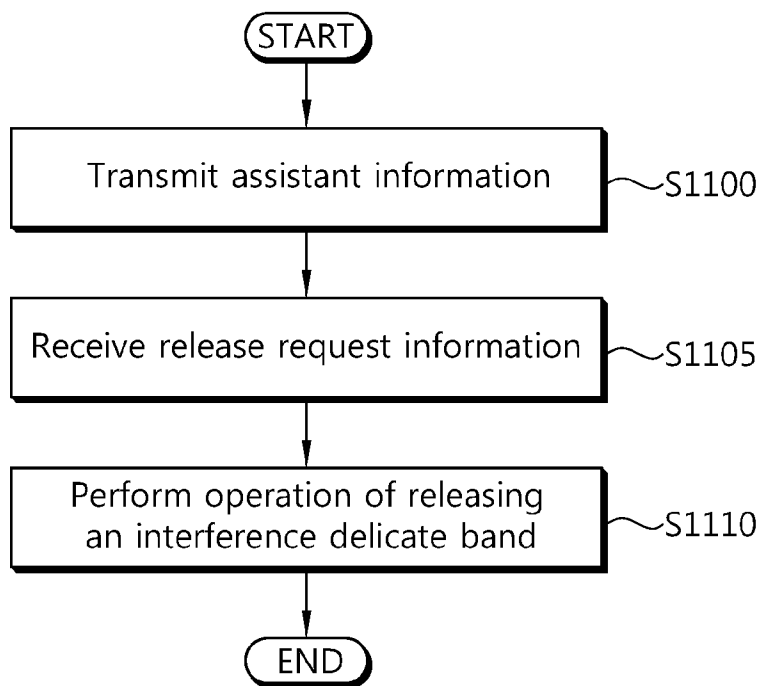
[Fig. 9]



[Fig. 10]



[Fig. 11]



[Fig. 12]

