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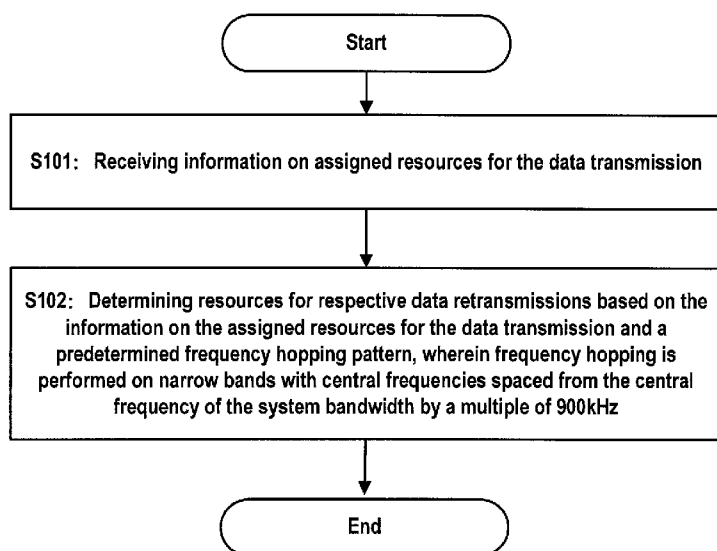


Fig. 1

(57) Abstract: Embodiments of the present disclosure relate to data transmission in a wireless communication system. In an embodiment of the present disclosure, there are provided a method and apparatus of data transmission in a wireless communication system. The method comprises receiving information on assigned resources for the data transmission; and determining resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern. Particularly, frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz. With embodiments of the present disclosure, there is provided a new solution for data transmission in which frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz, and thus it is possible perform the frequency hopping while meeting predetermined center frequency requirements.

METHOD AND APPARATUS FOR DATA TRANSMISSION IN A WIRELESS COMMUNICATION SYSTEM

5 FIELD OF THE INVENTION

[0001] Embodiments of the present disclosure generally relate to wireless communication techniques and more particularly relate to a method and apparatus for data transmission in a wireless communication system.

10 BACKGROUND OF THE INVENTION

[0002] With the constant increase of mobile data services, the 3rd Generation Partnership Project (3GPP) organization has developed long-term evolution (LTE) specifications and LTE-Advanced (LTE-A) specifications. As the next generation cellular communication standard, an LTE or LTE-A system can operate in both
15 Frequency Division Duplex (FDD) mode and Time Division Duplex (TDD) mode.

[0003] Machine-to-Machine (M2M) communication, which may also be called as Machine-Type Communications (MTC), is an emerging communication pattern. It refers to communication between computers, embedded processors, smart sensors, actuators and mobiles devices without or with only limited human intervention and it is
20 quite advantageous in many applications such as sensing in extreme or hazard environment. Generally, many of MTC UEs are targeted for low-end applications (low average revenue per user, and low data rate) that can be handled adequately by GSM/GPRS and thus they may be implemented at low cost.

[0004] As LTE deployments evolve, it is desirable to reduce the cost of overall
25 network maintenance by minimizing the number of Radio Access Technologies (RATs). However, there are deployed more and more MTC UEs in the field, which increases reliance on GSM/GPRS networks, and thus cost for operating these networks are increased. Hence, it will be very beneficial if low-end MTC UEs may be migrated from GSM/GPRS to LTE Networks.

[0005] Besides, in RAN1, #78bis, reduced UE bandwidth of 1.4MHz for both
30 downlink and uplink was agreed to be prioritized as the most important complexity reduction technique for Rel.13 MTC UEs.

[0006] In US patent application publication No. US2013/0294399A1, there is disclosed a data transmission method for machine type communication (MTC) and MTC Apparatus. In this application, each of a plurality of subframes configured with time slots and frequency resources is divided into a first region for transmitting control information and a second region for transmitting data; and resources for the MTC is allocated to the second according to a predetermined hopping period and a predetermined hopping frequency, wherein the RF retuning will be performed in the first region if the time for retuning is shorter than the time length of the first region or the first region and a part of the second region if the time for retuning is longer than the time length of the first region, and wherein the uplink reference f_u and the downlink reference signal f_d are determined based on center frequencies for the frequency up-conversion and the frequency down-conversion, a frequency offset and a hopping index respectively.

SUMMARY OF THE INVENTION

[0007] In the present disclosure, there is provided a new solution for uplink data transmission in a wireless communication system, which is quite different from those in the prior art.

[0008] According to a first aspect of the present disclosure, there is provided a method for data transmission in a wireless communication system. The method may comprise receiving information on assigned resources for the data transmission; and determining resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern. Particularly, frequency hopping may be performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

[0009] In an embodiment of the present disclosure, a plurality of symbols may be used to perform a radio frequency (RF) retuning and the time duration of the plurality of symbols is at least equal to a time interval required by the RF retuning.

[0010] In another embodiment of the present disclosure, the plurality of symbols may be a part of a subframe and resting symbols of the subframe may be used to perform the data retransmission.

[0011] In a further embodiment of the present disclosure, the subframe may be the first one of subframes planned for the data retransmission at the next hopped frequency. Or alternatively, the subframe may be the last one of subframes planned for the data retransmission before the next frequency hopping.

5 [0012] In a still further embodiment of the present disclosure, the number of symbols may be determined as a minimal value that meets the RF retuning.

[0013] In a yet further embodiment of the present disclosure, a whole subframe may be used to perform the RF retuning.

10 [0014] In a still yet embodiment of the present disclosure, the whole subframe may be the first one of subframes planned for the data retransmission at the next hopped frequency. Or alternatively, the whole subframe may be the last one of subframes planned for the data retransmission before the next frequency hopping.

[0015] In a yet further embodiment of the present disclosure, the predetermined frequency hopping pattern may indicate a frequency hopping interval of
15 at least two subframes in the time domain.

[0016] In a yet still further embodiment of the present disclosure, the RF retuning may be performed in a special subframe between two frequency hoppings.

[0017] In another embodiment of the present disclosure, a hopping interval for frequency hopping in the time domain may be determined based on a configuration of
20 subframe used for the data transmission.

[0018] In a further embodiment of the present disclosure, the data transmission may be an uplink data transmission for Machine Type Communication (MTC).

[0019] According to a second aspect of the present disclosure, there is also provided an apparatus for data transmission in wireless communication system,
25 comprising: an information receiving module configured to receive information on assigned resources for the data transmission; and a resource determination module, configured to determine resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern, wherein frequency hopping is performed on narrow bands
30 with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

[0020] According to a third aspect of the present disclosure, there is also

provided a computer-readable storage media with computer program code embodied thereon, the computer program code configured to, when executed, cause an apparatus to perform actions in the method according to any embodiment in the first aspect.

[0021] According to a fourth aspect of the present disclosure, there is provided a computer program product comprising a computer-readable storage media according to the fifth aspect.

[0022] With embodiments of the present disclosure, there is provided a new solution for data transmission in a wireless communication system, in which frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz. Thus, it is possible to perform the frequency hopping while meeting predetermined center frequency requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The above and other features of the present disclosure will become more apparent through detailed explanation on the embodiments as illustrated in the embodiments with reference to the accompanying drawings, throughout which like reference numbers represent same or similar components and wherein:

[0024] Fig. 1 schematically illustrates a flowchart of a method of data transmission in a wireless communication system according to an embodiment of the present disclosure;

[0025] Fig. 2 schematically illustrates a diagram of distribution of narrow bands used for data transmission in a wireless communication system according to an embodiment of the present disclosure;

[0026] Fig. 3 schematically illustrates an exemplary frequency hopping pattern of the frequency hopping interval for an FDD system according to an embodiment of the present disclosure;

[0027] Fig. 4A schematically illustrates exemplary configuration of the RF retuning for an FDD system according to an embodiment of the present disclosure;

[0028] Fig. 4B schematically illustrates another exemplary configuration of the RF retuning for an FDD according to an embodiment of the present disclosure;

[0029] Fig. 5A schematically illustrates a further exemplary configuration of

the RF retuning for an FDD system according to an embodiment of the present disclosure;

[0030] Fig. 5B schematically illustrates a still further exemplary configuration of the RF retuning for an FDD system according to an embodiment of the present disclosure;

[0031] Fig. 6 schematically illustrates a frame configuration for a TDD system;

[0032] Fig. 7 schematically illustrates an exemplary configuration of the RF retuning for a TDD system according to an embodiment of the present disclosure;

[0033] Fig. 8 schematically illustrates another exemplary configuration of the RF retuning for a TDD system according to an embodiment of the present disclosure; and

[0034] Fig. 9 schematically illustrates a block diagram of an apparatus for data transmission in a wireless communication system according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Hereinafter, the solution as provided in the present disclosure will be described in details through embodiments with reference to the accompanying drawings. It should be appreciated that these embodiments are presented only to enable those skilled in the art to better understand and implement the present disclosure, not intended to limit the scope of the present disclosure in any manner.

[0036] In the accompanying drawings, various embodiments of the present disclosure are illustrated in block diagrams, flow charts and other diagrams. Each block in the flowcharts or blocks may represent a module, a program, or a part of code, which contains one or more executable instructions for performing specified logic functions, and in the present disclosure, a dispensable block is illustrated in a dotted line. Besides, although these blocks are illustrated in particular sequences for performing the steps of the methods, as a matter of fact, they may not necessarily be performed strictly according to the illustrated sequence. For example, they might be performed in reverse sequence or simultaneously, which is dependent on natures of respective operations. It should also be noted that block diagrams and/or each block in the flowcharts and a combination of thereof may be implemented by a dedicated

hardware-based system for performing specified functions/operations or by a combination of dedicated hardware and computer instructions.

[0037] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein.

5 All references to "a/an/the/said [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, unit, step, etc., without excluding a plurality of such devices, components, means, units, steps, etc., unless explicitly stated otherwise. Besides, the indefinite article "a/an" as used herein does not exclude a plurality of such steps, units,
10 modules, devices, and objects, and etc.

[0038] Additionally, in a context of the present disclosure, a user equipment (UE) may refer to a terminal, a Mobile Terminal (MT), a Subscriber Station (SS), a Portable Subscriber Station (PSS), Mobile Station (MS), or an Access Terminal (AT), and some or all of the functions of the UE, the terminal, the MT, the SS, the PSS, the
15 MS, or the AT may be included. Furthermore, in the context of the present disclosure, the term "BS" may represent, e.g., a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a radio header (RH), a remote radio head (RRH), a relay, or a low power node such as a femto, a pico, and so on.

[0039] Next, reference will be made to the accompany drawings to describe
20 the solution as provided therein. In the following, the uplink transmission and MTC will be taken as examples to describe the embodiments of the present disclosure; however, it should be appreciated that the present disclosure is not limited thereto and in fact the solution as provided herein can also be used for the downlink data transmission.

[0040] Fig. 1 schematically illustrates a flowchart of a method of data
25 transmission in a wireless communication system according to an embodiment of the present disclosure. As illustrated in Fig. 1, first as step S101, information on assigned resources for the data transmission is received. For the uplink data transmission, for example, after determining assigned resource for a UE, the eNB sends the uplink grant to the UE through Physical Downlink Control Channel (PDCCH)/enhanced PDCCH
30 (EPDCCH) and the UE receives the uplink grant from the eNB. The uplink grant may indicate information on transmission resource assigned to the UE for the uplink transmission. For example, the uplink grant may comprise information for assigned

physical resource blocks (PRBs), and/or the location of narrow band for the data transmission. The assigned PRBs may indicate original assigned physical resource blocks (PRBs) for the uplink data transmission. The location of narrow band for the data transmission indicates the frequency resources which can be used for the uplink data transmission. As agreed in RAN 1# 781bis, a reduced bandwidth of 1.4MHz will be used. Thus, the location of narrow band indicates a segment of consecutive frequency resources, which may be indicated by the central frequency and the total bandwidth. The uplink grant may also comprise the number of the data retransmission N, i.e., the repetition times of PUSCH. The repetition times N can be configured by for example, high-layer signaling or through PDCCH/EPDCCH.

[0041] Then at step S102, resources for respective data retransmissions are determined based on the information on the assigned resource and a predetermined frequency hopping pattern. Particularly, frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

[0042] In the Third Generation Partner Project (3GPP) TS36.104, there is required that UE shall use narrow bands with central frequencies belongs to a 100kHz raster. Thus, a central frequency of the system bandwidth will belong to the 100kHz raster, or in other word the central frequency of the system bandwidth is at the multiple of the 100kHz. In the meanwhile, a narrow band comprises six PRBs, each of which has a frequency band of 180kHz. Thus, to meet the central frequency requirements as indicated hereinabove, the narrow band for the data retransmission shall be selected carefully.

[0043] Fig. 2 schematically illustrates a diagram of distribution of narrow bands used for data transmission in a wireless communication system according to an embodiment of the present disclosure. As illustrated in Fig 2, the access part is usually a central part of the system bandwidth of 20MHz and its central frequency (also the central frequency of the system bandwidth) belongs to the 100kHz raster. Since each of PRBs has a bandwidth of 180kHz, the distance between the central frequencies of a narrow band and the system bandwidth shall be the least common multiple of 100kHz and 180kHz to ensure that the central frequency of the narrow band be at the multiple of 100kHz and there are integral PRBs between these central frequencies.

[0044] In an embodiment of the present disclosure, the narrow bands for data retransmission on which the frequency hopping is performed are selected as those having central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz. Thus, it can guarantee not only a plurality of integral PRBs between a central frequency of a narrow band and the system bandwidth but also the central frequency of the narrow band belonging to a 100kHz raster (i.e., the central frequency of the narrow band being at the multiple of 100kHz). In such a case, it is possible to perform the frequency hopping while meeting predetermined center frequency requirements.

[0045] Besides, a plurality of symbols can be used to perform a radio frequency (RF) retuning and a time duration of the plurality of symbols is at least equal to a time interval required by the RF retuning.

[0046] As is known, many of MTC UEs are targeted for low-end applications (low average revenue per user, and low data rate), and those UEs also have a low SNR, which means a bad signal quality. To make up for the problems of bad signal quality, retransmission is used for MTC. Through the data retransmission, it is possible to use the joint detection, which could increase the possibility of obtaining the transmitted data correctly.

[0047] On the other hand, in order to obtain frequency diversity gain, the frequency hopping will be performed so as to improve the transmission efficiency of MTC terminals. The frequency hopping may be performed in accordance with a predetermined frequency hopping pattern. The predetermined frequency hopping pattern indicates the way in which a frequency hopping is to be performed, particularly parameters used in the frequency hopping. For example, the predetermined frequency hopping pattern may indicate a frequency hopping interval m , a base frequency f_0 , and a frequency offset Δf or frequency offset pattern to be used in frequency hopping. The frequency hopping interval m indicates the number of uplink subframes after which a frequency hopping will be performed in the time domain, which can be a predetermined value or configured by the eNB. The base frequency f_0 indicates the frequency at which the data transmission is performed. The base frequency f_0 may be determined based on the location of narrow band as indicated by the uplink grant. The frequency offset Δf or the frequency offset pattern indicates the amount of the frequency change

after a frequency hopping is performed, which can be a predetermined value or configured by the eNB.

[0048] Fig. 3 schematically illustrates an exemplary frequency hopping pattern for an FDD system according to an embodiment of the present disclosure. As illustrated in Fig. 3, two consecutive uplink frames are illustrated, each of which comprises ten uplink subframes numbered from 0 to 9. In Fig. 3, the frequency hopping interval is determined as 4, which means the transmission frequency for MTC UEs will be changed or hopped every four subframes. In Fig. 3, the x axis denotes a change over time and the y axis denotes the change of frequency.

[0049] Fig. 4A schematically illustrates exemplary configurations of the RF retuning for an FDD system according to an embodiment of the present disclosure. As illustrated in Fig. 4A, the frequency hopping interval is 4, which is same as that in Fig. 3. In the configuration as illustrated in Fig. 4A, the plurality of symbols used for the RF retuning are a part of one subframes and particularly, is a part of the first one of the four subframes planned for the data retransmission at the next hopped frequency, as illustrated by block filled with dots in Fig. 4A. That is to say, a first part of symbols in this subframe will be used to perform the RF retuning while the remaining symbols in this subframe will be used to perform the data retransmission on the PUSCH.

[0050] Particularly, the UE will determine the Physical Resource Block(s) (PRB) used to transmit the i -th PUSCH when i is less than N (the predetermined number of data retransmission). For example, regarding the second data retransmission as illustrated in Fig. 4A, the UE will determine subframes 4 to 7 will be used for the i -th PUSCH transmission, wherein the first j symbols in the first subframe will be used to perform the RF tuning. The number of symbols may be determined as a minimal value that meets the RF retuning. It can be understood that the resource for the RF retuning is assigned in a unit of symbol and thus it will not introduce any transmission mistake due to a transmission beginning from the middle of a symbol.

[0051] Generally, it requires about a half of subframe to perform the RF retuning and thus if the remaining symbols can be used to the data retransmission, it will be advantageous since the remaining resource can be used efficiently. However, it can be understood that it is also possible to use more symbols than that is required.

[0052] Moreover, the UE will also determine f_i , i.e., the frequency used to

transmit the i -th PUSCH based on, for example, the base frequency f_0 , and the frequency offset Δf as indicated by the predetermined frequency hopping pattern. For example f_i may be determined as $f_0 + i \cdot \Delta f$ or be determined based on f_0 and the predetermined frequency offset pattern. At the same time, it shall guarantee that all narrow bands to be used have central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz. Then the UE can perform the RF retuning in the determined plurality of symbols and after the RF retuning is finished, it may start to transmit the i -th PUSCH at the hopped frequency.

[0053] Fig. 4B schematically illustrates another exemplary configuration of the RF retuning for an FDD according to an embodiment of the present disclosure. Different from the configuration as illustrated in Fig. 4A, the plurality of symbols in the last one of the four subframes planned for the data retransmission before the next frequency hopping will be used to perform the RF tuning, instead of those in the first one of subframes planned for the data retransmission at the next hopped frequency. Through the configuration as illustrated in Fig. 4B, it is also possible to achieve the RF retuning before the frequency hopping for the next data retransmission.

[0054] Figs. 5A and 5B schematically illustrate two further alternative exemplary configurations of the RF retuning for an FDD system according to embodiments of the present disclosure. Different from Figs. 4A and 4B, in Figs. 5A and Fig. 5B, a whole subframe is used to perform the RF retuning instead of only a part of one subframe. This means all symbols in the subframe are used for the RF tuning although the time length required by the RF retuning might be shorter than the time duration of a subframe. In Fig. 5A, the first one of the four subframes planned for the data retransmission at the next hopped frequency is used to transmit the i -th PUSCH, while in Fig. 5B, the last one of the four subframes planned for the data retransmission before the next frequency hopping. By this, enough time is reserved for the RF retuning and thus it may also ensure the performing of the RF retuning.

[0055] Hereinabove, the embodiments of the present disclosure are described with reference to a FDD system to describe how to performing the RF tuning; however, the present disclosure is not only limited to the FDD system. In Fact, it is also applicable to a TDD system as well. Next, description will be made to a solution for a TDD system as provided herein.

[0056] For a purpose of illustration, in Fig. 6, there is schematically illustrated an exemplary frame structure for a TDD system. As illustrated in Fig. 6, similar to a FDD radio frame, a TDD radio frame also consists of ten subframes labeled with 0 to 9. While different from the FDD radio frame, each of the subframes may be used for DL transmission or UL transmission, or used as a special subframe between the DL period and the UL period. Taking configuration 0 as an example, subframes 0 and 5 are used for the DL transmission, subframes 2 to 4 and subframes 7 to 9 are used for the UL transmission and subframes 1 and 6 are used as special subframes, which are labeled as “D”, “U” and “S” respectively.

[0057] For example, regarding TDD configuration 0, there are three consecutive uplink subframe (i.e., subframes 2 to 4 and subframes 7 to 9), in such a case the hopping interval may be for example 3 uplink subframes. Thus, for the TDD configuration 0, similar to those illustrated in Fig.4A and 4B, the RF retuning can be performed in a plurality of symbols of the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next frequency hopping. Or alternatively, a whole subframe can be used to perform the RF retuning. The whole subframe particularly may be the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next frequency hopping.

[0058] However, the inventors further notice that the TDD frame has its own special structure, i.e., there is a special subframe between the DL period and the UL period, which is always located immediately after an downlink subframe “U” and before an uplink subframe “U.” Thus, it is possible to have the RF retuning to be performed during the special subframe.

[0059] Reference is made to Fig. 7, which schematically illustrates an exemplary configuration of the RF retuning for a TDD system according to an embodiment of the present disclosure. In Fig. 7, frame configuration 0 is taken as an example again, which comprises three consecutive uplink subframes after each special subframe. In other word, a special subframe will be available every three uplink subframes. In such a case, the frequency hopping interval can be set as 3 and the special subframe between the frequency hoppings can be used to perform the RF

retuning. In such a way, not only can the frequency diversity gain be obtained by the MTC during the repetitions but also the transmission mistakes can be avoided, and at the same time the impact of RF retuning time can be reduced.

[0060] Fig. 8 schematically illustrates another exemplary configuration of the RF retuning for a TDD system according to an embodiment of the present disclosure. In Fig. 8, the configuration of the RF retuning is for frame configuration 0 but the frequency hopping interval is set as 6 instead of 3 of Fig. 7. Thus only the special subframe corresponding subframe 1 in a second frame is used to perform the RF tuning, which is located between two frequency hoppings. It can be understood that, for frame configuration 0, the frequency hopping interval can be determined as the multiple of 3. That is to say, the frequency hopping interval can be determined based on the characteristics of the configuration.

[0061] From Fig. 6, it is clear that different frame configurations have different patterns and thus frequency hopping intervals suitable for different frame configurations are also different. Thus, the frequency hopping interval can be determined based on a configuration of subframe used for the data transmission. That is to say, for different subframe configurations, it can use different frequency hopping interval according to characteristics of different subframe configurations. Taking configuration 0 as an example, there are three consecutive subframes after a special subframe. Thus, in order to use the special subframe for RF retuning, the frequency hopping interval may be the multiple of 3, i.e., 3, 6 and so on, as illustrated in Figs. 7 and 8. For configuration 2, it contains two consecutive uplink subframes, and thus the frequency hopping interval may be the multiple of 2, i.e., 2, 4, 6 and so on. While, for configuration 6 which includes two or three consecutive uplink subframes after a special subframe, the frequency hopping interval may be the multiple of 5, i.e. 5, 10 and so on. In such a way, it may ensure that there is always a special subframe which can be used for the RF retuning.

[0062] With embodiments of the present disclosure, there is provided a new solution for data transmission in wireless communication system, in which frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz. Thus, it is possible to perform the frequency hopping while meeting predetermined center frequency

requirements. More particularly, the RF retuning can be performed in a plurality of symbols, which means when determining resource for the RF retuning, it considers not only the time length required by the RF retuning but also the starting point of the data retransmission to ensure that the data retransmission could start from a starting point of symbol instead of a middle thereof. In such a way, transmission mistakes can be reduced and the transmission efficiency can be improved. Besides, in the present disclosure, there is proposed to use a frequency hopping interval of at least two, preferable, 3 or more, which means cross-subframe channel estimation can be used, and thus the accuracy of channel estimation during each hopping period will be improved.

[0063] In addition to the method as described above, there is also provided an apparatus for data transmission in a wireless communication system according to an embodiment of the present disclosure. Next reference will be made to Fig. 9 to describe the apparatus as provided in the present disclosure.

[0064] As illustrated in Fig. 9, apparatus 900 may comprise an information receiving module 910 and a resource determination module 920. The information receiving module 910 is configured to receive information on assigned resources for the data transmission. The resource determination module 920 may be configured to determine resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern. Particularly, frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

[0065] In an embodiment of the present disclosure, a plurality of symbols may be used to perform a radio frequency (RF) retuning and the time duration of the plurality of symbols is at least equal to a time interval required by the RF retuning.

[0066] In another embodiment of the present disclosure, wherein the plurality of symbols may be a part of a subframe and resting symbols of the subframe may be used to perform the data retransmission. The subframe can be the first one of subframes planned for the data retransmission at the next hopped frequency. Or alternatively, the subframe can be the last one of subframes planned for the data retransmission before the next frequency hopping. Particularly, the number of symbols may be determined as a minimal value that meets the RF retuning.

[0067] In a further embodiment of the present disclosure, a whole subframe may be used to perform the RF retuning. Particularly, the whole subframe may be the first one of subframes planned for the data retransmission at the next hopped frequency. Or alternatively, the whole subframe may be the last one of subframes planned for the data retransmission before the next frequency hopping.

[0068] In a still further embodiment of the present disclosure, the predetermined frequency hopping pattern may indicate a frequency hopping interval of at least two subframes in the time domain.

[0069] In a yet further embodiment of the present disclosure, the RF retuning may be performed in a special subframe between two frequency hoppings. Particularly, the frequency hopping interval in the time domain may be determined based on a configuration of subframe used for the data transmission.

[0070] In a yet still further embodiment of the present disclosure, the data transmission may be an uplink data transmission for Machine Type Communication (MTC).

[0071] It is noted that the apparatus 900 may be configured to implement functionalities as described with reference to Figs. 1 to 8. Therefore, for details about the operations of modules in these apparatus, one may refer to those descriptions made with respect to the respective steps of the methods with reference to Figs. 1 to 8.

[0072] It is further noted that the components of the apparatus 900 may be embodied in hardware, software, firmware, and/or any combination thereof. For example, the components of apparatus 900 may be respectively implemented by a circuit, a processor or any other appropriate selection device. Those skilled in the art will appreciate that the aforesaid examples are only for illustration not limitation.

[0073] In some embodiment of the present disclosure, apparatus 900 may comprise at least one processor. The at least one processor suitable for use with embodiments of the present disclosure may include, by way of example, both general and special purpose processors already known or developed in the future. Apparatus 800 may further comprise at least one memory. The at least one memory may include, for example, semiconductor memory devices, e.g., RAM, ROM, EPROM, EEPROM, and flash memory devices. The at least one memory may be used to store program of computer executable instructions. The program can be written in any high-level and/or

low-level compliant or interpretable programming languages. In accordance with embodiments, the computer executable instructions may be configured, with the at least one processor, to cause apparatus 900 to at least perform operations according to the method as discussed with reference to Figs. 1 to 8 respectively.

5 [0074] Hereinbefore, detailed descriptions of solutions as provided in the present disclosure are given with reference to specific embodiments of the present disclosure; however, the present disclosure is not limited thereto. It may be appreciated that embodiments of the present disclosure are described with reference to MTC; however, the present invention is not limited thereto and the present invention
10 may be used any communication with a low SNR in LTE system. Besides, hereinabove, the uplink data transmission is described; however, the solution as provided in the present disclosure can also be used in the downlink data transmission. In such a case, the object of concern will be downlink subframe instead of the uplink subframe, and after the information on assigned resource is determined by the eNB, the
15 information will send to the module for determining resource for the data retransmission in the eNB and the resource determination will be performed at the eNB, instead of the UE. Besides, for the TDD system, the frequency hopping interval may be determined by considering the number of consecutive downlink subframes and the availability of the special subframe.

20 [0075] Additionally, based on the above description, the skilled in the art would appreciate that the present disclosure may be embodied in an apparatus, a method, or a computer program product. In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware,
25 while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the exemplary embodiments of this disclosure may be illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it is well understood that these blocks,
30 apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some

combination thereof.

[0076] The various blocks shown in the accompanying drawings may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s). At least some aspects of the exemplary embodiments of the disclosures may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this disclosure may be realized in an apparatus that is embodied as an integrated circuit, FPGA or ASIC that is configurable to operate in accordance with the exemplary embodiments of the present disclosure.

[0077] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any disclosure or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular disclosures. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[0078] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[0079] Various modifications, adaptations to the foregoing exemplary embodiments of this disclosure may become apparent to those skilled in the relevant

arts in view of the foregoing description, when read in conjunction with the accompanying drawings. Any and all modifications will still fall within the scope of the non-limiting and exemplary embodiments of this disclosure. Furthermore, other embodiments of the disclosures set forth herein will come to mind to one skilled in the art to which these embodiments of the disclosure pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings.

[0080] Therefore, it is to be understood that the embodiments of the disclosure are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims.

Although specific terms are used herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

WHAT IS CLAIMED IS:

1. A method of data transmission in a wireless communication system, comprising:
receiving information on assigned resources for the data transmission; and

5 determining resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern, wherein frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

10 2. The method according to Claim 1, wherein a plurality of symbols are used to perform a radio frequency (RF) retuning and the time duration of the plurality of symbols is at least equal to a time interval required by the RF retuning.

15 3. The method according to Claim 2, wherein the plurality of symbols are a part of a subframe and resting symbols of the subframe are used to perform the data retransmission.

20 4. The method according to Claim 3, wherein the subframe is any one of the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next frequency hopping.

25 5. The method according to any of Claims 2 to 4, wherein the number of symbols is determined as a minimal value that meets the RF retuning.

6. The method according to Claim 2, wherein a whole subframe is used to perform the RF retuning.

30 7. The method according to Claim 6, wherein the whole subframe is any one of the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next

frequency hopping.

8. The method according to any one of Claims 2 to 7, wherein the predetermined frequency hopping pattern indicates a frequency hopping interval of at least two subframes in the time domain.

9. The method according to Claim 2, wherein the RF retuning is performed in a special subframe between two frequency hoppings.

10. The method according to Claim 9, wherein a frequency hopping interval in the time domain is determined based on a configuration of subframe used for the data transmission.

11. The method according to any one of Claims 1 to 10, wherein the data transmission is an uplink data transmission for Machine Type Communication (MTC).

12. An apparatus for data transmission in wireless communication system, comprising:

an information receiving module, configured to receive information on assigned resources for the data transmission; and

a resource determination module, configured to determine resources for respective data retransmissions based on the information on the assigned resources for the data transmission and a predetermined frequency hopping pattern, wherein frequency hopping is performed on narrow bands with central frequencies spaced from a central frequency of the system bandwidth by a multiple of 900kHz.

13. The apparatus according to Claim 12, wherein a plurality of symbols are used to perform a radio frequency (RF) retuning and the time duration of the plurality of symbols is at least equal to a time interval required by the RF retuning.

14. The apparatus according to Claim 13, wherein the plurality of symbols are a part of a subframe and resting symbols of the subframe are used to perform the data

retransmission.

15. The apparatus according to Claim 14, wherein the subframe is any one of the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next frequency hopping.

16. The apparatus according to any of Claims 13 to 15, wherein the number of symbols is determined as a minimal value that meets the RF retuning.

17. The apparatus according to Claim 13, wherein a whole subframe is used to perform the RF retuning.

18. The apparatus according to Claim 17, wherein the whole subframe is any one of the first one of subframes planned for the data retransmission at the next hopped frequency or the last one of subframes planned for the data retransmission before the next frequency hopping.

19. The apparatus according to any one of Claims 13 to 18, wherein the predetermined frequency hopping pattern indicates a frequency hopping interval of at least two subframes in the time domain.

20. The apparatus according to Claim 13, wherein the RF retuning is performed in a special subframe between two frequency hoppings.

21. The apparatus according to Claim 20, wherein a frequency hopping interval in the time domain is determined based on a configuration of subframe used for the data transmission.

22. The apparatus according to any one of Claims 12 to 21, wherein the data transmission is uplink data transmission for Machine Type Communication (MTC).

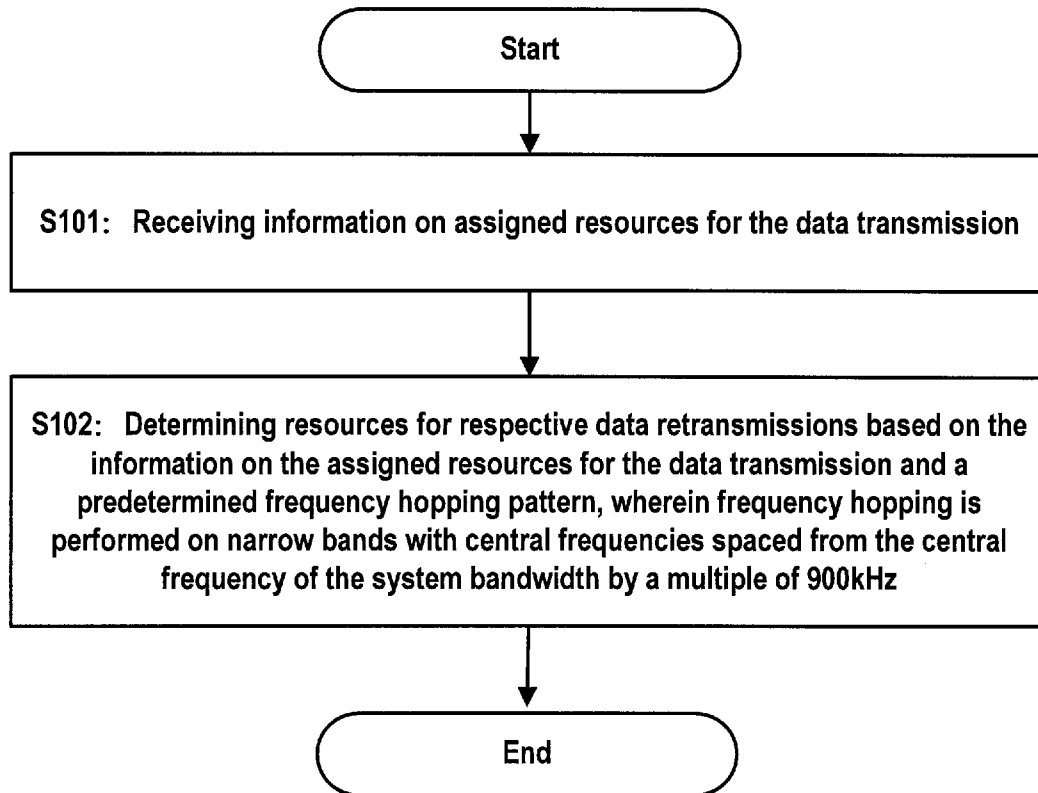


Fig. 1

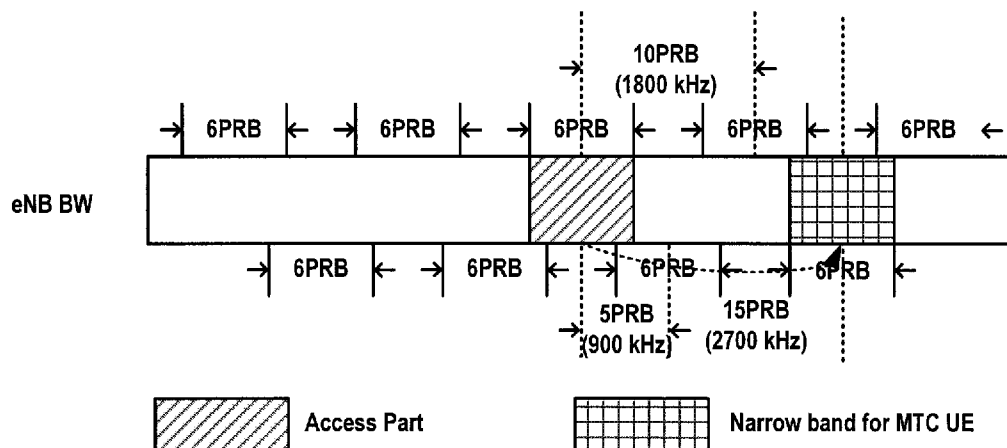


Fig. 2

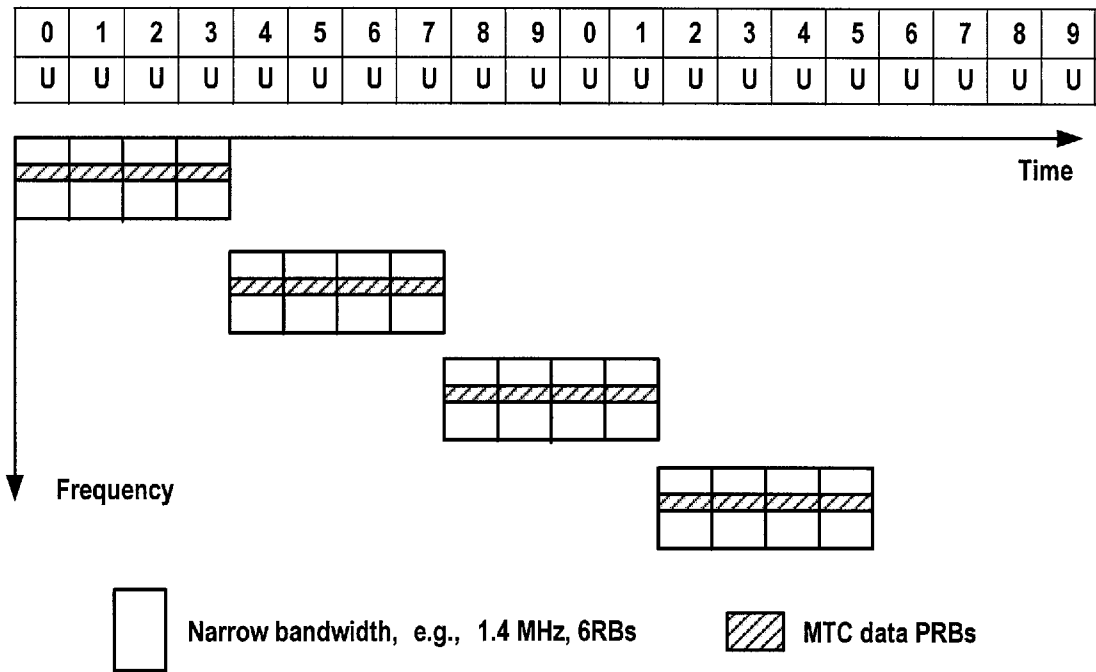


Fig. 3

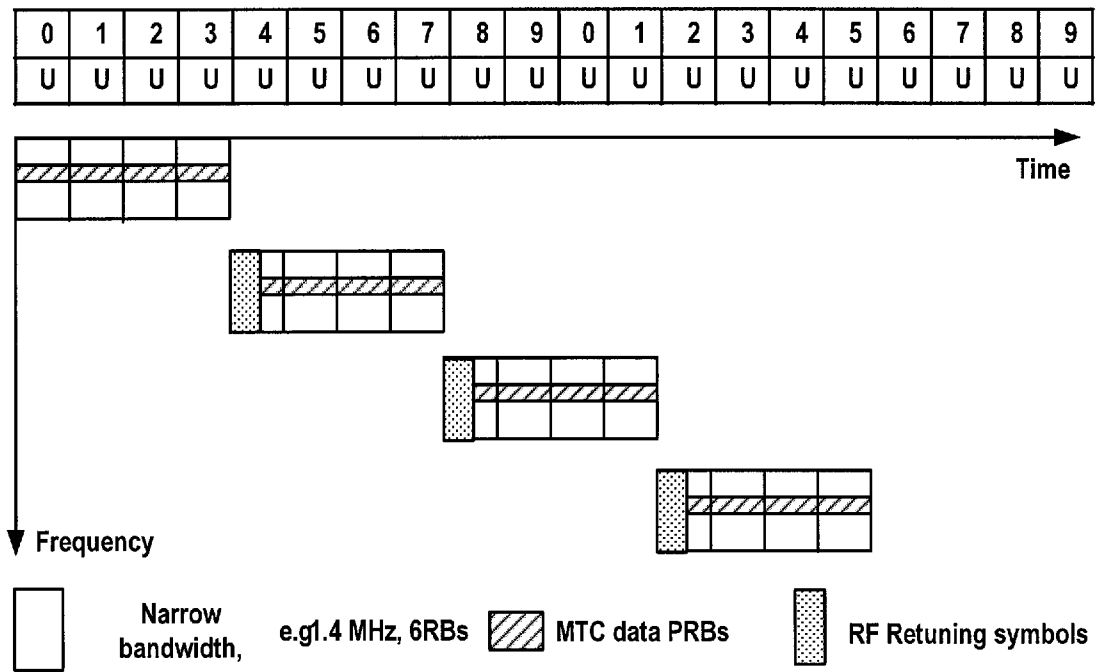


Fig. 4A

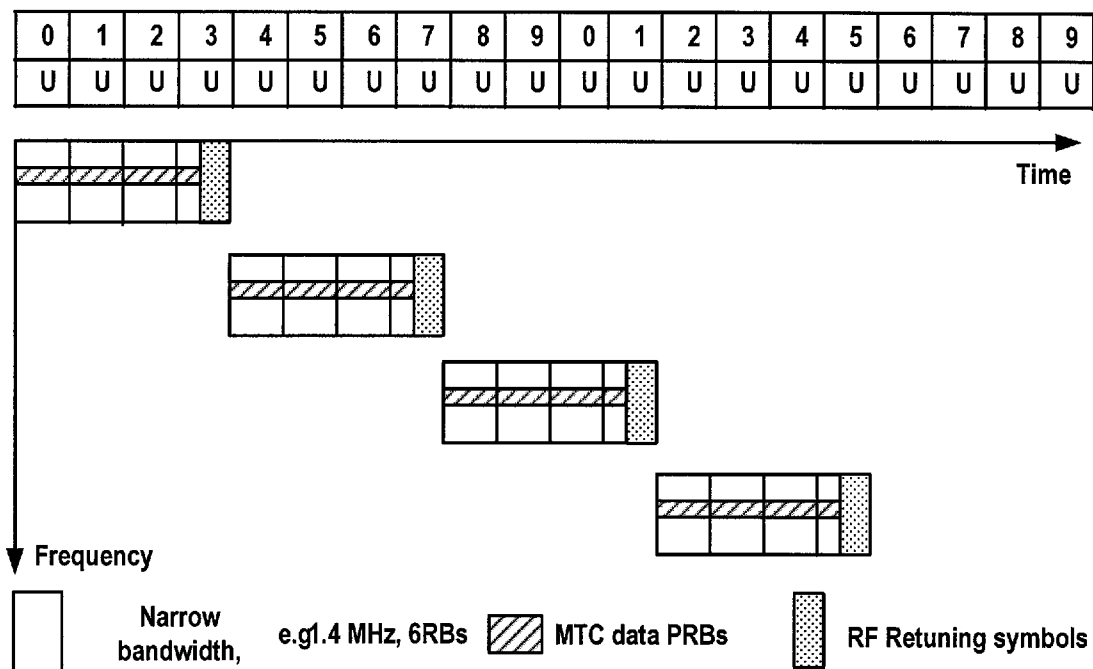


Fig. 4B

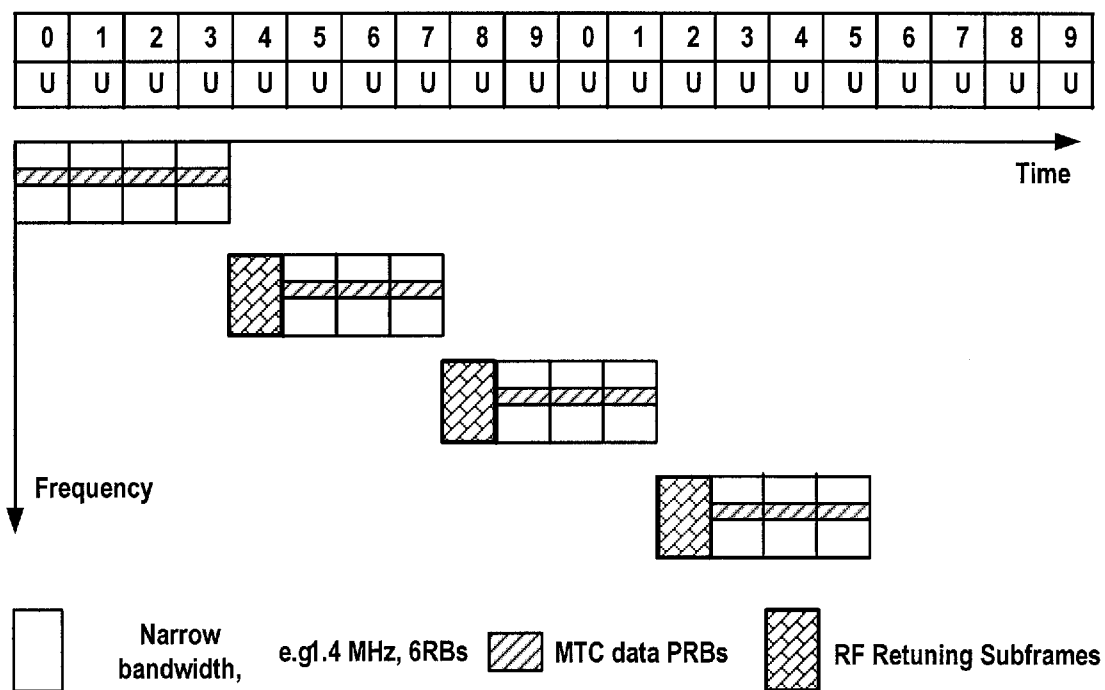


Fig. 5A

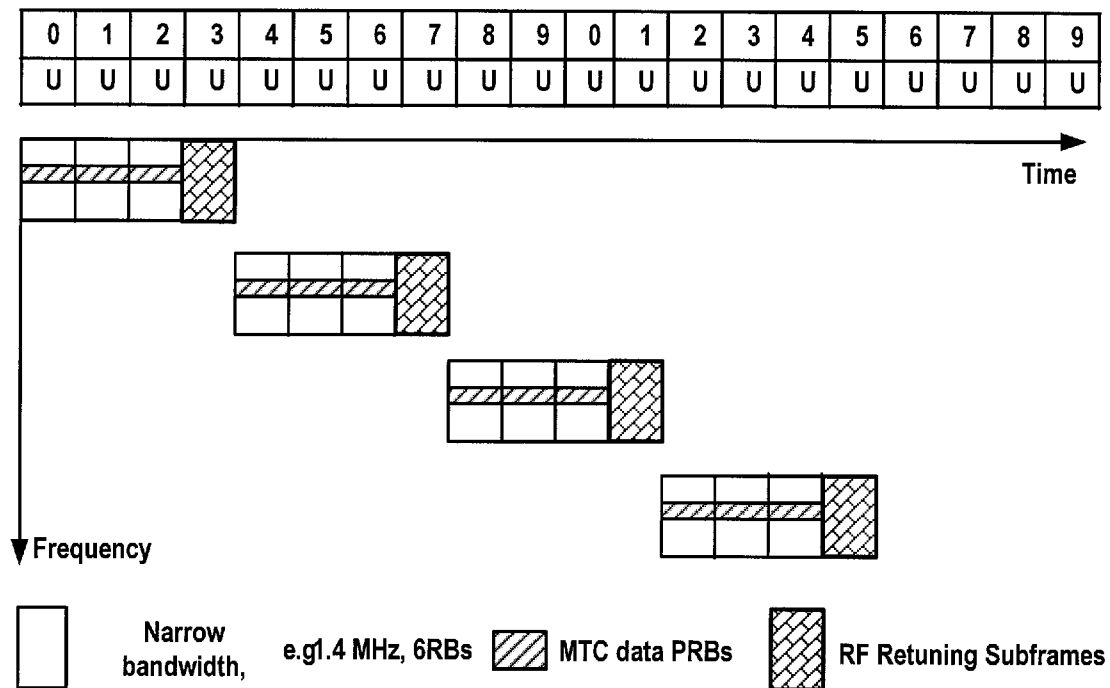


Fig. 5B

UL - DL Configuration	Switching - point periodicity	Subframe number									
		#0	#1	#2	#3	#4	#5	#6	#7	#8	#9
0	5ms	D	S	U	U	U	D	S	U	U	U
1	5ms	D	S	U	U	D	D	S	U	U	D
2	5ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5ms	D	S	U	U	U	D	S	U	U	D

Fig. 6

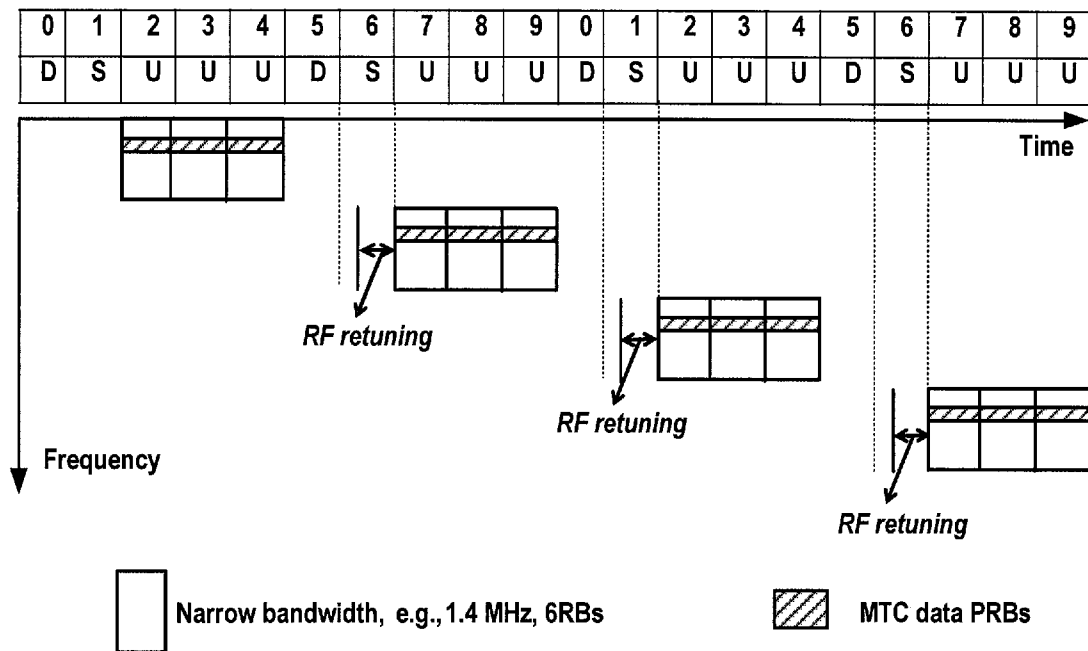


Fig. 7

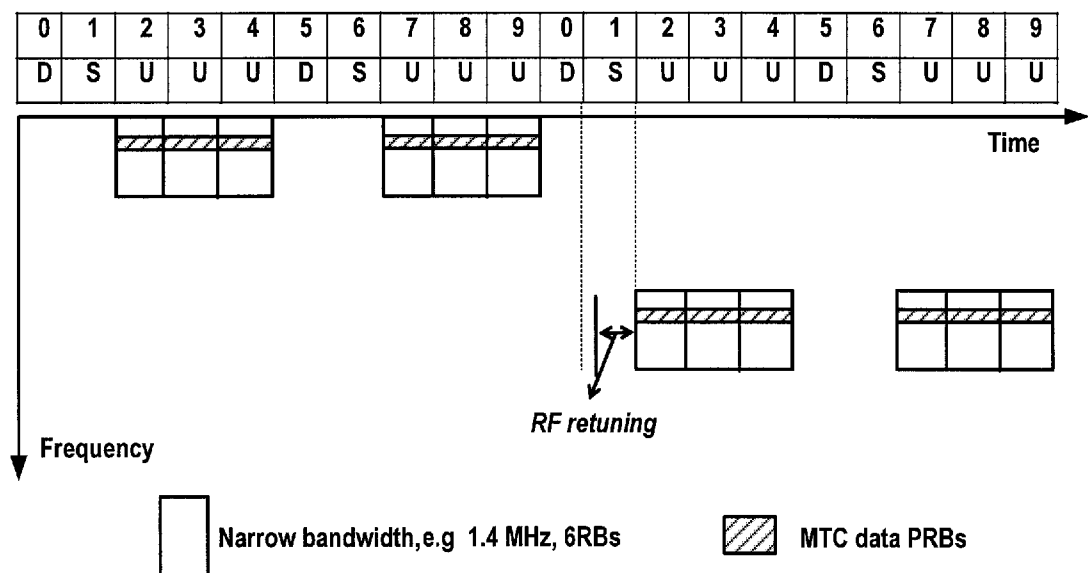


Fig. 8

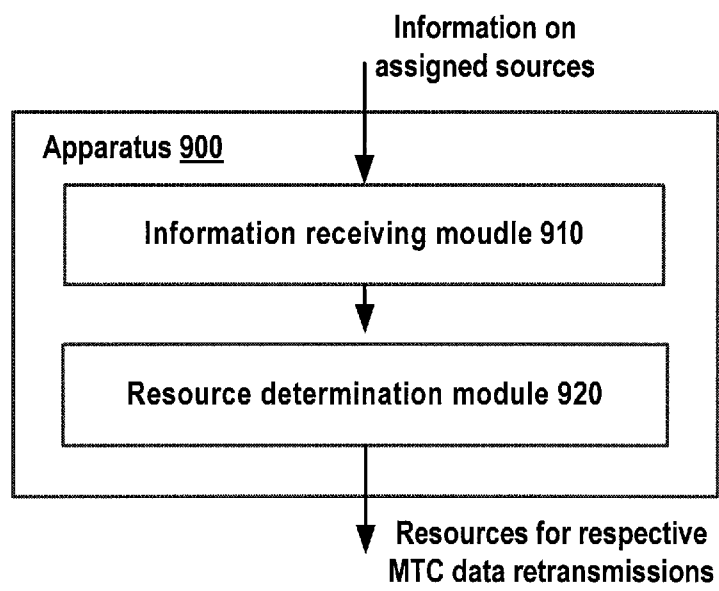


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/075457

A. CLASSIFICATION OF SUBJECT MATTER

H04W 4/00(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)

H04W,H04Q,H04L

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)

WPI,CNPAT,EPODOC,CNKI,3GPP:PRB, 900khz, data,transmission,transmit+,uplink,resource,hopping,central,frequenc+, bandwidth,pattern,narrow,time

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103517426 A (CHINA ACADEMY OF TELECOMMUNICATION TECHNOLOGY) 15 January 2014 (2014-01-15) see description, paragraphs [0041]-[0061]	1-22
A	US 2012327894 A1 (JOAKIM AXMON ET AL.) 27 December 2012 (2012-12-27) the whole document	1-22
A	CN 103327615 A (HUAWEI TECHNOLOGIES CO. LTD.,) 25 September 2013 (2013-09-25) the whole document	1-22
A	US 2013294399 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 07 November 2013 (2013-11-07) the whole document	1-22



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

16 December 2015

Date of mailing of the international search report

08 January 2016

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/075457

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103517426	A	15 January 2014	None			
US	2012327894	A1	27 December 2012	WO	2013000814	A2	03 January 2013
				CN	103621146	A	05 March 2014
				JP	2014526159	A	02 October 2014
				US	2014357272	A1	04 December 2014
				EP	2724565	A2	30 April 2014
CN	103327615	A	25 September 2013	WO	2013139278	A1	26 September 2013
				EP	2830378	A1	28 January 2015
				US	2015009939	A1	08 January 2015
US	2013294399	A1	07 November 2013	KR	20130119867	A	01 November 2013