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(54) Title: METHODS AND APPARATUSES FOR ADJUSTING CWS VALUE AT UE SIDE FOR UL TRANSMISSIONS

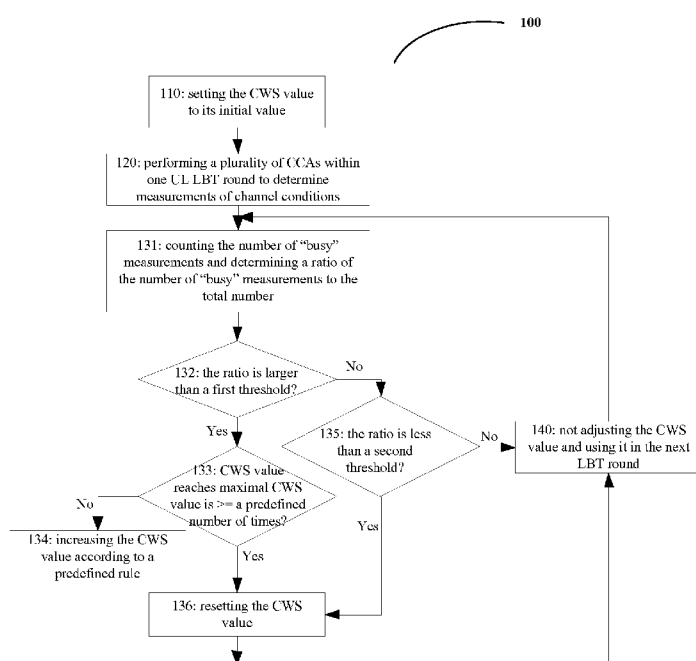


FIG. 1

(57) Abstract: The disclosure provides methods and apparatuses for adjusting a CWS value between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions. The method includes performing a plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and adjusting the CWS value according to the measurements of channel conditions in the plurality of CCAs for use in the next UL LBT round. Another method includes acquiring information about HARQ feedback values for a reference subframe set; and adjusting the CWS value according to the information for use in a next LBT round.



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METHODS AND APPARATUSES FOR ADJUSTING CWS VALUE AT UE SIDE FOR UL TRANSMISSIONS

FIELD

[0001] The present disclosure relates to the field of radio communication, and more specifically, to methods and apparatuses for adjusting a Contention Window Size (CWS) at a User Equipment (UE) side for Uplink (UL) transmissions.

BACKGROUND

[0002] In the Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) Rel-13, Downlink (DL) transmission is specified for Licensed-Assisted Access (LAA) to unlicensed spectrum (see document [1]). Listen-before-talk (LBT) is defined for LAA, which requires the base station to perform a channel access procedure before transmission, and it can only transmit when this procedure success. That is to say, before data transmission, a Clear Channel Assessment (CCA) through energy usage detection, carrier detection or a combination thereof, for example, is performed such that the channel may be accessed only if the channel condition is assessed to be idle by the base station.

[0003] In RAN#70, a new work item on enhanced Licensed-Assisted Access (eLAA) for LTE is approved to support LAA SCell operation on unlicensed spectrum for uplink (UL) (see document [2]). In the eLAA, a User Equipment (UE) should also perform a LBT operation before its data transmission. UL LBT based on a Cat-4 channel access procedure is agreed to be supported in RAN1 #84.

[0004] However, since a channel is used by multiple UEs for the UL transmission, the UL transmission is more complex than DL transmission.

[0005] Since a UE is only allocated with a part of the full bandwidth, when multiple UEs begin their UL transmissions after winning the channel through LBT, the start borders of their UL transmissions should be aligned. Otherwise the problem of interlock among the UEs would occur. A locked UE has to wait for the next UL transmission opportunity. There is no interlock problem among the base stations in DL transmissions.

[0006] In the UL transmissions, multiple UEs are multiplexed, whereas there is no such multiplexing among the base stations in DL transmissions. As a result, the contention among the UEs is very critical that it decides whether a UE is able to access the channel in time.

[0007] For example, not all UEs will have UL transmissions at their scheduled time, e.g., due to the interference from nearby other Radio Access Technologies (RATs) or neighboring UEs. Thus, the LBT parameters related to the contention among UEs should reflect the channel conditions and be flexible.

5 [0008] Therefore, if the scheduled UEs could not win the channel for a long time, it is necessary to adjust the LBT parameters related to the contention of these UEs.

[0009] The LBT parameters for the UL transmission of a UE could be either adjusted by the UE itself or by the serving base station of the UE. However, since the UE could rapidly obtain the real-time channel conditions, e.g., by CCA, and the final application of the adjusted LBT
10 parameters is at the UE side, a solution for adjusting LBT parameters for UL transmissions by the UE will be specifically investigated.

SUMMARY

[0010] In view of this, a LBT parameter adjustment mechanism at the UE side is designed for the UL transmission of UEs in the unlicensed band. The target of the adjustment is for the
15 harmony co-existence of the UEs, especially when their UL transmissions are multiplexed. The adjustment is mainly performed by the UE adjusting its contention window size.

[0011] According to some embodiments of the present disclosure, there is provided a method for adjusting a CWS value between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions. The method includes performing a
20 plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and adjusting the CWS value according to the measurements of channel conditions in the plurality of CCAs for use in a next UL LBT round.

[0012] According to another embodiment of the present disclosure, there is provided a method for adjusting a CWS value between a predefined minimal CWS value and a
25 predefined maximal CWS value at a UE side for UL transmissions. The method includes acquiring information about HARQ feedback values for a reference subframe set; and adjusting the CWS value according to the information about HARQ feedback values for use in a next UL LBT round.

[0013] According to another embodiment of the present disclosure, there is provided an
30 apparatus for adjusting a CWS value between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions. The apparatus includes a

CCA measuring unit configured to perform a plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and a CWS adjusting unit configured to adjust the CWS value according to the measurement of channel conditions in the plurality of CCAs for use in a next UL LBT round.

- 5 [0014] According to another embodiment of the present disclosure, there is provided an apparatus for adjusting a CWS value between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions. The apparatus includes a HARQ feedback value acquiring unit configured to acquire information about HARQ feedback values for a reference subframe set; and a CWS adjusting unit configured to adjust
10 the CWS value according to the information about the HARQ feedback values for use in a next UL LBT round.

[0015] With the solutions of this disclosure, by adjusting CWS values at the UE side, the problem of interlock and contention among UL transmissions of multiple UEs can be solved and the efficiency of adjustment of LBT parameters can be improved.

15 BRIEF DESCRIPTION OF THE DRAWINGS

[0016] This disclosure will be better understood and other features, objectives and advantages of the present disclosure will become more apparent from following detailed description of the embodiments of the disclosure in conjunction with the accompanying drawings, wherein:

- [0017] FIG. 1 illustrates a flow chart of a method for adjusting a CWS value at a UE side for
20 UL transmissions according to some embodiments of this disclosure;

[0018] FIG. 2 illustrates a schematic view of a UL LBT process with a variable CWS value;

[0019] FIG. 3 illustrates a flow chart of a method for adjusting a CWS value at a UE side for UL transmissions according to some other embodiments of this disclosure;

- [0020] FIG. 4 illustrates a block diagram of an apparatus for adjusting a CWS value at a UE
25 side for UL transmissions according to some embodiments of this disclosure; and

[0021] FIG. 5 illustrates a block diagram of an apparatus for adjusting a CWS value at a UE side for UL transmissions according to some other embodiments of this disclosure.

DETAILED DESCRIPTION

- [0022] Preferred embodiments of this disclosure will be described below in conjunction with
30 accompanying drawings. Although preferred embodiments are shown in accompanying

drawings, it should be understood that this disclosure can be implemented in various forms but not be limited by the embodiments described herein. On the contrary, these embodiments are provided to make the disclosure more thorough and complete and to make the scope of this disclosure delivered to those skilled in this art completely.

- 5 [0023] FIG. 1 illustrates a flow chart of a method 100 for adjusting a CWS value at a UE side for UL transmissions according to some embodiments of this disclosure. In the method 100, the CWS value is adjusted based on a CCA measurement.

[0024] As stated above, before a UL transmission, the UE can perform a plurality of CCAs within one UL LBT round to determine the channel conditions. FIG. 2 illustrates a schematic
10 view of a UL LBT process with a variable CWS value. As shown in FIG. 2, it is assumed that the first two symbols of the starting subframe in a burst transmission are reserved for the LBT process for the UL transmissions. It can be seen that the UE performs a plurality of CCAs after a contention window within one LBT round. After the UE have completed the plurality of CCAs in the LBT round and won the channel, no preamble would be transmitted. Instead, a
15 self-defer period would be applied in order to make the UL transmissions of multiple UEs are aligned in time. In the method 100, the CWS value is adjusted according to the CCA measurement in current LBT process so as to be used in the next LBT round.

[0025] It is to be noted that the CWS value adjustment is also applicable to the LBT process in the Uplink Pilot Time Slot (UpPTS). Furthermore, it can be understood by those skilled in
20 this art that FIG. 2 illustrates a frame structure with each subframe including 12 symbols (i.e. an extended Cyclic Prefix(CP) case) as an example. However, this disclosure can be similarly applied to a case in which each subframe includes 14 symbols (i.e. a normal CP case).

[0026] It is assumed that there are a maximum CWS value, CWS_{max} , and a minimum CWS value, CWS_{min} , predefined for each UE whose CWS value is adjustable between CWS_{max} and
25 CWS_{min} . Furthermore, CWS_{max} and CWS_{min} could be the same for all UEs or be different for different UEs. For simplicity, a case in which each UE has a same maximum CWS value and minimum CWS value is considered.

[0027] As shown in FIG. 1, the method 100 begins from Step 110, in which the CWS value of the UE is set to its minimum CWS value CWS_{min} as its initial value.

30 [0028] However, this disclosure is not limited thereto. The initial value of the CWS value of the UE can be set to any value between the CWS_{max} and the CWS_{min} without departing from the scope of the disclosure.

[0029] In Step 120, a plurality of CCAs are preformed within one UL LBT round to determine the measurements of the channel conditions in respective CCAs.

[0030] As stated above, an energy usage detection, a carrier detection or a combination thereof can be used to perform the CAAs, and the channel condition may be determined to be “busy” or “idle” according to the measurement. Methods for performing the CCAs are well-known for those skilled in this art and therefore will not be described herein.

[0031] Next, in Step 130, the CWS value is adjusted according to the measurements of Step 120 for use in the next UL LBT round.

[0032] Specifically, Step 130 includes Step 131, in which the number of “busy” measurements of channel conditions in Step 120 is counted, and a ratio of the number of “busy” measurements of channel conditions to the total number of CCAs is determined.

[0033] In Step 132, it is determined whether the ratio is larger than a first threshold.

[0034] If the determination result of Step 132 is “Yes”, which indicates that the channel condition is bad, then the CWS value is increased according to a predefined rule (Step 134).

[0035] In one implementation, the predefined rule includes increasing exponentially. For example, the CWS value is doubled in each adjustment.

[0036] In another implementation, the predefined rule includes increasing linearly. For example, if it is assumed that the possible range of the CWS value is {3, 4, 5, 6, 7}, then the CWS value can be gradually increased in each adjustment in the order of the discrete values within that range.

[0037] Between Step 132 and Step 134, Step 133 may further be included, in which it is determined whether the number of times that the CWS value reaches the maximal CWS value is larger than or equal to a predefined number of times, and the CWS value is increased according to the predefined rule only when it is determined that the number of times that the CWS value reaches the maximal CWS value is smaller than the predefined number of times (the result of Step 333 is “No”) (Step 134).

[0038] On the other hand, if the determination result of Step 132 is “No”, then it is further determined whether the ratio is less than a second threshold that is less than the first threshold (Step 135) .

[0039] If the determination result of Step 135 is “Yes”, which indicates that the channel condition is relatively idle, then the CWS value is reset to the minimum CWS value (Step

136).

[0040] In another implementation, it is determined whether the UE is scheduled in a predefined period of time, and the CWS value is reset to the minimal CWS value (not shown in the figure) when it is determined that the UE is not scheduled in the predefined period of time.

[0041] After Step 136 or when the determination result of Step 135 is “No” (which indicates that the ratio of the number of “busy” measurements of channel conditions to the total number of CCAs is within a normal range (i.e. larger than the second threshold and less than the first threshold)), the CWS value is left unadjusted and the current CWS value will be used for the next LBT round (Step 140).

[0042] FIG. 3 illustrates a flow chart of a method 300 for adjusting a CWS value at a UE side for UL transmissions according to some other embodiments of this disclosure. In the method 300, the CWS value is adjusted based on a Hybrid Automatic Repeat request (HARQ) feedback value for use in the next UL LBT round.

[0043] Similar to the method 100, it is assumed that there are a maximum CWS value, CWS_{max} , and a minimum CWS value, CWS_{min} , predefined for each UE whose CWS value is adjustable between CWS_{max} and CWS_{min} . Furthermore, CWS_{max} and CWS_{min} could be the same for all UEs or be different for each UE. For simplicity, a case in which each UE has a same maximum CWS value and minimum CWS value is considered.

[0044] As shown in FIG. 3, the method 300 begins from Step 310, in which the CWS value of the UE is set to its minimum CWS value CWS_{min} as its initial value.

[0045] However, this disclosure is not limited thereto. The initial value of the CWS value of the UE can be set to any value between the CWS_{max} and the CWS_{min} without departing from the scope of the disclosure.

[0046] In Step 320, the UE acquires information about HARQ feedback values for a reference subframe set. The HARQ feedback values include acknowledge (ACK) and nonacknowledge (NACK).

[0047] In one implementation, the UE can acquire the HARQ feedback values by detecting a corresponding Physical Downlink Control Channel (PDCCH)/Enhanced Physical Downlink Control Channel (EPDCCH) with the Downlink Control Information (DCI) format 0/4. For example, the UE can acquire a HARQ feedback value for a previous UL transmission by

detecting whether a new UL transmission is indicated in the PDCCH or EPDCCD.

[0048] In another implementation, the UE can obtain the HARQ feedback values (ACK/NACK) from a Physical Hybrid ARQ Indicator Channel (PHICH) in a licensed Carrier Component (CC).

5 [0049] In yet another implementation, the UE can obtain the HARQ feedback values (ACK/NACK) from a PHICH in an unlicensed CC if the PHICH is configured on that unlicensed CC.

[0050] Herein, it is described by taking an example that the base station transmits the HARQ feedbacks to the UE through a PHICH, however, it should be understood by those skilled in
10 this art that the HARQ feedback can be achieved by other mechanisms.

[0051] Furthermore, with regard to the reference subframe set, several examples are given below in this disclosure.

[0052] In one example, the HARQ feedback values of the reference subframe set may be the ACK or NACK of the first subframe in the previous burst. The contentions and collisions are
15 most likely to occur at the beginning of a burst. The afterwards transmission in a burst would grasp and hold the channel, during which the other RATs or UEs would detect the channel as busy and refrain from transmission.

[0053] In another example, the HARQ feedback values of the reference subframe set may be the ACK or NACK of the last subframe that has an available ACK/NACK in the previous
20 burst. That is because the last subframe with available ACK/NACK in the previous burst is the feedback of the most recent transmission in the UL unlicensed channel. This ACK/NACK is more accurately indicating the UL channel conditions.

[0054] In yet another example, the HARQ feedback values of the reference subframe set may be the ACKs or NACKs of all the subframes in the previous burst. That is to say, all the
25 ACK/NACKs of the subframes in the previous burst could be used for the CWS adjustment.

[0055] Next, in Step 330, the CWS value is adjusted according to the information about the HARQ feedback values acquired in Step 320 for use in the next UL LBT round.

[0056] Specifically, Step 330 includes Step 331, in which the ratio of NACKs to the HARQ feedback values of the reference subframe set is acquired.

30 [0057] In one implementation, the UE receives each individual HARQ feedback value (ACK or NACK) of the reference subframe set from the base station by any of the above methods,

and calculates the ratio of NACKs.

[0058] In another implementation, the UE receives a statistic about the HARQ feedback values of the reference subframe set, instead of individual ACK or NACK, from the base station, wherein the statistic indicates the ratio of NACKs to the HARQ feedback values of the reference subframe set.

[0059] In Step 332, it is determined whether the ratio is larger than a third threshold.

[0060] If the determination result of Step 332 is “Yes”, which indicates that the channel condition is bad, then the CWS value is increased according to a predefined rule (Step 334).

[0061] In one implementation, the predefined rule includes increasing exponentially. For example, the CWS value is doubled in each adjustment.

[0062] In another implementation, the predefined rule includes increasing linearly. For example, if it is assumed that the possible range of the CWS value is {3, 4, 5, 6, 7}, then the CWS value can be gradually increased in each adjustment in the order of the discrete values within that range.

[0063] Between Step and Step 334, Step 333 may further be included, in which it is determined whether the number of times that the CWS value reaches the maximal CWS value is larger than or equal to a predefined number of times, and the CWS value is increased according to the predefined rule only when it is determined that the number of times that the CWS value reaches the maximal CWS value is smaller than the predefined number of times (the result of Step 333 is “No”) (Step 334).

[0064] On the other hand, if the determination result of Step 332 is “No”, then it is further determined whether the ratio is less than a fourth threshold that is less than the third threshold (Step 335).

[0065] If the determination result of Step 335 is “Yes”, which indicates that the channel condition is relatively idle, then the CWS value is reset to the minimum CWS value (Step 336).

[0066] In another implementation, it is determined whether the UE is scheduled in a predefined period of time, and the CWS value is reset to the minimal CWS value (not shown in the figure) when it is determined that the UE is not scheduled in the predefined period of time.

[0067] After Step 336 or when the determination result of Step 335 is “No” (which indicates

that the ratio of NACKs to the HARQ feedback values of the reference subframe set is within a normal range (i.e. larger than the fourth threshold and less than the third threshold)), the CWS value is left unadjusted and the current CWS value will be used for the next LBT round (Step 340).

- 5 **[0068]** According to another aspect of this disclosure, in method 100 or 300, when only one LBT process is maintained by the UE for all traffic types, the CWS adjustment can be designed as below.

10 **[0069]** In one design, when the CWS of traffics belonging to one priority class (class 1, for example) is adjusted and a new traffic type of another priority class begins to transmit, there is no adjustment for the CWS values of other priority classes. Since the UE traffic is assigned with a specific priority, the CWS value is adapted by process and it works well for the priority class 1. The UE would begin a new CWS adapting process for the new traffic type according to the channel conditions and win the channel.

15 **[0070]** In another design, when the CWS of traffics belonging to one priority class (class 1, for example) is adjusted and a new traffic type of another priority class begins to transmit, there is an adjustment of the CWS values for all priority classes. The CWS shall be adjusted since a new traffic type arrives and it is belonging to a different priority class with a different CWS. The adjustment would ease the new traffic type to adapt to the channel conditions.

20 **[0071]** According to another aspect of this disclosure, in method 100 or 300, when multiple LBT processes with different CWS values are maintained simultaneously by the UE and one traffic type corresponds to one LBT process, the CWS value of each LBT process can be adjusted according any one of method 100 or 300.

25 **[0072]** In view of flexibility and efficiency, several LBT processes could be maintained for the UE UL transmission of different traffic types in the unlicensed band. Usually, each traffic type has a specific priority class, and specific priority classes have different CWSs. When the UL transmission is granted by the base station, the base station does not know which traffic type the UE intends to deliver. At this time, it is up to the UE to decide the traffic type for transmission. Therefore, the UE shall simultaneously maintain several LBT processes with different CWS values and one traffic type corresponds to one LBT process. The CWS value
30 of each LBT process might be adjusted independently. Once one of the LBT processes first wins the channel, the associated traffic type would be delivered first.

[0073] FIG. 4 illustrates a block diagram of an apparatus 400 for adjusting a CWS value

between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions according to some embodiments of this disclosure.

[0074] As shown in FIG. 4, the apparatus 400 includes a CCA measuring unit 410 configured to perform a plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and a CWS adjusting unit 420 configured to adjust the CWS value according to the measurements of the channel conditions in the plurality of CCAs for use in a next UL LBT round.

[0075] In one implementation, the CWS adjusting unit 420 is further configured to count a number of “busy” measurements of channel conditions and to adjust the CWS value according to a ratio of the number of “busy” measurements of channel conditions to a total number of the plurality of CCAs.

[0076] In one implementation, the CWS adjusting unit 420 is further configured to increase the CWS value according to a predefined rule if the ratio is larger than a first threshold.

[0077] In one implementation, the predefined rule includes increasing exponentially or linearly.

[0078] In one implementation, the CWS adjusting unit 420 is further configured to reset the CWS value to a minimum CWS value if the ratio is less than a second threshold.

[0079] In one implementation, the CWS adjusting unit 420 is further configured to determine whether a number of times that the CWS value reaches the maximal CWS value is larger than or equal to a predefined number of times and to reset the CWS value to the minimum CWS value if it is determined that the number of times that the CWS value reaches the maximal CWS value is larger than or equal to the predefined number of times.

[0080] In one implementation, the CWS adjusting unit 420 is further configured to determine whether the UE is scheduled in a predefined period of time and to reset the CWS value to the minimal CWS value if it is determined that the UE is not scheduled in the predefined period of time.

[0081] FIG. 5 illustrates a block diagram of an apparatus 50 for adjusting a CWS value between a predefined minimal CWS value and a predefined maximal CWS value at a UE side for UL transmissions according to some other embodiments of this disclosure.

[0082] As shown in FIG. 5, the apparatus 500 includes a HARQ feedback value acquiring unit 510 configured to acquire information about HARQ feedback values for a reference subframe

set; and a CWS adjusting unit 520 configured to adjusting the CWS value according to the information about HARQ feedback values for use in a next UL LBT round.

[0083] In one implementation, the HARQ feedback value acquiring unit 510 is configured to acquire the HARQ feedback values by any one of: obtaining the HARQ feedback values by detecting a Physical Downlink Control Channel (PDCCH)/Enhanced Physical Downlink Control Channel (EPDCCH) with a Downlink Control Information (DCI) format 0/4; obtaining the HARQ feedback values from a Physical Hybrid ARQ Indicator Channel (PHICH) in a licensed Carrier Component (CC); obtaining the HARQ feedback values from a PHICH in an unlicensed CC; or receiving a statistic about HARQ feedback values of the reference subframe set from the serving base station of the UE, wherein the statistic indicates the ratio of NACKs to the HARQ feedback values of the reference subframe set.

[0084] In one implementation, the CWS adjusting unit 520 is configured to acquire the ratio of NACKs to the HARQ feedback values of the reference subframe set and to adjust the CWS value according to the ratio.

[0085] In one implementation, the HARQ feedback values of the reference subframe set includes any one of: ACK or NACK of a first subframe in a previous burst; ACK or NACK of a last subframe that has an available ACK or NACK in a previous burst; or ACKs or NACKs of all subframes in a previous burst.

[0086] In one implementation, the CWS adjusting unit 520 is further configured to increase the CWS value according to a predefined rule if the ratio is larger than a third threshold.

[0087] In one implementation, the predefined rule includes increasing linearly or exponentially.

[0088] In one implementation, the CWS adjusting unit 520 is further configured to reset the CWS value to the minimal CWS value if the ratio is less than a fourth threshold.

[0089] In one implementation, the CWS adjusting unit 520 is further configured to determine whether the number of times that the CWS value reaches the maximal CWS value is larger than or equal to a predefined number of times and to reset the CWS value to the minimal CWS value if it is determined that the number of times that the CWS value reaches the maximal CWS value is larger than or equal to the predefined number of times.

[0090] In one implementation, the CWS adjusting unit 520 is configured to determine whether the UE is scheduled in a predefined period of time and to reset the CWS value to the

minimal CWS value if it is determined that the UE is not scheduled in the predefined period of time.

[0091] Herein, the first, second, third and/or fourth threshold, the predefined number of times (k) and the predefined period of time can be preset according to specific application or experiences. For example, the first threshold can be set to 70%; the second threshold can be set to 10%; the third threshold can be set to 80%; and the fourth threshold can be set to 10% as long as it is guaranteed that the first threshold is larger than the second threshold and the third threshold is larger than the fourth threshold. The predefined number of times (k) can be set to any positive integral and the predefined period of time can be set to several minutes after the UE becomes active.

[0092] According to solutions of this disclosure, by adjusting the CWS value at the UE side, the problem of interlock and contention among the UL transmissions of multiple UEs can be solved and the efficiency of adjustment for LBT parameters can be improved.

[0093] In the description, the methods of the present disclosure have been described with reference to accompanying figures. It is understood by those skilled in this art that any specific order of steps illustrated in the accompanying figures and described in the description is only illustrative such that the method steps and/or actions can be performed in other orders other than the specific order of steps illustrated in the accompanying figures and described in the description while remaining within the scope of the present disclosure.

[0094] In one or more exemplary embodiments, the functions described by this application may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both a computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted

pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium.

[0095] The various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented within or performed by a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0096] Those of ordinal skill in this art would further appreciate that any of the various illustrative logical blocks, modules, processors, means, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0097] The previous description of the disclosed aspects is provided to enable any person skilled in the art to make or use the present disclosure. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects without departing from the scope of the disclosure. Thus, the present disclosure is not intended to be limited to the examples and designs shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

Documents:

[1] 3GPP TS 36.213, "E-UTRA; Physical layer procedures (Release-13)", v13.0.0, Dec. 2015.

[2] RP-152272, "New Work Item on enhanced LAA for LTE," Ericsson, Huawei, 7th
5 -10th Dec. 2015

I/We Claim:

1. A method for adjusting a Contention Window Size (CWS) value between a predefined minimal CWS value and a predefined maximal CWS value at a User Equipment (UE) side for Uplink (UL) transmissions, comprising:

performing a plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and

adjusting the CWS value according to the measurements of channel conditions in the plurality of CCAs for use in a next UL LBT round.

2. The method of claim 1, wherein adjusting the CWS value according to the measurements of channel conditions in the plurality of CCAs comprises:

counting a number of “busy” measurements of channel conditions in the plurality of CCAs; and

adjusting the CWS value according to a ratio of the number of “busy” measurements of channel conditions in the plurality of CCAs to a total number of the plurality of CCAs.

3. The method of claim 2, wherein adjusting the CWS value according to the ratio comprises:

increasing the CWS value according to a predefined rule if the ratio is larger than a first threshold.

4. The method of claim 3, wherein the predefined rule includes increasing linearly or exponentially.

5. The method of claim 2, wherein adjusting the CWS value according to the ratio comprises:

resetting the CWS value to the minimal CWS value if the ratio is less than a second threshold.

6. The method of claim 3, further comprising:

determining whether a number of times that the CWS value reaches the maximal CWS value is larger than or equal to a predefined number of times; and

resetting the CWS value to the minimal CWS value if it is determined that the number of times that the CWS value reaches the maximal CWS value is larger than or equal to the predefined number of times.

7. The method of claim 3, further comprising:

determining whether the UE is scheduled in a predefined period of time; and

resetting the CWS value to the minimal CWS value if it is determined that the UE is

not scheduled in the predefined period of time.

8. A method for adjusting a Contention Window Size (CWS) value between a predefined minimal CWS value and a predefined maximal CWS value at a User Equipment (UE) side for Uplink (UL) transmissions, comprising:

5 acquiring information about HARQ feedback values for a reference subframe set; and
 adjusting the CWS value according to the information about the HARQ feedback values for use in a next UL LBT round.

9. The method of claim 8, wherein acquiring information about HARQ feedback values for a reference subframe set comprises any one of:

10 acquiring the HARQ feedback values by detecting a PDCCH/EPDCCH with a DCI format 0/4;

 obtaining the HARQ feedback values from a PHICH in a licensed CC;

 obtaining the HARQ feedback values from a PHICH in an unlicensed CC; or

 receiving a statistic of the HARQ feedback values of the reference subframe set from a
15 serving base station of the UE, wherein the statistic indicates a ratio of NACKs to the HARQ feedback values of the reference subframe set.

10. The method of claim 8, wherein adjusting the CWS value according to the information about the HARQ feedback values comprises:

 acquiring a ratio of NACKs to the HARQ feedback values of the reference subframe
20 set; and

 adjusting the CWS value according to the ratio.

11. The method of claim 10, wherein the HARQ feedback values of the reference subframe set comprise any one of:

 ACK or NACK of a first subframe in a previous burst;

25 ACK or NACK of a last subframe which has an available ACK or NACK in a previous burst transmission; or

 ACKs or NACKs of all subframe in a previous burst transmission.

12. The method of claim 10, wherein adjusting the CWS value according to the ratio comprises:

30 increasing the CWS value according to a predefined rule if the ratio is larger than a third threshold.

13. The method of claim 12, wherein the predefined rule includes increasing linearly or exponentially.

14. The method of claim 10, wherein adjusting the CWS value according to the ratio

comprises:

resetting the CWS value to the minimal CWS value if the ratio is less than a fourth threshold.

15. The method of claim 12, further comprising:

5 determining whether a number of times that the CWS value reaches the maximal CWS value is greater than or equal to a predefined number of times; and

resetting the CWS value to the minimal CWS value if it is determined that the number of times that the CWS value reaches the maximal CWS value is greater than or equal to the predefined number of times.

10 16. The method of claim 12, further comprising:

determining whether the UE is scheduled in a predefined period of time; and

resetting the CWS value to the minimal CWS value if it is determined that the UE is not scheduled in the predefined period of time.

15 17. An apparatus for adjusting a Contention Window Size (CWS) value between a predefined minimal CWS value and a predefined maximal CWS value at a User Equipment (UE) side for Uplink (UL) transmissions, comprising:

a CCA measuring unit configured to perform a plurality of CCAs within one UL LBT round to determine measurements of channel conditions in respective CCAs; and

20 a CWS adjusting unit configured to adjust the CWS value according to the measurements of channel conditions in the plurality of CCAs for use in a next UL LBT round.

18. An apparatus for adjusting a Contention Window Size (CWS) value between a predefined minimal CWS value and a predefined maximal CWS value at a User Equipment (UE) side for Uplink (UL) transmissions, comprising:

25 a HARQ feedback value acquiring unit configured to acquire information about HARQ feedback values for a reference subframe set; and

a CWS adjusting unit configured to adjust the CWS value according to the information about the HARQ feedback values for use in a next UL LBT round.

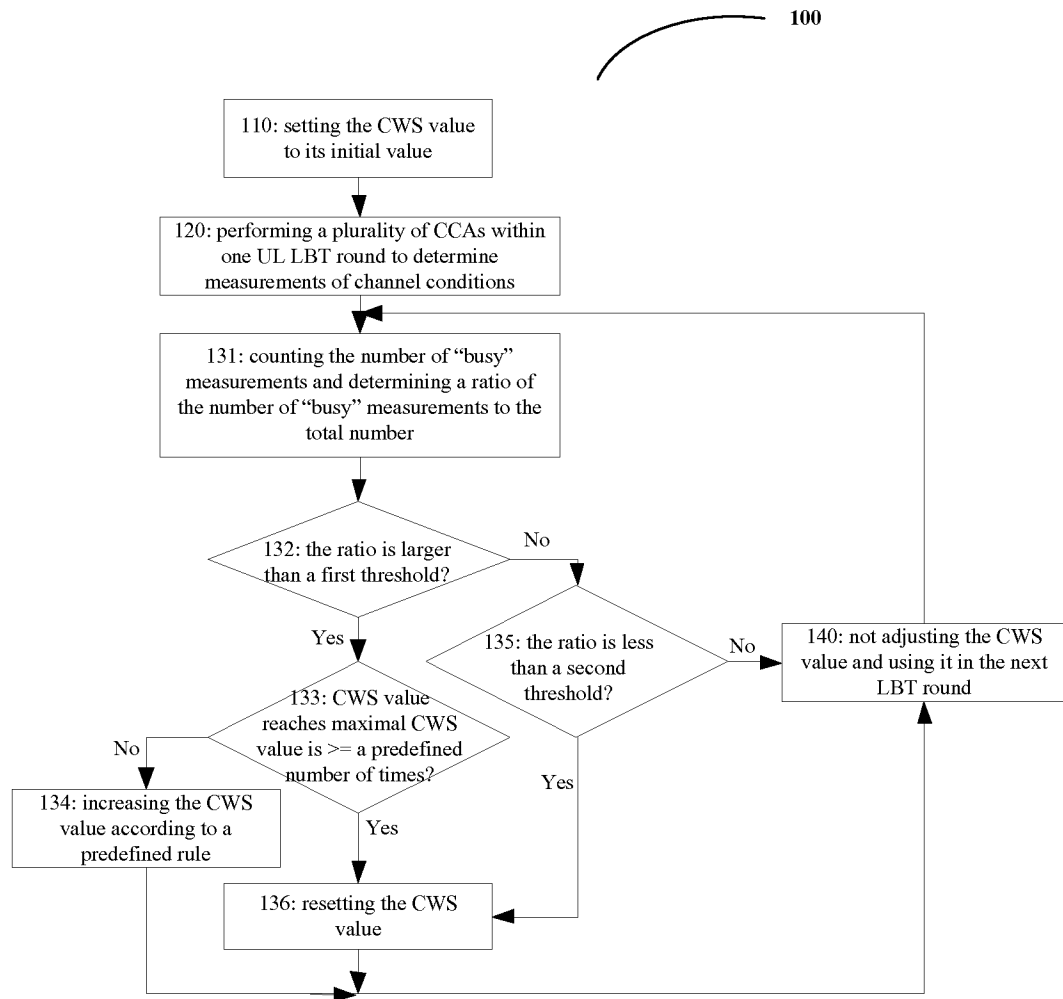


FIG. 1

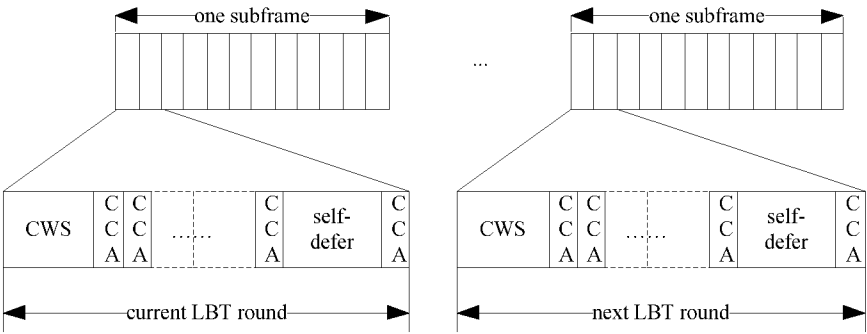


FIG. 2

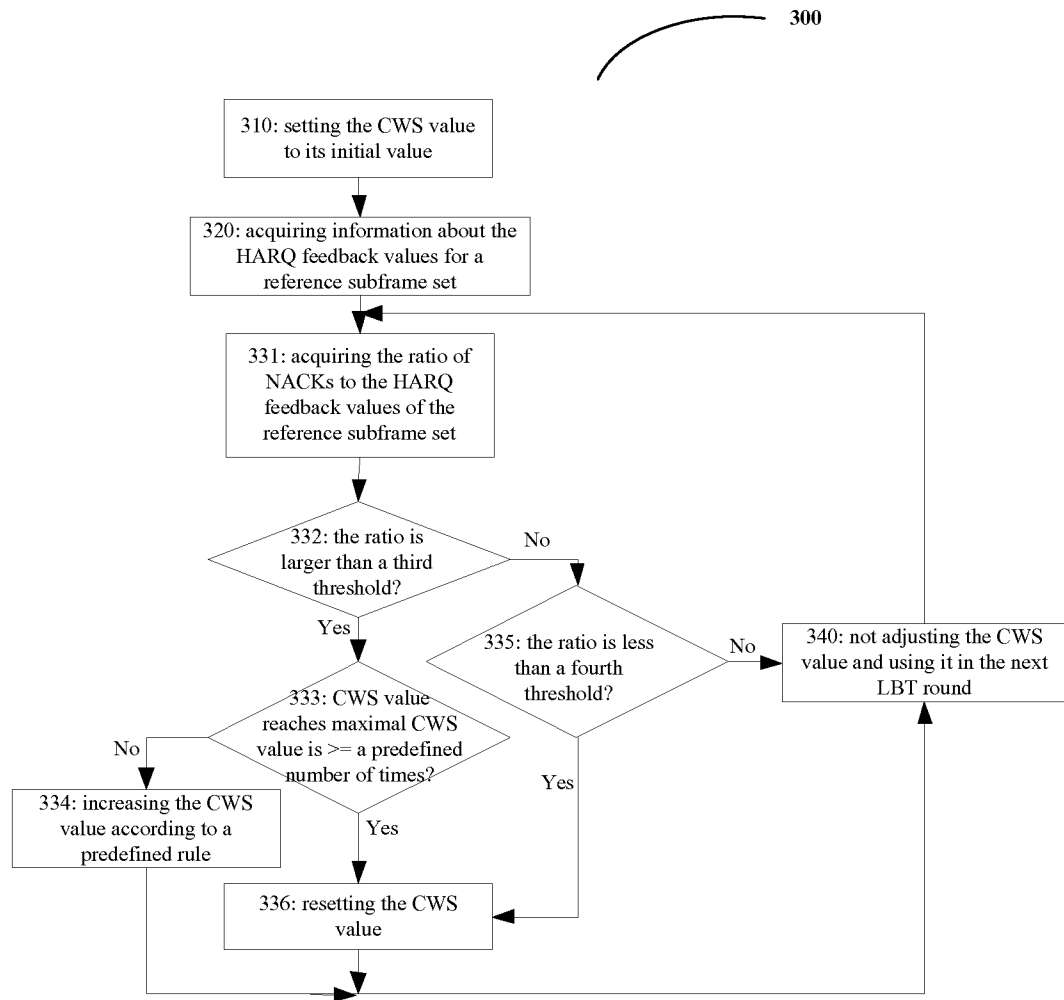


FIG. 3

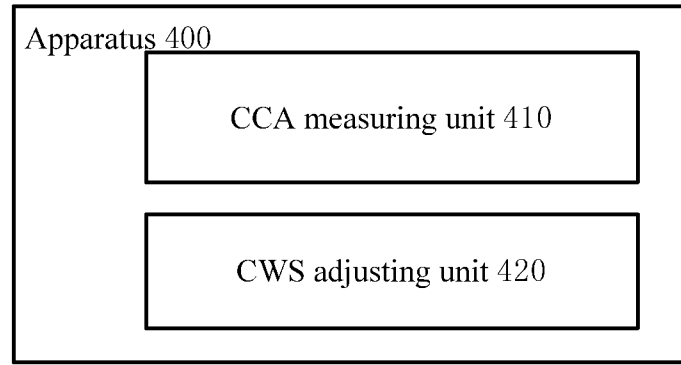


FIG. 4

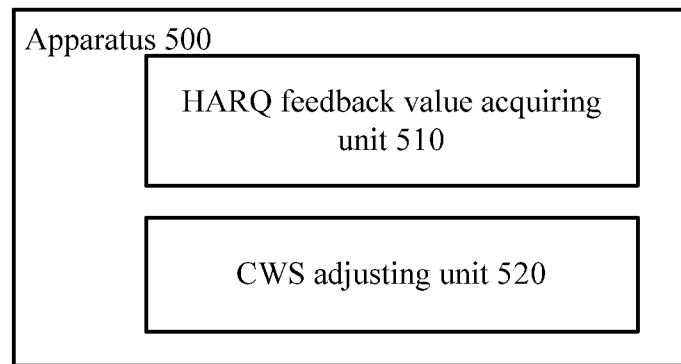


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/000506

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W74/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>CABLELABS: "LBT with Exponential Backoff Process for Fair Channel Access", 3GPP DRAFT; R1-150269 LBT WITH EXPONENTIAL V1, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Athens, Greece; 20150209 - 20150213 8 February 2015 (2015-02-08), XP050933481, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2015-02-08] paragraphs [0001], [02.1], [02.2] ----- -/--</p>	1-7,17

☒ 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

26 July 2017

Date of mailing of the international search report

03/08/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/000506

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>ERICSSON: "Coexistence Evaluation Results for DL+UL LAA with Cat 4 UL LBT", 3GPP DRAFT; R1-153129, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Fukuoka, Japan; 20150525 - 20150529 24 May 2015 (2015-05-24), XP050973084, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2015-05-24] paragraph [02.2]</p> <p>-----</p>	8-16,18
A	<p>ERICSSON: "Discussion on LBT Protocols", 3GPP DRAFT; R1-151996, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Belgrade, Serbia; 20150420 - 20150424 11 April 2015 (2015-04-11), XP050950277, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_80b/Docs/ [retrieved on 2015-04-11] paragraph [02.2]</p> <p>-----</p>	8-18
A	<p>LG ELECTRONICS: "DL LBT operation with variable contention window size", 3GPP DRAFT; R1-152732 CAT 4 DESIGN FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Fukuoka, Japan; 20150525 - 20150529 16 May 2015 (2015-05-16), XP050972717, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_81/Docs/ [retrieved on 2015-05-16] paragraph [0002]</p> <p>-----</p> <p style="text-align: center;">-/--</p>	1-18

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/000506

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>SHARP: "LAA contention window size adjustment with HARQ-ACK", 3GPP DRAFT; R1-155566, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE</p> <p>, vol. RAN WG1, no. Malmö, Sweden; 20151005 - 20151009 4 October 2015 (2015-10-04), XP051039693, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2015-10-04] paragraphs [0002], [0003] -----</p>	1-18