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(54) Title: METHODS OF TRANSMISSION ON UNLICENSED SPECTRUM

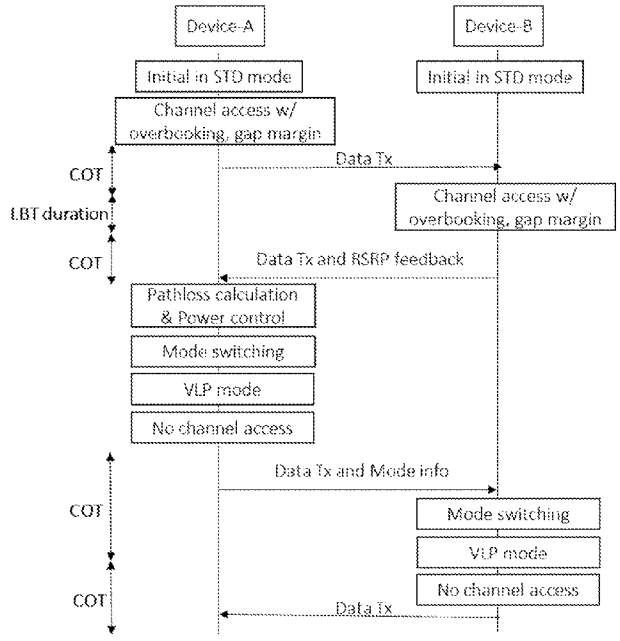


Figure 1

(57) Abstract: This disclosure describes the methods of transmission on unlicensed spectrum. The UE can switch between STD mode and VLP mode according to the maximum transmission power and/or the power after the power control based on pathloss. The mode determination and/or switching can be (pre-) configured and/or dynamically indicated by gNB, and/or cluster header, and/or the UE itself. The behaviors UE can execute in each mode (e.g., channel access, overbooking, gap margin) is also presented in this disclosure.

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METHODS OF TRANSMISSION ON UNLICENSED SPECTRUM

FIELD

The invention discussed below relates generally to wireless communication systems, and more particularly, to the methods of transmission on unlicensed spectrum.

BACKGROUND

To meet the increased demands of wireless data traffic, the utilization of unlicensed spectrum has drawn a lot of attention to improve the capacity of future wireless communication systems. For the device operated on unlicensed spectrum, different transmission methods can be applied to simplify the channel access procedures. Specifically, very-low-power (VLP) operation has been widely used or considered in some regions (e.g., EU/CN) for the important 5/6 GHz spectrum. For example, in EU, ECC Decision (20)01 supports Lower Power Indoor (LPI) and VLP devices in 5925~6425MHz. VLP is specified for indoor and outdoor use with max EIRP 14 dBm and max EIRP density -8 dBm/MHz. In CN, VLP operation is supported at 5725-5850MHz with max EIRP 14 dBm. Therefore, similar to short control signaling mechanism and OCB exemption for the simplification of channel access, VLP can be considered as another approach to meet regulator requirement.

SUMMARY

The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

Various aspects of the present disclosure relate to the methods of transmission on unlicensed spectrum. The UE starting a transmission on unlicensed spectrum can work in different modes. For example, standard mode (i.e., STD mode) and/or very-low-power mode (i.e., VLP mode). The UE can initially work in and/or switch to STD mode and/or VLP mode, which can be (pre-)configured and/or indicated by gNB and/or cluster header and/or determined by the UE itself. The determination and/or switching of different modes can be based on the (pre-)configured maximum transmission power, and/or (pre-)configured maximum transmission power density, and/or the derived transmission power after power control, and/or the derived transmission power density after power control, and/or the mode indication signaling, and/or the ACK/NACK feedback, and/or the RSSI/RSRP measurement, and/or the traffic loading, and/or the CAPC/priority of the traffic. The UE can be (pre-)configured to report the mode information/status to gNB and/or cluster header and/or the receiver and/or the COT sharing UE(s) and/or the other UEs in the group according to the (pre)configuration. Besides, the UE may execute different behaviors (e.g., channel access type, overbooking mechanism, gap margin configuration) under different modes according to the

(pre-)configuration.

In another aspect of the disclosure, the methods of consecutive transmissions on unlicensed spectrum for both out-of-COT and within COT are presented. Specifically, the enhancements to retain the channel for the guard symbol at the end of the SL slot, and/or the guard symbol before PSFCH, and/or the case that there is no transmission on the PSFCH position are presented. Additionally, the methods to config default/common BWP and/or UE specific BWP are described.

To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed figures set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an exemplary diagram of the present methods of transmission on unlicensed spectrum with mode switching between STD and VLP according to the power control results and the mode indication.

FIG. 2 illustrates an exemplary diagram of the present methods of consecutive transmissions for the case that there is no transmission on the position of PSFCH.

DETAILED DESCRIPTION

The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

Several aspects of telecommunication systems will now be presented with reference to various apparatus and methods. These apparatus and methods will be described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as “elements”). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

This invention is motived by, but not limited to, a scenario that a wireless system operated on unlicensed spectrum. Considering that in such scenario, commercial use cases such as smart home, personal access network will be focused for the use cases, the low power operation may not cause any coverage problem issue. Instead, very-low-power (VLP) mode may essentially reduce the interference significantly

due to the short communication range and more friendly for co-existence subject to the regulator requirements based on extensive studies. Additionally, the VLP mode provides the possibility for on-chip PA implementation to support the low cost/power devices which are dominated/required for the unlicensed spectrum usage. For VLP mode, it may also simplify the implementation since channel access (e.g., FBE and/or LBE) and the mechanisms of overbooking and/or gap margin may not be necessary and hence make the design and implementation easier, more friendly for the IoT device and fast deployment.

In this disclosure, the methods of transmission on unlicensed spectrum are presented. The UE transmitting on unlicensed spectrum can work in different modes. For example, standard power mode (i.e., STD mode) and/or VLP mode and/or standard channel access mode and/or simplified channel access mode and/or no channel access mode. In the following part of the disclosure, STD and VLP modes are taken for example to illustrate the principle of the disclosure. Specifically, UE can report its UE capability on whether it can support VLP mode, e.g., only VLP mode, and/or VLP + STD mode, and/or only STD mode. For the case that VLP + STD mode can be supported by the UE capability, the UE can be further (pre-)configured whether to be allowed working in VLP mode and/or STD mode.

In this disclosure, STD mode and VLP mode can be determined and/or switched according to the (pre-)configured maximum EIRP and/or maximum EIRP density. For example, the UE can work in and/or switch to VLP mode if the (pre-)configured maximum EIRP smaller than a threshold (e.g., 14 dBm), and/or the maximum EIRP density smaller than a threshold (e.g., 1 dBm/MHz). Otherwise, the UE may work in and/or switch to the STD mode. The determination and/or switching of STD mode and VLP mode can be (pre-)configured and/or indicated by the gNB, then share the mode information to the eligible UE(s) via RRC and/or MAC-CE and/or one additional bit in PDCCH. Alternatively, the determination and/or switching of STD mode and VLP mode can be (pre-)configured and/or indicated by the cluster header, then share the mode information to the eligible UE(s) via PC5-RRC and/or PC5-MAC-CE and/or one additional bit in PSCCH and/or PSSCH. Alternatively, the determination and/or switching of STD mode and VLP mode can be conducted by the UE itself who intends to start a transmission

Alternatively, STD mode and VLP mode can be determined and/or switched according to the derived transmission power and/or the derived transmission power density after power control at the UE side. The power control mechanism can be (pre-)configured based on, for example, the SL pathloss, and/or DL pathloss, and/or the (pre-)configured maximum transmission power. For example, the UE may determine the transmission power according to the power control mechanism (e.g., derived based on the measured SL pathloss and/or (pre-)configured maximum transmission power). Then if the determined transmission power is smaller than the threshold (e.g., total EIRP power < 5dBm), and/or the determined transmission power density is smaller than a threshold (e.g., total EIRP density < -8 dBm/MHz), the UE may work in and/or switch to VLP mode for transmission which may skip channel access or do simplified channel access before transmission. Otherwise, the UE may work in and/or switch to STD mode for transmission which may need channel access before transmission.

Alternatively, STD mode and VLP mode can be determined and/or switched according to some other

configurations and/or implementations. For example, the mode determination and/or switching can be based on the ACK/NACK feedback, and/or the RSSI/RSRP measurement, and/or the traffic loading, and/or the CAPC/priority of the traffic and/or the mode indication. For example, if a UE working in VLP mode receives *N* NACK feedbacks continuously and/or totally (in a (pre-)configured duration), and/or no feedback was received for *N* (continuous) times, and/or no feedback was received in a (pre-)configured duration, the UE can determine whether switch to STD mode. Another example is that for the case that the UE working in STD mode, if the measured RSSI smaller than a (pre-)configured threshold (in a specific duration), the UE can determine whether switch to VLP mode.

If UE work in STD mode, it may need channel access (e.g., FBE and/or LBE) before it can transmit on the unlicensed spectrum. Besides, the gNB and/or UE may need to consider the timing issue caused by the uncertainty duration of channel access when allocate resource. For example, some mechanisms like overbooking, and/or gap margin may need to be configured by gNB and/or UE to combat the potential channel access failure. If UE work in VLP mode, it may directly start a transmission on the unlicensed spectrum without channel access or with a simplified channel access according to the (pre-)configuration. Besides, in the VLP mode, the gNB and/or UE may be no need of overbooking or gap margin mechanisms for addressing the timing issue.

In this disclosure, the STD mode and/or VLP mode may be applied per signals/channels depending on the total (EIRP) power and/or total (EIRP) power density for the transmission as (pre-)configuration. For example, PSCCH/PSSCH/PSFCH/S-SSB signals/channels can be transmitted with individual modes according to the corresponding total (EIRP) power and/or (EIRP) power density. Besides, for multiple channel access, the STD mode and/or VLP mode may be applied per channel access channel/RB set based on the total (EIRP) power and/or total (EIRP) power density of each channel access channel/RB set as (pre-)configuration.

In this disclosure, for the case that the determination and/or switching of STD mode and VLP mode is conducted by the UE, the UE can be (pre-)configured to report the mode information to the gNB via RRC and/or MAC-CE (i.e., PUSCH) and/or one additional bit in PUCCH. Additionally, the UE can be (pre-)configured to report the mode information to the cluster header/anchor UE via PC5-RRC and/or MAC-CE and/or one additional bit in 1st SCI and/or 2nd SCI. Additionally, the UE can be (pre-)configured to indicate the mode information to the other eligible UE(s) (e.g., the receiver and/or COT sharing UE(s) and/or the other UE(s) in the group) via PC5-RRC and/or MAC-CE and/or one additional bit in 1st SCI and/or 2nd SCI. For the case that the determination and/or switching of STD mode and VLP mode is conduct by the gNB, the gNB may (pre-)config and/or indicate the mode information to the eligible UE(s) via RRC and/or MAC-CE and/or one additional bit in PDCCH. For the case that the determination and/or switching of STD mode and VLP mode is conduct by the cluster header, the cluster header can be (pre-)configured to indicate the mode information to the eligible UE(s) via PC5-RRC and/or PC5-MAC-CE and/or one additional bit in PSCCH and/or PSSCH. Additionally, the switching between STD mode and VLP mode can be dynamically indicated via DCI and/or SCI and/or semi-statically (pre-)configured via (PC5-)RRC

and/or (PC5-)MAC-CE.

In another aspect of the disclosure, for the case of broadcast, if the (pre-)configured maximum EIRP and maximum EIRP density of all UEs can satisfy the requirement of VLP mode as described above, then the UEs can work in and/or switch to VLP mode. Otherwise, the UEs should work in STD mode. For the case of groupcast, if the (pre-)configured maximum EIRP and maximum EIRP density of all UEs in the group can satisfy the requirement of VLP mode, then the UEs in the group can work in and/or switch to VLP mode. Otherwise, the UEs in the group should work in STD mode. Additionally, for the case of groupcast, if SL pathloss based power control can be used, the UE can work in and/or switch to VLP mode according to whether the highest derived transmission power and/or highest derived transmission power density after the power control of each link satisfy the requirement of VLP mode. If the SL pathloss based power control cannot be used in the case of groupcast, the UEs in the group can be (pre-)configured to work in STD mode.

In order to clarify the presented methods for transmission on unlicensed spectrum as described above more clearly, an example is given in Figure 1. As shown in Figure 1, for both device-A and device-B, the initial transmission mode is (pre-)configured as STD mode. Therefore, before start transmissions on the unlicensed spectrum, both device-A and device-B should conduct channel access to initiate a COT. Besides, to solve the timing issue caused by the uncertainty duration of channel access, the mechanisms of overbooking and gap margin is also configured. After receiving the RSRP feedback from device-B via one additional bit in SCI and/or higher layer signaling (e.g., PC5-RRC and/or PC5-MAC-CE), device-A can derive the sidelink pathloss between device-A and device-B, which can be further used for power control of device-A. In this example, after the power control, device-A switch from STD mode to VLP mode for the reason that the derived transmission power and or derived transmission power density after the power control satisfy the requirements of VLP mode as described above. Next, under VLP mode, device-A can directly start a transmission to device-B on the unlicensed spectrum without channel access and also without the mechanisms of overbooking and gap margin. Besides, device-A can also be (pre-)configured to send mode information to device-B via one additional bit in SCI and/or higher layer signaling (e.g., PC5-RRC, PC5-MAC-CE). After receiving the mode information from device-A, device-B can determine whether conduct the mode switching if the mode information received from device-A is different from that of device-B according to the (pre-)configuration. In this example, device-B conduct the mode switching and switch into VLP mode. Then under VLP mode, device-B can directly start a transmission to device-A on the unlicensed spectrum without channel access.

In another aspect of the disclosure, for the case that channel access procedure is finished but the SL transmission cannot be started immediately, some enhancements between the end of the channel access procedure and the start of the transmission is proposed to retain the channel. For example, the first case is that channel access is finished but the transmission is not ready. Specifically, the UE may not transmit a transmission on a channel on which the channel access procedure is finished. In this case, the UE will step into the self-defer duration. Then when the UE is ready to transmit the transmission, an additional short

sensing (i.e., a defer duration together with a sensing slot duration) is required immediately before the intended transmission

Additionally, for the case that the gap between the channel access finish point and the transmission starting point is less than one symbol, CPE operation can be used to achieve symbol-level alignment, e.g., use CPE to fulfil the gap no more than one symbol. This mechanism can be used for both out-of-COT gap and within COT gap as long as the gap between the channel access finish point and the transmission starting point is less than one symbol to retain the channel and/or achieve consecutive transmission. For example, the CPE operation can be used to fulfill the guard symbol before PSFCH and/or the guard symbol at the end of SL slot to retain the channel.

Additionally, for the case that the gap between the channel access finish point and the transmission starting point is larger than one symbol, the partial slot transmission of (dummy) data can be used here to fulfil the gap mentioned above and block the channel access of the other UEs, including the UEs from intra-cell and inter-cell, during this period. This mechanism can be used for both out out-of-COT gap and within COT gap as long as the gap between the channel access finish point and the transmission starting point is larger than one symbol to retain the channel and/or achieve consecutive transmission. For example, for the case that PSFCH is not transmitted (i.e., there is no ACK/NACK for trans at the position of PSFCH), a new sequence and/or (dummy) data on the position of PSFCH (i.e., one symbol) can be transmitted to retain the channel. Additionally, the PSFCH can be (pre-)configured at the end position of one initiated COT. Then if there is no transmission on the position of PSFCH, UE can be (pre-)configured to do nothing and the COT can be released. For any transmissions after the PSFCH position, if the UE work in STD mode, a simplified channel access can be (pre-)configured before the UE can start the transmission. Besides, for any transmissions after the PSFCH position, if the UE work in VLP mode, the UE can start the transmission without channel access.

An example to clarify the methods of consecutive transmissions is illustrated in Figure 2. For the case that there is no transmission on the position of PSFCH, there may have a gap with length of 4 symbols, i.e., the guard symbol before PSFCH (symbol #10), the AGC symbol of PSFCH (symbol #11), the symbol of PSFCH (symbol #12) and the guard symbol at the end of the slot (symbol #13). Follow the principle described above, as shown in Figure 2, at the position of PSFCH (i.e., symbol #12), a (dummy) data and/or a new sequence can be transmitted to retain the channel. Then, the AGC symbol (i.e., symbol #11) can be occupied by the repetition of PSFCH symbol as legacy. For the guard symbol #10, the CPE of AGC symbol can be used to retain the channel. For the guard symbol at the end of the slot (i.e., symbol #13), the CPE of the transmission of next slot can be used to retain the channel, which can be (pre-)configured and/or scheduled by the COT initiator.

In another aspect of the disclosure, multiple BWPs can be supported for SL. For example, a default BWP can be (pre-)configured to support unicast and/or groupcast and/or broadcast transmission (e.g., for the transmissions without any (PC5-)RRC connection). To save power of the inactive UE, UE can only monitor the default BWP as (pre-)configured. The BWP can be (pre-)configured with a set of RB sets (e.g.,

only one RB set). The default BWP can be (pre-)configured as a common BWP for all UEs.

Additionally, the UE specified BWP can be (pre-)configured to support unicast and/or groupcast and/or broadcast transmission (e.g., for the transmissions after (PC5-)RRC connection) where the UE capability and preferred BWP size can be negotiated based on QoS and/or CAPC of the traffic. UE may switch to the larger BWP (including the default BWP at least for reception/monitoring) for communication. That is, transmission can be any resources within the UE specific SL BWP from Tx UE. And the Rx UE can receive the transmission from Tx UE as well as the transmissions (unicast/broadcast) from other UEs in the resources at least including the default SL BWP. In this way, the UE does not need to monitor all RB sets all the time. The BWP can be (pre-)configured with a set of RB sets (e.g., only one RB set).

The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. 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. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "UE," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

CLAIMS

1. A method of transmissions on unlicensed spectrum, wherein the UE can work in STD mode and/or VLP mode according to UE capability and/or (pre-)configuration.

2.The method of claim 1, wherein the STD mode and VLP mode can be determined and/or switched according to the (pre-)configured maximum EIRP and/or maximum EIRP density.

3.The method of claim 1, wherein the STD mode and VLP mode can be determined and/or switched according to the derived EIRP and/or derived EIRP density after power control as (pre-)configuration.

4.The method of claim 1, wherein the determination and/or switching of STD mode and/or VLP mode can be conducted by gNB and/or cluster header and/or UE who intends to start a transmission.

5.The method of claim 4, wherein after the determination and/or switching of STD and/or VLP mode, the update mode information can be (pre-)configured to report to gNB and/or cluster header and/or the receiver and/or the other UEs in the group via (PC5-)RRC and/or (PC5-)MAC-CE and/or one additional bit in DCI and/or UCI and/or SCI.

6.The method of claim 1, wherein under STD mode, the UE may execute channel access before it can start transmissions on the unlicensed spectrum with the considerations of overbooking and/or gap margin to combat the timing issue caused by the uncertainty of channel access.

7.The method of claim 1, wherein under VLP mode, the UE can directly start transmissions on the unlicensed spectrum without the considerations of overbooking and/or gap margin.

8.The method of claim 1, wherein the STD mode and/or VLP mode may be applied per signals/channels depending on the total (EIRP) power and/or total (EIRP) power density for the transmission as (pre-)configuration.

9.The method of claim 1, wherein the switching between STD mode and VLP mode can be (pre-)configured to be based on the mode indication signaling, and/or the ACK/NACK feedback, and/or the RSSI/RSRP measurement, and/or the traffic loading, and/or the CAPC/priority of the traffic.

10.The method of claim 1, wherein the consecutive transmission can be achieved by the operations of CPE and partial slot transmission.

11.The method of claim 1, wherein a default BWP and UE specific BWP can be (pre-)configured.

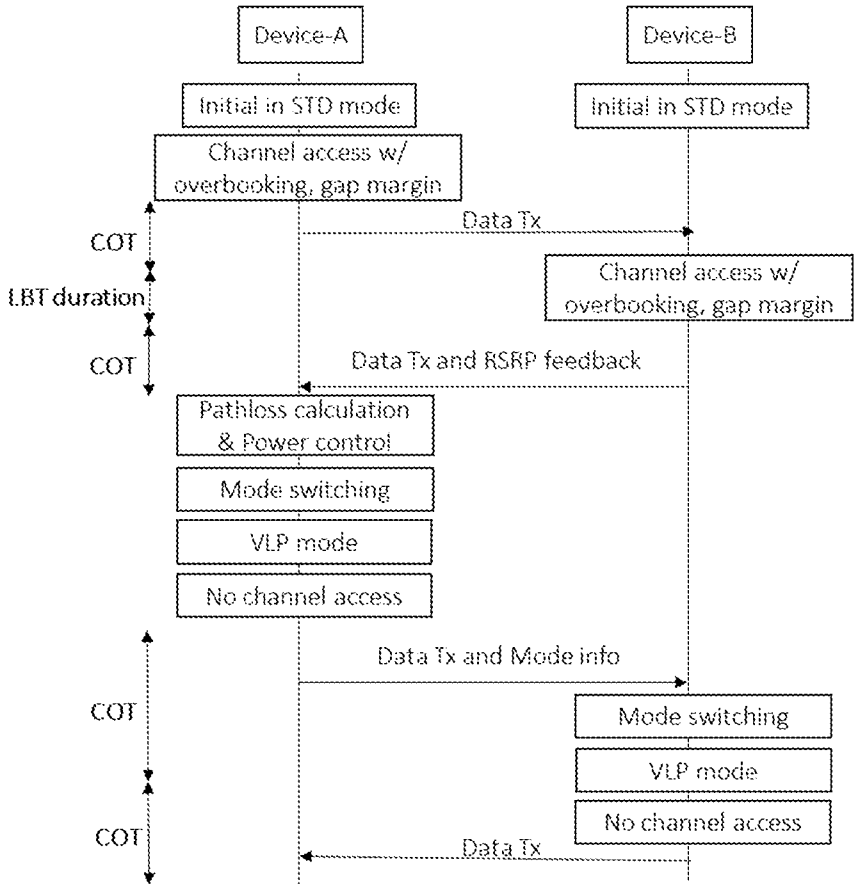


Figure 1

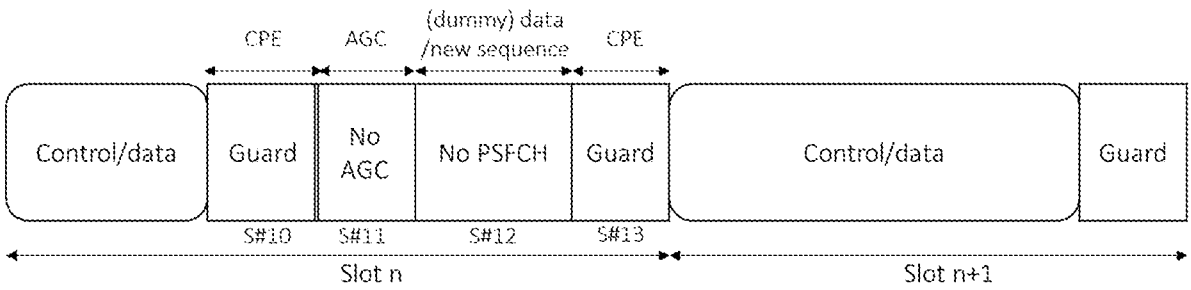


Figure 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/113670

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/30(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W,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)

CNTXT, VCN, ENTXT, DWPI, CNKI, 3GPP: unlicensed, mode, STD, VLP, capability, configuration, EIRP, density, cluster, RRC, MAC-CE, SCI, overbook, gap, margin, BWO, CAPC, RSRP, power

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2022240196 A1 (QUALCOMM INCORPORATED) 28 July 2022 (2022-07-28) description, paragraphs [0026]-[0073]	1-11
X	WO 2022006740 A1 (QUALCOMM INCORPORATED) 13 January 2022 (2022-01-13) description, paragraphs [0039]-[0077]	1-11
A	CN 111742527 A (TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)) 02 October 2020 (2020-10-02) the whole document	1-11
A	CN 113812110 A (APPLE INC.) 17 December 2021 (2021-12-17) the whole document	1-11
A	APPLE INC. "Email discussion summary for [100-e][109] NR_6GHz_unlic_full R4-2114709" *3GPP TSG-RAN WG4 Meeting #100-e,* 20 April 2021 (2021-04-20), the whole document	1-11

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

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Date of the actual completion of the international search	Date of mailing of the international search report
11 April 2023	**17 April 2023**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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