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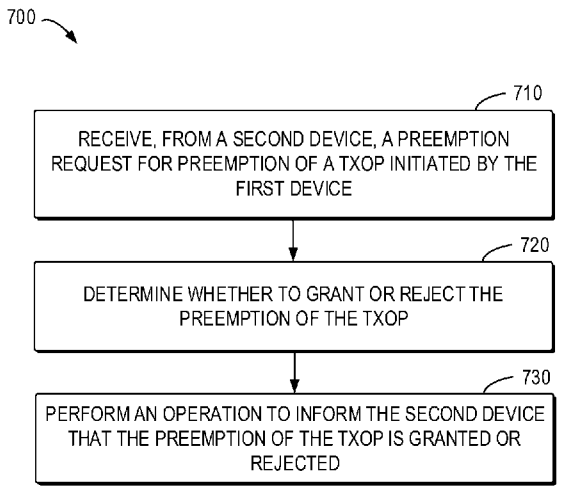

Fig. 7

(57) Abstract: Embodiments of the present disclosure relate to a preemption request and grant. In an aspect, a first device receives, from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device. The first device determines whether to grant or reject the preemption of the TXOP. The first device performs an operation to inform the second device that the preemption of the TXOP is granted or rejected. In this way, low latency data frame transmission can be facilitated by preempting a TXOP in a negotiation manner with the TXOP holder.

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PREEMPTION REQUEST AND GRANT

FIELD

[0001] Various example embodiments relate to the field of communications and in particular, to devices, methods, apparatuses, and a computer readable medium relating to preemption request and grant.

BACKGROUND

[0002] Recently, the institute of electrical and electronic engineers (IEEE) 802.11 Working Group has formed a new Study Group (SG) to define a project for new physical (PHY) and media access control (MAC) technologies to further increase the reliability and throughput of 802.11 wireless local area networks (WLANs). Latency improvement is one of the main requirements in the ultra-high reliability (UHR) Group as described in the approved motion for UHR SG formation and in the project authorization request (PAR).

[0003] Several new features are developed to support low latency data frame transmission. These features include multi-link operation (MLO), restricted target wake time (R-TWT) and the MLO stream classification service (MSCS) based quality of service (QoS) signaling mechanism. Combining R-TWT with the MSCS based QoS signaling on 802.11be device can achieve a bounded latency of less than 25ms. However, it still can't meet the industrial applications that require latencies of less than tens of milliseconds to a few milliseconds. To schedule a low latency data frame transmission, preemption solutions are under discussion.

SUMMARY

[0004] In general, example embodiments of the present disclosure provide a solution relating to preemption request and grant.

[0005] In a first aspect, there is provided a first device. The first device comprises at least one processor and at least one memory storing instructions that, when executed by the at least one processor, cause the first device at least to: receive, from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device; determine whether to grant or reject the preemption of the TXOP; and perform an operation to inform the second device that the preemption of the TXOP is granted or

rejected.

[0006] In a second aspect, there is provided a second device. The second device comprises at least one processor and at least one memory storing instructions that, when executed by the at least one processor, cause the second device at least to: determine to preempt a TXOP initiated by a first device; transmit, to the first device, a preemption request for the preemption of the TXOP; and determine, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

[0007] In a third aspect, there is provided a method. The method comprises: receiving, at a first device and from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device; determining whether to grant or reject the preemption of the TXOP; and performing an operation to inform the second device that the preemption of the TXOP is granted or rejected.

[0008] In a fourth aspect, there is provided a method. The method comprises: determining, at a second device, to preempt a TXOP initiated by a first device; transmitting, to the first device, a preemption request for the preemption of the TXOP; and determining, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

[0009] In a fifth aspect, there is provided an apparatus. The apparatus comprises: means for receiving, at a first device and from a second device, a preemption request for preemption of a TXOP initiated by the first device; means for determining whether to grant or reject the preemption of the TXOP; and means for performing an operation to inform the second device that the preemption of the TXOP is granted or rejected.

[0010] In a sixth aspect, there is provided an apparatus. The apparatus comprises: means for determining, at a second device, to preempt a transmission opportunity (TXOP) initiated by a first device; means for transmitting, to the first device, a preemption request for the preemption of the TXOP; and means for determining, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

[0011] In a seventh aspect, there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the method according to any one of the above third to fourth aspects.

[0012] In an eighth aspect, there is provided a computer program product comprising program instructions for performing at least the method according to any one of the above third to fourth aspects.

[0013] In a ninth aspect, there is provided a computer program comprising instructions, which, when executed by an apparatus, cause the apparatus to perform at least the method according to any one of the above third to fourth aspects.

[0014] In an tenth aspect, there is provided a first device. The first device comprises: receiving circuitry configured to receive, from a second device, a preemption request for preemption of a TXOP initiated by the first device; determining circuitry configured to determine whether to grant or reject the preemption of the TXOP; and performing circuitry configured to perform an operation to inform the second device that the preemption of the TXOP is granted or rejected.

[0015] In an eleventh aspect, there is provided a second device. The second device comprises: determining circuitry configured to determine to preempt a TXOP initiated by a first device; transmitting circuitry configured to transmit, to the first device, a preemption request for the preemption of the TXOP; and determining circuitry configured to determine, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

[0016] It is to be understood that the summary section is not intended to identify key or essential features of embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Some example embodiments will now be described with reference to the accompanying drawings, in which:

[0018] Fig. 1A illustrates an example communication system in which embodiments of the present disclosure may be implemented;

[0019] Fig. 1B illustrates a schematic diagram illustrating a preemption case for a low latency data frame transmission;

[0020] Fig. 1C illustrates a schematic diagram illustrating a delay issue that may be

caused in a preemption case for a low latency data frame transmission;

[0021] Fig. 2 illustrates an example signaling chart of an example process according to some embodiments of the present disclosure;

[0022] Fig. 3 illustrates an example signaling chart of an exemplary explicit preemption grant process according to some embodiments of the present disclosure;

[0023] Fig. 4 illustrates an example signaling chart of an exemplary implicit preemption grant process according to some embodiments of the present disclosure;

[0024] Fig. 5 illustrates a schematic diagram illustrating an explicit preemption grant procedure according to some embodiments of the present disclosure;

[0025] Fig. 6 illustrates a schematic diagram illustrating an implicit preemption grant procedure according to some embodiments of the present disclosure;

[0026] Fig. 7 illustrates a schematic diagram illustrating a method implemented at a first device according to some other embodiments of the present disclosure;

[0027] Fig. 8 illustrates a schematic diagram illustrating a method implemented at a second device according to some other embodiments of the present disclosure;

[0028] Fig. 9 illustrates a simplified block diagram of a device that is suitable for implementing embodiments of the present disclosure; and

[0029] Fig. 10 illustrates a block diagram of an example computer readable medium in accordance with some embodiments of the present disclosure.

[0030] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0031] Principles of the present disclosure will now be described with reference to some example embodiments. It is to be understood that these embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0032] In the following description and claims, unless defined otherwise, all technical and

scientific terms used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure belongs.

[0033] References in the present disclosure to "one embodiment," "an embodiment," "an example embodiment," and the like indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0034] It shall be understood that although the terms "first" and "second" etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0035] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. As used herein, "at least one of the following: <a list of two or more elements>" and "at least one of <a list of two or more elements>" and similar wording, where the list of two or more elements are joined by "and" or "or", mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements.

[0036] As used in this application, the term "circuitry" may refer to one or more or all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog

and/or digital circuitry) and

(b) combinations of hardware circuits and software, such as (as applicable):

(i) a combination of analog and/or digital hardware circuit(s) with software/firmware and

(ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

(c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0037] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

[0038] As used herein, the term "communication network" refers to a network following any suitable communication standards, such as WLAN, Long Term Evolution (LTE), LTE-Advanced (LTE-A), Wideband Code Division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Narrow Band Internet of Things (NB-IoT) and so on. Furthermore, the communications between a terminal device and a network device in the communication network may be performed according to any suitable generation communication protocols, including, but not limited to, the first generation (1G), the second generation (2G), 2.5G, 2.75G, the third generation (3G), the fourth generation (4G), 4.5G, the fifth generation (5G), the future sixth generation (6G) communication protocols, and/or any other protocols either currently known or to be developed in the future, wireless local network communication protocols such as IEEE 802.11 and the like and/or any other protocols either currently known or to be developed in the future. Embodiments of the present disclosure may be applied in various communication systems. Given the rapid development in communications, there will of course also be future type communication

technologies and systems with which the present disclosure may be embodied. It should not be seen as limiting the scope of the present disclosure to only the aforementioned system.

[0039] As used herein, the term "network device" refers to a node in a communication network via which a terminal device accesses the network and receives services therefrom. The network device may refer to an access point (AP) or a base station (BS), for example, a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a NR NB (also referred to as a gNB), a Remote Radio Unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node such as a femto, a pico, and so forth, depending on the applied terminology and technology. In the following description, the terms "network device", "network (NW)," "AP" may be used interchangeably.

[0040] The term "terminal device" refers to any end device that may be capable of wireless communication. By way of example rather than limitation, a terminal device may also be referred to as a station (STA), a communication device, user equipment (UE), a Subscriber Station (SS), a Portable Subscriber Station, a Mobile Station (MS), or an Access Terminal (AT). The terminal device may include, but not limited to, a mobile phone, a cellular phone, a smart phone, voice over IP (VoIP) phones, wireless local loop phones, a tablet, a wearable terminal device, a personal digital assistant (PDA), portable computers, desktop computer, image capture terminal devices such as digital cameras, gaming terminal devices, music storage and playback appliances, vehicle-mounted wireless terminal devices, wireless endpoints, mobile stations, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), USB dongles, smart devices, wireless customer-premises equipment (CPE), an Internet of Things (loT) device, a watch or other wearable, a head-mounted display (HMD), a vehicle, a drone, a medical device and applications (e.g., remote surgery), an industrial device and applications (e.g., a robot and/or other wireless devices operating in an industrial and/or an automated processing chain contexts), a consumer electronics device, a device operating on commercial and/or industrial wireless networks, and the like. In the following description, the terms "terminal device", "communication device", "terminal", "user equipment" ,"UE" and "STA" may be used interchangeably.

[0041] As used herein, the term "AP device" may refer to a device via which to access any wired or wireless network. For example, the wired or wireless network may be a broadband network, the Internet, a local area network, a metropolitan area network, a mobile communication network, or the like. For convenience, AP devices are also

referred to as AP stations or APs herein. The AP device may support, for example, the Wi-Fi protocol or any other known or future-developed similar protocols. For example, the AP device may be a wireless router, a terminal device with a router function, a network device with a router function, and so on.

[0042] As used herein, the term "TXOP holder" may refer to a device that initiates a TXOP to communicate with other device(s) within the TXOP. For example, the device may sense a channel and get the TXOP in a listen before talk (LBT) procedure. The TXOP holder can be also referred to as an initiating device. As used herein, the term "non-TXOP holder" may refer to a device that communicates with a TXOP holder or other device(s) within a TXOP initiated by the TXOP holder. The non-TXOP holder can be also referred to as a responding device.

[0043] Although functionalities described herein can be performed, in various example embodiments, in a fixed and/or a wireless network node, in other example embodiments, functionalities may be implemented in a user equipment apparatus (such as a cell phone or tablet computer or laptop computer or desktop computer or mobile IoT device or fixed IoT device). This user equipment apparatus can, for example, be furnished with corresponding capabilities as described in connection with the fixed and/or the wireless network node(s), as appropriate. The user equipment apparatus may be the user equipment and/or a control device, such as a chipset or processor, configured to control the user equipment when installed therein. Examples of such functionalities include the bootstrapping server function and/or the home subscriber server, which may be implemented in the user equipment apparatus by providing the user equipment apparatus with software configured to cause the user equipment apparatus to perform from the point of view of these functions/nodes.

[0044] Principles and implementations of the present disclosure will be described in detail below with reference to the figures. Fig. 1A illustrates an example communication system 100 in which embodiments of the present disclosure may be implemented. The system 100 includes an STA 110 and an AP 120. The system 100 may also include an STA 130. In some embodiments, the STA 110 may initiate a TXOP to communicate with the AP 120. In this case, the STA 110 is the TXOP holder and the AP 120 is the non-TXOP holder. Alternatively, the AP 120 may be the TXOP holder and the STA 110 may be the non-TXOP holder.

[0045] It is to be understood that the number of AP and STA and their connections are only for the purpose of illustration without suggesting any limitations. The system 100 may include any suitable number of AP and STA adapted for implementing embodiments of the present disclosure.

[0046] Communications in the communication system 100 may be implemented according to any proper communication protocol(s), comprising, but not limited to, wireless local network communication protocols such as IEEE 802.11 and the like, cellular communication protocols, and/or any other protocols currently known or to be developed in the future. Moreover, the communication may utilize any proper wireless communication technology, comprising but not limited to: Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Frequency Division Duplex (FDD), Time Division Duplex (TDD), Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiple (OFDM), Discrete Fourier Transform spread OFDM (DFT-s-OFDM) and/or any other technologies currently known or to be developed in the future.

[0047] To schedule a low latency data frame transmission, preemption solutions are under discussion. One possible case is to preempt the ongoing transmission or TXOP by the non-TXOP holder, i.e., in case of low latency data frame buffered at a non-TXOP holder, the low latency data frame can be transmitted before the current TXOP is end.

[0048] Fig. 1B illustrates a schematic diagram 150 illustrating a preemption case for a low latency data frame transmission. As illustrated in Fig.1B, the non-TXOP holder (i.e., AP) can transmit a low latency data frame to another device (i.e., STA2) by preempting current TXOP initiated by the TXOP holder (i.e., STA1).

[0049] For example, as shown in Fig. 1B, STA1 as a TXOP holder may transmit a request to send (RTS) frame 151 to AP and the AP may transmit a clear to send (CTS) frame 152 to the STA1 as a response. Then STA1 may transmit non-low latency data frame 153 to the AP. Low latency data for STA2 may arrive at time A at the AP STA1 while the STA1 is transmitting the non-low latency data frame 153 to the AP. To transmit the low latency data frame to STA2, the AP may need to preempt the TXOP initiated by the STA1. The AP may terminate the transmission of the non-low latency data frame by transmitting a block acknowledgment (BA) frame 154 to the STA1. Then, the AP may transmit the low latency data frame 155 to the STA2 within the STA1's TXOP. The STA2 may transmit a

BA frame 156 to the AP upon reception of the low latency data frame. The STA1 may continue transmission of the non-low latency data frame 157 to the AP in remaining time of the STA1's TXOP.

[0050] For this case, the AP needs to schedule a low latency data frame transmission by preempting the ongoing transmission or preempting the TXOP initiated by a STA. For the preemption operation, an open issue is that the STA may also buffer low-latency data frames for transmission within its TXOP, and the TXOP preemption proposal will be unfair and unfriendly to the STA.

[0051] Fig. 1C illustrates a schematic diagram 180 showing a delay issue that may be caused in a preemption case for a low latency data frame transmission. As illustrated in Fig. 1C, when the STA1 is transmitting data frame to the AP within its TXOP, low-latency data frames are buffered at both the AP and the STA1. If the AP interrupts the ongoing transmission from STA1 and schedules the low latency frame transmission 155 to the STA2 using the STA1's TXOP, and results in that the STA1 cannot transmit the low-latency data frame 158 to the AP in time, which would cause a higher delay issue for the low-latency data frame transmission for STA1.

[0052] Another open issue is that the AP may be not allowed to preempt the TXOP initiated by other device for low-latency data frame transmission. As an example, according to European Telecommunication Standards Institute (ETSI) regulation rule that Responding Device Channel Access Mechanism in 5GHz unlicensed band shown below, a Responding Device may perform transmissions on the current operating channel for the remaining Channel Occupancy Time (i.e., TXOP) after it received a transmission grant from an associated initiating device (i.e., TXOP holder). That means that the AP shall receive a transmission grant from the STA for the preemption operation so that it can schedule a low latency data frame transmission within the TXOP initiated by the STA.

Table 1: Responding Device Channel Access Mechanism

4.2.7.3.2.7 Responding Device Channel Access Mechanism
Clause 4.2.7.3.2.6, step 6) b) describes the possibility whereby an *Initiating Device* grants an authorization to one or more associated *Responding Devices* to transmit on the current *Operating Channel.* A *Responding Device* that receives such a grant shall follow the procedure described in step 1) to step 3): 1) A *Responding Device* that received a transmission grant from an associated

Initiating Device may proceed with transmissions on the current *Operating Channel*.

a) The *Responding Device* may proceed with such transmissions without performing a *Clear Channel Assessment* (CCA) if these transmissions are initiated at most 16 μs after the last transmission by the *Initiating Device* that issued the grant.

b) The *Responding Device* that does not proceed with such transmissions within 16 μs after the last transmission from the *Initiating Device* that issued the grant, shall perform a *Clear Channel Assessment* (CCA) on the *Operating Channel* during a single observation slot within a 25 μs period ending immediately before the granted transmission time. If energy was detected with a level above the *ED Threshold* defined in clause 4.2.7.3.2.5, the *Responding Device* shall proceed with step 3). Otherwise, the *Responding Device* shall proceed with step 2).

2) The *Responding Device* may perform transmissions on the current *Operating Channel* for the remaining *Channel Occupancy Time*. The *Responding Device* may have multiple transmissions on this *Operating Channel* provided that the gap in between such transmissions does not exceed 16 μs. When the transmissions by the *Responding Device* are completed the *Responding Device* shall proceed with step 3).

3) The transmission grant for the *Responding Device* is withdrawn.

[0053] In view of the above and other aspects, some embodiments of the present disclosure provide a negotiation-based grant solution for preemption operation within a TXOP. In the solution, a second device as a non-TXOP holder determines to preempt a TXOP initiated by a first device and transmits a preemption request for the preemption of the TXOP to the first device. Upon receiving the preemption request, the first device as a TXOP holder determines whether to grant or reject the preemption of the TXOP and performs an operation to inform the second device that the preemption of the TXOP is granted or rejected. Dependent on the operation performed by the first device, the second device determines that the preemption of the TXOP is granted or rejected by the first device. In this way, low latency data frame transmission can be facilitated by preempting a TXOP in a negotiation manner with the TXOP holder. Furthermore, the solution would be friendly to the TXOP holder as the TXOP holder can determine whether the preemption operation is allowed considering certain conditions, e.g., data frame type/QoS of itself during the negotiation procedure.

[0054] Fig. 2 illustrates an example signaling chart illustrating an example process 200 according to some embodiments of the present disclosure. The process 200 may involve a first device 201 and a second device 202. The first device 201 may be a TXOP holder, e.g., one of the STA 110 or the AP 120 as shown in Fig. 1A. The second device 202 may be a non-TXOP holder, e.g., the other one of the AP 120 or the STA 110 as shown in Fig. 1A.

[0055] With reference to Fig. 2, the second device 202 as a non-TXOP holder may transmit 210 an indication 211 to the first device 201 as a TXOP holder. The indication 211 may be used for configuring the first device 201 to support a negotiation for preemption of a TXOP initiated by the first device 201. The first device 201 may receive 212 the indication 211.

[0056] As shown in Fig. 2, the second device 202 determines 213 to preempt the TXOP initiated by the first device 201. Then, the second device 202 transmits 214 a preemption request 215 for the preemption of the TXOP to the first device 201.

[0057] Upon receiving 216 the preemption request 215, the first device 201 determines 217 whether to grant or reject the preemption of the TXOP and then performs 218 an operation to inform the second device 202 that the preemption of the TXOP is granted or rejected. Dependent on the operation performed by the first device 201, the second device 202 determines 219 that the preemption of the TXOP is granted or rejected by the first device 201.

[0058] In some embodiments, the second device 202 may transmit the preemption request through an ACK frame (e.g., a BA frame) in response to a PPDU frame received from the first device 201 within the TXOP. Alternatively or in addition, the second device 202 may transmit the preemption request through a frame in a further link among multi-links established between the first device 201 and the second device 202.

[0059] The preemption request may indicate at least one of type information, priority information or latency information of a data frame to be transmitted or received by the second device 202. The first device 201 may determine whether to grant or reject the preemption of the TXOP dependent on the at least one of type information, priority information or latency information of a data frame indicated in the preemption request. Alternatively or in addition, the first device 201 may also determine whether to grant or reject the preemption of the TXOP dependent on at least one of type information, priority

information or latency information of a data frame buffered at the first device 201.

[0060] In some embodiments, if a low latency data frame is to be transmitted by the first device 201 within the TXOP, the first device 201 may determine to reject the preemption of the TXOP. If the first device 201 doesn't need to transmit low latency data frame within the TXOP, it may determine to grant the preemption of the TXOP.

[0061] To inform the second device 202 that the preemption of the TXOP is granted or rejected, the first device 201 may transmit to the second device a preemption response to the preemption request.

[0062] If the preemption is granted, the first device 201 may terminate an ongoing transmission within the TXOP. The second device 202 may perform a data frame transmission with the first device 201 or a third device within the TXOP. If the preemption is rejected, the first device 201 may continue the ongoing transmission within the TXOP.

[0063] Instead of transmitting a preemption response directly, the first device 201 may implicitly inform the second device 202 that the preemption of the TXOP is granted or rejected. In this case, a time window can be configured after a transmission of the preemption request. The time window may comprise at least one inter frame space (IFS).

[0064] For example, if the first device 201 determines to grant the preemption, the first device 201 may terminate an ongoing transmission within the TXOP without transmitting a preemption response to the second device, and refrain from transmitting data during the time window. If the first device 201 determines to reject the preemption, the first device 201 may continue an ongoing transmission starting from the time window.

[0065] On the second device side, the second device 202 may monitor data transmission from the first device 201 during the time window. If data transmission from the first device 201 during the time window is detected, the second device 202 determines that the preemption of the TXOP is rejected. If it fails to detect data transmission from the first device 201 during the time window, the second device 202 determines that the preemption of the TXOP is granted by the first device.

[0066] To monitor whether there is data transmission from the first device 201 during the time window, the second device 202 may perform energy detection (ED) with the time window. For example, the second device 202 may detect energy within the time window, and compare the detected energy with a threshold. If the detected energy level is lower

than the ED threshold, the channel is considered idle and thus data transmission is allowed for the second device 202. Alternatively or in addition, the second device 202 may perform signal detection within the time window. For example, the second device 202 may detect preamble or/and MAC header to detect whether data transmission is performed by the first device 201.

[0067] In the case that the preemption of the TXOP is granted, the second device 202 may perform a data frame transmission with the first device 201 or a third device within the TXOP after the time window. Information on the time window can be pre-defined or pre-configured. Alternatively or in addition, the second device 202 may transmit information on the time window to the first device in the preemption request 215 or in the indication 211.

[0068] With the process 200, embodiments of the present disclosure provide a negotiation-based solution for preemption operations within a TXOP. The basic idea is if the non-TXOP holder (e.g., the second device 202) needs to preempt the current TXOP for low latency data frame transmission, it shall transmit a preemption request to the TXOP holder (e.g., the first device 201). Upon receiving the preemption request, the TXOP holder can determine whether to grant the preemption operation based on certain conditions, like the data frame type or/and QoS (e.g., priority, latency) of the data frames buffered at locally, while such conditions may be indicated in the preemption negotiation procedure.

[0069] If the preemption is allowed, the TXOP holder may respond with a preemption grant indication after receiving the preemption request from non-TXOP holder, and then terminate the on-going transmission through an implicit or explicit way. Otherwise, the TXOP holder continues the on-going transmission in the remaining TXOP.

[0070] If the non-TXOP holder receives the preemption grant indication in an implicit or explicit manner, it can schedule low latency data frame transmission within the remaining TXOP. Otherwise, it continues to receive the transmission from the TXOP holder if the non-TXOP holder is the PPDU receiver.

[0071] In an embodiment, the preemption request signaling may be delivered by non-TXOP holder via a new field in the BA frame solicited by the TXOP holder on its aggregate MAC Protocol Data Unit (a-MPDU) delivery, or through a frame (e.g., action/control frame) in a further active link which is setup between the non-TXOP holder and the TXOP holder for multiple link operations.

[0072] In another embodiment, the determination of preemption grant can be made at least based on that the TXOP holder doesn't intend to transmit a low latency data frame within the TXOP. Alternatively or in addition, the determination of preemption grant can be made at least based on that the preemption conditions set by the non-TXOP holder are met.

[0073] In a further embodiment, the TXOP holder can transmit the preemption grant indication to the non-TXOP holder in an implicit or explicit manner. For example, in the explicit manner, the TXOP holder can transmit preemption response carrying the preemption grant indication through a frame (e.g., action/control frame) in the current link or a further active link, on which that the preemption request was received. In the implicit manner, assuming a time window will be applied for the preemption grant operation. The time window can be configured after the preemption request frame transmission, the non-TXOP holder can determine whether the TXOP holders grant the preemption operation based on at least reception of data frame transmission during the time window.

[0074] The time window may comprise at least one IFS. For example, in some embodiments, the time window may comprise two preemption related inter frame spaces (P-IFSs), and the second P-IFS follows the first P-IFS. The P-IFS can be any IFS defined by 802.11 SPEC, like a Short Inter Frame Space (SIFS), a Point Coordination Function (PCF) Inter frame Space (PIFS), a Distributed Coordination Function (DCF) Inter frame Space (DIFS), an Extended Inter frame Space (EIFS), or a new IFS defined by the coming 802.11bn SPEC. The time window may be pre-defined, be negotiated between the TXOP holder and the non-TXOP holder or be indicated through the preemption request or other signaling.

[0075] In this way, low latency data frame transmission can be facilitated by preempting a TXOP in a negotiation manner with the TXOP holder. Furthermore, the solution would be friendly to the TXOP holder as the TXOP holder can determine whether the preemption operation is allowed considering certain conditions. It is to be noted that the above process 200 is merely an example, and may have additional or less operations. It is also to be noted that operations of the above process 200 may be carried out separately or in any suitable combination.

[0076] Fig. 3 illustrates an example signaling chart of an exemplary explicit preemption grant process 300 according to some embodiments of the present disclosure. The process 300 can be an example of the process 200 as shown in Fig. 2. The process 300 may

involve the first device 201 (i.e., TXOP holder) and the second device 202 (i.e., non-TXOP holder) as shown in Fig. 2 and a third device 203. The third device 203 may be an STA that communicates with at least one of the first device 201 and the second device 202.

[0077] As shown in Fig. 3, at 310, the TXOP holder can be set or/configured by the non-TXOP holder to support the preemption operation. At 311, the non-TXOP holder determines to transmit preemption request to the TXOP holder if low latency data frames are buffered at non-TXOP holder. In an embodiment, the preemption request can further carry at least one of the type information, priority information and/or latency information of the buffered QoS data frame.

[0078] At 312, the non-TXOP holder transmits the preemption request to the TXOP holder through a new field in the ACK frame, like Block ACK, Muti-traffic identifier (Muti-TID) Block ACK or Multi-STA Block ACK frame, after the TXOP holder sent a PPDU and solicited an ACK frame from the non-TXOP holder. Alternatively or in addition, the non-TXOP holder may transmit the preemption request to the TXOP holder through a frame (e.g., action/control frame) in a further active link which is setup between the non-TXOP holder and the TXOP holder for multiple link operation.

[0079] At 313, the TXOP holder determines whether to grant the preemption operation. The determination may be based on at least one of the type information, priority information and/or latency information of the buffered QoS data frame at the non-TXOP holder indicated in the preemption request. Alternatively or in addition, the determination may be based on at least one of the type information, priority information and/or latency information of the buffered QoS data frame at the TXOP holder side.

[0080] If the TXOP holder determines to grant the non-TXOP holder to preempt the current TXOP, it sends a preemption grant indication to the non-TXOP holder through a frame (e.g., action/control frame), as shown at 314. If the non-TXOP holder receives the preemption grant indication from the TXOP holder, it would transmit the low latency data frame within the remaining TXOP, as shown at 315. In an embodiment, the receiver of the low latency data frame can be either the TXOP holder or the third device.

[0081] If the TXOP holder determines to grant the non-TXOP holder to preempt the current TXOP, it needs to terminate the on-going transmission, as shown at 316. At 317, if the TXOP holder determines not to grant (e.g., reject) the non-TXOP holder to preempt the current TXOP, it will continue the on-going transmission to the non-TXOP holder.

[0082] With the process 300, embodiments of the present disclosure provide a negotiation-based explicit preemption grant. Low latency data frame transmission can be facilitated by preempting a TXOP in a negotiation manner with the TXOP holder. Furthermore, the solution would be friendly to the TXOP holder as the TXOP holder can determine whether the preemption operation is allowed considering certain conditions. It is to be noted that the above process 300 is merely an example, and may have additional or less operations. It is also to be noted that operations of the above process 300 may be carried out separately or in any suitable combination.

[0083] Fig. 4 illustrates an example signaling chart of an exemplary implicit preemption grant process 400 according to some embodiments of the present disclosure. The process 400 can be an example of the process 200 as shown in Fig. 2. Similar to Fig. 3, the process 400 may involve the first device 201 (i.e., TXOP holder) and the second device 202 (i.e., non-TXOP holder) as shown in Fig. 2 and a third device 203. The third device 203 may be an STA that communicates with at least one of the first device 201 and the second device 202.

[0084] As shown in Fig. 4, the 410-413 are similar to 310-313 in Fig. 3 and they will not be repeated here. What is difference is that, to support the implicit preemption grant, a time window is applied and information on the time window can be transmitted from the non-TXOP holder to the TXOP holder through the configuration at 410 and/or the preemption request at 412. It should be understood that the time window can also be pre-defined or pre-configured or can be configured by other device than the non-TXOP holder.

[0085] With reference to Fig. 4, if the TXOP holder determines to grant the non-TXOP holder to preempt the current TXOP, it would terminate the on-going transmission without TXOP preempt response transmission after receiving TXOP preempt request, as shown at 414.

[0086] At 415, the non-TXOP holder monitors data transmission from the TXOP holder during the time window. In an embodiment, the time window may comprise at least one IFS. As an example, the time window may comprise two P-IFSs and the second P-IFS follows the first P-IFS. In this scenario, the non-TXOP holder may monitor data transmission from the TXOP holder during the second P-IFS.

[0087] At 416, if the non-TXOP holder didn't detect transmission from the TXOP during

the time window (for example, during the second P-IFS), it would transmit the low latency data frame within the remaining TXOP immediately.

[0088] If the TXOP holder determines not to grant (e.g., reject) the non-TXOP holder to preempt the current TXOP, it would continue the go-going transmission starting from the first P-IFS, as shown at 417. At the same time, if the non-TXOP holder detects transmission from the TXOP during the time window, it would continue to receive data transmission from the TXOP holder if the non-TXOP is the PPDU receiver.

[0089] With the process 400, embodiments of the present disclosure provide a negotiation-based implicit preemption grant. Low latency data frame transmission can be facilitated by preempting a TXOP in a negotiation manner with the TXOP holder. Furthermore, the solution would be friendly to the TXOP holder as the TXOP holder can determine whether the preemption operation is allowed considering certain conditions. It is to be noted that the above process 400 is merely an example, and may have additional or less operations. It is also to be noted that operations of the above process 400 may be carried out separately or in any suitable combination.

[0090] An example for the explicit preemption grant will be described in details with reference to Fig. 5. In diagram 500 as illustrated in Fig. 5, STA1 (e.g., the first device 201 as shown in Figs. 24) is the TXOP holder, AP (e.g., the second device as shown in Figs. 2-4) and STA2 (e.g., the third device as shown in Figs. 3 and 4) are non-TXOP holders.

[0091] With reference to Fig. 5, the STA1 initiates a TXOP for communication with the AP. The STA1 may transmit an RTS frame 501 to AP and the AP may transmit a CTS frame 502 to STA1 as a response. When low latency data frame arrives at time A at the AP, the AP would transmit a preemption request to the TXOP holder (STA1) through a new field of the BA frame 504 solicited by the PPDU frame 503 sent from the STA1.

[0092] Upon receiving the preemption request from the AP, the STA1 would determine to transmit a preemption response frame 505 carrying preemption grant indication to the AP, in which the AP is allowed to preempt the TXOP for low latency traffic transmission. The determination may be caused by the STA1 lack of low latency data buffered. And then, the STA1 terminates its on-going non-low latency data frame transmission. After that, the AP may schedule a low latency frame transmission 506 to the STA2 in the remaining TXOP. The STA2 can transmit a BA frame 507 to the AP after the low latency frame transmission 506 finished.

[0093] Fig. 6 illustrates a schematic diagram 600 illustrating an implicit preemption grant procedure according to some embodiments of the present disclosure. In Fig. 6, STA1 (e.g., the first device 201 as shown in Figs. 2-4) is the TXOP holder, AP (e.g., the second device as shown in Figs. 2-4) and STA2 (e.g., the third device as shown in Figs. 3 and 4) are non-TXOP holders.

[0094] As shown in Fig. 6, the STA1 initiates a TXOP for communication with the AP. The STA1 may transmit an RTS frame 601 to AP and the AP may transmit a CTS frame 602 to STA1 as a response. When low latency data frame arrives at time A at the AP, the AP would transmit preemption request to the TXOP holder (STA1) through a new field of BA frame 604 after finishing reception of a PPDU frame 603 from the STA1.

[0095] Fig. 6 (a) depicts the case that the TXOP holder (STA1) doesn't grant the non-TXOP holder (AP) to preempt the current TXOP, it may continue the PPDU transmission 605 starting from the time window. In this case, the time window is shown to include two IFSs, i.e., xIFS#1 and xIFS#2. It should be understood that the time window can comprise any suitable number of IFSs or can be any suitable time duration for implicitly informing whether to grant or reject the preemption.

[0096] The AP would monitor data frame transmission from the STA1 during the time window. Since data frame transmission from the STA1 is already detected during the second P-IFS, the AP thought the STA1 denied its preemption request, and then the AP continues to receive the data frame transmission from the STA1.

[0097] Fig. 6 (b) illustrates that the STA1 grants the AP to preempt the current TXOP for low latency data frame transmission. In this case, the STA1 would terminate the on-going transmission. At the same time, the AP may not monitor data frame transmission from the STA1 during the time window. In this case, the time window is shown to include two IFSs, i.e., xIFS#1 and xIFS#2. As the PPDU transmission from the STA1 is not detected in either xIFS#1 or xIFS#2, the AP thought the STA1 granted its preemption request, and then the AP schedules a low latency frame transmission 606 within the remaining TXOP after the time window. The STA2 can transmit a BA frame 607 to the AP after the low latency frame transmission 606 finished.

[0098] Fig. 7 illustrates a schematic diagram illustrating a method 700 implemented at a first device according to some other embodiments of the present disclosure. For the purpose of discussion, the method 700 will be described from the perspective of the first

device 201 as shown in, e.g., Figs. 2-4. In some other embodiments, the first device 201 can also be the STA1 in Figs. 5-6.

[0099] As shown in Fig. 7, at block 710, the first device 201 receives, from a second device 202, a preemption request for preemption of a TXOP initiated by the first device 210. At block 720, the first device 201 determines whether to grant or reject the preemption of the TXOP. At block 730, the first device 201 performs an operation to inform the second device 202 that the preemption of the TXOP is granted or rejected.

[00100] In some embodiments, prior to receiving the preemption request, the first device 201 may receive an indication for configuring the first device 201 to support a negotiation for the preemption of the TXOP.

[00101] In some embodiments, the first device 201 may receive the preemption request through an ACK frame in response to a PPDU frame transmitted by the first device 201 within the TXOP. Alternatively or in addition, the first device 201 may receive the preemption request through a frame in a further link among multiple links established between the first device 201 and the second device 202.

[00102] In some embodiments, the first device 201 may determine whether to grant or reject the preemption of the TXOP dependent on at least one of type information, priority information or latency information of a data frame indicated in the preemption request. Alternatively or in addition, the first device 201 may determine whether to grant or reject the preemption of the TXOP dependent on at least one of type information, priority information or latency information of a data frame buffered at the first device 201.

[00103] In some embodiments, if a low latency data frame is to be transmitted by the first device 201 within the TXOP, the first device 201 may determine to reject the preemption. Alternatively or in addition, if no low latency data frame is to be transmitted by the first device 201 within the TXOP, the first device 201 may determine to grant the preemption.

[00104] In some embodiments, the first device 201 may transmit, to the second device 202, a preemption response to inform the second device 202 that the preemption of the TXOP is granted or rejected. If the first device 201 determines to grant the preemption, it may terminate an ongoing transmission within the TXOP. Alternatively, if the first device 201 determines to reject the preemption, it may continue the ongoing transmission within the TXOP.

[00105] In some embodiments, the first device 201 may inform the second device 202 that

the preemption of the TXOP is granted or rejected by performing a transmission or refraining from transmitting data during a time window configured after a transmission of the preemption request. The time window may comprise at least one IFS.

[00106] In some embodiments, if the first device 201 determines to grant the preemption, it may terminate an ongoing transmission within the TXOP without transmitting a preemption response to the second device 202, and it refrains from transmitting data during the time window. If the first device 201 determines to reject the preemption, it may continue an ongoing transmission starting from the time window.

[00107] In some embodiments, information on the time window may be pre-defined or pre-configured, or received from the second device 202 in the preemption request or in the indication.

[00108] In some embodiments, the first device 201 is one of an STA or an AP, and the second device 202 is the other one of an STA or an AP.

[00109] Fig. 8 illustrates a schematic diagram illustrating a method 800 implemented at a second device according to some other embodiments of the present disclosure. For the purpose of discussion, the method 800 will be described from the perspective of the second device 202 as shown in, e.g., Figs. 2-4. In some other embodiments, the second device 202 can also be the AP in Figs. 5-6.

[00110] As shown in Fig. 8, at block 810, the second device 202 determines to preempt a TXOP initiated by a first device 201. At block 820, the second device 202 transmits, to the first device 201, a preemption request for the preemption of the TXOP. At block 830, dependent on an operation performed by the first device 201, the second device 202 determines that the preemption of the TXOP is granted or rejected by the first device 201.

[00111] In some embodiments, prior to transmitting the preemption request, the second device 202 may transmit, to the first device 201, an indication for configuring the first device 201 to support a negotiation for the preemption of the TXOP.

[00112] In some embodiments, the second device 202 may transmit the preemption request through an ACK frame in response to a PPDU frame received from the first device 201 within the TXOP. Alternatively or in addition, the second device 202 may transmit the preemption request through a frame in a further link among multi-links established between the first device 201 and the second device 202.

[00113] In some embodiments, the preemption request may indicate at least one of type information, priority information or latency information of a data frame to be transmitted or received by the second device 202.

[00114] In some embodiments, the second device 202 may receive a preemption response to inform the second device 202 that the preemption of the TXOP is granted or rejected. If the preemption of the TXOP is granted, the second device 202 may perform a data frame transmission with the first device 201 or a third device within the TXOP.

[00115] In some embodiments, the second device 202 may be informed that the preemption of the TXOP is granted or rejected by the operation performed by the first device 210. The operation may comprise performing a transmission or refraining from transmitting data during a time window configured after a transmission of the preemption request. The time window may comprise at least one IFS.

[00116] In some embodiments, the second device 202 may monitor data transmission from the first device during the time window. If data transmission from the first device during the time window is detected, the second device 202 may determine that the preemption of the TXOP is rejected. If data transmission from the first device during the time window is failed to detect, the second device 202 may determine that the preemption of the TXOP is granted.

[00117] In some embodiments, if the preemption of the TXOP is granted, the second device 202 may perform a data frame transmission with the first device 201 or a third device within the TXOP after the time window.

[00118] In some embodiments, information on the time window may be pre-defined or pre-configured, or transmitted from the second device 202 to the first device 201 in the preemption request or in the indication.

[00119] In some embodiments, the first device 201 is one of an STA or an AP, and the second device is the other one of an STA or an AP.

[00120] In some embodiments, an apparatus capable of performing any of the method 700 (for example, the first device 201) may comprise means for performing the respective steps of the method 700. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[00121] In some embodiments, the apparatus comprises: means for receiving, at a first

device and from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device; means for determining whether to grant or reject the preemption of the TXOP; and means for performing an operation to inform the second device that the preemption of the TXOP is granted or rejected.

[00122] In some embodiments, the apparatus further comprises means for: prior to receiving the preemption request, receiving an indication for configuring the first device to support a negotiation for the preemption of the TXOP.

[00123] In some embodiments, the means for receiving the preemption request comprises means for receiving the preemption request through an acknowledgement (ACK) frame in response to a physical protocol data unit (PPDU) frame transmitted by the first device within the TXOP; or means for receiving the preemption request through a frame in a further link among multiple links established between the first device and the second device.

[00124] In some embodiments, the means for determining whether to grant or reject the preemption of the TXOP comprises means for determining whether to grant or reject the preemption of the TXOP dependent on at least one of the following: at least one of type information, priority information or latency information of a data frame indicated in the preemption request; or at least one of type information, priority information or latency information of a data frame buffered at the first device.

[00125] In some embodiments, the means for determining whether to grant or reject the preemption of the TXOP comprises means for determining whether to grant or reject the preemption of the TXOP dependent on at least one of the following: dependent on determining that a low latency data frame is to be transmitted by the first device within the TXOP, determining to reject the preemption; or means for dependent on determining that no low latency data frame is to be transmitted by the first device within the TXOP, determining to grant the preemption.

[00126] In some embodiments, the means for performing the operation to inform the second device comprises means for transmitting, to the second device, a preemption response to inform the second device that the preemption of the TXOP is granted or rejected.

[00127] In some embodiments, the apparatus further comprises means for dependent on determining to grant the preemption, terminating an ongoing transmission within the TXOP;

or means for dependent on determining to reject the preemption, continuing the ongoing transmission within the TXOP.

[00128] In some embodiments, the operation comprises performing a transmission or refraining from transmitting data during a time window configured after a transmission of the preemption request. In some embodiments, the time window comprises at least one IFS.

[00129] In some embodiments, the means for performing the operation to inform the second device comprises means for dependent on determining to grant the preemption, terminating an ongoing transmission within the TXOP without transmitting a preemption response to the second device; and means for refraining from transmitting data during the time window.

[00130] In some embodiments, the means for performing the operation to inform the second device comprises means for dependent on determining to reject the preemption, continuing an ongoing transmission starting from the time window.

[00131] In some embodiments, information on the time window is pre-defined or pre-configured, or received from the second device in the preemption request or in the indication. In some embodiments, the first device is one of an STA or an AP, and the second device is the other one of an STA or an AP.

[00132] In some embodiments, the apparatus further comprises means for performing other steps in some embodiments of the method 700. In some embodiments, the means comprises at least one processor and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[00133] In some embodiments, an apparatus capable of performing any of the method 800 (for example, the second device 202) may comprise means for performing the respective steps of the method 800. The means may be implemented in any suitable form. For example, the means may be implemented in a circuitry or software module.

[00134] In some embodiments, the apparatus comprises: means for determining, at a second device, to preempt a transmission opportunity (TXOP) initiated by a first device; means for transmitting, to the first device, a preemption request for the preemption of the TXOP; and means for determining, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

[00135] In some embodiments, the apparatus further comprises means for prior to transmitting the preemption request, transmitting, to the first device, an indication for configuring the first device to support a negotiation for the preemption of the TXOP.

[00136] In some embodiments, the means for transmitting the preemption request comprises means for transmitting the preemption request through an ACK frame in response to a PPDU frame received from the first device within the TXOP; or means for transmitting the preemption request through a frame in a further link among multi-links established between the first device and the second device.

[00137] In some embodiments, the preemption request may indicate at least one of type information, priority information or latency information of a data frame to be transmitted or received by the second device.

[00138] In some embodiments, the apparatus further comprises means for receiving a preemption response to inform the second device that the preemption of the TXOP is granted or rejected.

[00139] In some embodiments, the apparatus further comprises means for dependent on determining that the preemption of the TXOP is granted, performing a data frame transmission with the first device or a third device within the TXOP.

[00140] In some embodiments, the operation comprises performing a transmission or refraining from transmitting data by the first device during a time window, wherein the time window is configured after a transmission of the preemption request. In some embodiments, the time window comprises at least one IFS.

[00141] In some embodiments, the means for determining that the preemption of the TXOP is granted or rejected comprises means for dependent on detecting data transmission from the first device during the time window, determining that the preemption of the TXOP is rejected; or means for dependent on failing to detect data transmission from the first device during the time window, determining that the preemption of the TXOP is granted.

[00142] In some embodiments, the apparatus further comprises means for dependent on determining that the preemption of the TXOP is granted, perform a data frame transmission with the first device or a third device within the TXOP after the time window.

[00143] In some embodiments, information on the time window is pre-defined or pre-configured, or transmitted to the first device in the preemption request or in the

indication. In some embodiments, the first device is one of an STA or an AP, and the second device is the other one of an STA or an AP.

[00144] In some embodiments, the apparatus further comprises means for performing other steps in some embodiments of the method 800. In some embodiments, the means comprises at least one processor and at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performance of the apparatus.

[00145] Fig. 9 is a simplified block diagram of a device 900 that is suitable for implementing embodiments of the present disclosure. The device 900 may be provided to implement the communication device, for example the first device 201, or the second device 202 as shown in Figs. 2-4. As shown, the device 900 includes one or more processors 910, one or more memories 920 coupled to the processor 910, and one or more communication modules 940 coupled to the processor 910.

[00146] The communication module 940 is for bidirectional communications. The communication module 940 has at least one antenna to facilitate communication. The communication interface may represent any interface that is necessary for communication with other network elements.

[00147] The processor 910 may be of any type suitable to the local technical network and may include one or more of the following: general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 900 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00148] The memory 920 may include one or more non-volatile memories and one or more volatile memories. Examples of the non-volatile memories include, but are not limited to, a Read Only Memory (ROM) 924, an electrically programmable read only memory (EPROM), a flash memory, a hard disk, a compact disc (CD), a digital video disk (DVD), and other magnetic storage and/or optical storage. Examples of the volatile memories include, but are not limited to, a random access memory (RAM) 922 and other volatile memories that will not last in the power-down duration.

[00149] A computer program 930 includes computer executable instructions that are executed by the associated processor 910. The program 930 may be stored in the ROM

920. The processor 910 may perform any suitable actions and processing by loading the program 930 into the RAM 920.

[00150] The embodiments of the present disclosure may be implemented by means of the program 930 so that the device 900 may perform any process of the disclosure as discussed with reference to Figs. 2 to 8. The embodiments of the present disclosure may also be implemented by hardware or by a combination of software and hardware.

[00151] In some embodiments, the program 930 may be tangibly contained in a computer readable medium which may be included in the device 900 (such as in the memory 920) or other storage devices that are accessible by the device 900. The device 900 may load the program 930 from the computer readable medium to the RAM 922 for execution. The computer readable medium may include any types of tangible non-volatile storage, such as ROM, EPROM, a flash memory, a hard disk, CD, DVD, and the like. Fig. 10 shows an example of the computer readable medium 1000 in form of CD or DVD. The computer readable medium has the program 930 stored thereon.

[00152] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method 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.

[00153] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the method 700 or the method 800 as described above with reference to Figs. 7 and 8. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined

or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00154] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[00155] In the context of the present disclosure, the computer program codes or related data may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer readable medium, and the like.

[00156] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. The term "non-transitory," as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM).

[00157] Further, while operations are depicted 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. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

[00158] Although the present disclosure has been described in languages specific to structural features and/or methodological acts, it is to be understood that the present disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

WHAT IS CLAIMED IS:

1. A first device comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the first device at least to:

receive, from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device;

determine whether to grant or reject the preemption of the TXOP; and

perform an operation to inform the second device that the preemption of the TXOP is granted or rejected.

2. The first device of claim 1, wherein the first device is further caused to:

prior to receiving the preemption request, receive an indication for configuring the first device to support a negotiation for the preemption of the TXOP.

3. The first device of claim 1 or 2, wherein the first device is caused to receive the preemption request by:

receiving the preemption request through an acknowledgement (ACK) frame in response to a physical protocol data unit (PPDU) frame transmitted by the first device within the TXOP; or

receiving the preemption request through a frame in a further link among multiple links established between the first device and the second device.

4. The first device of any of claims 1-3, wherein the first device is caused to determine whether to grant or reject the preemption of the TXOP dependent on at least one of the following:

at least one of type information, priority information or latency information of a data frame indicated in the preemption request; or

at least one of type information, priority information or latency information of a data frame buffered at the first device.

5. The first device of any of claims 1-4, wherein the first device is caused to determine whether to grant or reject the preemption of the TXOP by at least one of the

following:

dependent on determining that a low latency data frame is to be transmitted by the first device within the TXOP, determining to reject the preemption; or

dependent on determining that no low latency data frame is to be transmitted by the first device within the TXOP, determining to grant the preemption.

6. The first device of any of claims 1-5, wherein the first device is caused to perform the operation to inform the second device by:

transmitting, to the second device, a preemption response to inform the second device that the preemption of the TXOP is granted or rejected.

7. The first device of claim 6, wherein the first device is further caused to:

dependent on determining to grant the preemption, terminate an ongoing transmission within the TXOP; or

dependent on determining to reject the preemption, continue the ongoing transmission within the TXOP.

8. The first device of any of claims 1-5, wherein the operation comprises performing a transmission or refraining from transmitting data during a time window configured after a transmission of the preemption request.

9. The first device of claim 8, wherein the time window comprises at least one inter frame space (IFS).

10. The first device of claim 8, wherein the first device is caused to perform the operation to inform the second device by:

dependent on determining to grant the preemption, terminating an ongoing transmission within the TXOP without transmitting a preemption response to the second device; and

refraining from transmitting data during the time window.

11. The first device of claim 8, wherein the first device is caused to perform the operation to inform the second device by:

dependent on determining to reject the preemption, continuing an ongoing

transmission starting from the time window.

12. The first device of any of claims 8-11, wherein information on the time window is pre-defined or pre-configured, or received from the second device in the preemption request or in the indication.

13. The first device of any of claims 1-121, wherein the first device is one of a station (STA) or an access point (AP), and the second device is one of an STA or an AP.

14. A second device comprising:

at least one processor; and

at least one memory storing instructions that, when executed by the at least one processor, cause the second device at least to:

determine to preempt a transmission opportunity (TXOP) initiated by a first device;

transmit, to the first device, a preemption request for the preemption of the TXOP; and

determine, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

15. The second device of claim 14, wherein the second device is further caused to:

prior to transmitting the preemption request, transmit, to the first device, an indication for configuring the first device to support a negotiation for the preemption of the TXOP.

16. The second device of claim 14 or 15, wherein the second device is caused to transmit the preemption request by:

transmitting the preemption request through an acknowledgement (ACK) frame in response to a physical protocol data unit (PPDU) frame received from the first device within the TXOP; or

transmitting the preemption request through a frame in a further link among multi-links established between the first device and the second device.

17. The second device of claim 16, wherein the preemption request indicates at least

one of type information, priority information or latency information of a data frame to be transmitted or received by the second device.

18. The second device of any of claims 14-16, wherein the second device is further caused to:

receive a preemption response to inform the second device that the preemption of the TXOP is granted or rejected.

19. The second device of claim 18, wherein the second device is further caused to:

dependent on determining that the preemption of the TXOP is granted, perform a data frame transmission with the first device or a third device within the TXOP.

20. The second device of any of claims 14-16, wherein the operation comprises performing a transmission or refraining from transmitting data by the first device during a time window, wherein the time window is configured after a transmission of the preemption request.

21. The second device of claim 20, wherein the time window comprises at least one inter frame space (IFS).

22. The second device of claim 20, wherein the second device is caused to determine that the preemption of the TXOP is granted or rejected by:

dependent on detecting data transmission from the first device during the time window, determining that the preemption of the TXOP is rejected; or

dependent on failing to detect data transmission from the first device during the time window, determining that the preemption of the TXOP is granted.

23. The second device of claim 22, wherein the second device is further caused to:

dependent on determining that the preemption of the TXOP is granted, perform a data frame transmission with the first device or a third device within the TXOP after the time window.

24. The second device of claim 20, wherein information on the time window is pre-defined or pre-configured, or transmitted to the first device in the preemption request or

in the indication.

25. The second device of any of claims 14-24, wherein the first device is one of a station (STA) or an access point (AP), and the second device is one of an STA or an AP.

26. A method comprising:

receiving, at a first device and from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device;

determining whether to grant or reject the preemption of the TXOP; and

performing an operation to inform the second device that the preemption of the TXOP is granted or rejected.

27. A method comprising:

determining, at a second device, to preempt a transmission opportunity (TXOP) initiated by a first device;

transmitting, to the first device, a preemption request for the preemption of the TXOP; and

determining, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

28. An apparatus comprising:

means for receiving, at a first device and from a second device, a preemption request for preemption of a transmission opportunity (TXOP) initiated by the first device;

means for determining whether to grant or reject the preemption of the TXOP; and

means for performing an operation to inform the second device that the preemption of the TXOP is granted or rejected.

29. An apparatus comprising:

means for determining, at a second device, to preempt a transmission opportunity (TXOP) initiated by a first device;

means for transmitting, to the first device, a preemption request for the preemption of the TXOP; and

means for determining, dependent on an operation performed by the first device, that the preemption of the TXOP is granted or rejected by the first device.

30. A computer readable medium comprising program instructions that, when executed by an apparatus, cause the apparatus to perform any of the methods of claims 26 and 27.

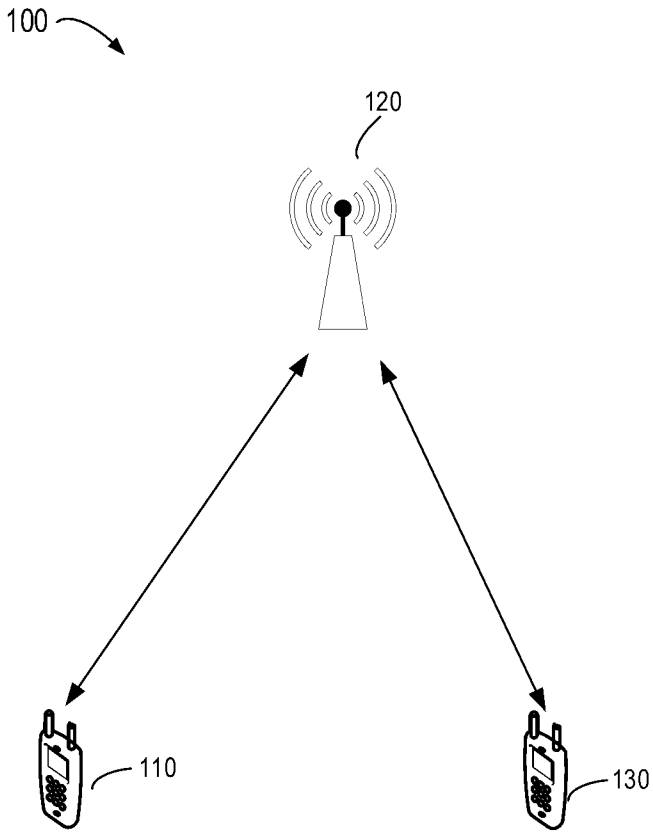

Fig. 1A

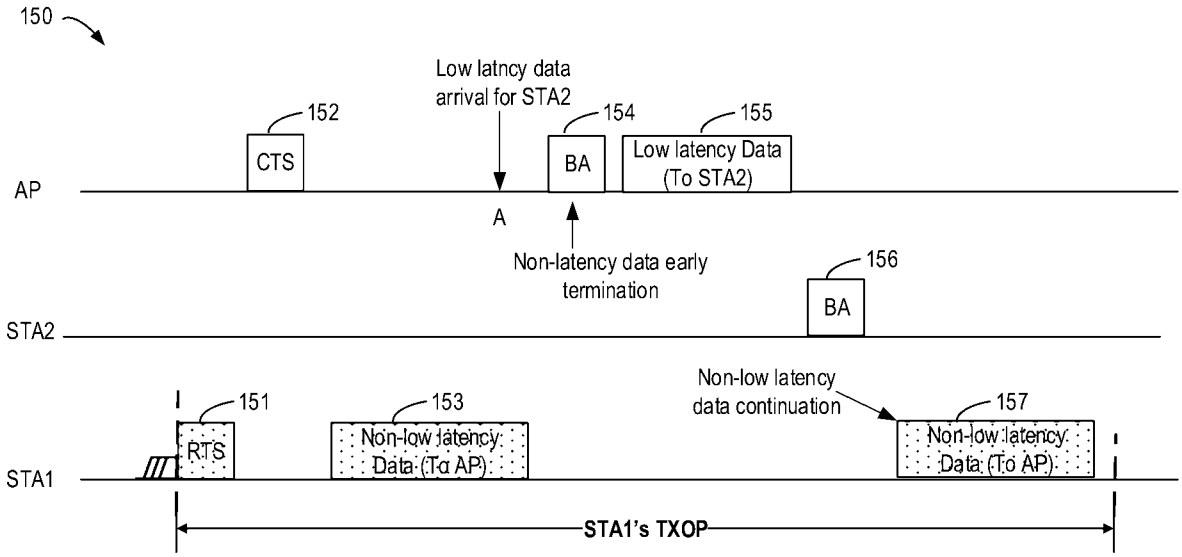
150
Low latncy data arrival for STA2
152
154
155
CTS
BA
Low latency Data (To STA2)
AP
A
Non-latency data early termination
156
BA
STA2
Non-low latency data continuation
151
153
157
RTS
Non-low latency Data (To AP)
Non-low latency Data (To AP)
STA1
STA1's TXOP

Fig. 1B

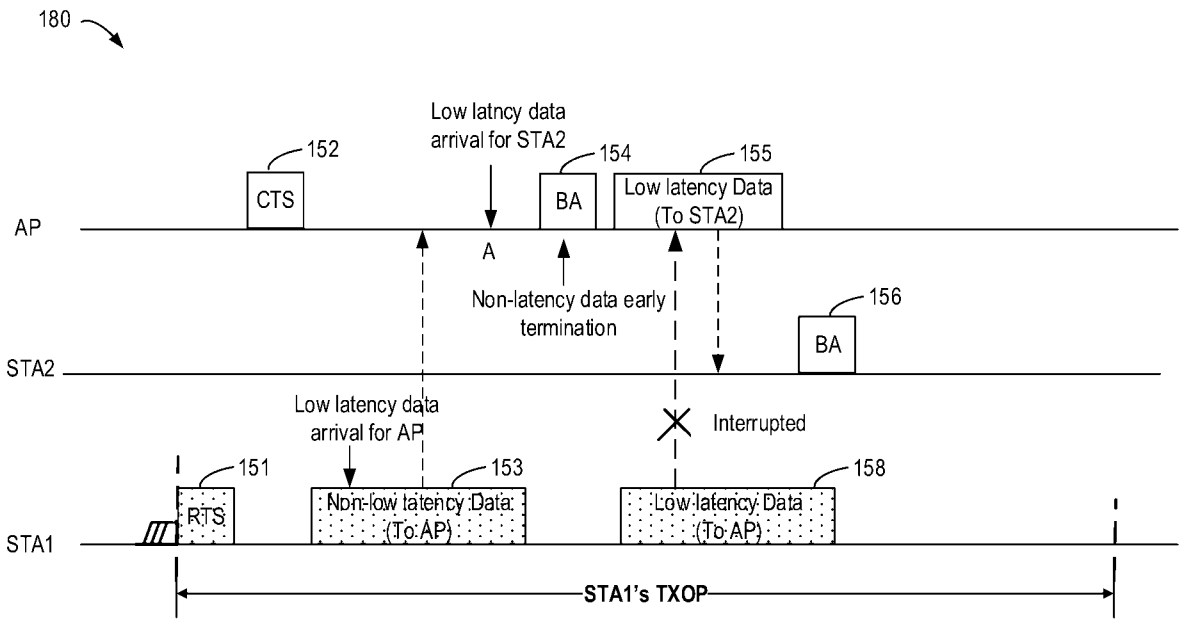
180
Low latncy data arrival for STA2
152
154
155
CTS
BA
Low latency Data (To STA2)
AP
A
Non-latency data early termination
156
BA
STA2
Low latency data arrival for AP
Interrupted
151
153
158
RTS
Non-low latency Data (To AP)
Low latency Data (To AP)
STA1
STA1's TXOP

Fig. 1C

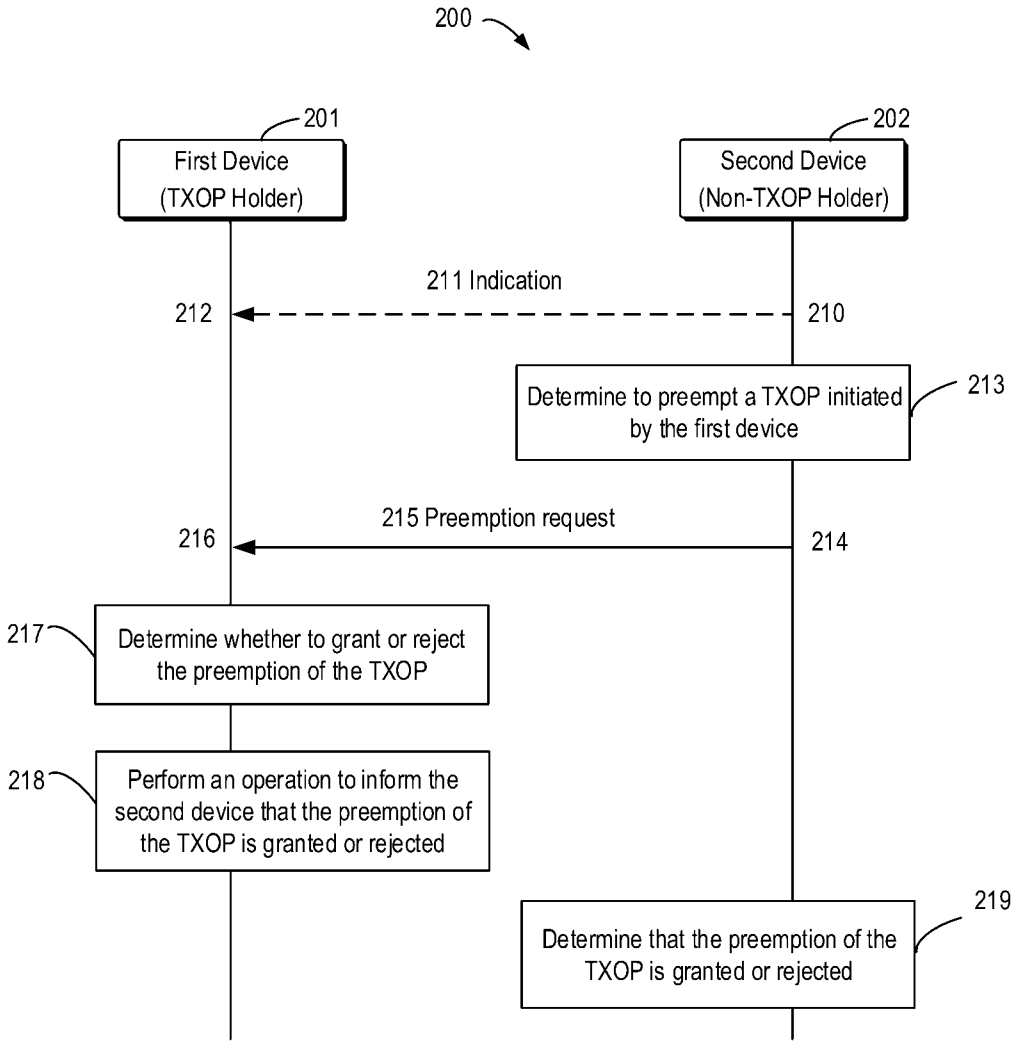
200
201
First Device
(TXOP Holder)
202
Second Device
(Non-TXOP Holder)
211 Indication
212
210
Determine to preempt a TXOP initiated by the first device
213
215 Preemption request
216
214
217
Determine whether to grant or reject the preemption of the TXOP
218
Perform an operation to inform the second device that the preemption of the TXOP is granted or rejected
219
Determine that the preemption of the TXOP is granted or rejected

Fig. 2

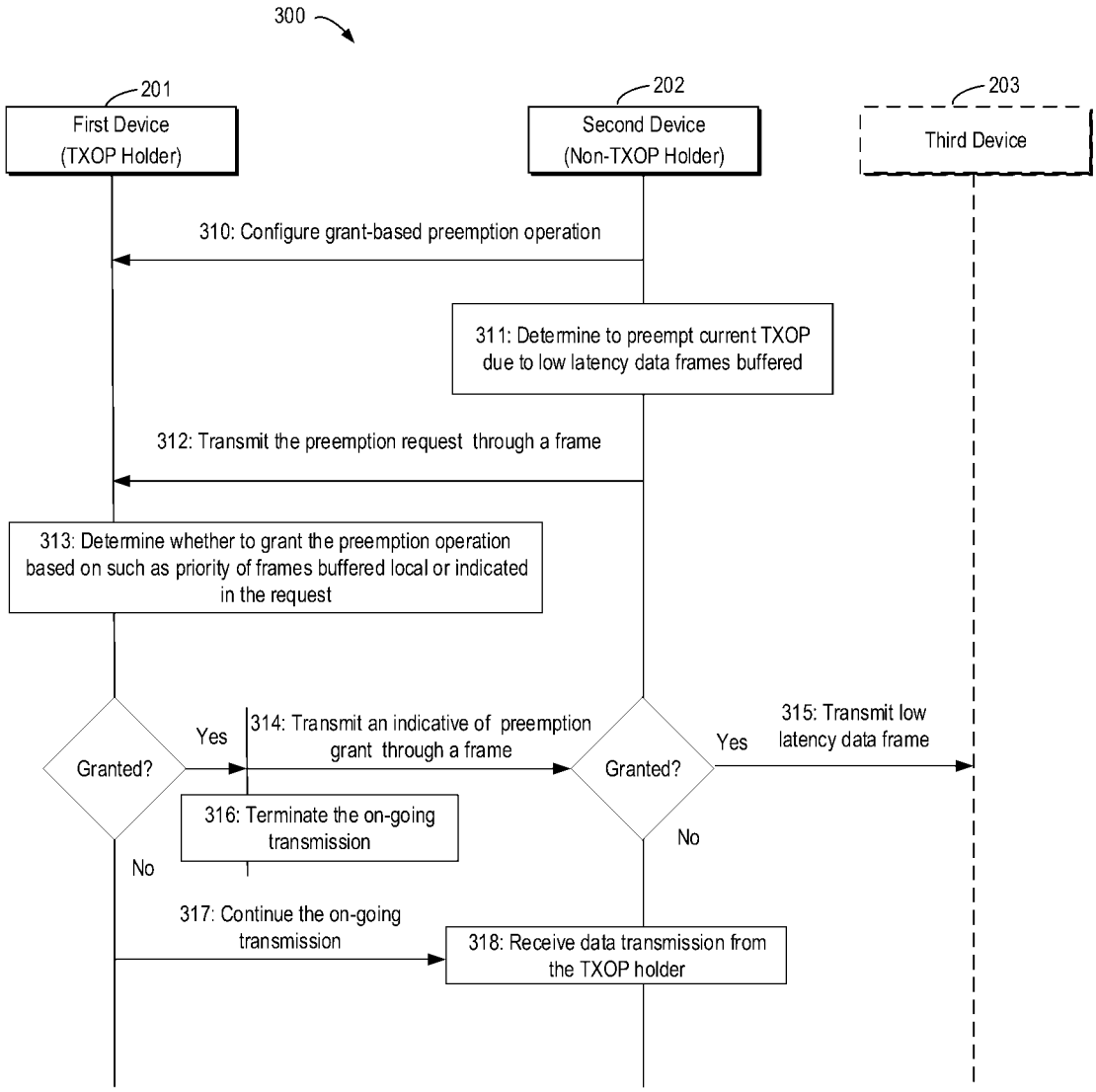
300
201
First Device
(TXOP Holder)
202
Second Device
(Non-TXOP Holder)
203
Third Device
310: Configure grant-based preemption operation
311: Determine to preempt current TXOP due to low latency data frames buffered
312: Transmit the preemption request through a frame
313: Determine whether to grant the preemption operation based on such as priority of frames buffered local or indicated in the request
Granted?
Yes
314: Transmit an indicative of preemption grant through a frame
316: Terminate the on-going transmission
No
Granted?
Yes
315: Transmit low latency data frame
No
317: Continue the on-going transmission
318: Receive data transmission from the TXOP holder

Fig. 3

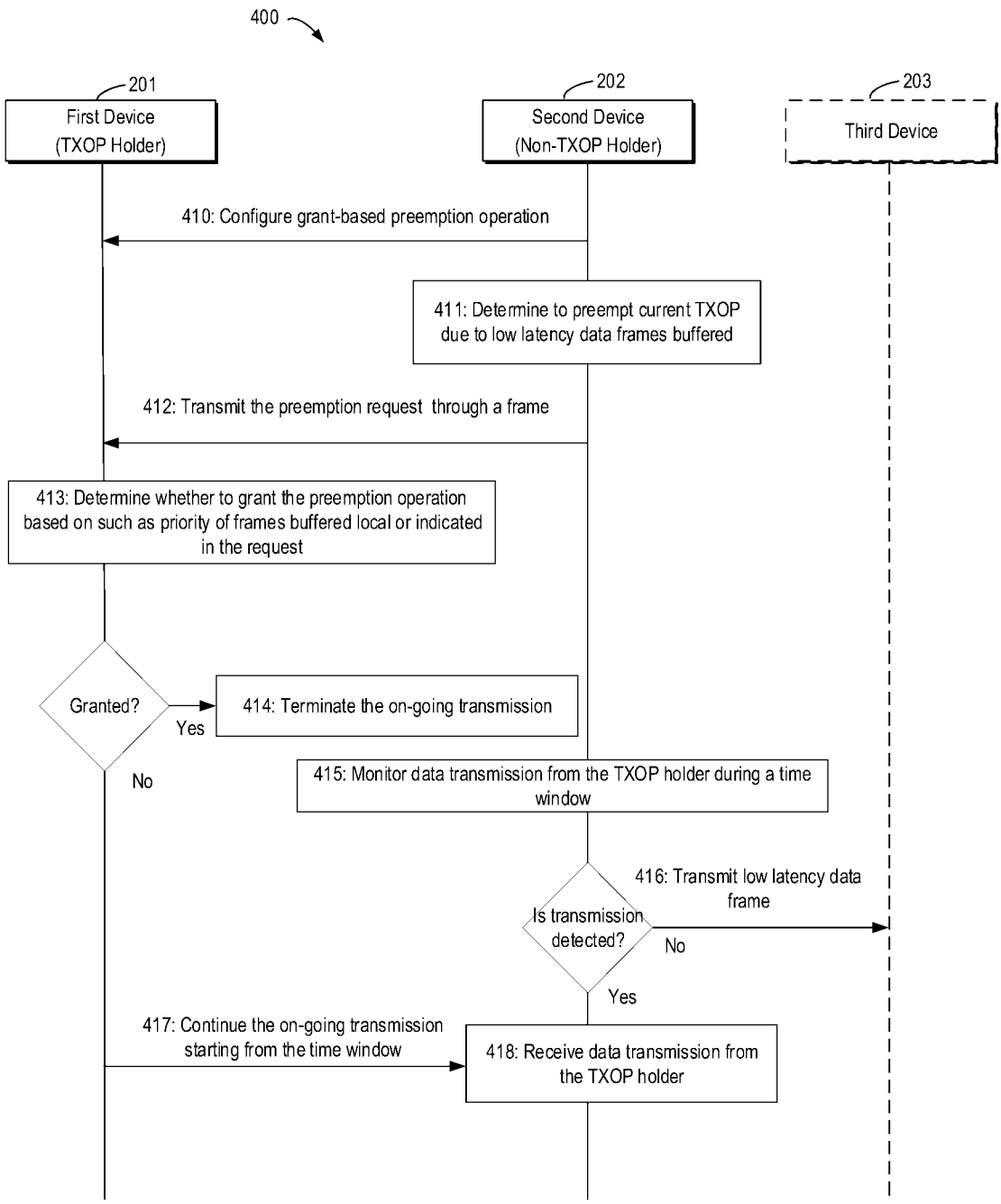
400
201
First Device
(TXOP Holder)
202
Second Device
(Non-TXOP Holder)
203
Third Device
410: Configure grant-based preemption operation
411: Determine to preempt current TXOP due to low latency data frames buffered
412: Transmit the preemption request through a frame
413: Determine whether to grant the preemption operation based on such as priority of frames buffered local or indicated in the request
Granted?
Yes
414: Terminate the on-going transmission
No
415: Monitor data transmission from the TXOP holder during a time window
Is transmission detected?
416: Transmit low latency data frame
No
Yes
417: Continue the on-going transmission starting from the time window
418: Receive data transmission from the TXOP holder

Fig. 4

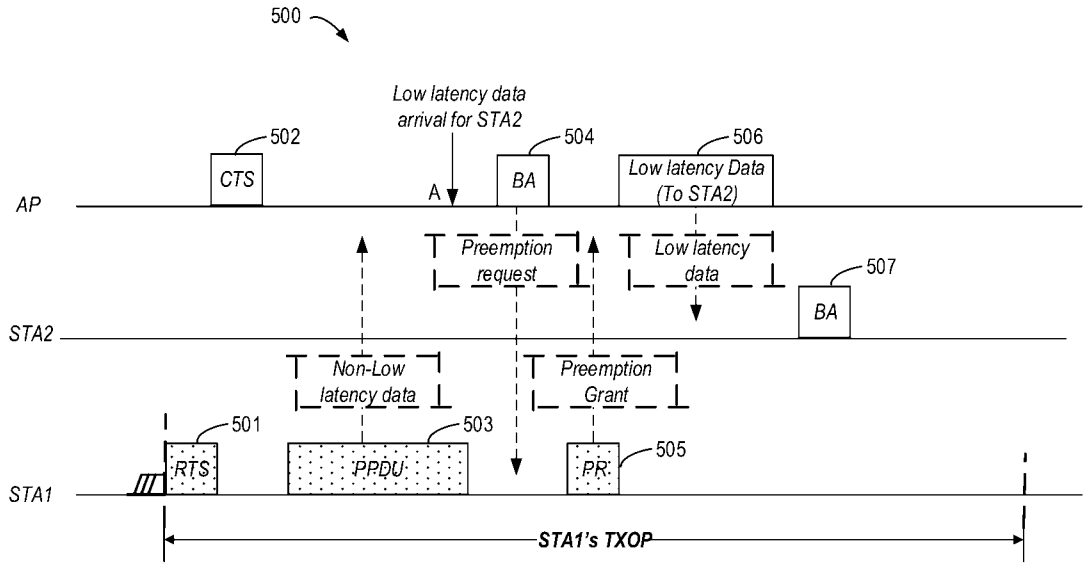
500
Low latency data arrival for STA2
502
504
506
CTS
A
BA
Low latency Data (To STA2)
AP
Preemption request
Low latency data
507
BA
STA2
Non-Low latency data
Preemption Grant
501
503
505
RTS
PPDU
PR
STA1
STA1's TXOP

Fig. 5

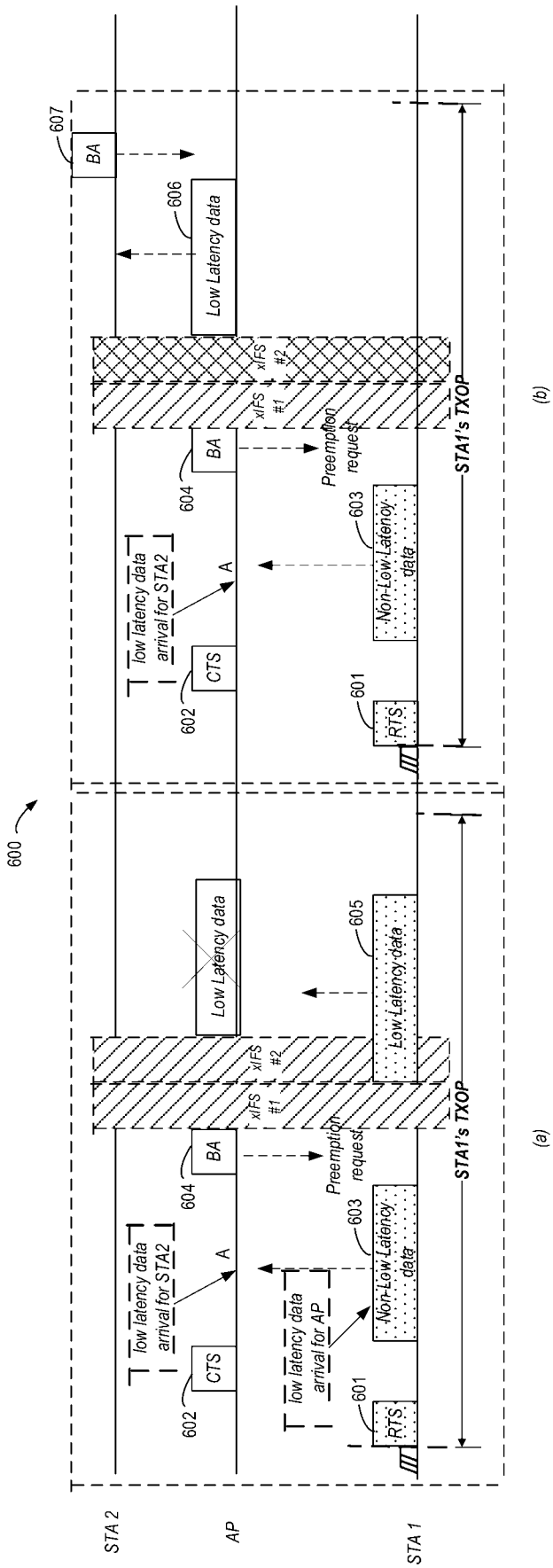
600
STA 2
AP
STA 1
(a)
(b)
BA
CTS
RTS
Low Latency data
Non-Low-Latency data
Low-Latency data
low latency data arrival for STA2
low latency data arrival for AP
xIFS #1
xIFS #2
Preemption request
STA1's TXOP
601
602
603
604
605
606
607
A

Fig. 6

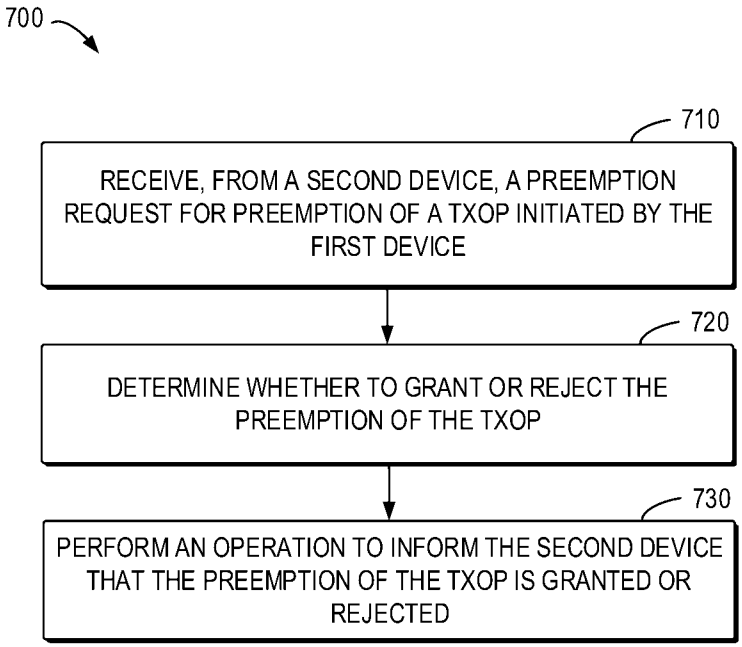
700
710
RECEIVE, FROM A SECOND DEVICE, A PREEMPTION REQUEST FOR PREEMPTION OF A TXOP INITIATED BY THE FIRST DEVICE
720
DETERMINE WHETHER TO GRANT OR REJECT THE PREEMPTION OF THE TXOP
730
PERFORM AN OPERATION TO INFORM THE SECOND DEVICE THAT THE PREEMPTION OF THE TXOP IS GRANTED OR REJECTED

Fig. 7

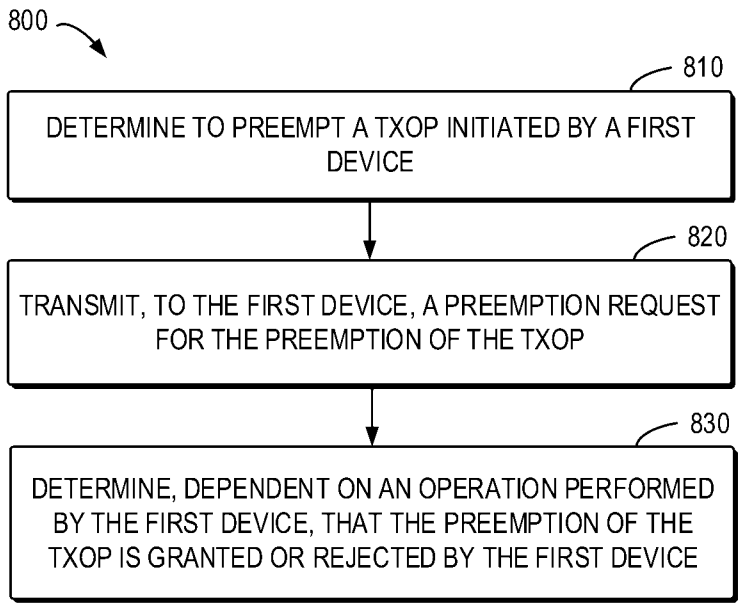
800
810
DETERMINE TO PREEMPT A TXOP INITIATED BY A FIRST DEVICE
820
TRANSMIT, TO THE FIRST DEVICE, A PREEMPTION REQUEST FOR THE PREEMPTION OF THE TXOP
830
DETERMINE, DEPENDENT ON AN OPERATION PERFORMED BY THE FIRST DEVICE, THAT THE PREEMPTION OF THE TXOP IS GRANTED OR REJECTED BY THE FIRST DEVICE

Fig. 8

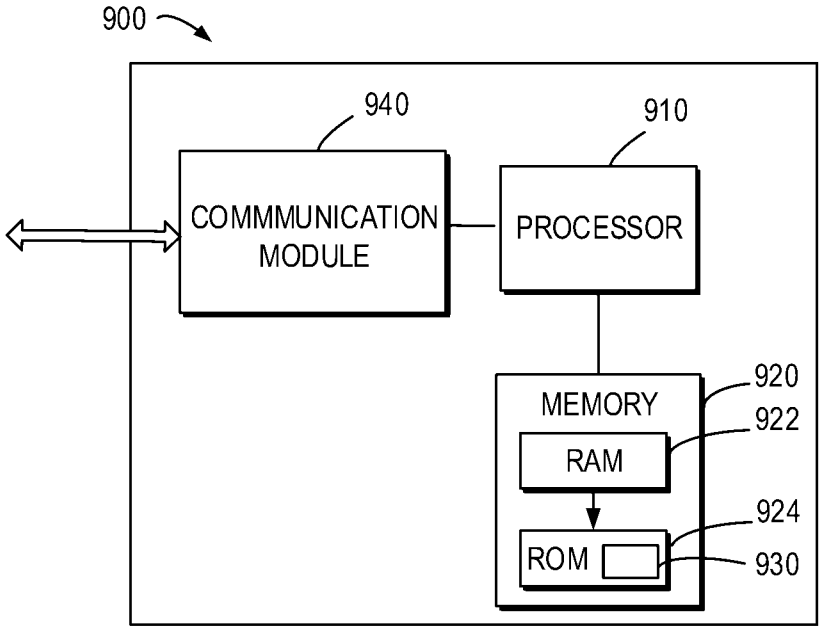
900
940
910
COMMMUNICATION MODULE
PROCESSOR
MEMORY
920
922
RAM
924
ROM
930

Fig. 9

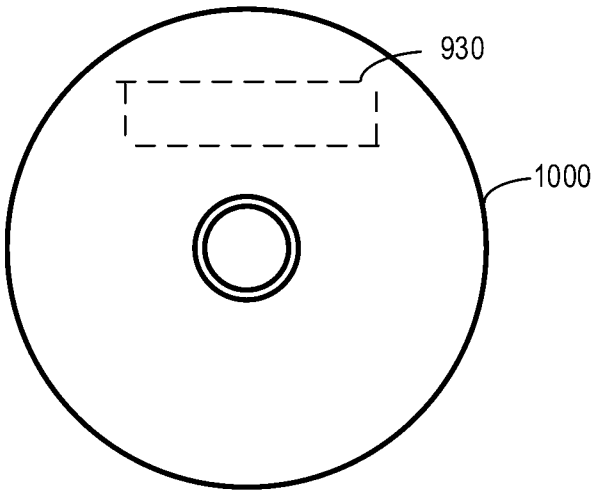
930
1000

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/100202

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/512(2023.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04W

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

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

CNTXT,ENTXT,DWPI,CNKI,IEEE:preemption,TXOP,grant,reject,STA,AP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2023081745 A1 (SONY GROUP CORPORATION et al.) 16 March 2023 (2023-03-16) description, paragraphs [0125]-[0126], [0255]-[0262]	1-30
A	CN 114051709 A (TELEFONAKTIEBOLAGET LM ERICSSON(PUBL)) 15 February 2022 (2022-02-15) the whole document	1-30
A	CN 111345101 A (NEC CORPORATION) 26 June 2020 (2020-06-26) the whole document	1-30
A	CN 113519197 A (TELEFONAKTIEBOLAGET LM ERICSSON(PUBL)) 19 October 2021 (2021-10-19) the whole document	1-30

☐ 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
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 2023	**06 December 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.
PCT/CN2023/100202

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2023081745 A1	16 March 2023	WO 2023044263 A1	23 March 2023
		CN 116803184 A	22 September 2023
		KR 20230136220 A	26 September 2023
CN 114051709 A	15 February 2022	JP 2022533634 A	25 July 2022
		WO 2020229555 A1	19 November 2020
		US 2022210793 A1	30 June 2022
		EP 3970400 A1	23 March 2022
CN 111345101 A	26 June 2020	US 2022201692 A1	23 June 2022
		EP 3677083 A1	08 July 2020
		US 2020351887 A1	05 November 2020
		JP 2020528253 A	17 September 2020
		US 2023254882 A1	10 August 2023
		WO 2019041137 A1	07 March 2019
		JP 2022009495 A	14 January 2022
CN 113519197 A	19 October 2021	US 2022104241 A1	31 March 2022
		WO 2020144299 A1	16 July 2020
		EP 3909369 A1	17 November 2021