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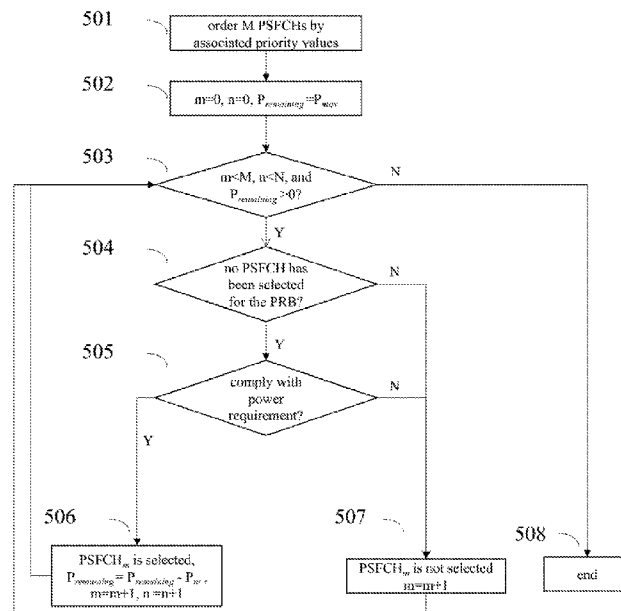


Figure 5(a)

(57) Abstract: The present application relates to a method and apparatus for transmitting physical sidelink feedback channels. One embodiment of the subject application provides a method for transmitting physical sidelink feedback channels (PSFCHs), including: selecting a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with each PSFCH in the second set of PSFCHs; and transmitting the first set of PSFCHs.

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METHOD AND APPARATUS FOR TRANSMITTING PHYSICAL SIDELINK FEEDBACK CHANNELS

TECHNICAL FIELD

[0001] The subject application relates to sidelink communication, and more specifically relates to transmitting physical sidelink feedback channels (PSFCHs) during sidelink communication.

BACKGROUND OF THE INVENTION

[0002] Vehicle to everything (V2X) has been introduced into 5G wireless communication technology. In terms of a channel structure of V2X communication, a direct link between two User Equipments (UEs) is called a sidelink (SL). Sidelink is a long-term evolution (LTE) feature introduced in 3GPP Release 12, and enables a direct communication between proximal UEs, and data does not need to go through a base station (BS) or a core network.

[0003] When a UE needs to transmit multiple PSFCHs simultaneously during sidelink communication, some PSFCHs in the multiple PSFCHs might be mapped to the same PRB. Therefore, PSFCH selection is required before transmitting the PSFCHs.

SUMMARY

[0004] One embodiment of the subject application provides a method for transmitting physical sidelink feedback channels (PSFCHs), including: selecting a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with each PSFCH in the second set of PSFCHs; and transmitting the first set of PSFCHs.

[0005] Another embodiment of the subject application provides an apparatus, including: a non-transitory computer-readable medium having stored thereon computer-executable instructions; a receiving circuitry; a transmitting circuitry; and a processor coupled to the non-transitory computer-readable medium, the receiving circuitry and the transmitting circuitry, wherein the computer-executable instructions

cause the processor to implement the method for transmitting PSFCHs, including: selecting a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with each PSFCH in the second set of PSFCHs; and transmitting the first set of PSFCHs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 illustrates a schematic diagram of a wireless communication system 100 in accordance with some embodiments of the subject disclosure.

[0007] Figure 2 illustrates an example of PSFCH resource collision according to some embodiments of the subject disclosure.

[0008] Figure 3 illustrates an example of two PSFCHs mapped to the same PRB according to some embodiments of the subject disclosure.

[0009] Figure 4 illustrates a solution for selecting PSFCHs based on the priority values and duplex schemes according to some embodiments of the subject application.

[0010] Figure 5(a) illustrates a flow chart for selecting PSFCHs based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application.

[0011] Figure 5(b) illustrates another flow chart for selecting PSFCHs based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application.

[0012] Figure 5(c) illustrates an embodiment for selecting PSFCHs with different power spectral density (PSD) based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application.

[0013] Figure 5(d) illustrates an embodiment for selecting PSFCHs with the same or similar PSD based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application.

[0014] Figure 6 illustrates a method performed by a UE for transmitting physical sidelink feedback channel according to a preferred embodiment of the subject disclosure.

[0015] Figure 7 illustrates a block diagram of a UE according to the embodiments of the subject disclosure.

DETAILED DESCRIPTION

[0016] The detailed description of the appended drawings is intended as a description of the currently preferred embodiments of the present invention, and is not intended to represent the only form in which the present invention may be practiced. It should be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the spirit and scope of the present invention.

[0017] Reference will now be made in detail to some embodiments of the present application, examples of which are illustrated in the accompanying drawings. To facilitate understanding, embodiments are provided under specific network architecture and new service scenarios, such as 3GPP 5G, 3GPP LTE Release 8 and so on. It is contemplated that along with developments of network architectures and new service scenarios, all embodiments in the present application are also applicable to similar technical problems; and moreover, the terminologies recited in the present application may change, which should not affect the principle of the present application.

[0018] UE(s) under new radio (NR) V2X scenario may be referred to as V2X UE(s). A V2X UE, which transmits data according to sidelink resource(s) scheduled by a base station (BS), may be referred to as a UE for transmitting, a transmitting UE, a transmitting V2X UE, a Tx UE, a V2X Tx UE, a SL Tx UE, or the like. A V2X UE, which receives data according to sidelink resource(s) scheduled by a BS, may be referred to as a UE for receiving, a receiving UE, a receiving V2X UE, a Rx UE, a V2X Rx UE, a SL Rx UE, or the like.

[0019] V2X UE(s) may include computing devices, such as desktop computers,

laptop computers, personal digital assistants (PDAs), tablet computers, smart televisions (e.g., televisions connected to the Internet), set-top boxes, game consoles, security systems (including security cameras), vehicle on-board computers, network devices (e.g., routers, switches, and modems), internet of things (IoT) devices, or the like.

[0020] According to some embodiments of the present application, V2X UE(s) may include a portable wireless communication device, a smart phone, a cellular telephone, a flip phone, a device having a subscriber identity module, a personal computer, a selective call receiver, or any other device that is capable of sending and receiving communication signals on a wireless network.

[0021] According to some embodiments of the present application, V2X UE(s) includes wearable devices, such as smart watches, fitness bands, optical head-mounted displays, or the like. Moreover, V2X UE(s) may be referred to as a subscriber unit, a mobile, a mobile station, a user, a terminal, a mobile terminal, a wireless terminal, a fixed terminal, a subscriber station, a user terminal, or a device, or described using other terminology used in the art. V2X UE(s) may communicate directly with BS(s) via uplink (UL) communication signals.

[0022] A BS under NR V2X scenario may be referred to as a base unit, a base, an access point, an access terminal, a macro cell, a Node-B, an enhanced Node B (eNB), a gNB, a Home Node-B, a relay node, a device, a remote unit, or by any other terminology used in the art. A BS may be distributed over a geographic region. Generally, a BS is a part of a radio access network that may include one or more controllers communicably coupled to one or more corresponding base stations.

[0023] A BS is generally communicably coupled to one or more packet core networks (PCN), which may be coupled to other networks, like the packet data network (PDN) (e.g., the Internet) and public switched telephone networks, among other networks. These and other elements of radio access and core networks are not illustrated but are well known generally by those having ordinary skill in the art. For example, one or more BSs may be communicably coupled to a mobility management entity (MME), a serving gateway (SGW), and/or a packet data network gateway (PGW).

[0024] A BS may serve a number of V2X UEs within a serving area, for example, a cell or a cell sector via a wireless communication link. A BS may communicate directly with one or more of V2X UEs via communication signals. For example, a BS may serve V2X UEs within a macro cell.

[0025] Sidelink communication between a Tx UE and an Rx UE under NR V2X scenario includes groupcast communication, unicast communication, or broadcast communication.

[0026] Embodiments of the present application may be provided in a network architecture that adopts various service scenarios, for example but is not limited to, 3GPP 3G, long-term evolution (LTE), LTE-Advanced (LTE-A), 3GPP 4G, 3GPP 5G NR (new radio), 3GPP LTE Release 12 and onwards, etc. It is contemplated that along with the 3GPP and related communication technology development, the terminologies recited in the present application may change, which should not affect the principle of the present application.

[0027] Figure 1 illustrates an exemplary V2X communication system in accordance with some embodiments of the present application.

[0028] As shown in Figure 1, the V2X communication system includes a base station, i.e., BS 102 and some V2X UEs, i.e., UE 101-A, UE 101-B, and UE 101-C. UE 101-A and UE 101-B are within the coverage of BS 102, and UE 101-C is not. UE 101-A and UE 101-B may perform sidelink unicast transmission, sidelink groupcast transmission, or sidelink broadcast transmission. It is contemplated that, in accordance with some other embodiments of the present application, a V2X communication system may include more or fewer BSs, and more or fewer V2X UEs. Moreover, it is contemplated that names of V2X UEs (which represent a Tx UE, a Rx UE, and etc.) as illustrated and shown in Figure 1 may be different, e.g., UE 101c, UE 104f, and UE 108g or the like.

[0029] In addition, although each V2X UE as shown in Figure 1 is illustrated in the shape of a car, it is contemplated that a V2X communication system may include any type of UE (e.g., a roadmap device, a cell phone, a computer, a laptop, IoT (internet of things) device or other type of device) in accordance with some other embodiments of

the present application.

[0030] According to some embodiments of Figure 1, UE 101-A functions as a Tx UE, and UE 101-B and UE 101-C function as an Rx UE. UE 101-A may exchange V2X messages with UE 101-B, or UE 101-C through a sidelink, for example, PC5 interface as defined in 3GPP TS 23.303. UE 101-A may transmit information or data to other UE(s) within the V2X communication system, through sidelink unicast, sidelink groupcast, or sidelink broadcast. For instance, UE 101-A transmits data to UE 101-B in a sidelink unicast session. UE 101-A may transmit data to UE 101-B and UE 101-C in a groupcast group by a sidelink groupcast transmission session. Also, UE 102 may transmit data to UE 101-B and UE 101-C by a sidelink broadcast transmission session.

[0031] Alternatively, according to some other embodiments of Figure 1, UE 101-B and 101-C functions a Tx UEs and transmit V2X messages, UE 101-A functions as a Rx UE and receives the V2X messages from UE 101-B and 101-C.

[0032] Both UE 101-A and UE 101-B in the embodiments of Figure 1 may transmit information to BS 102 and receive control information from BS 102, for example, via NR Uu interface. BS 102 may define one or more cells, and each cell may have a coverage area. As shown in Figure 1, both UE 101-A and UE 101-B are within coverage of BS 102, and UE 101-C is outside of the coverage of BS 102.

[0033] BS 102 as illustrated and shown in Figure 1 is not a specific base station, but may be any base station(s) in the V2X communication system. For example, if the V2X communication system includes two BSs 102, UE 101-A being within a coverage area of any one the two BSs 102 may be called as a case that UE 101-A is within a coverage of BS 102 in the V2X communication system; and only UE 101-A being outside of coverage area(s) of both BSs 102 can be called as a case that UE 101-A is outside of the coverage of BS 102 in the V2X communication system.

[0034] In NR Rel-16 V2X, the PSFCH resources can be preconfigured or configured periodically with a period of 1 slot, 2 slots, or 4 slots. There is a case that a UE may receive multiple physical sidelink control channels (PSCCH) or physical sidelink shared channels (PSSCH) from different TX UEs, the UE may need to transmit

multiple PSFCHs associated with received PSCCHs or PSSCHs.

[0035] At present, the UE may select some PSFCHs from a number of PSFCHs based on the associated priorities in received sidelink control information (SCI), after selection, the UE may transmit the selected PSFCHs at the same time. The PSFCH resources can be frequency division multiplexed or code division multiplexed. If some PSFCH resources among the selected PSFCH resources are code division multiplexed, then the UE cannot transmit these code division multiplexed PSFCHs simultaneously since some PSFCHs may be mapped to the same physical resource blocks (PRBs).

[0036] There are two options on the association between PSSCH and PSFCH resources that can be configured per resource pool are presented as followed:

- Option 1: the set of physical resource blocks (PRBs) for the candidate PSFCH resource is determined by the starting sub-channel and slot used for that PSSCH.
- Option 2: the set of PRBs for the candidate PSFCH resource is determined by sub-channel(s) and slot used for that PSSCH.

[0037] If option 2 is adopted, there is a possibility that PSFCH resource collision might happen.

[0038] Figure 2 illustrates an example of PSFCH resource collision according to some embodiments of the subject disclosure.

[0039] In Figure 2, both UE 201-B and UE 201-C transmit sidelink PSSCH to UE 201-A in slot n , and UE 201-A needs to transmit PSFCH to both UE 201-B and UE 201-C. UE 201-C transmits a PSSCH to UE 201-A indicating PSFCH resources 2001, 2002, and 2003 in slot n ; UE 201-B transmits a PSSCH to UE 201-A indicating PSFCH resources 2002, and 2003 in slot n . Therefore, the set of PRBs for transmitting PSFCH for UE 201-C is determined by PSFCH resource 2001, PSFCH resource 2002, and PSFCH resource 2003 in slot n , and the set of PRBs for transmitting PSFCH for UE 201-B is determined by PSFCH resource 2002 and

PSFCH resource 2003 in slot n . As can be seen, the PSFCH resource 2002 and PSFCH resource 2003 from different UE are overlapped.

[0040] In view of the above, the PSFCHs are determined by the sub-channels and slot, and there is a probability that the PSFCH for UE 201-B and the PSFCH for UE 201-C may be mapped to the same PRB.

[0041] In current specification, a UE may simultaneously transmit a number of (hereinafter the number is represented with " N ") PSFCHs. For example, in TS 38.213, it stipulate the following rule:

If a UE would transmit M PSFCHs in a PSFCH transmission occasion, the UE transmits $\min(M, N)$ PSFCHs corresponding to the smallest $\min(M, N)$ priority field values indicated in all SCI formats 0_1 associated with the PSFCH transmission occasion.

[0042] According to the current rule, if the M PSFCHs are located in different PRBs, the UE can transmit the M PSFCHs without any problem. However if there are some PSFCHs located in the same PRBs with different cyclic shift pairs (CSPs), there is a probability that some PSFCHs among the $\min(M, N)$ PSFCHs may located in the same PRB when only the priority field indicated in the SCI format 0_1 is considered.

[0043] Figure 3 illustrates an example of two PSFCHs mapped to the same PRB according to the above rule.

[0044] In Figure 3, there are 6 PSFCHs, which are PSFCH₀, PSFCH₁, PSFCH₂, PSFCH₃, PSFCH₄, and PSFCH₅, and they are mapped to 4 PRBs, PRB₁, PRB₂, PRB₃, and PRB₄. The UE may simultaneously transmit 4 PSFCHs. According to the above rule, M equals to 6, and N equals to 4. Therefore, the UE transmits $\min(6, 4)$ PSFCHs corresponding to the smallest $\min(M, N)$ priority field values indicated in all SCI formats 0_1 associated with the PSFCH transmission occasion.

[0045] According to Figure 3, the priority value of PSFCH₀ is 6, the priority value of PSFCH₁ is 3, the priority value of PSFCH₂ is 0, the priority value of PSFCH₃ is 1, the priority value of PSFCH₄ is 0, and the priority value of PSFCH₅ is 5. The UE may

transmit $\min(6, 4)$, which is 4 PSFCHs simultaneously, and the 4 PSFCHs are selected based on their priority values. Therefore, PSFCH₁, PSFCH₂, PSFCH₃, and PSFCH₄ are selected. As can be seen, two PSFCHs, PSFCH₂ and PSFCH₃, which are mapped to the same PRB, PRB₃, are selected. The UE cannot transmit the two PSFCHs at the same time, and an error occurs.

[0046] In order to solve the above problem, the subject disclosure proposes to select the PSFCHs with additional requirements in addition to priority value.

[0047] Figure 4 illustrates a solution for selecting PSFCHs based on the priority values and duplex schemes according to some embodiments of the subject application.

[0048] In Figure 4, there are P PRBs, which are PRB₁, PRB₂, ..., PRB_P, and there are M PSFCHs, which are PSFCH₀, PSFCH₁, PSFCH₂, PSFCH₃, PSFCH₄, ..., and PSFCH_{M-1}. When P < M, which means that there are more than one PSFCHs that are mapped to the same PRB. For example, in status 1 in Figure 4, PSFCH₂ and PSFCH₃ are both mapped to PRB₃, and PSFCH₅ and PSFCH₆ are both mapped to PRB₅.

[0049] For each PRB in the P PRBs, if there are more than one PSFCHs to be transmitted, the UE selects one PSFCH with the smallest priority field values indicated in the SCI formats 0_1 associated with the PSFCH. As shown in Figure 4, for PRB₃, the PSFCH₂ is associated with a smaller priority value, which is 0, thus the UE selects PSFCH₂, instead of PSFCH₃, for PRB₃. Similarly, the UE selects PSFCH₅, instead of PSFCH₆, for PRB₅. After the selection, in status 2, P PSFCHs are mapped to P PRBs, and the condition that two or more PSFCHs are mapped to the same PRB does not exist.

[0050] The UE may transmit N PSFCHs simultaneously; therefore, the UE selects $\min(P, N)$ PSFCHs based on the priority field values indicated in the SCI formats 0_1 associated with the PSFCH with an ascending order. In Figure 4, suppose that P is greater than N, thus the P PSFCHs needs to be further selected. Suppose the UE can transmit 2 PSFCHs simultaneously, then two PSFCHs with the priority "0", i.e., PSFCH₂ and PSFCH₅, are selected. Therefore, in status 3 in Figure 4, there are 2

PSFCHs in 2 PRBs to be transmitted.

[0051] The technical solution in Figure 4 does not take the power control of PSFCH into consideration. In another preferred solution of the subject disclosure, the power control for PSFCH based on sidelink path loss is configured or enabled.

[0052] In Rel-16 V2X, the power control of PSFCH is only based on the path loss between the UE and the BS, in the subject disclosure, the power control of PSFCH is not only based on the path loss between the UE and the BS, but also based on the path loss between the sidelink UEs, and the PSFCHs are selected based on the path loss between the UE and the BS as well as the path loss between the sidelink UEs. Therefore, the selection of multiple PSFCHs for simultaneous transmission should also consider the transmitting power of the PSFCHs.

[0053] Figure 5(a) illustrates a flow chart for selecting PSFCHs based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application.

[0054] In step 501, the UE first considers the priority of the PSFCH, specifically, the UE orders the M PSFCHs by their associated priority values by an ascending order. The priority values of the PSFCHs are indicated in the SCI format 0_1 respectively. The ordered PSFCHs will be referred to as PSFCH₀, PSFCH₁, PSFCH₂, ..., PSFCH _{$M-1$} hereinafter. In this subject disclosure, the transmitting power of PSFCH is a function of one or two parameters, i) the path loss between the UE transmitting the PSFCH and the BS, and ii) the path loss between the UE transmitting the PSFCH and the UE to which the PSFCH is transmitted. For example, the transmitting power P_0 is based on the path loss between the UE which is transmitting PSFCH₀ and the BS; and the path loss between the UE transmitting PSFCH₀ and the UE receiving PSFCH₀.

[0055] In step 502, the UE sets the remaining power $P_{remaining}$ for transmitting the PSFCHs. Since no PSFCHs have been selected yet, $P_{remaining}$ equals to the maximum transmitting power of the UE, P_{max} . The UE also configures two counters, one is denoted with m , and is used to count the PSFCHs to be determined whether to be selected or not; the other is denoted with n , and is used to count the selected PSFCHs. The UE would like to transmit M PSFCHs and it may select at most N PSFCHs for

simultaneous transmission, thus the value of m ranges from 0 to $M-1$, and the value of n ranges from 0 to $N-1$.

[0056] In step 503, when $m < M$, $n < N$ and $P_{remaining} > 0$, the UE determines whether PSFCH $_m$ is selected or not in steps 504-505. If yes, in step 506, the remaining power $P_{remaining}$ for transmitting the PSFCHs is set to $P_{remaining} - P_m$, the counter $m = m+1$, and the counter $n = n+1$. The method goes back to step 503, to determine whether the next PSFCH, PSFCH $_{m+1}$ is to be selected or not.

[0057] If PSFCH $_m$ is not selected, in step 507, the counter $m = m + 1$. The method goes back to step 503, to determine whether the next PSFCH, PSFCH $_{m+1}$ is to be selected or not.

[0058] In step 503, when any one of $m < M$, $n < N$, and $P_{remaining} > 0$ is not met, the UE terminates the selection (step 508).

[0059] In step 504, the UE determines whether a PSFCH has been selected for the PRB of the current PSFCH, PSFCH $_m$. If a PSFCH has been selected for the PRB of the current PSFCH, PSFCH $_m$, it goes to step 505, otherwise, it goes to step 505. As mentioned above, the PSFCH may use frequency division multiplexing, or code division multiplexing which may cause collision at the same PRB. Step 504 can prevent the PSFCHs transmitted simultaneously are mapped to the same PRB.

[0060] In step 505, the UE determines whether the transmitting power of the current PSFCH, PSFCH $_m$, complied with the power requirement. There are several different scenarios for implementing the power requirement in the step 505. In Scenario 1, different power spectral density (PSD) of the simultaneously transmitted PSFCHs is allowed. In step 505, the UE considers whether the remaining power $P_{remaining}$ can satisfy the requirement on the coverage of the PSFCH $_m$, i.e. whether the remaining power $P_{remaining}$ is greater than the transmitting power P_m of the PSFCH $_m$. If $P_m \leq P_{remaining}$, then PSFCH $_m$ is selected for transmission in the PRB of PSFCH $_m$.

[0061] It is contemplated that the sequence of steps 501-508 is not limited to the above embodiments. For example, the step 504 may be moved following step 505. Thus, the methods for selecting the PSFCHs of the present disclosure are not limited

to the above embodiments.

[0062] Figure 5(b) illustrates another flow chart for selecting PSFCHs based on a priority value, duplex schemes, and the power requirements according to some embodiments of the subject application. In this embodiment, instead of determining whether the remaining power of the UE $P_{remaining}$ is greater than or equal to the transmitting power of the m^{th} PSFCH, the UE determines whether the current occupied transmitting power by the total selected UEs, $P_{occupied}$, is less than or equal to the maximum transmitting power of the UE, P_{max} . That is, $P_{occupied} = P_0 + P_1 + \dots + P_m$, and whether $P_{occupied} \leq P_{max}$, wherein P_m is the transmitting power of the current PSFCH, PSFCH_{*m*}. It should be noted that the PSFCH_{*m*} may not be selected continuously, thus the number 0, 1, ..., *m* may not be continuous numbers, for example, it may be 0, 1, 3, 6, ..., *m*.

[0063] This embodiment differs from the technical solution in Figure 5(a) in three steps, step 502, step 503, and step 506. In step 502, before the selection started, the occupied transmitting power of the UE is 0, thus $P_{occupied} = 0$. In step 503, the UE needs to determine whether the UE's maximum transmitting power is greater than or equal to the current occupied transmitting power plus the transmitting power of the current PSFCH_{*m*}, that is, whether $P_{occupied} + P_m \leq P_{max}$. If the current PSFCH_{*m*} is selected, then in step 506, the current occupied power of the UE, $P_{occupied}$ equals to the current occupied transmitting power plus the power of the current PSFCH_{*m*}, that is, $P_{occupied} = P_{occupied} + P_m$, the counter $m = m+1$, and the counter $n = n+1$. The method goes back to step 503, to determine whether the next PSFCH, PSFCH_{*m+1*} is be selected or not.

[0064] Figures 5(c) illustrates an example for selecting PSFCHs based on Scenario 1.

[0065] In Scenario 1, different PSDs of the simultaneously transmitted PSFCHs are allowed. In other words, the transmitting powers of different PSFCHs may have different PSDs. In Figure 5(c), there are 5 ordered PSFCHs, PSFCH₀, PSFCH₁, PSFCH₂, PSFCH₃, and PSFCH₄ with an ascending order, and the transmitting powers of these PSFCHs are P_0 , P_1 , P_2 , P_3 , and P_4 respectively. PSFCH₀ has the lowest priority value, 0, thus is placed in the first position, and PSFCH₄ has the highest

priority value, 6, thus is placed in the last position. In the beginning, the remaining power for transmitting the PSFCHs, i.e. $P_{remaining}$, equals to the maximum transmitting power of the UE, i.e. P_{max} , that is, $P_{remaining} = P_{max}$.

[0066] The selection process first determines whether the remaining power is allowed to transmit the PSFCH₀, i.e. whether the remaining power $P_{remaining}$ is greater than or equal to the transmitting power of P_0 . If $P_0 \leq P_{remaining}$, then PSFCH₀ is selected for transmission in the PRB of PSFCH₀, and is added to a set of PSFCHs later to be transmitted at the same time. Since PSFCH₀ is selected, the remaining power for transmitting the PSFCHs $P_{remaining}$ becomes: $P_{remaining} - P_0$. The UE then moves on to the next PSFCH, PSFCH₁, and determines whether the remaining power is allowed to transmit the PSFCH₁, i.e. whether the remaining power $P_{remaining}$ is greater than the transmitting power of P_1 . If $P_1 > P_{remaining}$, then PSFCH₁ is not selected for transmission in the PRB of PSFCH₁. Since PSFCH₁ is not selected, then the remaining power for transmitting the PSFCHs stays the same, i.e. $P_{remaining} = P_{remaining}$. The selection process then moves on to the next PSFCH, PSFCH₂, and determines whether it would be selected in a similar fashion until the selection process ends.

[0067] In a preferred embodiment, the PSFCH₀ is always selected, due to its highest priority. Thus, the transmitting power of PSFCH₀ is set to $\min(P_0, P_{max})$. If $P_0 = P_{max}$, which means the UE does not have any power to transmit another PSFCH, the UE would only transmit PSFCH₀. If the UE still have some remaining power, then the UE would select PSFCHs according to the above solutions. In another embodiment, the PSFCH₀ is selected only if the transmitting power of PSFCH₀ is equal to or smaller than the maximum transmitting power P_{max} .

[0068] In Scenario 2, the simultaneously transmitted PSFCHs are required to have the same or similar PSD. That is, in step 505, the power requirement is that the transmitting power for PSFCH_m not only has to be less than or equal to the remaining transmitting power of the UE, $P_{remaining}$, but also has to be within a predetermined range of the transmitting power of the PSFCH with smallest priority value among the selected PSFCHs, which is represented with $P_{smallest}$. For example, $P_{smallest} - W/2 \leq P_m \leq P_{smallest} + W/2$, wherein W is a predetermined or a preconfigured number. W may

be zero and it means that all the selected PSFCHs will be transmitted with equal power.

[0069] In Scenario 3, if the PSFCH_m is selected, the transmitting power of PSFCH_m is set to the transmitting power for the selected PSFCH with smallest priority value, i.e. $P_{smallest}$. Thus, in Scenario 3, the selected PSFCHs are transmitted simultaneously with the same PSD. Specifically, if the transmitting power of PSFCH_m is less than or equal to the transmitting power for the selected PSFCH with smallest priority value, i.e. $P_m \leq P_{smallest}$, and the transmitting power $P_{smallest}$ is less than or equal to the remaining power, i.e. $P_{smallest} \leq P_{remaining}$, the PSFCH_m is selected for transmission and the transmitting power P_m is adjusted to be equal to the transmitting power of the PSFCH with smallest priority value among the M PSFCHs, $P_{smallest}$. In this embodiment, if PSFCH_m is selected, then the remaining power is set to $P_{remaining} - P_{smallest}$.

[0070] Figures 5(d) illustrates an example for selecting PSFCHs based on Scenario 3. In Figure 5(d), there are 5 ordered PSFCHs, PSFCH₀, PSFCH₁, PSFCH₂, PSFCH₃, and PSFCH₄ with an ascending order, and the transmitting powers of these PSFCHs are P_0 , P_1 , P_2 , P_3 , and P_4 , respectively. In the beginning, the remaining power for transmitting the PSFCHs, i.e. $P_{remaining}$, equals to the maximum transmitting power of the UE, i.e. P_{max} , that is, $P_{remaining} = P_{max}$. The UE first determines whether the remaining power is allowed to transmit the PSFCH₀, i.e. whether the remaining power $P_{remaining}$ is greater than the transmitting power of P_0 . If $P_0 \leq P_{remaining}$, then PSFCH₀ is selected for transmission in the PRB of PSFCH₀, and is added to a set of PSFCHs later to be transmitted at the same time. In this case, P_0 is deemed as the transmitting power for the PSFCH with smallest priority value among the 5 PSFCHs, i.e. $P_{smallest}$. Since PSFCH₀ is selected, the remaining power for transmitting the PSFCHs becomes $P_{remaining} = P_{remaining} - P_0$.

[0071] The UE then moves on to the next PSFCH, PSFCH₁, and determines whether the remaining power complies with the power requirement. In particular, whether the transmitting power of PSFCH₁ is less than or equal to the transmitting power for the PSFCH with smallest priority value, i.e. $P_1 \leq P_{smallest}$, and whether $P_0 \leq P_{remaining}$. In Figure 5(c), the transmitting power of PSFCH₁ is greater than $P_{smallest}$, then PSFCH₁

is not selected, and the remaining power for transmitting the PSFCHs stays the same: $P_{remaining} = P_{remaining}$. In some other cases, if the transmitting power of PSFCH_l is less than or equal to than $P_{smallest}$ but the remaining power cannot satisfy the requirement on the coverage of the PSFCH_m, then PSFCH_l is not selected either.

[0072] The UE then goes on to the next PSFCH, PSFCH₂, the transmitting power of PSFCH₂ is less than or equal to $P_{smallest}$, and P_0 also is less than or equal to the remaining transmitting power of the UE, i.e. $P_0 \leq P_{remaining}$, thus PSFCH₂ is selected for transmission in the PRB of PSFCH₂, and is added to a set of PSFCHs later to be transmitted at the same time. Since the same or similar PSD is required, then the transmitting power of P_2 is adjusted to the transmitting power for the PSFCH with smallest priority value among the selected PSFCHs, i.e. $P_{smallest}$. After PSFCH₂ is selected, the remaining power for transmitting the PSFCHs becomes $P_{remaining} = P_{remaining} - P_{smallest}$. The UE then selects the rest of the PSFCHs similarly. When the selection ends, all the selected PSFCHs have the same PSD, i.e. $P_{smallest}$. Therefore, the PSD requirement is satisfied.

[0073] In a preferred embodiment, the PSFCH₀ is always selected, due to its highest priority. Thus, the transmitting power of PSFCH₀ is $\min(P_0, P_{max})$, and P_0 is equal to the $P_{smallest}$. If $P_0 = P_{max}$, which means the UE does not have any power to transmit another PSFCH, the UE would only transmit PSFCH₀. If the UE still have some remaining power, then the UE would select PSFCHs according to the above solutions. In some other embodiments, the PSFCH₀ is selected only if the transmitting power of PSFCH₀ is equal to or smaller than the maximum transmitting power P_{max} .

[0074] In Scenario 4, the transmitting power for P_m may be adjusted based on the type of the PSFCH. If PSFCH_m relates to unicast or groupcast with negative acknowledgement (NACK) only feedback on shared PSFCH resource, the transmitting power of PSFCH_m is less than or equal to the transmitting power of the PSFCH with smallest priority value among the M PSFCHs, i.e. $P_m \leq P_{smallest}$ and $P_{smallest} \leq P_{remaining}$, P_m is selected for transmission, then the remaining power is set to $P_{remaining} - P_{smallest}$. Otherwise, the PSFCH_m is not selected and the remaining power remains unchanged. If PSFCH_m relates to groupcast with acknowledgement (ACK) or negative acknowledgement (NACK) feedback on dedicated PSFCH resource, and

if $P_m \leq P_{remaining}$ and $P_{smallest} - W/2 \leq P_m \leq P_{smallest} + W/2$, , then PSFCH_m is selected for transmission in the PRB and the remaining power is set to $P_{remaining} - P_m$. Otherwise, the PSFCH_m is not selected and the remaining power remains unchanged.

[0075] That is, Scenario 4 relates to a combination of Scenario 2 and Scenario 3. While the PSFCH_m relates to groupcast with acknowledgement (ACK) or negative acknowledgement (NACK) feedback on dedicated PSFCH resource, Scenario 3 is applied; and while the PSFCH_m relates to groupcast with acknowledgement (ACK) or negative acknowledgement (NACK) feedback on dedicated PSFCH resource, Scenario 2 is applied.

[0076] Figure 6 illustrates a method performed by a UE for transmitting physical sidelink feedback channels according to a preferred embodiment of the subject disclosure.

[0077] In step 601, the UE selects a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with each PSFCH in the second set of PSFCHs. In step 602, the UE transmits the first set of PSFCHs. For example, in Figure 4, the UE selects PSFCHs from M PSFCHs, and then transmits the selected PSFCHs.

[0078] In status 1 in Figure 4, the M PSFCHs are mapped to P PRBs. As can be seen, two PSFCHs, PSFCH₂ and PSFCH₃, are mapped to PRB₃, and only one PSFCH between the two PSFCHs is selected. The PSFCH is selected based on the priority, and the rule is, the PSFCH with a smallest priority value among the one or more PSFCHs so as to form a third set of PSFCHs. In PRB₃, PSFCH₂ has the smaller priority and is selected. In status 2 in Figure 4, the selected PSFCHs form the third set of PSFCHs. In status 3 in Figure 4, based on an ascending order of the priority values associated with the PSFCHs, the UE selects the first set of PSFCHs from the third set of PSFCHs. For example, the UE can only transmit two PSFCHs at the same time, and then UE selects PSFCH₂ and PSFCH₅, which have the first two highest priority levels. If the first set is equal to or greater than the third set in size, the third set of PSFCHs is deemed as the first set of PSFCHs. That is, in status 2, there are P PSFCHs selected, if the UE can transmit more than P PSFCHs at the same time, then all of the P PSFCHs in status 2 would be selected into the PSFCHs in status

3.

[0079] In one embodiment, the selecting the first set of PSFCHs is further based on a power requirement for transmitting each PSFCH in the second set of PSFCHs and a remaining transmitting power of a UE. For example, in step 504, a PSFCH_m is selected based on whether the transmitting power P_m is less than or equal to $P_{remaining}$. In one preferred embodiment, the first PSFCH, PSFCH₀, which has the smallest priority among the M PSFCHs, is always selected, and the transmitting power of PSFCH₀, P_0 , is a smaller one of a maximum transmitting power of a UE and a transmitting power required for transmitting the first PSFCH, i.e. $P_0 = \min(P_{max}, P_0)$. PSFCH₀ then is added to the first set of PSFCHs.

[0080] In another embodiment, the first PSFCH, PSFCH₀, is added to the first set of PSFCHs if the first transmitting power P_0 is equal to or smaller than a maximum transmitting power of a UE, i.e. $P_0 \leq P_{max}$.

[0081] After the first PSFCH is selected, the first PSFCH is removed from the second set of PSFCHs, which is to be determined whether to be selected, and the remaining transmitting power $P_{remaining}$ is calculated by $P_{remaining}$ minus P_0 . The UE then determines whether a second PSFCH, for instance, PSFCH₁, with a smallest priority value among remaining PSFCHs in the second set of PSFCHs is added to the first set of PSFCHs or not; and then removes PSFCH₁ from the second set of PSFCHs after determining whether the PSFCH₁ is added to the first set of PSFCHs or not. In one embodiment, PSFCH₁ is added to the first set of PSFCHs if a second transmitting power required for transmitting the second PSFCH, i.e. P_1 , is equal to or smaller than the remaining transmitting power of the UE, i.e. $P_1 \leq P_{remaining}$. If P_1 is added to the first set of PSFCHs, the remaining transmitting power is updated, i.e. $P_{remaining} = P_{remaining} - P_1$.

[0082] Alternatively, PSFCH₁ is added to the first set of PSFCHs if a difference between a second transmitting power required for transmitting the second PSFCH and the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs is within a predetermined range, i.e. $P_1 \leq P_{remaining}$ and $P_{smallest} - W/2 \leq P_1 \leq P_{smallest} + W/2$, wherein W is the predetermined range. If P_1 is added to the first set of PSFCHs, the remaining transmitting power is updated, i.e. $P_{remaining} = P_{remaining} - P_1$.

If the second PSFCH is added to the first set of PSFCHs, the second transmitting power is set equal to the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs, in other words, $P_I = P_{smallest}$.

[0083] In still another embodiment, PSFCH_I is added to the first set of PSFCHs if the transmitting power of PSFCH_I, i.e. P_I , is equal to or smaller than the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs i.e. $P_{smallest}$, and is equal to or smaller than the remaining transmitting power of the UE, i.e. $P_I \leq P_{smallest}$ and $P_I \leq P_{remaining}$. In addition, P_I is adjusted to $P_{smallest}$. If the second PSFCH is added to the first set of PSFCHs, then the remaining transmitting power is updated, $P_{remaining} = P_{remaining} - P_I$.

[0084] In another embodiment, when the second PSFCH, PSFCH_I, relates to unicast or groupcast with negative acknowledgement (NACK) only feedback on shared PSFCH resource, if $P_I \leq P_{smallest}$, and there is no PSFCH selected for transmission in the PRB of P_m and $P_0 \leq P_{remaining}$, P_m is selected for transmission, then the remaining power is set to $P_{remaining} - P_{smallest}$. When the second PSFCH, PSFCH_I, relates to groupcast with acknowledgement (ACK) or negative acknowledgement (NACK) feedback on dedicated PSFCH resource, and if $P_I \leq P_{remaining}$, and $P_{smallest} - W/2 \leq P_I \leq P_{smallest} + W/2$, and there is no PSFCH selected for transmission in the PRB of P_m , PSFCH_I is selected for transmission in the PRB, then the remaining power is set to $P_{remaining} - P_I$.

[0085] Figure 7 illustrates a block diagram of a UE according to the embodiments of the present disclosure. The UE 101 may include a receiving circuitry, a processor, and a transmitting circuitry. In one embodiment, the UE 101 may include a non-transitory computer-readable medium having stored thereon computer-executable instructions; a receiving circuitry; a transmitting circuitry; and a processor coupled to the non-transitory computer-readable medium, the receiving circuitry and the transmitting circuitry. The computer executable instructions can be programmed to implement a method (e.g. the method in Figure 6) with the receiving circuitry, the transmitting circuitry and the processor. That is, upon performing the computer executable instructions, the processor of the UE selects a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with

each PSFCH in the second set of PSFCHs; and transmitting circuitry transmits the first set of PSFCHs.

[0086] The method of the present disclosure can be implemented on a programmed processor. However, the controllers, flowcharts, and modules may also be implemented on a general purpose or special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit elements, an integrated circuit, a hardware electronic or logic circuit such as a discrete element circuit, a programmable logic device, or the like. In general, any device that has a finite state machine capable of implementing the flowcharts shown in the figures may be used to implement the processing functions of the present disclosure.

[0087] While the present disclosure has been described with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. For example, various components of the embodiments may be interchanged, added, or substituted in the other embodiments. Also, all of the elements shown in each figure are not necessary for operation of the disclosed embodiments. For example, one skilled in the art of the disclosed embodiments would be capable of making and using the teachings of the present disclosure by simply employing the elements of the independent claims. Accordingly, the embodiments of the present disclosure as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the present disclosure.

[0088] In this disclosure, relational terms such as "first," "second," and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "a," "an," or the like does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

Also, the term "another" is defined as at least a second or more. The terms "including," "having," and the like, as used herein, are defined as "comprising."

We claim:

1. A method for transmitting physical sidelink feedback channels (PSFCHs), comprising:

selecting a first set of PSFCHs from a second set of PSFCHs based on a priority value and a duplex scheme associated with each PSFCH in the second set of PSFCHs;;
and

transmitting the first set of PSFCHs.

2. The method of Claim 1, further comprising:

mapping the second set of PSFCHs to one or more physical resource blocks (PRB), wherein if more than one PSFCHs are mapped to a PRB, only one PSFCH among the more than one PSFCHs may be added to the first set of PSFCHs.

3. The method of Claim 2, wherein selecting the first set of PSFCHs comprising:

for one or more PSFCHs mapped to each PRB, selecting a PSFCH with a smallest priority value among the one or more PSFCHs so as to form a third set of PSFCHs.

4. The method of Claim 3, wherein selecting the first set of PSFCHs further comprising:

selecting the first set of PSFCHs from the third set of PSFCHs based on an ascending order of the priority values associated with the PSFCHs, wherein if the first set is equal to or greater than the third set in size, the third set of PSFCHs is deemed as the first set of PSFCHs.

5. The method of Claim 2, wherein selecting the first set of PSFCHs is further based on a power requirement for transmitting each PSFCH in the second set of PSFCHs and a remaining transmitting power of a user equipment (UE).

6. The method of Claim 5, wherein selecting the first set of PSFCHs further comprises:

selecting the first PSFCH with the smallest priority among the second set of PSFCHs, wherein a transmitting power of the first PSFCH is a first transmitting power.

7. The method of Claim 6, wherein the first transmitting power is a smaller one of a maximum transmitting power of a user equipment (UE) and a transmitting power required for transmitting the first PSFCH.

8. The method of Claim 6, wherein the first PSFCH is added to the first set of PSFCHs.

9. The method of Claim 6, wherein the first PSFCH is added to the first set of PSFCHs if the first transmitting power is equal to or smaller than a maximum transmitting power of a user equipment (UE).

10. The method of Claim 6, wherein selecting the first set of PSFCHs further comprises:

removing the first PSFCH from the second set of PSFCHs; and

calculating the remaining transmitting power of a user equipment (UE) by subtracting the first transmitting power from a maximum transmitting power of the UE if the first PSFCH is added to the first set of PSFCHs.

11. The method of Claim 10, wherein selecting the first set of PSFCHs further comprises:

determining whether a second PSFCH with a smallest priority value among remaining PSFCHs in the second set of PSFCHs is added to the first set of PSFCHs or not; and

removing the second PSFCH from the second set of PSFCHs after determining whether the second PSFCH is added to the first set of PSFCHs or not.

12. The method of Claim 11, wherein the second PSFCH is added to the first set of PSFCHs if a second transmitting power required for transmitting the second PSFCH is equal to or smaller than the remaining transmitting power of the UE.

13. The method of Claim 12, wherein selecting the first set of PSFCHs further comprises:

updating the remaining transmitting power by subtracting the second transmitting power required for transmitting the second PSFCH from the remaining transmitting power of the UE if the second PSFCH is added to the first set of PSFCHs.

14. The method of Claim 11, wherein the second PSFCH in the second set of PSFCHs is added to the first set of PSFCHs if a difference between a second transmitting power required for transmitting the second PSFCH and the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs is within a predetermined range.

15. The method of Claim 14, wherein selecting the first set of PSFCHs further comprises:

updating the remaining transmitting power by subtracting the second transmitting power required for transmitting the second PSFCH from the remaining transmitting power of the UE if the second PSFCH is added to the first set of PSFCHs.

16. The method of Claim 11, wherein the second PSFCH is added to the first set of PSFCHs if a second transmitting power required for transmitting the second PSFCH is equal to or smaller than the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs and is equal to or smaller than the remaining transmitting power of the UE.

17. The method of Claim 16, wherein if the second PSFCH is added to the first set of PSFCHs, the second transmitting power is set equal to the transmitting power of the PSFCH with a smallest priority value among the first set of PSFCHs.

18. The method of Claim 17, wherein selecting the first set of PSFCHs further comprises:

updating the remaining transmitting power by subtracting the second transmitting power required for transmitting the second PSFCH from the remaining transmitting power of the UE if the second PSFCH is added to the first set of PSFCHs.

19. The method of Claim 16, wherein the second PSFCH relates to unicast or groupcast with negative acknowledgement (NACK) only feedback on shared PSFCH resource.

20. The method of Claim 14, wherein the second PSFCH relates to groupcast with acknowledgement (ACK) or negative acknowledgement (NACK) feedback on dedicated PSFCH resource.

21. An apparatus, comprising:

a non-transitory computer-readable medium having stored thereon computer-executable instructions;

a receiving circuitry;

a transmitting circuitry; and

a processor coupled to the non-transitory computer-readable medium, the receiving circuitry and the transmitting circuitry,

wherein the computer-executable instructions cause the processor to implement the method of any of Claims 1-20.

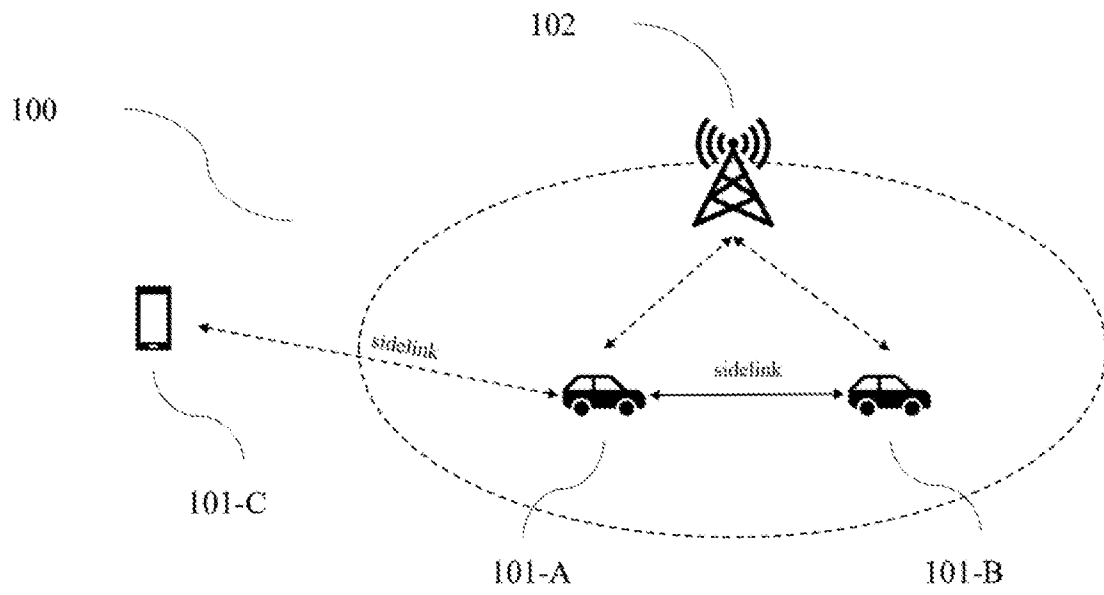


Figure 1

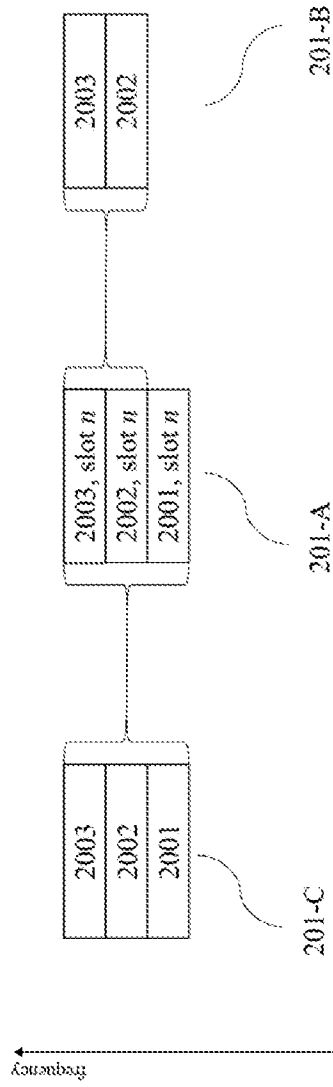


Figure 2

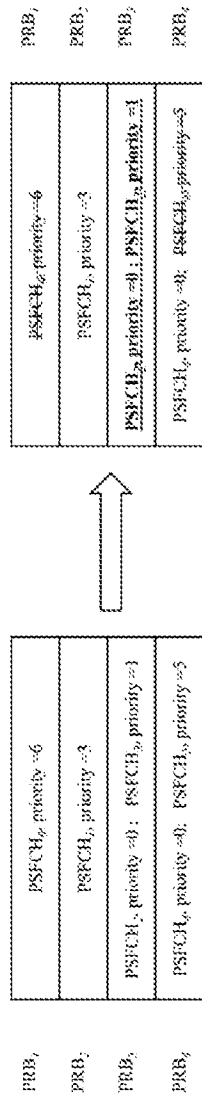


Figure 3

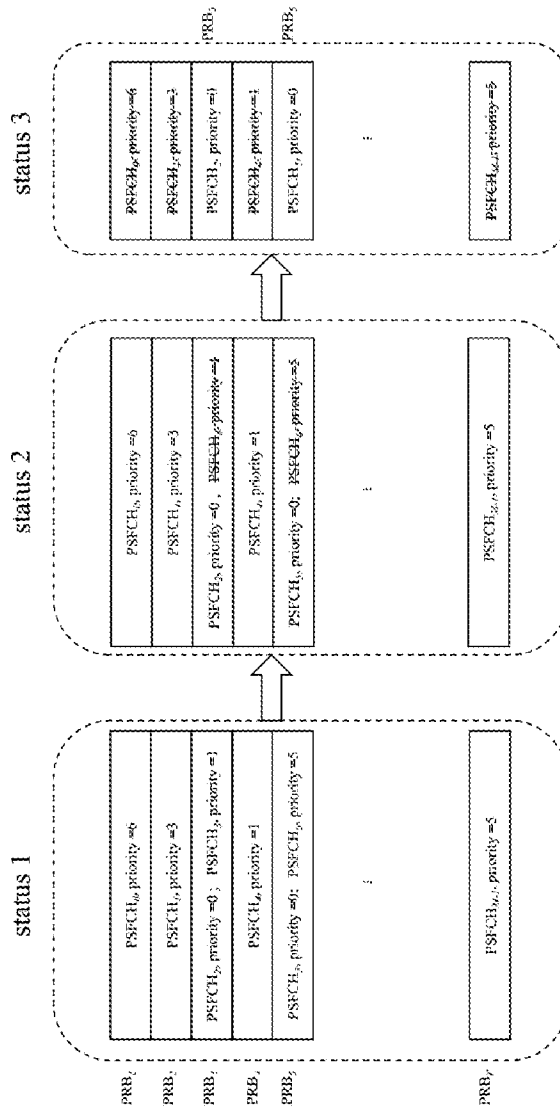


Figure 4

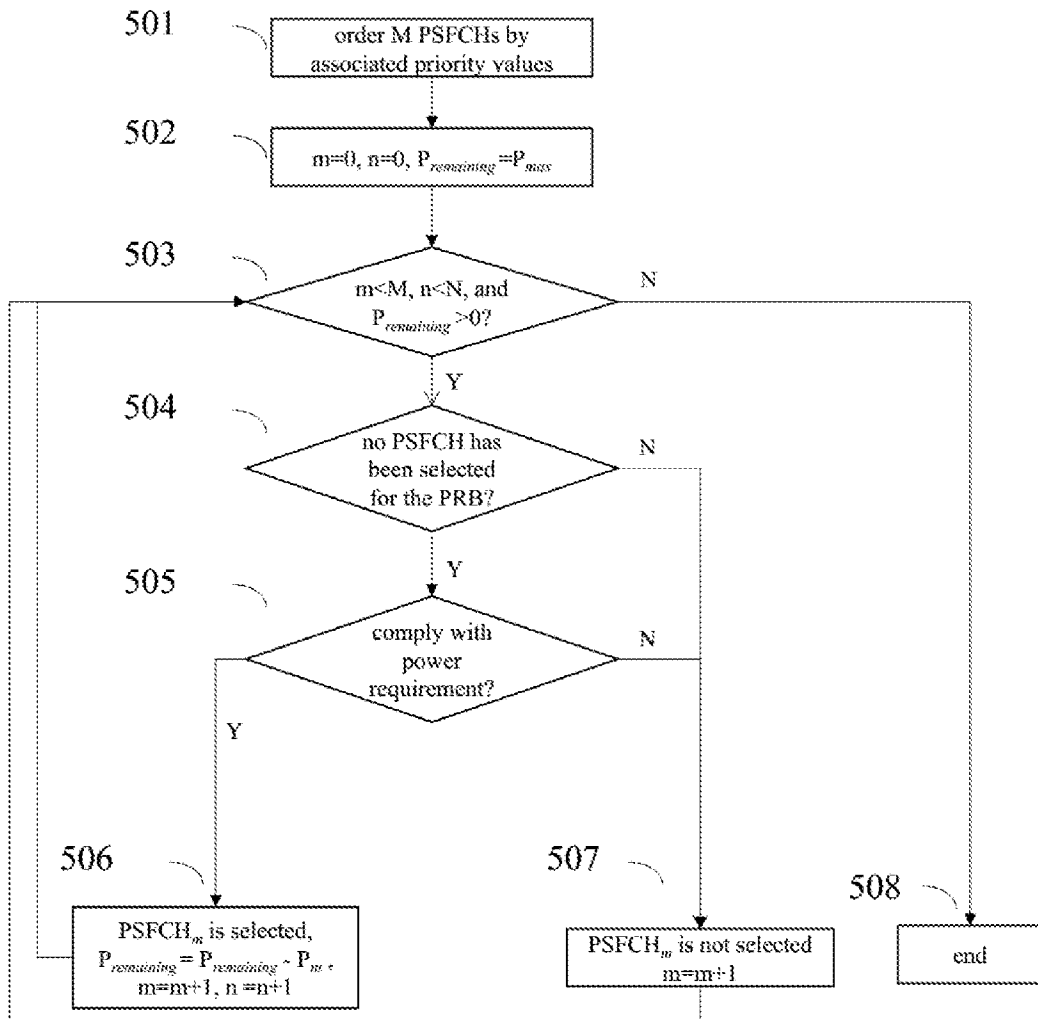


Figure 5(a)

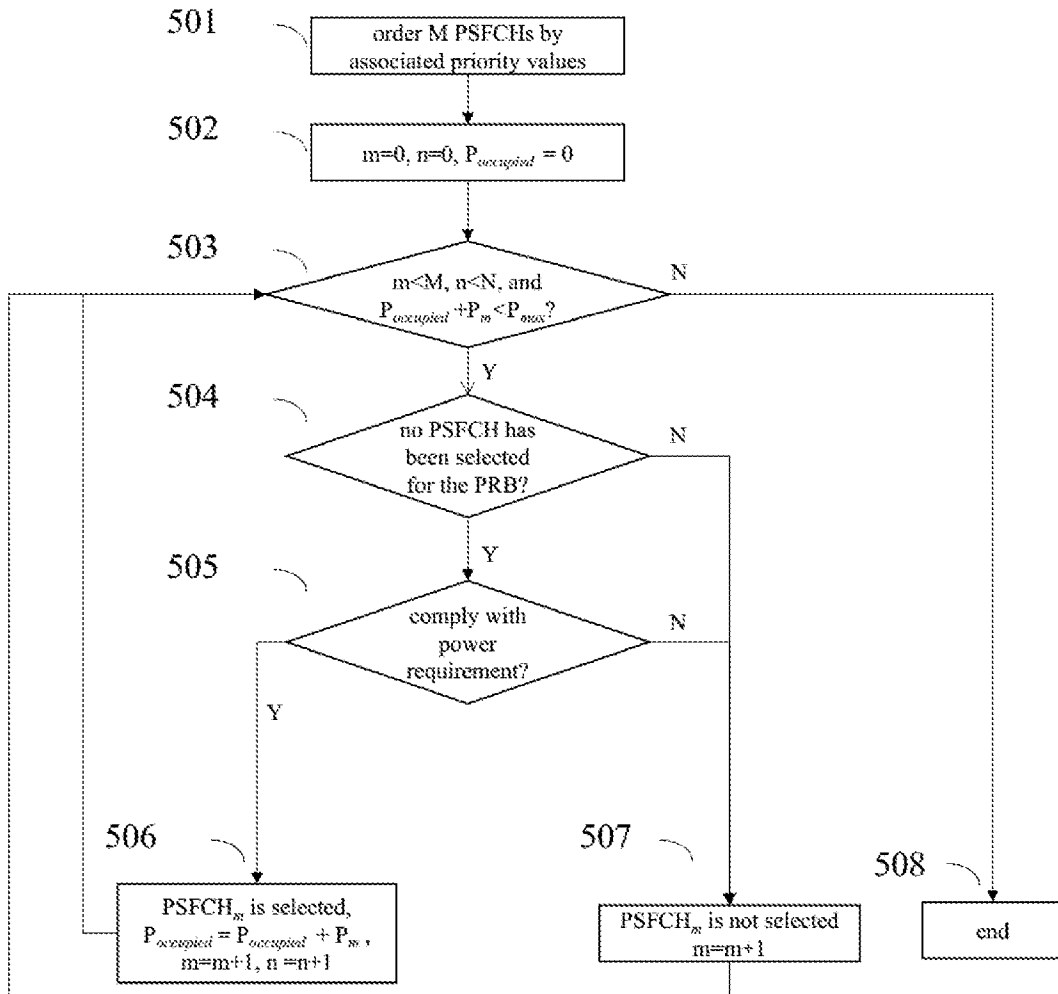


Figure 5(b)

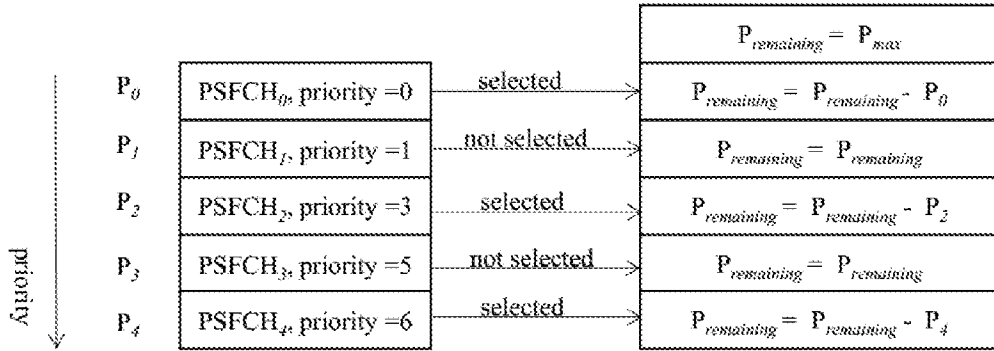


Figure 5(c)

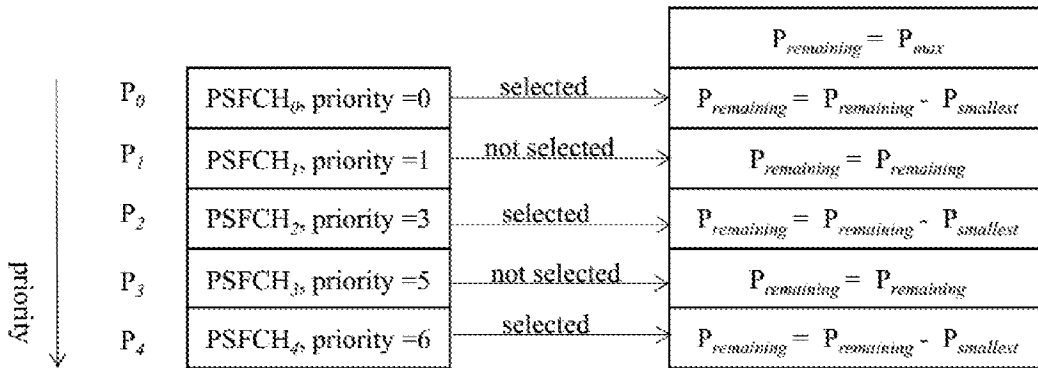


Figure 5(d)

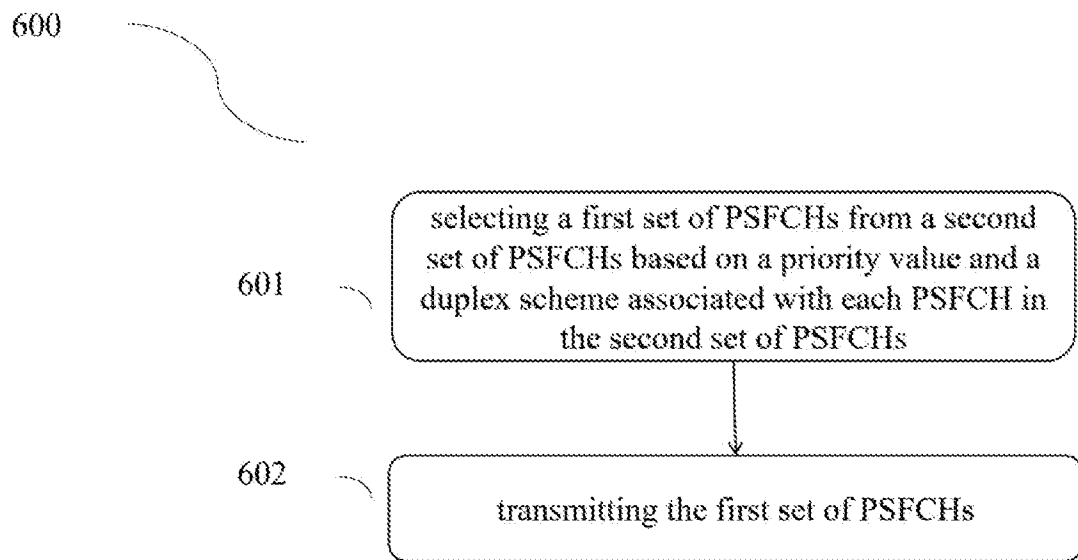


Figure 6

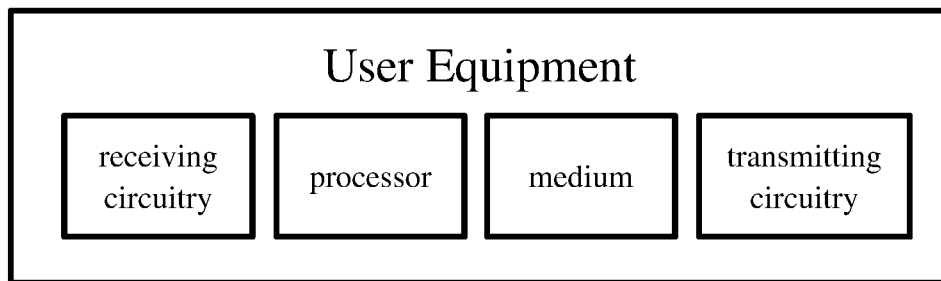


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/085407

A. CLASSIFICATION OF SUBJECT MATTER		
H04W 72/02(2009.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
H04W; H04Q; H04L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
CNPAT,CNKI,WPLEPODOC,3GPP: PSFCH, sidelink, feedback, channel, prior+, duplex, set, group, select, cho?se, determine, at least, more than, power, level, energy, PRB, overlap, overlay		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	INTERDIGITAL, INC. ""Physical Layer Procedures for NR V2X Sidelink"" "3GPP TSG RAN WG1 #98bis R1-1911280", 07 October 2019 (2019-10-07), sections 1, 2, 4	1-21
X	INTERDIGITAL, INC. ""Physical Layer Procedures for NR V2X Sidelink"" "3GPP TSG RAN WG1 #99 R1-1912742", 08 November 2019 (2019-11-08), sections 1, 2, 4	1-21
A	CN 110856192 A (SPREADTRUM COMMUNICATIONS SHANGHAI CO., LTD.) 28 February 2020 (2020-02-28) the whole document	1-21
A	WO 2020022781 A1 (SAMSUNG ELECTRONICS CO., LTD.) 30 January 2020 (2020-01-30) the whole document	1-21
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
30 December 2020		18 January 2021
Name and mailing address of the ISA/CN		Authorized officer
National Intellectual Property Administration, PRC 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China		ZHANG,Feng
Facsimile No. (86-10)62019451		Telephone No. 86-(10)-53961628

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/085407

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	110856192	A	28 February 2020	None			
WO	2020022781	A1	30 January 2020	US	2020037343	A1	30 January 2020