METHOD AND APPARATUS OF SUPPORTING UPLINK COMMUNICATIONS

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to techniques for supporting uplink communications.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

SUMMARY

[0003] An article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is

described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0004] Some implementations of the methods and apparatuses described herein may further include a UE for wireless communication, which includes: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive first information indicating whether one or more resources are available for uplink; receive second information indicating application of an orthogonal cover code (OCC) sequence to a set of physical uplink shared channel (PUSCH) transmissions; and determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and second information.

[0005] In some implementations of the methods and apparatuses described herein, the first information is one or more of: a synchronization signal (SS)/PBCH block (SSB) configuration, a semi-static time divisional duplex (TDD) configuration, a dynamic TDD configuration received via a downlink control information (DCI) format 2_0, an interruption indication received via a DCI format 2_6, a semi-static physical downlink control channel (PDCCH) configuration, a signaling related to overlapping between physical uplink control channel (PUCCH) and PUSCH, a signaling related to overlapping between PUSCH and physical random access channel (PRACH), a signaling related to overlapping between downlink and uplink, or a signaling indicating unavailable resources for uplink transmissions.

[0006] In some implementations of the methods and apparatuses described herein, the first information indicates that the one or more resources are unavailable for uplink, the at least one processor is configured to cause the UE to: delay mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions; or discard the mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmission.

[0007] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine a first number of repetitions associated with the set of PUSCH transmissions or the subset of PUSCH transmissions based on a configuration; and determine a second number of repetitions by adjusting or maintaining the first number of repetitions based on the first information indicating that the one or more resources are unavailable for uplink and another received signaling.

[0008] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: expect that one or more resources associated with the set of PUSCH transmissions or the subset of PUSCH transmissions to which the OCC sequence is applied are available.

[0009] In some implementations of the methods and apparatuses described herein, in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are associated with PUSCH repetition type B, the at least one processor is configured to cause the UE to: map the elements of the OCC sequence only to actual repetitions of the set of PUSCH transmissions or the subset of PUSCH transmissions; or map the elements of the OCC sequence to remaining resources of the set of PUSCH transmissions or the subset of PUSCH transmissions after excluding invalid resources from configured resources of the set of PUSCH transmissions or the subset of PUSCH transmissions based on a number of resources configured for a nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0010] In some implementations of the methods and apparatuses described herein, mapping the elements of the OCC sequence to the remaining resources of the set of PUSCH transmissions or the subset of PUSCH transmissions further includes excluding demodulation reference signal (DMRS) symbols from the configured resources of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0011] In some implementations of the methods and apparatuses described herein, the DMRS symbols are based on slot-level configuration associated with the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0012] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to further cause the UE to: disable mapping between the set of PUSCH transmissions or the subset of PUSCH transmissions and one or more of sounding reference signal (SRS) resource sets or redundancy versions (RVs); or map the elements of the OCC sequence only to PUSCH transmissions associated with a same SRS resource set or a same RV of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0013] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: perform mapping between the set of PUSCH transmissions or the subset of PUSCH transmissions and the elements of the OCC sequence and one or more of: SRS resource sets or RVs based on a configured or predefined mapping order.

[0014] In some implementations of the methods and apparatuses described herein, the mapping order includes firstly mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0015] In some implementations of the methods and apparatuses described herein, in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are PUSCH transmissions with transport block (TB) processing over multiple slots, each element of the OCC sequence is associated with a number of the multiple slots or a number of slots to determine a size of the TB.

[0016] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine uplink transmission power for the set of PUSCH transmissions or the subset of PUSCH transmissions based on one or more of: a number of frequency domain resources before OCC spreading in frequency domain, a number of frequency domain resources after OCC spreading in frequency domain, or a length of the OCC sequence.

[0017] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a

first scheduled slot of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0018] In some implementations of the methods and apparatuses described herein, in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are configured grant (CG) type 2 PUSCH, the at least one processor is configured to cause the UE to: start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a first scheduled slot of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions after DCI activation plus a configured or predefined delay.

[0019] In some implementations of the methods and apparatuses described herein, the first repetition is a first actual repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions, or is determined based on remaining symbols of the set of PUSCH transmissions or the subset of PUSCH transmissions after excluding invalid resources and a number of resources configured for a nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0020] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a configured or predefined time domain position.

[0021] In some implementations of the methods and apparatuses described herein, the time domain position is configured by a periodicity and offset of the set of PUSCH transmissions or the subset of PUSCH transmissions.

[0022] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which may include: at least one controller coupled with at least one memory and configured to cause the processor to: receive first information indicating whether one or more resources are available for uplink; receive second information indicating application of an OCC sequence to a set of PUSCH

transmissions; and determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and second information.

[0023] Some implementations of the methods and apparatuses described herein may further include a network equipment (NE) for wireless communication, which may include: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the NE to: transmit first information indicating whether one or more resources are available for uplink; transmit second information indicating application of an OCC sequence to a set of PUSCH transmissions; and determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

[0024] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which may include: receiving first information indicating whether one or more resources are available for uplink; receiving second information indicating application of an OCC sequence to a set of PUSCH transmissions; and determining mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0026] Figure 2 illustrates an example of OCC sequence application to PUSCH transmissions in accordance with aspects of the present disclosure.

[0027] Figure 3 illustrates another example of OCC sequence application to PUSCH transmissions in accordance with aspects of the present disclosure.

[0028] Figure 4 illustrates an example of uplink power control in the case of OCC sequence application in accordance with aspects of the present disclosure.

[0029] Figure 5 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0030] Figure 6 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0031] Figure 7 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0032] Figure 8 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0033] Figure 9 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0034] Some wireless communications systems may deploy non-terrestrial (NTN) NE, such as satellite and high-altitude platforms to extend coverage and services of the wireless communication systems. The NTN NE may be operable to or configured as relay equipment for processing (e.g., receiving, transmitting, forwarding) communications between terrestrial NE (e.g., base stations) or UE (both may be referred to as ground devices). NTN uses radio frequency (RF) resources on board a satellite or an airborne aircraft. The baseband (i.e. gNB) can be at the satellite or at ground. In an NTN network, a subset or all functions of a base station may be deployed at a satellite, an airborne aircraft, or another NTN NE. One or more of the satellite, the airborne aircraft, or NTN NE may provide services to UEs located in one or more of geographic areas (also referred to as, an area, or a sub-area, or a footprint, or the like).

[0035] As demand for higher throughput and efficient utilization of resources in the wireless communications system increases, it may be desirable to support multiplexing of uplink communications (e.g., mobile-originated (MO) data transmissions) associated with multiple UEs, for example, over a single subcarrier, such as 3.75 kilohertz (kHz) with a multiplexing sequence (e.g., an OCC sequence). In some wireless communications systems, such as NTN, it may be challenging to apply the multiplexing sequence (e.g., the OCC

sequence) to uplink communications (e.g., PUSCH transmissions in view of UE and uplink receptions and PUSCH receptions in view of network side).

[0036] In some cases, it may be challenging on how to apply the multiplexing sequence (e.g., the OCC sequence) to the uplink communications, for example, when the uplink communications includes a repetition of uplink transmissions. In some other cases, it may be challenging on how to apply the multiplexing sequence (e.g., the OCC sequence) to the uplink communications, for example, when there are multiple SRS resource sets associated with the uplink communications. In other cases, it may be challenging on how to apply the multiplexing sequence (e.g., the OCC sequence) to the uplink communications, for example, when a TB may have to be processed over multiple slots. In yet other cases, it may be challenging on how to manage power control for the uplink communications, for example, when applying intra-symbol OCC sequence.

[0037] Various aspects of the present disclosure provide one or more technical solutions of supporting uplink communications and addressing the shortcomings and challenges of as described above. It should be understood that although the present disclosure may reference and describe the one or more technical solutions in context of NTN, the one or more technical solutions may be applicable to other networks (e.g., terrestrial networks, and the like). Additionally, it should be understood that although the one or more technical solutions of the present disclosure relate to applying an OCC sequence to uplink channels, such as PUSCH (including PUSCH resources, or PUSCH transmissions, or the like), the one or more technical solutions may be applicable other channels (e.g., downlink channels, sidelink channels, feedback channels, etc.).

[0038] A network entity (e.g., an NTN base station) may transmit, to a UE, first information, which may indicate whether one or more resources (e.g., one or more of slots or symbols) are available (or valid) for uplink. Examples of first information may include, but is not limited to, one or more of: an SSB configuration, a semi-static TDD configuration, a dynamic TDD configuration received via a DCI format 2-0 from the network entity, an interruption indication received via a DCI format 2-6 from the network entity, a semi-static PDCCH configuration, a signaling related to overlapping between a PUCCH and a PUSCH, a signaling related to overlapping between a PUSCH and a PRACH, a signaling related to

overlapping between downlink and uplink, or a signaling indicating unavailable (or invalid) resources for uplink. The network entity may transmit, to the UE, second information, which may indicate to apply an OCC sequence to a set of uplink transmissions (e.g., one or multiple PUSCH transmissions). Based on one or more of the first information and second information, the UE may determine a mapping (e.g., an association, or the like) between elements (also referred to as sequence elements) of the OCC sequence and the set of uplink transmissions or a subset of uplink transmissions of the set of uplink transmissions. Additionally, or alternatively, the network entity may determine a mapping between elements of the OCC sequence and the set of uplink transmissions or a subset of uplink transmissions of the set of uplink transmissions based on one or more of the first and second information.

[0039] Aspects of the present disclosure are described in the context of a wireless communications system.

[0040] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0041] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element,

a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0042] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0043] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0044] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0045] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106. In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0046] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

[0047] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0048] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0049] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0050] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0051] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ =0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0052] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0053] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0054] To support multiplexing of uplink communications associated with multiple UE, the network side may transmit a signaling to UE, indicating application of an OCC sequence to PUSCH with or without repetitions, PUSCH with TB processing over multiple slots etc., various PUSCH transmissions.

[0055] Regarding a PUSCH with repetitions, it may be also referred to as a PUSCH repetition transmission or the like. A PUSCH repetition transmission may be PUSCH repetitions scheduled by DCI, CG type 1 PUSCH repetitions, or CG type 2 PUSCH repetitions etc. PUSCH repetitions may further include PUSCH repetition type A and PUSCH repetition type B. PUSCH repetition type A is based on a slot-level repetition, and each PUSCH occasion of a repetition is within a slot and different PUSCH repetitions are at different slots. The number of repetitions for PUSCH repetition type A may be implicitly determined based on the associated configuration or explicitly configured. PUSCH repetition type B is based on a time domain span repetition, e.g., a symbol-group level repetition, and the number of repetitions will be configured (referred to "nominal repetition number" or "the number of nominal repetitions"). In some cases, a repetition may also be regarded as a transmission.

[0056] When to start the application of the OCC sequence to PUSCH transmissions can be determined based on various manners.

[0057] For example, in some implementations of the present disclosure, the application of the OCC sequence to PUSCH transmissions may be from the first scheduled slot of the PUSCH transmissions, or the first repetition of the PUSCH transmission. For example, a

PUSCH transmission being PUSCH repetition type A may start the application of the OCC sequence to the PUSCH transmission from the first scheduled slot of the PUSCH transmission. A PUSCH transmission being PUSCH repetition type B may start the application of the OCC sequence to the PUSCH transmission from the first repetition of the PUSCH transmission. Regarding the first repetition, it may be various for PUSCH repetition type B in view of different mapping manners, e.g., being a nominal repetition, an actual repetition or other repetition type (e.g., a final repetition as illustrated in the following).

[0058] In some implementations of the present disclosure, the application of the OCC sequence to PUSCH transmissions may start from a configured or predefined time domain position, e.g., based on the periodicity and offset of the associated PUSCH transmissions. For example, for PUSCH transmissions being CG type 1 PUSCH repetitions with a periodicity of 40ms and an offset of 5ms, the application of the OCC sequence to the PUSCH transmissions may start from 5ms, or 45ms etc.

[0059] In some implementations of the present disclosure, the application of the OCC sequence to PUSCH transmissions may start from the first scheduled slot or the first repetition of the PUSCH transmissions after DCI activation associated with the PUSCH transmissions plus a configured or predefined delay. The minimum delay between the DCI activation and the first scheduled slot or the first repetition may also be configured or predefined. The delay can also be set to be 0. For example, for PUSCH transmissions being CG type 2 PUSCH repetitions, the application of the OCC sequence to the PUSCH transmissions may start from the first scheduled slot or the first repetition of the PUSCH transmissions after the DCI activation associated with the PUSCH transmissions.

[0060] In some cases, resources, e.g., slots and/or symbols may be unavailable (or invalid) for uplink even if the slots and/or symbols were configured for the uplink, which may impact the application of the OCC sequence to PUSCH transmissions. Considering that, when an OCC sequence is applied to PUSCH transmissions with unavailable resource(s), UE may delay or discard the mapping between the elements of the OCC sequence and the PUSCH transmissions. In some other implementations, it may be predefined that UE does not expect that the OCC sequence will be applied for PUSCH transmissions with unavailable resource(s). That is, the network side will only indicate UE to apply an OCC sequence for PUSCH

transmissions where all the associated resources are available. Which solution or scheme will be used or selected may be configured or predefined rules.

[0061] In the case that the PUSCH transmission, to which an OCC sequence is indicated to be applied, is a repetition transmission with a number of repetitions, and there are unavailable resources for the PUSCH transmission (that is, some repeated occasions of the PUSCH transmission may be omitted or missed), UE may also adjust or maintain the number of repetitions when applying the OCC sequence to the repetition transmission based on configured or predefined rules. In some implementations of the present disclosure, the PUSCH transmissions indicated to be applied an OCC sequence are always those have only available resources.

[0062] More detailed implementations of the present disclosure will be illustrated in the following respectively in view of PUSCH repetition type A and PUSCH repetition type B.

[0063] Specifically, regarding PUSCH repetition type A, some repeated occasions or repetitions thereof may be omitted or missed due to various factors or conditions. For example, legacy 3GPP specification specifies that for PUSCH repetition type A and TB processing over multiple slots, a PUSCH transmission in a slot of a multi-slot PUSCH transmission is omitted according to the conditions (hereinafter conditons#1) or factors in Clause 9, Clause 11.1, Clause 11.2A, Clause 15 and Clause 17.2 of TS 38.213, which are listed below for reference:

- Clause 9 is: due to collision between PUCCH and PUSCH, some PUSCH may not be able to be transmitted
- Clause 11.1 is: due to slot format indicated by DCI format 2-0, some PUSCH may not be able to be transmitted as the slot and/or symbol changed to downlink
- Clause 11.2A is: due to uplink interruption indicated by DCI format 2-6 for enhanced mobile broadband (eMBB)/ultra-reliable and low latency communications (URLLC) multiplexing, PUSCH for one traffic type may not be able to be transmitted as it is occupied by another traffic type
- Clause 15 is: due to collision between PUSCH and PRACH in dual connectivity (DC) scenarios, so PUSCH may not be able to be transmitted
- Clause 17.2 is: due to restriction of Redcap UE, such as half duplex (HD)-frequency divisional duplex (FDD), so a Redcap UE cannot receive downlink and transmit uplink simultaneously, and PUSCH may not be able to be transmitted.

[0064] There are also other factors or conditions (hereafter conditions#2) impacting the availability of uplink resources for PUSCH, e.g., TDD configuration common, TDD configuration dedicated, SSB configuration etc.

[0065] In some implementations of the present disclosure (scheme 1), for the unavailable resources, e.g., the slots and/or symbols related to conditions#1, UE may still consider them when mapping elements of the OCC sequence to the PUSCH transmission, while discard the unavailable slots and/or symbols after the mapping. That is, mapping between elements of the OCC sequence and PUSCH transmission occasions will not be impacted by the unavailable slots and/or symbols, and the number of repetitions of the PUSCH transmission may be reduced due to the unavailable resources.

[0066] In some implementations of the present disclosure (scheme 2), for the unavailable resources, e.g., the slots and/or symbols related to conditions#1 or conditions#2, UE may exclude them before mapping elements of the OCC sequence to the PUSCH transmission. Whether to delay (or extend) a repetition corresponding to an unavailable resource (or corresponding to resource omission (missing or the like) caused by excluding unavailable resources) to the following available uplink resources may be explicitly configured, or may be implicitly determined, e.g., based on a legacy configuration on whether repetitions can be delayed or extended by available slots or the like. Accordingly, the number of repetitions of the PUSCH transmission may be adjusted or maintained depending on whether to delay a corresponding repetition to the following available uplink resources and another signaling. For example, if the signaling indicates to keep the number of repetitions with 4, the repetitions occupy slot #0, 1, 2 and 3, and slot#2 and 3 are missed due to contradiction with DL slot, and slot#4 and 5 will be used for the corresponding repetitions so that the total number of repetitions are still 4. If the signaling indicates not to keep the number of repetitions, in the case above, only slot#0 and 1 will be used, and the number of repetitions is 2.

[0067] It can be seen that, for unavailable resources, e.g., the slots and/or symbols related to conditions#1, the unavailable resources may be excluded or included when mapping elements of the OCC sequence to the associated PUSCH transmission. For example, for a PUSCH occasion or repetition not transmitted due to DCI format 2-0 indication, the OCC

sequence to PUSCH mapping may exclude the un-transmitted PUSCH occasion or repetition. While for unavailable resources due to uplink interruption indicated by DCI format 2-6 and/or collision between PUCCH and PUSCH etc., the OCC sequence to PUSCH mapping may include the un-transmitted PUSCH occasion(s) or repetition(s).

[0068] Figure 2 illustrates an example of OCC sequence application to PUSCH transmissions in accordance with aspects of the present disclosure.

[0069] Referring to Figure 2, in case (a), it is assumed that there are data, e.g., d1, d2 and d3 to be transmitted in PUSCH transmission or channel, which is a PUSCH repetition type A with a repetition number 4. It is also assumed the configured length of the OCC sequence applied to the PUSCH transmission is 4, which means there are 4 elements, each corresponding to one slot. Then, the 4 elements of the OCC sequence will be mapped to each repetition of d1, d2, and d3 respectively, which totally needs 12 slots available for the PUSCH transmission. However, as illustrated in case (b), it is assumed that there are unavailable (or invalid) resources for the PUSCH transmission, e.g., the 4^{th} and 5^{th} slots for downlink, and the 9^{th} and t$10t^{h}$ slots for SSB.

[0070] In accordance with scheme 1, after mapping the elements of the OCC sequence to repetitions or repeated occasions of d1, d2 and d3, the last repetition of d1, the first repetition of d2 and the first two repetitions of d3 will be discarded as shown in case (c).

[0071] In accordance with scheme 2, when mapping the elements of the OCC sequence to repetitions or repeated occasions of d1, d2 and d3, if a repetition corresponding to an unavailable resource will be delayed to the following available UL resources as shown in case (d), then the mapping between the last element of the OCC sequence and the last repetition of d1 will be delayed to the $6t^{h}$ slot. Accordingly, the mapping between the elements of the OCC sequence and each repetition of d2 will also be delayed, and start from the 7^{th} slot and so on.

[0072] Regarding PUSCH repetition type B, there are also various factors or conditions which will cause resources for uplink invalid, e.g., those specified in 6 of TS 38.214 etc.

[0073] In some implementations of the present disclosure, for PUSCH transmissions being PUSCH repetition type B, UE may map the elements of the OCC sequence to actual

repetitions of the PUSCH transmissions. For example, after determining invalid symbols, UE will determine actual repetitions of the PUSCH transmissions based on the nominal repetitions configured for the PUSCH transmissions and invalid symbols as specified in legacy 3GPP specification, e.g., TS 38.214. When determining an actual repetition of PUSCH repetition type B, UE will also consider the slot boundary, and an actual repetition of PUSCH repetition type B will not cross the slot boundary. If there are actual repetition omissions, e.g., due to some of factors or conditions specified in Clause 9, 11.1, 11.2A, 15 and 17.2 of TS 38.213, the omitted actual repetitions will not be used when applying the OCC sequence to the PUSCH transmission.

[0074] In some implementations of the present disclosure, for PUSCH transmissions being PUSCH repetition type B, a novel repetition type, e.g., final repetition (just for clearness and simplification, may be referred to other names) may be introduced besides the nominal repetition and actual repetition. UE may map the elements of the OCC sequence to final repetitions of the PUSCH transmissions. Regarding the final repetition, it is determined based on remaining resources of the PUSCH transmissions after excluding invalid resources from configured resources of the PUSCH transmissions based on a number of resources, e.g., a number of symbols (or referred to as symbol level length) configured for a nominal repetition, which may start from the first available symbols of the PUSCH transmission. That is, UE will map the elements of the OCC sequence to remaining resources of the PUSCH transmissions after excluding invalid resources from the configured resources of the PUSCH transmissions. The number of symbols for each final repetition is based on a number of symbols configured for a nominal repetition of the PUSCH transmissions. Different from actual repetitions, final repetitions do not consider the slot boundary and thus may cross the slot boundary. In the case of using final repetition, the TB size may also be determined based on the number of symbols of a nominal repetition.

[0075] In some implementations of the present disclosure, DMRS symbols may also be excluded from the configured resources of the PUSCH transmissions during determining the final repetitions. The DMRS symbols may be determined based on slot-level configuration associated with the PUSCH transmissions. For example, there may be one front-loaded DMRS symbol and one additional DMRS symbol in a slot. The number of symbols in a slot

and position of DMRS symbol is not impacted by the time domain position of each final repetition.

[0076] In some implementations of the present disclosure, the network side may configure the factors or conditions which cause resources invalid for associated PUSCH repetition type B to be deactivated, e.g., for a group UE by a group common DCI or the like. That is, all the related resources for the associated PUSCH repetition type B will be available.

[0077] In some implementations of the present disclosure, the network side may configure dedicated uplink time frequency resources for associated PUSCH repetition type B, e.g., to a group of UE by a group common DCI or the like to apply the OCC sequence, which will ensure that all the related resources for the associated PUSCH repetition type B will be available. The OCC sequence application may be started from the beginning of the configured uplink time domain resources.

[0078] Figure 3 illustrates another example of OCC sequence application to PUSCH transmissions in accordance with aspects of the present disclosure.

[0079] Referring to Figure 3, in case (a), it is assumed that there are uplink data, e.g., d1, d2, d3, d4, d5, d6 and d7 in two slots, e.g., slot#1 and slot#2 in a PUSCH transmission or channel, which is a PUSCH repetition Type B with a configured repetition number (the nominal repetition number) of 4. It is also assumed the configured length of the OCC sequence applied to the PUSCH transmission is 4, which means that there are 4 elements, each corresponding to one symbol. Then, the 4 elements of the OCC sequence will be mapped to each repetition of d1 to d7 respectively, which totally needs available or valid 28 symbols within 2 slots for the PUSCH transmission. However, as illustrated in case (b), it is assumed that there are unavailable or invalid resources for the PUSCH transmission, e.g., the 4^{th}, 5^{th}, 10^{th} and 11^{th} symbols within each of the slot#1 and slot#2.

[0080] Case (c) illustrates mapping of the elements of the OCC sequence to final repetitions of the PUSCH transmission, wherein the elements of the OCC sequence are applied to the remaining valid resources. The number of repetitions for each data is based on the number of symbols configured for a nominal repetition, i.e., 4. The slot boundary between

slot#1 and slot#2 does not impact the mapping between elements of the OCC sequence to the final repetitions.

[0081] Case (d) illustrates mapping of the elements of the OCC sequence to actual repetitions of the PUSCH transmission. The slot boundary between slot#1 and slot#2 impacts the mapping between elements of the OCC sequence to the actual repetitions. The interrupted nominal repetition is divided into multiple actual repetitions, so OCC application will restart for each actual repetition.

[0082] In some cases, there may be mapping or association among PUSCH occasions, SRS resource set(s) and/or RV(s). Thus, mapping among SRS resource set(s) (if any), RV(s) (if any) and PUSCH transmissions also needs to be considered when applying the OCC sequence to PUSCH transmissions.

[0083] For PUSCH repetition type A, when performing the mapping among SRS resource set(s) (if any), RV(s) (if any) and PUSCH repetition transmissions, the repetition is still slot level. For PUSCH repetition type B, in accordance with legacy 3GPP specification, mapping between SRS resource set(s) and PUSCH repetition transmissions is based on nominal repetitions, while mapping between RV(s) and PUSCH repetition transmissions is based on actual repetitions. However, when an OCC sequence is applied, mapping between SRS resource set(s) and PUSCH repetition transmissions (if any) and mapping between RV(s) and PUSCH repetition transmissions (if any) will be based on the same repetition type, e.g., actual repetitions or final repetitions. For example, UE may perform mapping between one or more of SRS resource set(s), RV version(s), elements of the OCC sequence and PUSCH actual repetitions. Regarding mapping RV(s) to PUSCH repetition type B, in the case that actual repetitions are considered and there is actual repetition missing due to factor specified in Clause 9, 11.1, 11.2A, 15 and 17.2 of TS 38.213, the mapping between actual repetitions and RV(s) will not be impacted. Similarly, which mapping manner (e.g., legacy or novel mapping manner) will be adopted based on an explicit indication via signaling or implicit indication via the associated indication of OCC sequence application. For example, if there is no OCC application indication, legacy mapping manner will be used, otherwise, new mapping manner is considered.

[0084] In some scenarios, there may be multiple, e.g., two SRS resource sets in the network, e.g., two SRS resource sets corresponding to two TRPs at network side or two panels at UE side. Different PUSCH transmissions (e.g., repetitions or repeated occasions etc.) may be associated with different SRS resource sets based on DCI indication. Similarly, there may be multiple RVs. Thus, when applying an OCC sequence to PUSCH transmissions, the association or mapping among the OCC sequence with PUSCH transmissions, multiple SRS resource sets (if any) and multiple RVs (if any) may also be considered.

[0085] In some implementations of the present disclosure, when an OCC sequence is applied to PUSCH transmissions, UE may disable mapping between PUSCH transmissions and one or more of SRS resource sets or RVs, which may be based on explicitly indication by a signaling or based on the information indicating the application of OCC sequence to PUSCH transmissions. For example, in the case of two SRS resource sets, if the OCC sequence application is indicated, UE may disable mapping between PUSCH transmissions and one of the two SRS resource sets, so that there is only mapping between PUSCH transmissions and one SRS resource set (e.g., the first SRS resource set). In the case of multiple RVs, if the OCC sequence application is indicated, UE may disable mapping between PUSCH transmissions and one or more of the multiple RVs, so that there is only mapping between PUSCH transmissions and one RV (e.g., RV 0). In the case of multiple SRS resource sets and RVs, if the OCC sequence application is indicated, UE may only map PUSCH transmissions to one SRS resource set and one RV and disable other mapping, or disable all mapping between PUSCH transmissions and SRS resource sets and/or RVs etc. (that is, only considering the mapping the OCC sequence and PUSCH transmissions).

[0086] In some implementations of the present disclosure, when an OCC sequence is applied to PUSCH transmissions, UE may perform mapping among PUSCH transmissions, the elements of the OCC sequence and one or more of SRS resource sets or RVs based on a configured or predefined mapping order. An exemplary mapping order may be OCC sequence first, following by SRS resource set and/or RV, e.g., firstly mapping the elements of the OCC sequence to the PUSCH transmissions, then mapping the SRS resource sets (if any) to the PUSCH transmissions, and then mapping the RVs (if any) to the PUSCH transmissions. This scheme or solution can be independently used or combine with other

scheme(s). For example, in some cases, the SRS resource sets (if any) and RVs (if any) may be the remaining SRS resource sets (if any) and RVs (if any) after excluding the SRS resource set (if any) and RVs (if any) whose mapping being disabled as illustrated above. For repeated occasions or repetitions of a PUSCH repetition transmission, mapping among repeated occasions, SRS resource sets and/or RVs may also update compared with the legacy 3GPP specification due to the application of the OCC sequence.

[0087] In some implementations of the present disclosure, mapping or association among PUSCH transmissions and SRS resource sets (if any) and RVs (if any) are the same as in legacy 3GPP specification even in the case of OCC sequence application. UE may map the elements of the OCC sequence only to PUSCH transmissions associated with the same SRS resource set (if any) and the same RV (if any).

[0088] In some cases, when the application of OCC sequence is indicated, for a PUSCH repetition transmission with a repetition containing channel state information (CSI), the CSI will be multiplexed in all repetitions associated with the same SRS resource set and/or same RV version, wherein the repetition is slot for PUSCH repetition type A, and is a symbol group for PUSCH repetition type B. The symbol group can be based on actual or final repetition for PUSCH repetition type B.

[0089] In some scenarios, there are PUSCH transmissions with TB processing over multiple slots. In the case of OCC sequence application, each element of the OCC sequence will be associated with the number of the multiple slots or associated with the number of slots to determine the size of the TB. For example, for a PUSCH repetition transmissions with TB processing over 2 slots, the number of repetitions is 4, the length of the OCC sequence may also be 4, and there will be 8 slots for the PUSCH transmission, wherein, each OCC element is applied to 2 slots.

[0090] In addition, uplink power control is also considered for PUSCH transmissions. In legacy 3GPP specification for uplink power control, the uplink transmission power is determined by the number of occupied frequency domain RBs. When there is intra-symbol OCC sequence application, although there is OCC spreading in frequency domain based on the OCC length, the actual number of occupied RBs is impacted by the OCC length due to

the comb structure in frequency domain. Thus, power control issues should also be considered in this case.

[0091] In accordance with aspects of the present disclosure, UE may determine uplink transmission power for PUSCH transmissions based on one or more of the following: a number of frequency domain resources before OCC spreading in frequency domain, a number of frequency domain resources after OCC spreading in frequency domain, or a length of the OCC sequence. For example, when there is intra-symbol OCC sequence application, the number of frequency domain RBs may be a number of RBs before OCC spreading in frequency domain (hereinafter, frequency spreading), or a number of RBs after frequency spreading; or a number of RBs after frequency spreading divided by the OCC sequence length; or a number of RBs before frequency spreading multiplied by the OCC sequence length etc.

[0092] Figure 4 illustrates an example of uplink power control in the case of OCC sequence application in accordance with aspects of the present disclosure.

[0093] Referring to Figure 4, case (a) illustrates frequency domain resources before frequency spreading for a PUSCH transmission of UE#1 and frequency domain resources before frequency spreading for a PUSCH transmission of UE#2. Case (b) illustrates frequency domain resources after frequency spreading for the PUSCH transmission of UE#1 and frequency domain resources after frequency spreading for the PUSCH transmission of UE#2. Case (c) illustrates frequency domain resources after discrete Fourier transform (DFT) and OCC sequence application for the PUSCH transmissions of UE#1 and UE#2. It can also be seen that although there is OCC spreading in frequency domain based on the OCC length as shown in case (c), the actual number of occupied subcarriers of the associated PUSCH transmission is not impacted by the OCC length due to the comb structure in frequency domain. UE may determine uplink transmission power for the PUSCH transmissions for UE#1 based on the number of frequency domain resources of the PUSCH transmission as shown in case (a), in case (b) or in case (c) or a combination thereof. It is similar for uplink power control for UE#2, and thus will not repeat.

[0094] Figure 5 illustrates an example of a UE 500 in accordance with aspects of the present disclosure. The UE 500 may include a processor 502, a memory 504, a controller 506, and a transceiver 508. The processor 502, the memory 504, the controller 506, or the

transceiver 508, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0095] The processor 502, the memory 504, the controller 506, or the transceiver 508, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0096] The processor 502 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 502 may be configured to operate the memory 504. In some other implementations, the memory 504 may be integrated into the processor 502. The processor 502 may be configured to execute computer-readable instructions stored in the memory 504 to cause the UE 500 to perform various functions of the present disclosure.

[0097] The memory 504 may include volatile or non-volatile memory. The memory 504 may store computer-readable, computer-executable code including instructions when executed by the processor 502 cause the UE 500 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 504 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0098] In some implementations, the processor 502 and the memory 504 coupled with the processor 502 may be configured to cause the UE 500 to perform one or more of the functions described herein (e.g., executing, by the processor 502, instructions stored in the memory 504). For example, the processor 502 may support wireless communication at the UE 500 in accordance with examples as disclosed herein. The UE 500 may be configured to

support a means for receiving first information indicating whether one or more resources are available for uplink; means for receiving second information indicating application of an OCC sequence to a set of PUSCH transmissions; and means for determining mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

[0099] The controller 506 may manage input and output signals for the UE 500. The controller 506 may also manage peripherals not integrated into the UE 500. In some implementations, the controller 506 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 506 may be implemented as part of the processor 502.

[0100] In some implementations, the UE 500 may include at least one transceiver 508. In some other implementations, the UE 500 may have more than one transceiver 508. The transceiver 508 may represent a wireless transceiver. The transceiver 508 may include one or more receiver chains 510, one or more transmitter chains 512, or a combination thereof.

[0101] A receiver chain 510 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 510 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 510 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 510 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 510 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0102] A transmitter chain 512 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 512 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation

(QAM). The transmitter chain 512 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 512 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0103] Figure 6 illustrates an example of a processor 600 in accordance with aspects of the present disclosure. The processor 600 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 600 may include a controller 602 configured to perform various operations in accordance with examples as described herein. The processor 600 may optionally include at least one memory 604, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 600 may optionally include one or more arithmetic-logic units (ALUs) 606. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0104] The processor 600 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 600) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0105] The controller 602 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. For example, the controller 602 may operate as a control unit of the processor 600, generating control signals that manage the operation of various components

of the processor 600. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0106] The controller 602 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 604 and determine subsequent instruction(s) to be executed to cause the processor 600 to support various operations in accordance with examples as described herein. The controller 602 may be configured to track memory address of instructions associated with the memory 604. The controller 602 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 602 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 600 to cause the processor 600 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 602 may be configured to manage flow of data within the processor 600. The controller 602 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 600.

[0107] The memory 604 may include one or more caches (e.g., memory local to or included in the processor 600 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 604 may reside within or on a processor chipset (e.g., local to the processor 600). In some other implementations, the memory 604 may reside external to the processor chipset (e.g., remote to the processor 600).

[0108] The memory 604 may store computer-readable, computer-executable code including instructions that, when executed by the processor 600, cause the processor 600 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 602 and/or the processor 600 may be configured to execute computer-readable instructions stored in the memory 604 to cause the processor 600 to perform various functions. For example, the processor 600 and/or the controller 602 may be coupled with or to the memory 604, the processor 600, the controller 602, and the memory 604 may be configured to perform various functions described herein. In some examples, the processor 600 may include multiple processors and the memory 604 may include multiple memories. One or

more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0109] The one or more ALUs 606 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 606 may reside within or on a processor chipset (e.g., the processor 600). In some other implementations, the one or more ALUs 606 may reside external to the processor chipset (e.g., the processor 600). One or more ALUs 606 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 606 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 606 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 606 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 606 to handle conditional operations, comparisons, and bitwise operations.

[0110] The processor 600 may support wireless communication in accordance with examples as disclosed herein. The processor 600 may be configured to or operable to support a means for receiving first information indicating whether one or more resources are available for uplink; means for receiving second information indicating application of an OCC sequence to a set of PUSCH transmissions; and means for determining mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

[0111] Figure 7 illustrates an example of a NE 700 in accordance with aspects of the present disclosure. The NE 700 may include a processor 702, a memory 704, a controller 706, and a transceiver 708. The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0112] The processor 702, the memory 704, the controller 706, or the transceiver 708, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0113] The processor 702 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 702 may be configured to operate the memory 704. In some other implementations, the memory 704 may be integrated into the processor 702. The processor 702 may be configured to execute computer-readable instructions stored in the memory 704 to cause the NE 700 to perform various functions of the present disclosure.

[0114] The memory 704 may include volatile or non-volatile memory. The memory 704 may store computer-readable, computer-executable code including instructions when executed by the processor 702 cause the NE 700 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 704 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0115] In some implementations, the processor 702 and the memory 704 coupled with the processor 702 may be configured to cause the NE 700 to perform one or more of the functions described herein (e.g., executing, by the processor 702, instructions stored in the memory 704). For example, the processor 702 may support wireless communication at the NE 700 in accordance with examples as disclosed herein. The NE 700 may be configured to support a means for transmitting first information indicating whether one or more resources are available for uplink; means for transmitting second information indicating application of an OCC sequence to a set of PUSCH transmissions; and means for determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of

PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

[0116] The controller 706 may manage input and output signals for the NE 700. The controller 706 may also manage peripherals not integrated into the NE 700. In some implementations, the controller 706 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 706 may be implemented as part of the processor 702.

[0117] In some implementations, the NE 700 may include at least one transceiver 708. In some other implementations, the NE 700 may have more than one transceiver 708. The transceiver 708 may represent a wireless transceiver. The transceiver 708 may include one or more receiver chains 710, one or more transmitter chains 712, or a combination thereof.

[0118] A receiver chain 710 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 710 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 710 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 710 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 710 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0119] A transmitter chain 712 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 712 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 712 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 712 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0120] Figure 8 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0121] At step 801, the method may include receiving first information indicating whether one or more resources are available for uplink. The operations of step 801 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 801 may be performed by a UE as described with reference to Figure 5.

[0122] At step 803, the method may include for receiving second information indicating application of an OCC sequence to a set of PUSCH transmissions. The operations of step 803 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 803 may be performed by a UE as described with reference to Figure 5.

[0123] At step 805, the method may include determining mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information. The operations of step 803 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 805 may be performed by a UE as described with reference to Figure 5.

[0124] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0125] Figure 9 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions.

[0126] At step 901, the method may include transmitting first information indicating whether one or more resources are available for uplink. The operations of step 901 may be

performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 901 may be performed by a NE as described with reference to Figure 7.

[0127] At step 903, the method may include transmitting second information indicating application of an OCC sequence to a set of PUSCH transmissions. The operations of step 903 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 903 may be performed by a NE as described with reference to Figure 7.

[0128] At step 905, the method may include determining mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information. The operations of step 905 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 903 may be performed by a NE as described with reference to Figure 7.

[0129] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0130] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the UE to:

receive first information indicating whether one or more resources are available for uplink;

receive second information indicating application of an orthogonal cover code (OCC) sequence to a set of physical uplink shared channel (PUSCH) transmissions; and

determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

2. The UE of claim 1, wherein the first information is one or more of: a synchronization signal (SS)/PBCH block (SSB) configuration, a semi-static time divisional duplex (TDD) configuration, a dynamic TDD configuration received via a downlink control information (DCI) format 2_0, an interruption indication received via a DCI format 2_6, a semi-static physical downlink control channel (PDCCH) configuration, a signaling related to overlapping between physical uplink control channel (PUCCH) and PUSCH, a signaling related to overlapping between PUSCH and physical random access channel (PRACH), a signaling related to overlapping between downlink and uplink, or a signaling indicating unavailable resources for uplink transmissions.

3. The UE of claim 1, wherein the first information indicates that the one or more resources are unavailable for uplink, the at least one processor is configured to cause the UE to:

delay mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions; or

discard the mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions.

4. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

determine a first number of repetitions associated with the set of PUSCH transmissions or the subset of PUSCH transmissions based on a configuration; and

determine a second number of repetitions by adjusting or maintaining the first number of repetitions based on the first information indicating that the one or more resources are unavailable for uplink and another received signaling.

5. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

expect that one or more resources associated with the set of PUSCH transmissions or the subset of PUSCH transmissions to which the OCC sequence is applied are available.

6. The UE of claim 1, wherein in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are associated with PUSCH repetition type B, the at least one processor is configured to cause the UE to:

map the elements of the OCC sequence only to actual repetitions of the set of PUSCH transmissions or the subset of PUSCH transmissions; or

map the elements of the OCC sequence to remaining resources of the set of PUSCH transmissions or the subset of PUSCH transmissions after excluding invalid resources from configured resources of the set of PUSCH transmissions or the subset of PUSCH transmissions based on a number of resources configured for a nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

7. The UE of claim 6, wherein mapping the elements of the OCC sequence to the remaining resources of the set of PUSCH transmissions or the subset of PUSCH

transmissions further comprises excluding demodulation reference signal (DMRS) symbols from the configured resources of the set of PUSCH transmissions or the subset of PUSCH transmissions.

8. The UE of claim 1, wherein the at least one processor is configured to further cause the UE to:

disable mapping between the set of PUSCH transmissions or the subset of PUSCH transmissions and one or more of sounding reference signal (SRS) resource sets or redundancy versions (RVs); or

map the elements of the OCC sequence only to PUSCH transmissions associated with a same SRS resource set or a same RV of the set of PUSCH transmissions or the subset of PUSCH transmissions.

9. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

perform mapping between the set of PUSCH transmissions or the subset of PUSCH transmissions and the elements of the OCC sequence and one or more of: sounding reference signal (SRS) resource sets or redundancy versions (RVs) based on a configured or predefined mapping order.

10. The UE of claim 9, wherein the mapping order comprises firstly mapping the elements of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions.

11. The UE of claim 1, wherein in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are PUSCH transmissions with transport block (TB) processing over multiple slots, each element of the OCC sequence is associated with a number of the multiple slots or a number of slots to determine a size of the TB.

12. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

determine uplink transmission power for the set of PUSCH transmissions or the subset of PUSCH transmissions based on one or more of: a number of frequency domain resources before OCC spreading in frequency domain, a number of frequency domain resources after OCC spreading in frequency domain, or a length of the OCC sequence.

13. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a first scheduled slot of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

14. The UE of claim 1, wherein in the case that the set of PUSCH transmissions or the subset of PUSCH transmissions are configured grant type 2 PUSCH, the at least one processor is configured to cause the UE to:

start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a first scheduled slot of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions after downlink control information (DCI) activation plus a configured or predefined delay.

15. The UE of Claim 13 or 14, wherein the first repetition is a first actual repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions, or a first nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions, or is determined based on remaining symbols of the set of PUSCH transmissions or the subset of PUSCH transmissions after excluding invalid resources and a number of resources configured for a nominal repetition of the set of PUSCH transmissions or the subset of PUSCH transmissions.

16. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:

start the application of the OCC sequence to the set of PUSCH transmissions or the subset of PUSCH transmissions from a configured or predefined time domain position.

17. The UE of claim 16, wherein the time domain position is configured by a periodicity and offset of the set of PUSCH transmissions or the subset of PUSCH transmissions.

18. A processor for wireless communication, comprising:

at least one controller coupled with at least one memory and configured to cause the processor to:

receive first information indicating whether one or more resources are available for uplink;

receive second information indicating application of an orthogonal cover code (OCC) sequence to a set of physical uplink shared channel (PUSCH) transmissions; and

determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and second information.

19. A network equipment (NE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the NE to:

transmit first information indicating whether one or more resources are available for uplink;

transmit second information indicating application of an orthogonal cover code (OCC) sequence to a set of physical uplink shared channel (PUSCH) transmissions; and

determine mapping between elements of the OCC sequence and the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.

20. A method performed by a user equipment (UE), comprising:

receiving first information indicating whether one or more resources are available for uplink;

receiving second information indicating application of an orthogonal cover code (OCC) sequence to a set of physical uplink shared channel (PUSCH) transmissions; and

determining mapping between elements of the OCC sequence to the set of PUSCH transmissions or a subset of PUSCH transmissions of the set of PUSCH transmissions based on the first information and the second information.