INTER AND INTRA SLOT ORTHOGONAL COVER CODE APPLICATION FOR PHYSICAL UPLINK SHARED CHANNEL

PRIORITY APPLICATION

[0001] This application claims priority to U.S. Provisional Application No. 63/574,803 filed April 4, 2024, the content of which is fully incorporated herein.

TECHNICAL FIELD

[0002] The present disclosure relates to wireless communications, and more specifically to wireless communication devices performing uplink transmission using orthogonal cover code (OCC).

BACKGROUND

[0003] 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

[0004] Aspects of the disclosure provide a user equipment, a processor, a base station, and corresponding methods enabling use of orthogonal cover code (OCC) sequencing within physical uplink shared channel (PUSCH) transmission. Some implementations of the method

and apparatuses described herein may include receiving, from a base station, a configuration that comprises a set of one or more parameters associated with mapping at least one OCC sequence to a set of one or more symbols. The method may further include applying the at least one OCC sequence to a PUSCH transmission based on the received configuration and performing the PUSCH transmission with the applied at least one OCC sequence. In one embodiment, the configuration includes an indication that enables the UE to apply the at least one OCC sequence to the PUSCH transmission. The configuration may include an indication of a type of OCC from among intra-slot and inter-slot OCC.

[0005] Within the description of the various aspects of the disclosure, 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.

[0006] Some implementations of the method and apparatuses described herein may further include receiving a radio resource control (RRC) message that indicates the configuration, and receiving downlink control information that schedules the PUSCH transmission and includes an indication of a type of OCC, from among intra-slot and inter-slot, to apply to the PUSCH transmission.

[0007] In one or more embodiments, the set of one or more parameters indicates an OCC length and an OCC index that identifies the at least one OCC sequence. Some implementations of the method and apparatuses described herein may further include: receiving, from among the set of one or more parameters within the configuration, an

indication for applying intra-slot OCC. The method may further include applying the at least one OCC sequence to symbols within a slot by: accessing, based on the parameters, an OCC look-up table corresponding to the OCC length and the index for OCC scheduling information; and determining a distribution of a transport block of data utilizing a number of consecutive time domain symbols within an allocated slot. According to one embodiment, the time domain resources for the transport block is determined as the number of consecutive time domain symbols within the allocated slot minus assigned DMRS symbols, with a resulting difference divided by the OCC length.

[0008] In some implementations of the method and apparatuses described herein, the method for network communication by a base station includes receiving, from a UE, an indication comprising UE capability information to support intra-slot or inter-slot OCC application for PUSCH transmission. The method includes, generating, based on the received indication, a configuration comprising parameters associated with mapping, at the UE, at least one OCC sequence to a set of one or more symbols for PUSCH transmission. The method includes transmitting the configuration to the UE. According to one aspect, the transmitting further includes transmitting a RRC message that indicates the configuration and transmitting downlink control information (DCI) that schedules the PUSCH transmission and includes an indication of the type of OCC, from among intra-slot and inter-slot, to apply to the PUSCH transmission.

[0009] The above contains simplifications, generalizations and omissions of detail and is not intended as a comprehensive description of the claimed subject matter but, rather, is intended to provide a brief overview of some of the functionality associated therewith. Other systems, methods, functionality, features, and advantages of the claimed subject matter will be or will become apparent to one with skill in the art upon examination of the figures and the remaining detailed written description. The above as well as additional objectives, features, and advantages of the present disclosure will become apparent in the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **Figure 1** illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0011] **Figure 2** illustrates Intra-slot OCC application with length 2 and symbol by symbol application of sequence, in accordance with aspects of the present disclosure.

[0012] **Figure 3** illustrates intra-slot OCC application with length 2 and grouping based application of the sequence, in accordance with aspects of the present disclosure.

[0013] **Figure 4** illustrates an intra-slot OCC application with different mapping types for length 4 OCC sequence, in accordance with aspects of the present disclosure.

[0014] **Figure 5** illustrates an Intra-slot OCC application with different length sequences, in accordance with aspects of the present disclosure.

[0015] **Figure 6** illustrates an inter-slot OCC application with length 2, in accordance with aspects of the present disclosure.

[0016] **Figure 7** illustrates a length 2 OCC application with fixed redundancy version (RV), in accordance with aspects of the present disclosure.

[0017] **Figure 8** illustrates an example of a UE in accordance with aspects of the present disclosure.

[0018] **Figure 9** illustrates an example of a processor in accordance with aspects of the present disclosure.

[0019] **Figure 10** illustrates an example of a network equipment (NE) or base station (BS) in accordance with aspects of the present disclosure.

[0020] **Figure 11** illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0021] **Figure 12** illustrates a flowchart of method performed by a NE/BS in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0022] Uplink (UL) coverage enhancements have been specified as part of 5G New Radio (NR) non-terrestrial network (NTN) Enhancements, such as repetitions and DeModulation Reference Signal (DMRS) bundling. However, the use of repetitions by itself has the effect of significantly reducing the system capacity and the individual user throughput by reducing the resources available for data, both for individual users as well as for the whole system. The use of repetitions will also increase UE transmission time, therefore driving higher utilization of UL resources in the time domain before they can be released to other users.

[0023] Moreover, in NTN, the coverage of satellites is very wide, and considering device density, it is expected that a large number of UEs will be within a satellite's coverage. Especially for low earth orbiting (LEO) satellites, a large number of UEs in coverage must succeed in transmitting desired data during satellite coverage, which means that rapid access to and release of satellite resources is required. The limitation of total spectrum resources available to the network will further require significantly improving system capacity efficiency. Some users will require higher resources than others, depending on their traffic patterns, and thus, further granularity of resource multiplexing may be needed.

[0024] In conventional NR, the uplink data is scheduled based on slot, where no repetitions are supported in the slot. Current methods do not specify the use of orthogonal cover codes for multiplexing multiple user uplink data. The use of orthogonal cover code (OCC) is currently limited to control channels where the codes are used to have multi-port transmission. Secondly, the flexibility of time domain resource scheduling in NR requires enhanced signaling mechanism for the application of one or multiple OCC sequences.

[0025] Aspects of the disclosure provide new configurations for PUSCH allocation that includes applying OCC when the uplink data is scheduled for either single slots or across multiple slots. Two different applications of OCC sequencing are supported, intra-slot application and inter-slot application. Thus, depending on the specific application for the particular UE, the application of OCC to a PUSCH will require the UE spreading the OCC across multiple symbols within a single slot (intra-slot application) or across multiple slots (inter-slot application), with repetition of the transport block (TB) to the length of the OCC.

The process for transmitting the data of the TB using OCC may require that the resources be configured according to the length of the OCC. As an example, if a length 4 OCC is configured for inter or intra slot application, then the TB would be repeated four times, requiring four times additional time domain resources as compared to the case when OCC is not applied. The present disclosure provides the additional signaling required to accurately map the time domain resources when OCC are enabled/applied to the PUSCH assigned to a UE. Moreover, the present disclosure appreciates and addresses the fact that the UE has to be aware of how the OCC are applied, whether across slots or within a slot, and accordingly, aspects of the disclosure provides that this detail may either be implicitly or explicitly indicated to the UE by the network. Accordingly, with the application of OCC for PUSCH, the uplink capacity for network communication from multiple UEs in a coverage area may be improved. Additionally, implementation of the OCC configuration scheme enables the base station to multiplex more UEs in the same slot and may also help in scheduling increased TB size for uplink data.

[0026] Aspects of the present disclosure are described in the context of a wireless communications system. **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.

[0027] 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 112, 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 (112).

[0028] 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 109 associated with a non-terrestrial network (NTN) that communicates with the wireless communications system 100 via a satellite link 111. In some implementations, different geographic coverage areas 110 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0029] The one or more UE 104 may be dispersed throughout a geographic region (110) 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.

[0030] 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 114. 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.

[0031] 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, N3, 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 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).

[0032] 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.

[0033] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N3, 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).

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] The following description is presented with reference to a UE 102 and a network entity 102 or base station (102) that operate within the wireless communication system. Referring to the above-described example of wireless communication system 100, the present disclosure enables the application of OCC to the PUSCH assigned to multiple UEs 104 by a network entity/base station 102. UEs 104 are assumed to be within a coverage area (110) of the assigning network entity/base station 102. To apply the OCC, the present disclosure provides that the uplink data need to be repeated to at least the length of the provided OCC sequence.

[0041] Aspects of the disclosure apply to enhance the conventional standards for PUSCH signal generation. With the uplink transmission scheme, two transmission schemes are supported for PUSCH: codebook-based transmission and non-codebook based transmission. For codebook-based transmission, the gNB provides the UE with a transmit precoding matrix indication in the downlink control information (DCI). The UE uses the indication to select the PUSCH transmit precoder from the codebook. For non-codebook based transmission, the UE determines its PUSCH precoder based on wideband SRI field from the DCI. A closed-loop DMRS based spatial multiplexing is supported for PUSCH. For a given UE, up to four (4) layer transmissions are supported. The number of code words is one. When transform precoding is used, only a single multiple-input multiple-output (MIMO) layer transmission is supported. Transmission durations from 1 to 14 symbols in a slot is supported. Aggregation of multiple slots with TB repetition is supported. Two types of frequency hopping are

supported, intra-slot frequency hopping, and in case of slot aggregation, inter-slot frequency hopping. Intra-slot and inter-slot frequency hopping are not supported when PRB interlace uplink transmission waveform is used.

[0042] The present disclosure presents configuration aspects for applying OCC when the uplink data is scheduled for single slots or across multiple slots. Specifically, the present disclosure addresses the configuration aspects for inter-slot and intra-slot OCC application for uplink data channel capacity improvement, while employing DFT-s-OFDM waveform. The present disclosure provides configuration aspects for applying OCC when the uplink data is scheduled for single slots or across multiple slots.

[0043] According to a first aspect, the network entity 102 (e.g., base station) explicitly indicates to the UE 104 whether OCC are to be applied intra-slot or inter-slot to the PUSCH. In one or more embodiments, this indication by the network entity 102 may be carried out either dynamically or through higher layer signaling. For example, in one implementation, RRC signaling is used for indicating that OCC application is enabled and how the OCC are applied, i.e., inter-slot or intra-slot. As an example of this implementation, fields may be added either in *PUSCH-Config* or *ConfiguredGrantConfig* Information Element (IEs) to indicate these OCC parameters, as illustrated by the below *PUSCH-Config* IE sequence (where red font indicates new parameters).

PUSCH-Config ::= SEQUENCE {
...
dataScramblingIdentityPUSCH INTEGER (0..1023) OPTIONAL,
txConfig ENUMERATED {codebook, nonCodebook}
resourceAllocation ENUMERATED {
resourceAllocationType0,
resourceAllocationType1,
dynamicSwitch},
pusch-TimeDomainAllocationList SetupRelease {
PUSCH-TimeDomainResourceAllocationList
}
OCC ENUMERATED (enabled, disabled)
OCCMethodolgy ENUMERATED (inter-slot, intra-slot, across symbol)
}

[0044] In one implementation, the type of OCC (e.g., inter-slot or intra-slot) may be included as part of downlink control information (DCI) configuration for scheduling PUSCH transmissions, as such indication may be essential for the UE, especially in case of dynamic or semi-persistent scheduling of PUSCH resources. In one implementation, it is implicitly assumed that when an OCC length is configured dynamically or through a higher layer configuration, the same code would be used for all scheduled time domain resources for both inter-slot and intra-slot OCC application. In one embodiment, the OCC length configuration is released only if the UE receives a new OCC configuration over a higher-layer configuration, DCI, or a combination thereof. In another embodiment, the OCC length configuration is released once the PUSCH transmission of the scheduled transport block is completed.

[0045] In one embodiment, the UE 104 indicates to the network entity/base station 102 about the UE's capabilities to support intra-slot or inter-slot OCC application for PUSCH transmission. The UE capability may be indicated by a specific field in IE *Phy-Parameters*, which is used to convey physical layer capabilities, during capability exchange messages through RRC signaling. According to one embodiment, the base station 102 may configure how an OCC sequence may need to be applied by the UE 104, e.g., inter-slot or intra-slot, only if the base station 102 knows that the UE 104 has the capability to apply an OCC.

[0046] According to a second embodiment, the UE is configured to apply intra-slot OCC along with OCC parameters, such as OCC length and index. The UE is further scheduled with a number of consecutive time domain symbols within a slot, either dynamically through DCI or through RRC signaling using *ConfiguredGrantConfig* IE. With this second embodiment, an implicit implication can be made that time domain resources for one transport block for uplink data (i.e., symbols where the OCC are to applied) are equivalent to the number of scheduled consecutive symbols within the slot minus the DMRS symbols, and the resulting difference is then divided by the OCC sequence length. As an example, if a UE is scheduled with six (6) time domain symbols for PUSCH data and the UE is further configured to apply a length 2 OCC, the number of time domain resources to calculate the transport block size would be 3 (excluding the DMRS), as the other 3 symbols would be used for repetition of the TB in order to apply the length 2 OCC code. However, in the provided

example, if DMRS are also included in TB size determination, then the TB size would be of 5 symbols.

[0047] In one embodiment, the UE is further configured with a parameter that indicates the pattern to used when applying the OCC within a slot. This parameter indicates how the repetition to apply the OCC code is carried out. For instance, different patterns to apply the OCC code could be realized, i.e., symbol by symbol (alternative), with a gap, or group based.

[0048] With the application of code-based orthogonality, the network entity/base station 102 is able to schedule multiple UEs 104 to transmit respective TBs using the same slot and time domain allocation. The base station 102 transmits and each UE 104 within the set of UEs sharing the slot receives a configuration, which assigns the same slot and applies OCC to the respective UE's PUSCH transmission of a TB of uplink data, e.g., with or without DMRS. The UEs then perform similar allocations of symbols and repeated symbols (for the purpose of applying OCC) to their respective TB, based on the pattern identified in the configuration.

[0049] **Figure 2** illustrates Intra-slot OCC application **200** with length 2 and symbol by symbol application of OCC sequence, in accordance with aspects of the present disclosure. In the embodiment illustrated by **Figure 2**, each UE utilizes 8 symbols within the assigned slot 205 for PUSCH transmission. Two symbols are assigned to DMRS, three symbols assigned as PUSCH data symbols, and three symbols assigned as PUSCH data repeat symbols.

[0050] As presented by **Figure 2**, first UE (UE1) is configured with PUSCH data symbols having OCC parameters of length 2, index 1, and mapping type 1. For the example shown by **Figure 2**, the UE is scheduled with 6 symbols, a length 2 code, and configured with the alternative application pattern (e.g., namely as mapping type 1). Note that mapping type 1 here defines the mapping pattern for OCC spreading where one symbols is repeated before mapping of the next symbol and OCC are applied on these interlaced symbols. When UE1 receives this configuration from the base station, UE1 retrieves/accesses a corresponding OCC look-up table 210 (or look-up table 210), with index 2 and OCC sequence of length 2. UE1 then schedules the TB data within the 6 assigned symbols according to the mapping type for the OCC sequence. As shown, the same applicability

pattern may be carried out for all of the scheduled symbols. The UE would first apply the complete sequence on the first two symbols by repeating the first symbol and carry out the same process for the rest of the symbols. Specifically, with mapping type 1, the OCC is always applied to alternative symbols, i.e., the first symbol would use the first code from the sequence of a configured index, then the symbol would be repeated, and the second code of the same sequence would be used to provide this repeated symbol. Additionally, with OCC look-up table 210, UE1 would apply the sequence for index 1, in row 1 of OCC look-up table 210, as indicated below the first slot 205 in **Figure 2**. UE1 utilizes the two OCCs from OCC look-up table 210 to apply code spreading to each TB data encoded within a respective PUSCH data symbol and PUSCH data repeat symbol. UE2 would apply the sequence for index 2, in row 2 of OCC look-up table 210, as indicated below the second slot 206 in **Figure 2**.

[0051] Second UE (UE2) is similarly configured with PUSCH data symbols having OCC parameters of length 2, index 1, and mapping type 2. Note that mapping type 2 here defines the mapping pattern for OCC spreading where all symbols without repetitions are first mapped and then repeated as a group and OCC code from the sequence is applied to each group. When UE2 receives this configuration from the base station, UE2 retrieves/accesses a similar OCC look-up table 210, with index 2 and OCC sequence of length 2. UE2 then schedules the TB data within the 6 assigned symbols according to the same mapping type for the OCC sequence.

[0052] Referring now to **Figure 3**, there is illustrated intra-slot OCC application with length 2 and grouping based application of the sequence, in accordance with aspects of the present disclosure. In one alternate embodiment, the symbols are grouped according to the length of configured code, i.e., the number of symbols in a group would be the total number of allocated PUSCH data symbols in a slot divided by the length of the configured OCC code. Then, the symbols are repeated according to the length of the code. The first code of the sequence would be applied to the first group of symbols, the second code of the sequence would be applied to the second group (repetition of first group), and so on, until all the codes in the sequence have been applied. With the example illustrated by **Figure 3**, each UE, UE1 and UE2, is configured with 6 symbols for PUSCH transmission with OCC parameters of

length 2, index 3, and mapping type 2 (a grouping pattern). Then, with this mapping type, one TB data would consist of three (3) time domain symbols, where the first code from the sequence would be first applied to these 3 symbols, and then the second code of the sequence would be applied to group of next 3 symbols (as a repetition of the first 3 symbols). Notably, both UEs retrieve/access the same OCC look-up table 210 as in the example of **Figure 2**, and thus, the different allocations of the TB data across the symbols in the assigned slot 305 is controlled by the mapping type parameter.

[0053] In one implementation, the DMRS for OCC multiplexed UEs are always scheduled by the network at the same number in the slot in order to avoid mismatch between OCC multiplexed symbols, as illustrated in **Figures 2** and **3**.

[0054] **Figure 4** provides an intra-slot OCC application 400 with two different mapping types for length 4 OCC sequence. In the illustrated example, the UE is scheduled with 8 consecutive symbols for PUSCH uplink data transmission, either through DCI or RRC signaling. Notably, the illustration omits the DMRS symbols, for simplicity in describing the embodiments. The UE may further be scheduled to apply length 4 OCC with index 1. In this case, the TB size would be two symbols that would be implicitly known to the UE, based on the received configuration, and these two symbols would be repeated three times to apply OCC. The UE may further be configured with a mapping type to correctly apply the repetition and the code. Referring to the figure, in the first example PUSCH allocation with 8 symbols, the UE receives OCC parameters of length 4, index 1 and mapping type 1. The UE retrieves/accesses a corresponding OCC look-up table 410 for index 4 and OCC length 4 to perform the coding of the TB data within slot 405. The UE then assigns the TB data to the two symbols in an alternating sequence with three repeated symbols after each allocation, according to mapping type 1. In the second example PUSCH allocation with 8 symbols, the UE receives OCC parameters of length 4, index 1 and mapping type 2. The UE retrieves/accesses the same corresponding OCC look-up table 410 for index 4 and OCC length 4 to perform the coding of the TB data within slot 415. The UE then assigns the TB data to the two symbols in a group sequence with three repeated symbols for each of the two symbols also in group sequence, according to mapping type 2. It is appreciated that with OCC look-up table 410, each of four different UEs can receive a configuration to share a slot

for PUSCH transmission, with each UE receiving an index parameter for a different one of the indices (1, 2, 3, or 4) within the received configuration.

[0055] With reference to **Figure 5**, there is illustrated an Intra-slot OCC application 500 with different length sequences, in accordance with additional aspects of the present disclosure. According to one aspect of the disclosure, in one embodiment, the UE may be configured with more than two sequences of different length that are to be applied in the same slot. The multi-length OCC configuration may be carried out through DCI, Medium Access Control Element (MAC-CE), or through RRC signaling. Implementation of this configuration scheme enables the base station to multiplex more UEs in the same slot and may also help in scheduling increased TB size for uplink data. In the example shown by Figure 5, the UE is scheduled with 10 symbols in slot 505 for uplink data transmission (excluding DMRS symbols). Specifically, the UE receives a configuration providing a PUSCH allocation with 10 symbols and OCC parameters of lengths 4 and 2, with index 1. The single index is applied to both lengths. If the UE was only scheduled with length 4 OCC, then the UE may only utilize 8 symbols with TB size of two symbols. However, with a length 2 code additionally scheduled, then the UE may use a TB size of 3 in 10 symbols and up to 5 UEs may also be multiplexed. With the example, the UE references both the OCC look-up table 210 with index 2 and the OCC look-up table 410 with index 4 to perform the corresponding OCC allocations of symbols and repeated symbols. Mapping type 1 is applied in the presented example.

[0056] In one embodiment, the order for applying the different lengths to the scheduled symbols would be the order of OCC length configuration, e.g., in sequential order. The UE may further be configured with parameters presenting the number of symbols to be used for each length table. Alternatively, in another embodiment, the UE implicitly calculates the number of symbols based on the configured lengths and also the order of length. For example, if a UE is configured with OCC length of 4 and 2, e.g., *OCClength* {4,2}, and indices 1 and 1, e.g., *OCCindices* {1,1}, then the UE would first select the sequence corresponding to index 1 from the OCC look-up table of length 4 and apply the sequence. Then, the UE would select the sequence corresponding to the index 1 from the OCC look-up table of OCC length 2 and apply that sequence.

[0057] In one embodiment, the OCC length is indicated implicitly for intra-slot application, where this implicit indication would directly correspond to the number of scheduled symbols in start and length indicator value (SLIV) parameter. For example, if a UE is scheduled with 4 symbols for uplink data transmission excluding the DMRS symbols, then the UE would choose length 4 table and select the sequence according to the configured index, where TB size would be one symbol and that one symbol is repeated four times consecutively.

[0058] In one embodiment, the uplink data is block-wise spread (i.e., repeated) after the application of discrete Fourier transform according to the length of OCC, when transform precoding is enabled and time domain OCC scheme, i.e., intra-slot or inter-slot, is applied.

[0059] In one embodiment, the PTRS are not code multiplexed and are excluded from the application of OCC, where the PTRS sequence would be generated for each scheduled symbol, including the repeated symbols. Alternatively, in another embodiment, the PTRS are part of symbols that are intra-slot code multiplexed. In this case, the PTRS are also repeated along with the PUSCH data according to the length of OCC code.

[0060] **Figure 6** illustrates an inter-slot OCC application 600 with length 2, in accordance with aspects of the present disclosure. According to one additional aspect of the disclosure, when a UE is configured to apply the inter-slot OCC, the UE may be explicitly or implicitly indicated about the OCC length to choose the accurate OCC look-up table. For example, the length of repetition of slots may always correspond to the length of the OCC sequence, thus implicitly indicating about the selection of the OCC look-up table. In the illustrated example, the OCC parameters include OCC sequence of length 2 and index 2, resulting in the UE accessing OCC look-up table 210 and applying OCC sequence across consecutive slots 605 and 606.

[0061] In one embodiment, when the UL transmission is configured with repetition having a value greater than 1 to increase the PUSCH coverage by dynamic scheduling e.g., by *pusch-AggregationFactor* within *PUSCH-Config* IE, the repetition length indicated by *pusch-AggregationFactor* field may be used by the UE to select the OCC look-up table, e.g., length 2, 4, or 8 table. The repetition value being greater than one (1) indicates that the same

transport block (TB) is repeated on multiple slots. The UE would additionally be configured with the index to select the sequence from the OCC look-up table 210. For example, if the repetition is indicated by 2, the UE1 would choose the length 2 OCC look-up table 210 and apply the sequence for index 1, as indicated in **Figure 6**. UE2 would also choose the length 2 table, but apply the sequence for index 2, as also indicated in **Figure 6**.

[0062] In one embodiment, a fixed redundancy version (RV) is always used for OCC with inter-slot application, whereas the repetitions are scheduled with variable RVs. For example, if a UE is scheduled by DCI for PUSCH repetition, e.g., by *pusch-AggregationFactor* field, the RV of PUSCH would change according to the pattern [0, 2,3,1]. If a UE is additionally configured with OCC, the UE would implicitly apply the repetition to the length of OCC for each value of the RV. Basically, the RV would be fixed for each OCC application and the total number of repetitions would be repetition configured by the repetition parameter multiplied with the OCC length. **Figure 7** illustrates a length 2 OCC application 700 with fixed RV, in accordance with aspects of the present disclosure.

[0063] In one implementation, a fixed RV is always used for all type of PUSCH data when OCC are enabled. Basically, in case of PUSCH repetitions scheduled by DCI or RRC signaling and with OCC, the UE would implicitly use only the indicated RV value, e.g., RV 0, for all of the repetitions that are used for OCC spreading across slots. In another implementation, the UE is scheduled by DCI or by RRC with a fixed RV pattern for PUSCH repetitions when OCC are enabled.

[0064] In one embodiment, when the UL transmission is configured with repetition value greater than 1 to increase the PUSCH coverage by configured grant scheduling e.g., by *repK* within *ConfiguredGrantConfig* IE, the repetition length indicated by *repK* field may be used by the UE to select the OCC look-up table, e.g., length 2, 4, or 8 OCC look-up table.

[0065] In one embodiment, the UE is expected to apply the inter-slot OCC of at least one transmission occasion of the two or more inter-slot transmission occasions only if the two or more inter-slot transmission occasions fall within the cell Discontinuous Reception (DRX) active time, if cell DRX is activated. In other words, the inter-slot OCC transmission is not supported if at least one of the slots overlaps within non-active time of cell DRX. The reason

for this DRX handling approach is that the orthogonality of the cover code is broken if at least one transmission occasion is aborted.

[0066] Additionally, the UE is expected to apply the inter-slot OCC if all transmission occasions of the two or more inter-slot transmission occasions fall within a same period of a cell DRX active time, if cell DRX is activated. In other words, the inter-slot OCC transmission is not supported if the UE encounters a cell DRX inactive time between any two transmission occasions. The reason for this DRX handling approach is that the orthogonality of the cover code may be broken due to phase rotation variation, if the UE turns off its RF components between the two transmission occasions.

[0067] **Figure 8** illustrates an example of a UE 800 in accordance with aspects of the present disclosure. The UE 800 may include a processor 802, a memory 804, a controller 806, and a transceiver 808 within baseband chipset 820. The processor 802, the memory 804, the controller 806, or the transceiver 808, 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.

[0068] The processor 802, the memory 804, the controller 806, or the transceiver 808, 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.

[0069] The processor 802 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 802 may be configured to operate the memory 804. In some other implementations, the memory 804 may be integrated into the processor 802. The processor 802 may be configured to execute computer-readable instructions stored in the memory 804 to cause the UE 800 to perform various functions of the present disclosure.

[0070] The memory 804 may include volatile or non-volatile memory. The memory 804 may store computer-readable, computer-executable code including instructions when executed by the processor 802 cause the UE 800 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 804 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.

[0071] In some implementations, the processor 802 and the memory 804 coupled with the processor 802 may be configured to cause the UE 800 to perform one or more of the functions described herein (e.g., executing, by the processor 802, instructions stored in the memory 804). For example, the processor 802 may support wireless communication at the UE 800 in accordance with examples as disclosed herein. The UE 800 may be configured to support a means for applying OCC to a PUSCH transmission.

[0072] In one embodiment, a UE for wireless communication 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, from a base station, a configuration that comprises a set of one or more parameters associated with mapping at least one OCC sequence to a set of one or more symbols. The at least one processor is further configured to cause the UE to apply the at least one OCC sequence to a PUSCH transmission based on the received configuration and perform the PUSCH transmission with the applied at least one OCC sequence.

[0073] In one or more embodiments, the configuration includes an indication that enables the UE to apply the at least one OCC sequence to the PUSCH transmission. In one or more embodiments, the set of one or more symbols is spread across at least one slot and the at least one processor is further configured to cause the UE to: receive a RRC message that indicates the configuration; and receive downlink control information that schedules the PUSCH transmission and includes an indication of a type of OCC application, from among intra-slot, inter-slot, and across symbol, to apply to the PUSCH transmission.

[0074] In one or more embodiments, the set of one or more symbols is spread across at least one slot and at least one parameter of the set of one or more parameters enables the UE to apply the OCC in accordance with an intra-slot. The at least one processor is further configured to cause the UE to apply the at least one OCC sequence to symbols within a slot.

[0075] In one or more embodiments, the set of one or more parameters indicates an OCC length and an index that maps to at least one OCC sequence. The at least one processor is configured to cause the UE to access, based on the parameters, an OCC look-up table (or look-up table) corresponding to the OCC length and the index that maps to the at least one OCC sequence. The at least one processor is further configured to cause the UE to determine a distribution of a transport block of uplink data utilizing a number of consecutive time domain symbols within an allocated slot, where time domain resources in the transport block that are to be used for applying the OCC sequence are determined as the number of consecutive time domain symbols within the allocated slot minus assigned DMRS symbols, with a resulting difference divided by the OCC length.

[0076] In one or more embodiments, the at least one processor is configured to cause the UE to: assign, for transmission of the transport block, a first subset of time domain resources among the number of consecutive time domain symbols; and assign, for transmission of repetition of the transport block, a remaining subset of time domain resources within the number of consecutive time domain symbols.

[0077] In one or more embodiments, the set of one or more parameters comprises a mapping pattern to apply the at least one OCC sequence within the allocated slot and the at least one processor is configured to cause the UE to apply the mapping pattern while allocating a transport block and repetitions thereof to the symbols within the allocated slot.

[0078] In one or more embodiments, the at least one processor is configured to cause the UE to group the symbols according to the OCC length and repeat the symbols according to the OCC length.

[0079] According to one aspect, to receive the configuration, the at least one processor is configured to cause the UE to receive a multi-length OCC configuration indicating a

plurality of OCC sequences of different length to be applied within the allocated slot. The at least one processor is further configured to cause the UE to assign a PUSCH symbol with at least one PUSCH data repeated symbol, utilizing the number of symbols according to the multi-length OCC configuration, enabling an increased transport block size for uplink data.

[0080] In one or more embodiments, at least one parameter of the set of one or more parameters enables the UE to apply the OCC in accordance with an inter-slot, and the at least one processor is further configured to cause the UE to apply the at least one OCC sequence utilizing symbols across multiple slots.

[0081] In one or more embodiments, before receiving the configuration, the at least one processor is configured to cause the UE to indicate, to the base station, UE capability information to support intra-slot or inter-slot OCC application for PUSCH transmission.

[0082] Returning to the description of **Figure 8**, the controller 806 may manage input and output signals for the UE 800. The controller 806 may also manage peripherals not integrated into the UE 800. In some implementations, the controller 806 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 806 may be implemented as part of the processor 802.

[0083] In some implementations, the UE 800 may include at least one transceiver 808. In some other implementations, the UE 800 may have more than one transceiver 808. The transceiver 808 may represent a wireless transceiver. The transceiver 808 may include one or more receiver chains 810, one or more transmitter chains 812, or a combination thereof. The transceiver 808 may also include main radio 814 and low power wake-up radio 816.

[0084] A receiver chain 810 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 810 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 810 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 810 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 810 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0085] A transmitter chain 812 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 812 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 812 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 812 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0086] **Figure 9** illustrates an example of a processor 900 in accordance with aspects of the present disclosure. The processor 900 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 900 may include a controller 902 configured to perform various operations in accordance with examples as described herein. The processor 900 may optionally include at least one memory 904, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 900 may optionally include one or more arithmetic-logic units (ALUs) 906. 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).

[0087] The processor 900 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 900) 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).

[0088] The controller 902 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 900 to cause the processor 900 to support various operations in accordance with examples as described herein. For example, the controller 902 may operate as a control unit of the processor 900, generating control signals that manage the operation of various components of the processor 900. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0089] The controller 902 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 904 and determine subsequent instruction(s) to be executed to cause the processor 900 to support various operations in accordance with examples as described herein. The controller 902 may be configured to track memory address of instructions associated with the memory 904. The controller 902 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 902 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 900 to cause the processor 900 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 902 may be configured to manage flow of data within the processor 900. The controller 902 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 900.

[0090] The memory 904 may include one or more caches (e.g., memory local to or included in the processor 900 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 904 may reside within or on a processor chipset (e.g., local to the processor 900). In some other implementations, the memory 904 may reside external to the processor chipset (e.g., remote to the processor 900).

[0091] The memory 904 may store computer-readable, computer-executable code including instructions that, when executed by the processor 900, cause the processor 900 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 902 and/or the processor 900 may be configured to execute computer-readable instructions stored in the memory 904 to cause the processor 900 to perform various functions. For example, the processor 900 and/or the controller 902 may be coupled with or to the memory 904, the processor 900, the controller 902, and the memory 904 may be configured to perform various functions described herein. In some examples, the processor 900 may include multiple processors and the memory 904 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.

[0092] The one or more ALUs 906 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 906 may reside within or on a processor chipset (e.g., the processor 900). In some other implementations, the one or more ALUs 906 may reside external to the processor chipset (e.g., the processor 900). One or more ALUs 906 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 906 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 906 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 906 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 906 to handle conditional operations, comparisons, and bitwise operations.

[0093] The processor 900 may support wireless communication in accordance with examples as disclosed herein. The processor 900 may be configured to or operable to support a means for enabling a UE to provide OCC applications for PUSCH transmissions. In one or more embodiments, the processor includes at least one controller coupled with at least one memory and configured to cause the processor to: receive, from a base station, a configuration that comprises a set of one or more parameters associated with mapping at least

one OCC sequence to a set of one or more symbols. The at least one controller is further configured to cause the processor to: apply the at least one OCC sequence to a PUSCH transmission based on the received configuration; and perform the PUSCH transmission with the applied at least one OCC sequence. In one or more embodiment, the at least one controller is further configured to cause the processor to perform the various processes described herein as being performed by the UE.

[0094] **Figure 10** illustrates an example of a NE (or base station) 1000 in accordance with aspects of the present disclosure. The NE 1000 may include a processor 1002, a memory 1004, a controller 1006, and a transceiver 1008. The processor 1002, the memory 1004, the controller 1006, or the transceiver 1008, 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 1002, the memory 1004, the controller 1006, or the transceiver 1008, 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 1002 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 1002 may be configured to operate the memory 1004. In some other implementations, the memory 1004 may be integrated into the processor 1002. The processor 1002 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the NE 1000 to perform various functions of the present disclosure.

[0097] The memory 1004 may include volatile or non-volatile memory. The memory 1004 may store computer-readable, computer-executable code including instructions when executed by the processor 1002 cause the NE 1000 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 1004 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 1002 and the memory 1004 coupled with the processor 1002 may be configured to cause the NE 1000 to perform one or more of the functions described herein (e.g., executing, by the processor 1002, instructions stored in the memory 1004). For example, the processor 1002 may support wireless communication at the NE 1000 in accordance with examples as disclosed herein. The NE 1000 may be configured to support a means for configuring a UE to provide OCC application to PUSCH transmissions.

[0099] In one embodiment, the NE 1000 can be a base station that includes at least one memory and at least one processor coupled with the at least one memory and configured to cause the base station to: transmit, to at least one UE, a configuration that comprises a set of one or more parameters associated with mapping at least one OCC sequence to a set of one or more symbols. The configuration triggers the at least one UE to: apply at least one OCC sequence to a PUSCH within at least one slot based on the received configuration; and perform a corresponding PUSCH transmission with the applied at least one OCC sequence.

[0100] In one or more embodiments, the at least one processor is further configured to cause the base station to: incorporate within the configuration an indication for enabling application of time domain orthogonal cover codes for the PUSCH transmission.

[0101] In one or more embodiments, the at least one processor is further configured to cause the base station to: receive, from the UE, prior to transmitting the configuration, an indication comprising UE capability information to support intra-slot or inter-slot OCC application for PUSCH transmission; and generate the configuration based on receipt of the indication of UE capability information.

[0102] In one or more embodiments, the at least one processor is further configured to cause the base station to: transmit a RRC message that indicates the configuration; and transmit downlink control information that schedules the PUSCH transmission and that comprises an

indication of a type of OCC from among intra-slot, inter-slot, and across symbol, to the at least one UE to apply to the PUSCH transmission.

[0103] In one or more embodiments, the at least one processor is further configured to cause the base station to configure, within the configuration parameters, an indication of a mapping pattern to apply the OCC within an allocated slot. In one or more embodiment, the processor is further configured to cause the base station to provide, within the configuration parameters, an indication of a multi-length OCC configuration comprising a plurality of OCC sequences of different length to be applied within the allocated slot.

[0104] Returning to the description of the **Figure 10**, the controller 1006 may manage input and output signals for the NE 1000. The controller 1006 may also manage peripherals not integrated into the NE 1000. In some implementations, the controller 1006 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1006 may be implemented as part of the processor 1002.

[0105] In some implementations, the NE 1000 may include at least one transceiver 1008. In some other implementations, the NE 1000 may have more than one transceiver 1008. The transceiver 1008 may represent a wireless transceiver. The transceiver 1008 may include one or more receiver chains 1010, one or more transmitter chains 1012, or a combination thereof.

[0106] A receiver chain 1010 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1010 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 1010 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1010 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 1010 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0107] A transmitter chain 1012 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1012 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 1012 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 1012 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0108] **Figure 11** 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.

[0109] At 1105, the method may include receiving, from a base station, a configuration that comprises a set of one or more parameters associated with mapping at least one OCC sequence to a set of one or more symbols. The operations of 1105 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1105 may be performed by a UE as described with reference to Figure 8.

[0110] At 1110, the method may include applying the at least one OCC sequence to a PUSCH transmission based on the received configuration. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a UE as described with reference to Figure 8.

[0111] At 1115, the method may include performing the PUSCH transmission with the applied at least one OCC sequence. The operations of 1115 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1115 may be performed by a UE as described with reference to Figure 8.

[0112] In one or more embodiments the configuration includes an indication that enables the UE to apply the at least one OCC sequence to the PUSCH transmission. In one or more embodiments, the set of one or more symbols is spread across at least one slot. The method

may further include: receiving a RRC message that indicates the configuration; and receiving downlink control information that schedules the PUSCH transmission and includes an indication of a type of OCC, from among intra-slot, inter-slot, and across symbol to apply to the PUSCH transmission.

[0113] In one or more embodiments, the set of one or more parameters indicates an OCC length and an index that maps to the at least one OCC sequence. The method may further include: receiving, from among the set of one or more parameters within the configuration, an indication for applying intra-slot OCC. The method may further include applying the at least one OCC sequence to symbols within a slot by: accessing, based on the parameters, an OCC look-up table corresponding to the OCC length and the index that maps to the at least one OCC sequence; and determining a distribution of a transport block of uplink data utilizing a number of consecutive time domain symbols within an allocated slot, wherein time domain resources in the transport block that are to be used for applying the OCC sequence are determined as the number of consecutive time domain symbols within the allocated slot minus assigned DMRS symbols, with a resulting difference divided by the OCC length.

[0114] In one or more embodiments, the method may further include assigning, for transmission of the transport block, a first subset of time domain resources among the number of consecutive time domain symbols. The method may further include assigning, for transmission of repetition of the transport block, a remaining subset of time domain resources within the number of consecutive time domain symbols.

[0115] In one or more embodiments, the method may further include: receiving a multi-length OCC configuration comprising a plurality of OCC sequences of different length to be applied within the allocated slot; and assigning the transport block with repeated transport blocks utilizing the number of symbols, according to the multi-length OCC configuration.

[0116] In one or more embodiments, the method may further include, before receiving the configuration, indicating, to the base station, UE capability information to support intra-slot or inter-slot OCC application for PUSCH transmission.

[0117] It should be noted that the method described herein describes one possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0118] **Figure 12** illustrates a flowchart of a method for wireless communication by a base station, in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE, such as a base station, as described herein. In some implementations, the processor of the base station may execute a set of instructions to control the function elements of the base station to perform the described functions.

[0119] At 1205, the method may include receiving, from a UE, an indication comprising UE capability information to support intra-slot or inter-slot OCC application for PUSCH transmission. The operations of 1205 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1205 may be performed by a NE as described with reference to Figure 10.

[0120] At 1210, the method may include generating, based on the received indication, a configuration comprising parameters associated with mapping, at the UE, at least one OCC sequence to a set of one or more symbols for PUSCH transmission. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a NE as described with reference to Figure 10.

[0121] At 1215, the method may include transmitting the configuration to the UE. The operations of 1215 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1215 may be performed by a NE as described with reference to Figure 10.

[0122] In one or more embodiments, the transmitting may further include: transmitting a RRC message that indicates the configuration; and transmitting downlink control information (DCI) that schedules the PUSCH transmission and includes an indication of the type of OCC, from among intra-slot, inter-slot, and across symbol, to apply to the PUSCH transmission.

[0123] It should be noted that the method described herein describes one possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0124] 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.