

METHOD AND APPARATUS OF UPLINK TRANSMISSIONS

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to technologies of supporting uplink transmissions, e.g., methods and apparatuses of uplink transmissions.

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 uplink transmission configuration; and transmit an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0005] In some implementations of the methods and apparatuses described herein, the multiplexing sequence is based on an orthogonal cover code (OCC) sequence or a cyclic shift value.

[0006] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine a sequence index of the OCC sequence for the multiplexing sequence based on high layer parameters in the uplink transmission configuration or UE identity (ID) related information or a predefined rule.

[0007] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine the cyclic shift value based on high layer parameters in the uplink transmission configuration or UE ID related information or a predefined rule.

[0008] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine a base sequence associated with the reference signal based on cell ID related information.

[0009] In some implementations of the methods and apparatuses described herein, a length of the multiplexing sequence or a maximum multiplexing sequence number of the multiplexing sequence is configured by high layer parameters in the uplink transmission configuration, or is determined based on a format of the uplink transmission, or is a constant.

[0010] In some implementations of the methods and apparatuses described herein, the time duration is configured by higher layer parameters in the uplink transmission configuration, or is determined by a resource unit (RU) length, a RU number, a slot number of the uplink transmission, a scheduled uplink subcarrier number, a repetition number of the uplink transmission, a format of the uplink transmission, continuous slots for identical uplink transmissions, or any combination thereof.

[0011] In some implementations of the methods and apparatuses described herein, the time duration is one or more slots, or one or more valid slots excluding reserved slots, or one or more reference signal samples, or one or more reference symbols, or one or more preamble symbol groups, or one or more preamble duration.

[0012] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine an element of the multiplexing sequence adopted to the uplink transmission or the reference signal based on a time offset.

[0013] In some implementations of the methods and apparatuses described herein, the time offset is a time offset relative to a reference slot, or is a time offset relative to a reference slot counting valid uplink slots and excluding reserved subframes or reserved slots.

[0014] In some implementations of the methods and apparatuses described herein, the reserved subframes or the reserved slots are determined based on a resource reserved slot pattern.

[0015] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine an absolute valid uplink subframe or slot based on the time offset; and determine an element of the multiplexing sequence adopted to the uplink transmission or the reference signal based on the absolute valid uplink subframe or slot.

[0016] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which includes: at least one controller coupled with at least one memory and configured to cause the at least one processor to: receive uplink transmission configuration; and transmit an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0017] Some implementations of the methods and apparatuses described herein may further include a network equipment (NE) 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 NE to: transmit uplink transmission configuration; and receive an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0018] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which includes: receiving uplink transmission configuration; and transmitting an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0020] Figure 2 illustrates an example of a reference signal sequence in the case of signal tone under Scheme 1 in accordance with aspects of the present disclosure.

[0021] Figure 3 illustrates another example of a reference signal sequence in the case of single tone under Scheme 1 in accordance with aspects of the present disclosure.

[0022] Figure 4 illustrates an example of a reference signal sequence in the case of multi-tone under Scheme 1 in accordance with aspects of the present disclosure.

[0023] Figure 5 illustrates an example of an uplink transmission in the case of multi-tone under Scheme 2 in accordance with aspects of the present disclosure.

[0024] Figure 6 illustrates an example of NPRACH under Scheme 2 in accordance with aspects of the present disclosure.

[0025] Figure 7 illustrates an example of multiplexing of multiple UEs under Scheme 3 in accordance with aspects of the present disclosure.

[0026] Figure 8 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0027] Figure 9 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0028] Figure 10 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0029] Figure 11 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0030] Figure 12 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0031] Primarily for mobile originated (MO) data transmissions and removing dependency on downlink (DL) signaling, the industry desires enhancements, such as those to enable multiplexing of multiple UEs in a single subcarrier, e.g., 3.75 kHz subcarrier for uplink transmission.

[0032] At least considering these enhancements, aspects of the present disclosure propose a technical solution of uplink transmissions, which supports multiplexing multiple UEs in the same physical resource for uplink transmission with an OCC or cyclic shift sequence.

[0033] For example, in some implementations of the present disclosure, uplink transmissions (or uplink transmission signals) and/or reference signal(s) for the uplink transmissions (if any) will be transmitted from the UE and received in the network side based on a multiplexing sequence. Each element of the multiplexing sequence adopted to the uplink transmissions or the reference signals will last for a time duration.

[0034] Given the above, the present disclosure mainly solves the technical problems of multiplexing multiple UEs in the same physical resource for uplink transmission, and thus will enhance uplink capacities and reduce dependencies on downlink signaling.

[0035] Aspects of the present disclosure are described in the context of a wireless communications system.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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).

[0042] 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.

[0043] 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).

[0044] 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.

[0045] 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., $\mu=0$) 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., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) 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., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0046] 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.

[0047] 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., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) 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., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0048] 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.

[0049] 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., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), 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., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0050] The network side, e.g., from a gNB will transmit uplink transmission configuration to UE, e.g., by radio resource control (RRC) signaling or the like, so that UE will transmit uplink transmissions and reference signals thereof (if any) based on the uplink transmission configuration. Consistently, the network side will receive the uplink transmissions and reference signals (if any) based on the uplink transmission configuration. Exemplary uplink transmissions are PUSCH transmissions (or referred to as PUSCHs or the like), PUCCH transmissions (or referred to as PUCCHs or the like), and random access channels (RACHs) (or physical random access channels (PRACHs)), e.g., preambles of RACHs/PRACHs. Exemplary reference signals are demodulation reference signals (DMRSs), e.g., DMRSs for PUSCHs and PUCCHs. Taking IoT NTN especially for narrowband (NB) IoT (NB-IoT) as an example, an uplink transmission may be a NB PUSCH (NPUSCH) or a NB PRACH (NPRACH), e.g., the preamble of NPRACH. A reference signal of an uplink transmission in IoT NTN may be a NPUSCH DMRS, which is a special type of physical layer signal which functions as a reference signal for decoding NPUSCH.

[0051] In accordance with aspects of the present disclosure, uplink transmissions and/or the corresponding reference signals thereof (if any) from different UEs will be multiplexed at the same physical resource for uplink transmission, e.g., the same time-frequency resource in scheduled uplink resources or preconfigured uplink resources (PURs), wherein a

multiplexing sequence, e.g., based on an OCC sequence or a cyclic shift value, will be applied for the uplink transmissions and/or the corresponding reference signals thereof (if any) to differentiate UEs. Regarding a PUR, it may be a dedicated PUR where uplink time-frequency resources can be used exclusively by one UE at a time, or a shared PUR where the same uplink time-frequency resources can be used simultaneously by one or more UEs, e.g., up to two UEs. For example, UE will transmit an uplink transmission, or a reference signal for the uplink transmission, or both the uplink transmission and the reference signal in accordance with a multiplexing sequence in addition to the uplink transmission configuration; and accordingly, the network side will receive the uplink transmission, or the reference signal for the uplink transmission, or both the uplink transmission and the reference signal in accordance with the multiplexing sequence in addition to the uplink transmission configuration. That is, the multiplexing sequence will be adopted for only the reference signal (Scheme 1), or only for the uplink transmission (Scheme 2), or for both the reference signal and the uplink transmission (Scheme 3).

[0052] Each element of the multiplexing sequence adopted to the uplink transmission or the reference signal will last for a time duration. That is, the multiplexing sequence is also based on the time duration. In some implementations of the present disclosure, the time duration is configured by higher layer parameters in the uplink transmission configuration. In some other implementations of the present disclosure, the time duration is determined by a RU length, a RU number, a slot number of the uplink transmission, a scheduled uplink subcarrier number, a repetition number of the uplink transmission, a format of the uplink transmission, continuous slots for identical uplink transmissions, or any combination thereof (e.g., a combination of the RU length, the repetition number of the uplink transmission, and a format of the uplink transmission).

[0053] For example, an exemplary time duration, e.g., V can be determined by: $V = \min(16, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$, $V = \min(16, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$, $V = \max(1, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$, or $V = \min(1, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$, or $V = 2M_{\text{identical}}$ or $V = 1$ or 2 etc. M_{rep} is the repetition number of the uplink transmission. $N_{\text{slots}}^{\text{UL}}$ is the number of uplink slots. For example, $N_{\text{slots}}^{\text{UL}}$ is 16 for NPUSCH format 1 (for uplink data not for feedback information) and 4 for NPUSCH format 2 (for uplink data for feedback information). N_{RU} is the number of RUs. For example, N_{RU} is

configured by higher layer signaling, e.g., by high layer parameters in the uplink transmission configuration, as $\{1, 2, 3, 4, 5, 6, 8\}$. S is the length of the multiplexing sequence or the maximal multiplexing sequence number of the multiplexing sequence (or the maximal multiplexing sequence number, or the total number of the orthogonal sequence or cyclic shift sequence or the like), which can be determined in various manners as illustrated as the following. $M_{\text{identical}}$ is continuous slots for identical uplink transmissions, e.g., for NPUSCH transmission with the identical signal, which is a kind of uplink resource mapping scheme for NB-IoT with large repetition transmission and is designed for facilitating uplink signal symbol level combining. For example, in the case of single tone, $M_{\text{identical}}$ is 1; and in the case of multiple tones, $M_{\text{identical}}$ is $\min(|M_{\text{rep}}/2|, 4)$.

[0054] In accordance with aspects of the present disclosure, the time duration can be described in various manners. For example, an exemplary time duration may be one or more slots, or one or more valid slots excluding reserved slots, or one or more reference signal samples, or one or more reference symbols, or one or more preamble symbol groups, or one or more preamble duration etc. Regarding a reserved subframe, it may be fully reserved or be partially reserved. For example, for a subframe, which includes multiple slots, e.g., two slots, in the case that one slot of the subframe is reserved, the subframe will be regarded as a reserved subframe. In some cases, reserved slots may also be referred to as invalid slots, e.g., invalid slots indicated by higher layer signaling. Similarly, reserved subframes may also be referred to as invalid subframes.

[0055] The length of the multiplexing sequence or the maximal multiplexing sequence number of the multiplexing sequence can be determined in various manners. For example, the length of the multiplexing sequence or the maximal multiplexing sequence number may be configured by higher layer parameters in the uplink transmission configuration, e.g., 2, 4, or 8; or may be predefined to be a constant, e.g., 4; or may be determined by the format of the uplink transmission. For example, in the case of NPUSCH with format 1, the length of the multiplexing sequence or the maximal multiplexing sequence number is 4, and in the case of NPUSCH with format 2, the length of the multiplexing sequence or the maximal multiplexing sequence number is 2.

[0056] In some implementations of the present disclosure, the multiplexing sequence is based on an OCC sequence, e.g., a Hadamard sequence or a Walsh sequence or other orthogonal sequence. A sequence index of the OCC sequence for the multiplexing sequence may be configured by high layer parameters in the uplink transmission configuration, or may be determined based on UE ID related information, e.g., UEID, or cell-radio network temporary identifier (C-RNTI) etc., or may be determined by a predefined rule. For example, the sequence index for a multiplexing sequence may be generated or determined as C-RNTI mod the maximal multiplexing sequence number. For another example, the sequence index for a multiplexing sequence may be generated or determined by a predefined association or mapping manner, e.g., a predefined association or mapping between DMRS and corresponding RACH resource and PUSCH etc.

[0057] In some other implementations of the present disclosure, the multiplexing sequence is based on a cyclic shift value. Similarly, the cyclic shift value may be configured by high layer parameters in the uplink transmission configuration, or may be determined by a predefined rule or based on UE ID related information, e.g., UEID or C-RNTI etc. For example, a multiplexing sequence may be generated or determined as $e^{j\alpha n}$, wherein the cyclic shift value $\alpha = 0, \frac{2\pi}{S}, \frac{4\pi}{S} \dots$, where α is configured, or is determined by UEID mod the length of the multiplexing sequence or by a predefined rule.

[0058] More details of the present disclosure will be illustrated in the following respectively in view of Scheme 1, Scheme 2 and Scheme 3. Persons skilled in the art should well know that although the implementations are illustrated in view of NPUSCH and NPRACH, the present disclosure can also be applied to other uplink transmissions and reference signals and thus should not be unduly limited by the illustrated implementations.

Scheme 1

[0059] In accordance with aspects of the present disclosure, under Scheme 1, a reference signal (e.g., DMRS) for an uplink transmission is a sequence for an uplink transmission generated from a multiplexing sequence in addition to a base sequence. An exemplary base sequence is determined by cell ID related information. Accordingly, the reference signal may also be referred to as a reference signal sequence under Scheme 1.

[0060] For example, in some implementations of the present disclosure, the reference signal sequence for single subcarrier (or single tone, or the number of subcarriers $N_{sc}^{RU}=1$), e.g., $\bar{r}_u(n)$ for uplink transmission, e.g., NPUSCH is defined as $\bar{r}_u(n) = \frac{1}{\sqrt{2}}(1+j)(1 - 2c(n))w(n \bmod 16)v(\frac{n}{V} \bmod S)$, $0 \leq n < M_{rep}N_{slots}^{UL}N_{RU}$. Regarding $\frac{1}{\sqrt{2}}(1+j)(1 - 2c(n))w(n \bmod 16)$, it represents the base sequence of the sequence signal, and is similar to the reference signal sequence $\bar{r}_u(n)$ for $N_{sc}^{RU}=1$ defined in 10.1.4.1.1 of TS 36.213, wherein, $c(n)$ is a binary sequence, e.g., defined by clause 7.2 of TS 36.213, and $w(n)$ is an orthogonal sequence related to cell ID, e.g., given by Table 10.1.4.1.1-1 in TS 36.213. No details will be repeated. $v(n)$ is the multiplexing sequence, e.g., an orthogonal sequence (based on an OCC sequence) or cyclic shift sequence (based on a cyclic shift value), and is associated with UE information (e.g., UEID, C-RNTI, or UE-specific RRC configured information etc.).

[0061] Table 1 is an exemplary Hadamard sequence for generation of a multiplexing sequence, which is based on a 4*4 matrix. It is supposed $a=C-RNTI \bmod 4$, wherein "a" is the sequence index for generating the multiplexing sequence. $v(0)$, $v(1)$, $v(2)$ and $v(3)$ are elements of the multiplexing sequence $v(n)$, wherein $v(0)$ is the first element of the multiplexing sequence $v(n)$.

Table 1

$Va(0)$	$v(0)$	$v(1)$	$v(2)$	$v(3)$
a=0	1	1	1	1
a=1	1	-1	1	-1
a=2	1	1	-1	-1
a=3	1	-1	-1	1

[0062] Each element of the multiplexing sequence lasts for a time duration. As stated above, the time duration can be determined in various manners, which may be one or more slots, one or more valid slots (excluding the slots reserved for other purpose) or one or more reference signal samples etc. For example, for scheduled uplink subcarrier number of 1 and

NPUSCH, the time duration of an element of the multiplexing sequence adopted to the reference signal sequence is $V = \min(16, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$.

[0063] Figure 2 illustrates an example of a reference signal sequence in the case of signal tone under Scheme 1 in accordance with aspects of the present disclosure.

[0064] Referring to Figure 2, it is supposed that the format of the uplink transmission is NPUSCH format 1 and the associated reference signal is for uplink shared data transmission, i.e., $N_{\text{slots}}^{\text{UL}}$ is 16, the repetition number of the NPUSCH is 2, i.e., $M_{\text{rep}}=2$, and N_{RU} is configured to be 4. Elements of the multiplexing sequence are respectively corresponding to $v(0)$, $v(1)$, $v(2)$ and $v(3)$. Then, the time duration of each element of the multiplexing sequence adopted to the reference signal sequence lasts for $\min(16, 2*16*4/4=16)$ for single tone case, which is 16 slots, i.e., one RU.

[0065] Figure 3 illustrates another example of a reference signal sequence in the case of single tone under Scheme 1 in accordance with aspects of the present disclosure.

[0066] Referring to Figure 3, it is supposed that the format of the uplink transmission is NPUSCH format 1 and the associated reference signal is for uplink shared data transmission, i.e., $N_{\text{slots}}^{\text{UL}}$ is 16, the repetition number of the NPUSCH is 1 (or regarded as no repetition), i.e., $M_{\text{rep}}=1$, N_{RU} is configured to be 2. Elements of the multiplexing sequence are respectively corresponding to $v(0)$, $v(1)$, $v(2)$ and $v(3)$. Then, each element of the multiplexing sequence, e.g., $v(0)$ adopted to the reference signal sequence lasts for $\min(16, 2*16*1/4)=8$ slots for single tone case.

[0067] In some other implementations of the present disclosure, the reference signal sequence for multiple subcarriers (or multiple tones, or, the number of subcarriers $N_{\text{sc}}^{\text{RU}} > 1$), e.g., $r_u(n, n_s)$ for uplink transmission, e.g., NPUSCH is defined as $r_u(n, n_s) = e^{jan} e^{j\frac{\phi(n)\pi}{4}} v\left(\left(\frac{n_s}{V}\right) \bmod S\right)$, $0 \leq n < N_{\text{sc}}^{\text{RU}}$. Similarly, $e^{jan} e^{j\frac{\phi(n)\pi}{4}}$ represents the base sequence of the reference signal, which is similar to the reference signal sequences $r_u(n)$ for $N_{\text{sc}}^{\text{RU}} > 1$ defined in clause 10.1.4.1.2 of TS 36. 213, and thus will not be repeated. n is subcarrier index in the frequency domain. n_s is slot index. $v(n)$ is the multiplexing sequence, e.g., an orthogonal sequence or cyclic shift sequence, which is associated with UE

information (e.g., UEID, C-RNTI, or UE-specific RRC configured). Each element of the multiplexing sequence lasts for a time duration, which may be one or more slots, one or more valid slots (excluding the reserved slots), or one or more reference signal samples etc. For example, the time duration of an element of the multiplexing sequence adopted to the reference signal sequence is $V = \max(1, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$, or $V = \min(1, M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}/S)$ or $V = 2M_{\text{identical}}$ etc.

[0068] Figure 4 illustrates an example of a reference signal sequence in the case of multi-tone under Scheme 1 in accordance with aspects of the present disclosure.

[0069] Referring to Figure 4, it is supposed that the format of the uplink transmission is NPUSCH format 1 and the associated reference signal is for uplink shared data transmission, i.e., $N_{\text{slots}}^{\text{UL}} = 16$, the number of subcarriers, $N_{\text{sc}}^{\text{RU}} = 6$, the repetition number of the NPUSCH, M_{rep} is 1, and N_{RU} is 2. Elements of the multiplexing sequence are respectively corresponding to $v(0)$, $v(1)$, $v(2)$ and $v(3)$. The time duration of each element, e.g., $v(0)$ of the multiplexing sequence adopted to the reference signal sequence lasts for $\max(1, 1 \cdot 4 \cdot 2/4) = 2$ slots ($2 \cdot 0.5\text{ms}$) for multi-tone case.

Scheme 2

[0070] In accordance with aspects of the present disclosure, under Scheme 2, the uplink transmission is processed (or pre-processed) by a multiplexing sequence, e.g., an orthogonal (e.g., OCC) or cyclic shift sequence, which can be designed similar to that for the reference signal.

[0071] For example, in some implementations of the present disclosure, an uplink transmission (or uplink signal) in slot n , e.g., $s(n)$ for single subcarrier is processed by an orthogonal or cyclic shift sequence (n) , and then the processed uplink transmission in slot n is expressed as: $\bar{s}(n, \text{sym}) = s(n, \text{sym}) v\left(\left(\frac{n}{V}\right) \bmod S\right)$, $0 \leq n < M_{\text{rep}} N_{\text{slots}}^{\text{UL}} N_{\text{RU}}$, where sym is the symbol index for uplink transmission within the slot n , $0 \leq \text{sym} < 7$. Similarly, S is the length of the multiplexing sequence or the total number of the orthogonal sequence or cyclic shift sequence, e.g., $S = 2, 4, 8$. V is the time duration of an element of the multiplexing sequence adopted to the uplink transmission, which can be one or more slots, one or more

valid slots (excluding the reserved slots), or one or more reference symbols etc. For example, the time duration of an element of the uplink transmission to which the multiplexing sequence is adopted is: $V = \min(16, 16M_{\text{rep}}N_{\text{RU}}/S)$ for NPUSCH format 1 or $V=1$ etc.

[0072] In some other implementations of the present disclosure, an uplink transmission in slot n , e.g., $s(n, \text{sym}, k)$ for multiple subcarriers is processed by an OCC or cyclic shift sequence $v(n)$, and then the processed uplink transmission in slot n is expressed as $\bar{s}(n, \text{sym}, k) = s(n, \text{sym}, k)v(\left(\frac{n}{V}\right) \bmod S)$, $0 \leq n < M_{\text{rep}}N_{\text{slots}}^{\text{UL}}N_{\text{RU}}$, k is a frequency index of RE corresponding to the subcarriers assigned for transmission and not used for transmission of reference signals. Similarly, sym is the symbol for uplink transmission within the slot n , $0 \leq \text{sym} < 7$. S is the length of the multiplexing sequence or the total number of orthogonal sequence or cyclic shift sequence. V is the time duration of the element of the adopted multiplexing sequence, which can be one or more slots, one or more valid slots (excluding the reserved slots), or one or more reference symbols etc. For example, the time duration of an element of the multiplexing sequence is: $V = \max(1, M_{\text{rep}}N_{\text{slots}}^{\text{UL}}N_{\text{RU}}/S)$, or $V = \min(1, M_{\text{rep}}N_{\text{slots}}^{\text{UL}}N_{\text{RU}}/S)$, or $V = 2M_{\text{identical}}$ or $V = 2$. In the case that the length of the multiplexing sequence or the total number of orthogonal sequence or cyclic shift sequence S is smaller than or equal to 4, and V is 2slots, the orthogonal sequence within the identical slots will facilitate the eNB early termination reception.

[0073] Figure 5 illustrates an example of an uplink transmission in the case of multi-tone under Scheme 2 in accordance with aspects of the present disclosure.

[0074] Referring to Figure 5, it is supposed that the uplink transmission is NPUSCH format 1 transmission with multiple tones, e.g., 12 tones. Each NPUSCH codeword can be mapped to one or more resource units, each of which shall be transmitted multiple times. For example, one transmission block (TB) maps to 2 RUs, and each RU includes 2 slots for 12 tones allocation. The repetition number of the NPUSCH, M_{rep} is 8. N_{RU} is 2. Thus, the NPUSCH transmission with multiple tone case will repeat up to 4 times of 2-slot unit in consecutive slots with the identical signal. Specifically, for NPUSCH format 1 shown in Figure 5, the first 2 slots are repeated 4 times, and then the second 2 slots are repeated 4 times, ... till the end of all transmissions. In accordance with option 1, the time duration of

each element, e.g., $v(0)$ of the multiplex sequence is $2M_{\text{identical}}=2*4=8$ slots. In accordance with option 2, the time duration of each element, e.g., $v(0)$ of the multiplex sequence is 2 slots, which makes the OCC duration (with the length of 4) within the identical transmission (8 slots).

[0075] In some yet other implementations of the present disclosure, an uplink transmission in slot n , e.g., $s(n, sym, k)$ for multiple subcarriers is processed by an orthogonal or cyclic shift sequence sequentially with frequency first, time second order for each resource element. The multiplexing sequence can be designed in similar manners as described above.

[0076] In some yet other implementations of the present disclosure, RACH/PRACH, e.g., the preamble in NPRACH (or NPRACH transmission, or NPRACH transmission signal or the like) is processed by a multiplexing sequence, e.g., an orthogonal sequence or cyclic shift sequence. For NPRACH frequency hopping, inter-carrier frequency hopping and intra-carrier frequency hopping are adopted. Each element of the multiplexing sequence adopted to the preamble in the RACH/PRACH transmission lasts for one or more slots, one or more valid slots (excluding the reserved slots), or one or more preamble symbol groups, or one or more preamble duration etc. For example, in the case that a symbol-group, e.g., 1.4ms or 1.6ms is the basic resource unit of the preamble for NPRACH transmission, each element of the multiplexing sequence adopted to the preamble in the NPRACH transmission lasts for multiple symbol-groups or multiple repetition numbers.

[0077] Figure 6 illustrates an example of NPRACH under Scheme 2 in accordance with aspects of the present disclosure.

[0078] Referring to Figure 6, 4 symbols are combined into a 4-symbol group, which may be 1.4ms or 1.6ms. The frequency hopping among carriers occurs every 4-symbol group(s) (only considering valid subframe). Each carrier has a plurality of subcarriers, e.g., 48 subcarriers in Figure 6. Among the plurality of subcarriers, some subcarriers, e.g., subcarrier 12 to subcarrier 23 in Figure 6 may be configured to be RACH resources. Regarding carrier hopping, it is between configured carriers in turns, while regarding subcarrier hopping, it is pseudorandom as legacy.

[0079] It is supposed that the repetition number is 4. Then, taking UE1 as an example, in the first repetition, the NPRACH of UE 1 is transmitted in Carrier A, e.g., in subcarrier 21 for symbol group #0, in subcarrier 20 for symbol group #1, in subcarrier 14 for symbol group #2 and in subcarrier 15 for symbol group #3. In the second repetition, the NPRACH of UE 1 is still in Carrier A if carrier hopping is not supported or the NPRACH can be hopped to Carrier B if carrier hopping is supported, e.g., in subcarrier 17 for symbol #4, in subcarrier 16 for symbol #5, in subcarrier 22 for symbol #6 and in subcarrier 23 for symbol #7. In the third repetition, the NPRACH of UE 1 is still in Carrier A if carrier hopping is not supported or the NPRACH is hopped back to Carrier A if carrier hopping is supported, e.g., in subcarrier 14 for symbol #8, in subcarrier 15 for symbol #9, in subcarrier 21 for symbol #10 and in subcarrier 20 for symbol #11. In the fourth repetition, the NPRACH of UE 1 is still in Carrier A if carrier hopping is not supported or the NPRACH is hopped back to Carrier B if carrier hopping is supported, e.g., in subcarrier 22 for symbol #12, in subcarrier 23 for symbol #13, in subcarrier 17 for symbol #14 and in subcarrier 16 for symbol #15. NPRACH of UE2 is similar to UE1, if carrier hopping is not supported, the NPRACH of UE2 will be within Carrier 2, and the detailed procedure will not be repeated.

Scheme 3

[0080] In accordance with some aspects of the present disclosure, in order to avoid destroying the orthogonality among UEs with different transmission configuration (e.g., different repetition numbers, or RU numbers etc.), the common design will be considered. Both the uplink transmission e.g., NPUSCH and its reference signal, e.g., DMRS will be based on a multiplexing sequence, e.g., the uplink transmission is processed by the multiplexing sequence and the reference signal will be generated based on the multiplexing sequence. Each element of the adopted multiplexing sequence will last for a time duration, e.g., one or more slots, or one or more valid slots excluding reserved slots, or one or more reference signal samples, or one or more reference symbols etc.

[0081] The element of the multiplexing sequence adopted to the reference signal and corresponding uplink transmission may further determined by a time offset. An exemplary time offset is relative to a reference slot, or relative to a reference slot counting valid uplink

slots and excluding reserved subframes or reserved slots. The time offset may be determined by the resource reserved slot pattern, e.g., by resourceReservationConfigUL.

[0082] For example, in some implementations of the present disclosure, the reference signal sequence $\bar{r}_u(n)$ for uplink transmissions (e.g., NPUSCHs) and reference signals associated with the uplink transmissions in the case of single subcarrier is defined as $\bar{r}_u(n) = \frac{1}{\sqrt{2}}(1+j)(1-2c(n))w(n \bmod 16)v\left(\left(\frac{n+\Delta n}{V}\right) \bmod S\right)$, $0 \leq n < M_{\text{rep}}N_{\text{slots}}^{\text{UL}}N_{\text{RU}}$. Δn is the time offset to the reference slot, e.g., slot 0 counting the valid uplink subframe (full subframe without reserved slot).

[0083] In some other implementations of the present disclosure, an absolute valid uplink subframe (full subframe without reserved slot) or slot will be determined based on the time offset. UE (or the network side) will determine an element of the multiplexing sequence adopted to the uplink transmission or the reference signal based on the determined absolute valid uplink subframe or slot.

[0084] Figure 7 illustrates an example of multiplexing of multiple UEs under Scheme 3 in accordance with aspects of the present disclosure.

[0085] Referring to Figure 7, it is supposed that there are four elements, e.g., $v(0)$, $v(1)$, $v(2)$ and $v(3)$ in the multiplexing sequence adopted to the NPUSCH (or reference signal) respectively from UE1 and UE2. When there are reserved subframe(s) and reserved slot(s), e.g. slots 7 and 8, the corresponding element, e.g., $v(3)$ will be postponed to the valid uplink frame or slot after the reserved subframe or slot, e.g., to the end of slot8. A time offset Δn relative to slot 0 will be used to determine the element of NPUSCH from UE2. Accordingly, the elements of the multiplexing sequence adopted to the uplink transmissions from UE1 and UE2 will be consistent.

[0086] 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. 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.

[0087] 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.

[0088] 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.

[0089] 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.

[0090] 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 receiving uplink transmission configuration; and a means for transmitting an uplink transmission, or a reference signal associated with the uplink

transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0091] 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.

[0092] 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.

[0093] 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.

[0094] 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.

[0095] 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).

[0096] 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).

[0097] 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.

[0098] 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.

[0099] 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).

[0100] 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.

[0101] 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.

[0102] 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 receiving uplink transmission configuration; and a means for transmitting an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0103] Figure 10 illustrates an example of a NE 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.

[0104] 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.

[0105] 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.

[0106] 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.

[0107] 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 transmitting uplink transmission configuration; and receiving an uplink transmission, or a reference signal associated with the uplink transmission, or the

uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

[0108] 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.

[0109] 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.

[0110] 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.

[0111] 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.

[0112] 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.

[0113] At 1101, the method may include receiving uplink transmission configuration. The operations of 1101 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1101 may be performed by a UE as described with reference to Figure 8.

[0114] At 1103, the method may include transmitting an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration. The operations of 1103 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1103 may be performed by a UE as described with reference to Figure 8.

[0115] 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.

[0116] Figure 12 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.

[0117] At 1201, the method may include transmitting uplink transmission configuration. The operations of 1201 may be performed in accordance with examples as described herein.

In some implementations, aspects of the operations of 1201 may be performed by a NE as described with reference to Figure 10.

[0118] At 1203, the method may include receiving an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration. The operations of 1203 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1203 may be performed by a NE as described with reference to Figure 10.

[0119] 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.

[0120] 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 uplink transmission configuration; and
 - transmit an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.
2. The UE of claim 1, wherein, the multiplexing sequence is based on an orthogonal cover code (OCC) sequence or a cyclic shift value.
3. The UE of claim 2, wherein, the at least one processor is configured to cause the UE to:
 - determine a sequence index of the OCC sequence for the multiplexing sequence based on high layer parameters in the uplink transmission configuration or user equipment (UE) identity (ID) related information or a predefined rule.
4. The UE of claim 2, wherein, the at least one processor is configured to cause the UE to:
 - determine the cyclic shift value based on high layer parameters in the uplink transmission configuration or user equipment (UE) identity (ID) related information or predefined rule.

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

determine a base sequence associated with the reference signal based on cell identity (ID) related information.

6. The UE of claim 1, wherein, a length of the multiplexing sequence or a maximum multiplexing sequence number of the multiplexing sequence is configured by high layer parameters in the uplink transmission configuration, or is determined based on a format of the uplink transmission, or is a constant.

7. The UE of claim 1, wherein, the time duration is configured by higher layer parameters in the uplink transmission configuration, or is determined by a resource unit (RU) length, a RU number, a slot number of the uplink transmission, a repetition number of the uplink transmission, a scheduled uplink subcarrier number, a format of the uplink transmission, continuous slots for identical uplink transmissions, or any combination thereof.

8. The UE of claim 1, wherein, the time duration is one or more slots, or one or more valid slots excluding reserved slots, or one or more reference signal samples, or one or more reference symbols, or one or more preamble symbol groups, or one or more preamble duration.

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

determine an element of the multiplexing sequence adopted to the uplink transmission or the reference signal based on a time offset.

10. The UE of claim 9, wherein, the time offset is a time offset relative to a reference slot, or is a time offset relative to a reference slot counting valid uplink slots and excluding reserved subframes or reserved slots.

11. The UE of claim 10, wherein, the reserved subframes or the reserved slots are determined based on a resource reserved slot pattern.

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

- determine an absolute valid uplink subframe or slot based on the time offset; and
- determine an element of the multiplexing sequence adopted to the uplink transmission or the reference signal based on the absolute valid uplink subframe or slot.

13. A processor for wireless communication, comprising:

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

- receive uplink transmission configuration; and

- transmit an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

14. 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 uplink transmission configuration; and

- receive an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing

sequence adopted to the uplink transmission or the reference signal lasts for a time duration.

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

receiving uplink transmission configuration; and

transmitting an uplink transmission, or a reference signal associated with the uplink transmission, or the uplink transmission and the reference signal based on the uplink transmission configuration and a multiplexing sequence, wherein, the uplink transmission is processed by the multiplexing sequence, the reference signal is generated from the multiplexing sequence, and each element of the multiplexing sequence adopted to the uplink transmission or the reference signal lasts for a time duration.