METHOD AND APPARATUS OF UPLINK TRANSMISSIONS

TECHNICAL FIELD

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

BACKGROUND

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

SUMMARY

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

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

[0004] Some implementations of the methods and apparatuses described herein may further include a UE for wireless communication, which may include: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive an uplink configuration; apply a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and transmit the processed uplink data in physical resources based on the uplink configuration.

[0005] In some implementations of the methods and apparatuses described herein, applying the multiplexing sequence to process the uplink data includes: dividing samples of each transport block (TB) of the uplink data into a number of segments; and applying the multiplexing sequence to process each segment of the uplink data, wherein each processed segment is spreaded with the spreading factor in time domain.

[0006] In some implementations of the methods and apparatuses described herein, the number of segments is based on one or more of uplink data frequency domain allocation, a resource unit number or a slot number per each resource unit.

[0007] In some implementations of the methods and apparatuses described herein, applying the multiplexing sequence to process each segment is based on a single slot level, a multi-slot level, a single sample level, a multi-sample level, a single symbol level or a multi-symbol level.

[0008] In some implementations of the methods and apparatuses described herein, transmitting the processed uplink data in physical resources includes: repeatedly transmitting the processed uplink data with a first repetition number in a plurality of slots.

[0009] In some implementations of the methods and apparatuses described herein, the first repetition number is based on a configured repetition number and the spreading factor.

[0010] In some implementations of the methods and apparatuses described herein, transmitting the processed uplink data in physical resources includes: cyclically adopting two redundancy versions (RVs) across subblocks of the plurality of slots, wherein a length of each subblock is based on one or more of uplink data frequency domain allocation, a resource unit number, a slot number per each resource unit or the spreading factor.

[0011] In some implementations of the methods and apparatuses described herein, the spreading factor is based on one or more of uplink data frequency domain allocation, a configured repetition number or a preconfigured spreading factor.

[0012] In some implementations of the methods and apparatuses described herein, the uplink data includes multiple TBs, and the at least one processor is configured to cause the UE to: transmit the multiple TBs by an interleaved way, wherein each TB spans a duration of a number of slots determined by the spreading factor.

[0013] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which include: at least one controller coupled with at least one memory and configured to cause the at least one processor to: receive an uplink configuration; apply a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and transmit the processed uplink data in physical resources based on the uplink configuration.

[0014] 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 an uplink configuration; and receive uplink data in physical resources based on the uplink configuration, wherein the uplink data is processed by applying a multiplexing sequence based on the uplink configuration, and the multiplexing sequence is associated with a spreading factor.

[0015] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which includes: receiving an uplink configuration; applying a multiplexing sequence to process uplink data based on the uplink

configuration, wherein the multiplexing sequence is associated with a spreading factor; and transmitting the processed uplink data in physical resources based on the uplink configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0017] Figure 2 is an example of a NPUSCH processed by an OCC sequence in a single tone case in accordance with aspects of the present disclosure.

[0018] Figure 3 is an example of a NPUSCH transmission in the single tone case in accordance with aspects of the present disclosure.

[0019] Figure 4 is another example of a NPUSCH transmission in the single tone case in accordance with aspects of the present disclosure.

[0020] Figure 5 is an example of a NPUSCH transmission in the multiple tone case in accordance with aspects of the present disclosure.

[0021] Figure 6 is another example of a NPUSCH transmission in the multiple tone case in accordance with aspects of the present disclosure.

[0022] Figure 7 is an example of multiple TB interleaved transmission in the single tone case in accordance with aspects of the present disclosure.

[0023] Figure 8 is another example of multiple TB interleaved transmission in the single tone case in accordance with aspects of the present disclosure.

[0024] Figure 9 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0025] Figure 10 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0026] Figure 11 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0027] Figure 12 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0028] Figure 13 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0029] In a wireless communications system, a network communication device, such as a base station (e.g., eNB, gNB) may support transmitting downlink communications to one or multiple user communication devices (e.g., UE). Additionally, or alternatively, the network communication device may support receiving uplink communications from one or multiple user communication devices. As demand for higher throughput and efficient utilization of resources in the wireless communications system increases, it may be desirable to support multiplexing of uplink communications (e.g., mobile-originated (MO) data transmissions) associated with multiple user communication devices (e.g., multiple UE), for example, over a single subcarrier, such as 3.75 kilohertz (kHz). By enabling multiplexing of uplink communications associated with multiple user communication devices over a single subcarrier, the wireless communication system may improve throughput (e.g., capacity) in an uplink.

[0030] Various aspects of the present disclosure relate to enabling a wireless communication system, including one or more of a network communication device or a user communication device to support multiplexing uplink communications associated with multiple UEs on the same resource (e.g., one or more of a time resource or a frequency resource) for an uplink transmission with a multiplexing sequence (e.g., an orthogonal cover code (OCC) sequence). In some implementations, the network communication device (e.g., a base station) may transmit an uplink configuration to a UE (e.g., via radio resource control (RRC) signaling or the like). Based on the uplink configuration, the UE may apply a multiplexing sequence to process uplink data, wherein the multiplexing sequence is associated with a spreading factor. UE will also transmit the processed uplink data in physical resources based on the uplink configuration to the network communication device. The multiplexing sequence will differentiate between UEs multiplexed at the same time-

frequency resource, which will result in improvement of throughput (e.g., capacity) in an uplink.

[0031] Aspects of the present disclosure are described in the context of a wireless communications system.

[0032] 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.

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] 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).

[0038] 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.

[0039] 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).

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] In order to multiplex UEs at the same physical resource for uplink transmission, e.g., the same time-frequency resource in scheduled uplink resources or preconfigured uplink resources (PURs), a multiplexing sequence will be used to process the uplink data (cyclically

if necessary) to differentiate the UEs, e.g., beginning from a reference time slot (or an absolute slot, e.g., slot#0, or a starting slot of the scheduled uplink transmission). Regarding a PUR, it may be a dedicated PUR where uplink time-frequency resources can 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.

[0047] Exemplary uplink data for which a multiplexing sequence is applied may be a PUSCH transmission (or referred to as PUSCH or the like). Taking IoT NTN especially for narrowband (NB) IoT (NBIoT) as an example, the uplink data may be an NBIoT PUSCH (NPUSCH), e.g., NPUSCH format 1 (which is for uplink data while not for feedback information). An exemplary NPUSCH format 1 resource occupies $N = N_{rep}N_{RU}N_{slots}^{UL}$ uplink slots. N_{rep} is a repetition number indicated by repetition number field of downlink control information (DCI) format N0 or configured by higher layer for preconfigured uplink. N_{RU} is the number of resource units indicated by the resource assignment field of DCI format N0 or configured by higher layer parameter for preconfigured uplink. N_{slots}^{UL} is the number of slots in a resource unit, which is specified in the TS36.211, e.g., Table 10.1.2.3-1 as illustrated below, where N_{sc}^{RU} is the allocated subcarrier number for the NPUSCH transmission, and N_{symb}^{UL} is the symbol number per each uplink slot (e.g., 7).

36.211-Table 10.1.2.3-1

NPUSCH format	Δ f	N_{sc}^{RU}	N_{slots}^{UL}	N_{symb}^{UL}
1	3.75kHz	1	16	7
	15kHz	1	16	
		3	8	
		6	4	
		12	2	
2	3.75kHz	1	4	
	15kHz	1	4	

[0048] In addition, regarding NBIoT resource unit (RU), it is a kind of new concept in uplink resource assignment comparing to legacy LTE, and is introduced by LTE-NB as a basic unit for PUSCH allocation. This unit can take several different types of configurations. Each NPUSCH codeword can be mapped to one or more resource units, each of which shall be transmitted multiple times (or with repetitions).

[0049] In some implementations of the present disclosure, the multiplexing sequence is based on an OCC sequence, e.g., a Walsh sequence or other qual-orthogonal sequence. A sequence index of the OCC sequence for the multiplexing sequence may be configured by high layer parameters in the uplink configuration, or may be determined based on predefined rules or UE ID related information, e.g., UEID, or cell-radio network temporary identifier (C-RNTI) etc. For example, the sequence index for a multiplexing sequence may be generated or determined as C-RNTI mod the maximum multiplexing sequence number (or referred to as maximum multiplexing number of devices or the spreading factor associated with the multiplexing sequence).

[0050] Figure 2 is an example of a NPUSCH processed by an OCC sequence in a single tone (or subscarrier) case in accordance with aspects of the present disclosure.

[0051] Referring to Figure 2, it is assumed that the uplink data is a NPUSCH format 1 transmission in the single tone case, wherein N_{rep}=4, N_{RU}=2 and N_{slots}^{UL}=16. For NPUSCH in the single tone case (or single-tone NPUSCH), UE may transmit a full TB and then another TB with different RVs, and the RV cycling will continue until reach the repetition number, which implies that the time span of an OCC sequence may be with the unit of one TB transmission (or 2 repetitions for each RVs (e.g., RV0 and RV2)). Thus, the TB is transmitted with 4 repetitions (N_{rep}=4), e.g., Block#1, Blcok#2, Block#3 and Block#4. Each TB includes 2 Rus (N_{RU}=2), and each RU includes 16 slots (N_{slots}^{UL}=16) in accordance with 36.211-Table 10.1.2.3-1. So the total transmission duration for each repetition is 32 slots. RV cycling is supported for the NPUSCH format 1 transmission in the pattern of [0, 2]. Thus, in Figure 2, OCC operation (or OCC application) in time domain may span 64 slots (e.g., OCC operation between two identical data in uplink transmission slots is 64 slots). That is, the time span for OCC operation in the single tone case is long, there may be phase rotation during the time span of the OCC sequence caused by timing and frequency error and drift, which will degrade the performance of NPUSCH.

[0052] For a NPUCH in a multi-tone case (or multi-tone NPUSCH), OCC operation among repetitions or identical data in slots may be applicable to avoid long time span. However, how to dynamically adjust the length of the OCC sequence in the case the NPUSCH transmission repetition number changes should be solved.

[0053] Considering the aforementioned issues related to the time span of multiplexing sequence operation in the single tone (or single-tone mode, $N_{\mathrm{sc}}^{\mathrm{RU}} = 1$) or multi-tone case (or multi-tone mode, $N_{\mathrm{sc}}^{\mathrm{RU}} > 1$), resource mapping improvements are considered in some aspects of the present disclosure. The multiplexing sequence will be associated with a spreading factor, e.g., M_{occ} which may be the length of the multiplexing sequence. The spreading factor is based on one or more of uplink data frequency domain allocation, a configured repetition number or a preconfigured spreading factor, e.g., $M_{\mathrm{occ\text{-}1}}$. For example, an OCC sequence may be Walsh codes with an OCC length that is a power of 2 or discrete Fourier transform (DFT) codes with form of $e^{\mathrm{j}2\pi im/Mocc}$ support at least an OCC length up to 7 (e.g., 1, 2, 3, 4, 5, 6, 7), and the associated spreading factor is a power of 2, or 1, 2, 3, 4, 5, 6, 7.

[0054] When using the multiplexing sequence to process the uplink data, UE will divide each TB of the uplink data (e.g., uplink data after channel coding and modulation, before physical resource mapping), e.g., samples of each TB into a number of segments, e.g., $N_{segment}$ segments (e.g., $N_{RU}N_{ul,slot}$ for single tone case and $2N_{RU}N_{ul,slot}$ for multiple tone case). Each segment (e.g., the number of uplink data mapping to a unit of slot) includes, e.g., $M_{segment}$ uplink data. The number of segments is based on one or more of uplink data frequency domain allocation (N_{sc}), a resource unit number, e.g., N_{RU} or a slot number per each resource unit, e.g., N_{slots}^{UL}. Then, UE will use the multiplexing sequence to process each segment of the uplink data, wherein each processed segment is spreaded with the spreading factor in time domain, which may be based on a single slot level, a multi-slot level, a single sample level, a multi-sample level, a single symbol level or a multi-symbol level etc. That is, the multiplexing sequence may spread across the time domain in single or multi-sample level, single or multi-slot level or single or multi-symbol level. For example, in the single tone case, the spreading factor, e.g., M_{occ}= min ($N_{\mathrm{rep}}/2$, $M_{\mathrm{occ\text{-}1}}$), or M_{occ}=2 for N_{rep}=2 otherwise M_{occ}= $M_{\mathrm{occ\text{-}1}}$; and in the multiple tone case, M_{occ}= $M_{\mathrm{occ\text{-}1}}$ if N_{rep}>4, otherwise M_{occ} = 2. Occasionally, the spreading can be based on symbol level (e.g., OCC operation is between to two or more consecutive OFDM symbols), and $N_{segment}$ =$(N_{symb}^{\mathrm{UL}} - 1)N_{RU}N_{ul,slot}$ where one symbol for each uplink slot is used for demodulation reference signal (DMRS) transmission.

[0055] For example, the uplink data processed by a multiplexing sequence, e.g., OCC sequence with a spreading factor may be represented by:

$$S(nM_{occ}M_{segment} + iM_{ssegment} + m) = s(nM_{segment} + m) * w(i)$$

Where, S(*) is the processed uplink data, s(*) is the uplink data before spreading or procssing with a length of M_{total}, $n = 0,1, \ldots N_{segment}$; $m = 0,1, \ldots M_{segment}$; $i = 0,1, \ldots M_{OCC}$ and the uplink data is spreaded with a multiplexing sequence $w(*)$ associated with a spreading factor, e.g., M_{occ}, which may be per slot or several slots level or even per symbols etc. Each segment of the uplink data is spreaded with the multiplexing sequence $w(*)$. For example, in the single tone case, it may be one-slot based OCC spreading, $N_{segment}=N_{RU}N_{slots}^{UL}$. That is, each segment processed by a multiplexing sequence will be mapped to one slot in the single tone case. For multiple tone case, it may be two-slot based OCC spreading, $N_{segment}=2N_{RU}N_{slots}^{UL}$. That is, each segment processed by a multiplexing sequence will be mapped to two-slot in the multiple tone case.

[0056] The uplink data spreaded with the multiplexing sequence w(*) will be transmitted in time domain. For example, the spreaded uplink data may be repeatedly transmitted with a repetition number, e.g., M_{rep}. The repetition number M_{rep} is determined by a configured repetition number, e.g., the repetition number N_{rep} and the spreading factor, e.g., $M_{rep} = N_{rep}/M_{occ}$.

[0057] RV cycling may also be applied for repetitions of the uplink data spreaded with the multiplexing sequence w(*). For example, UE will cyclically adopting two RVs across subblocks of the plurality of slots, e.g., in the pattern of [0, 2]. The length of each subblock, e.g., $N_{rv,subblock}$ is based on one or more of uplink data frequency domain allocation, a resource unit number, a slot number per each resource unit N_{slots}^{UL} or the spreading factor. For example, in the single tone case, the length of each subblock (with a number of slots), $N_{rv,subblock}= M_{occ} N_{RU}N_{slots}^{UL}$; and in the multiple tone case, $N_{rv,subblock}= 4\ N_{RU}N_{slots}^{UL}$ if $N_{rep}>=4$, *otherwise* $N_{rv,subblock}= 2\ N_{RU}N_{slots}^{UL}$.

[0058] Figure 3 is an example of a NPUSCH transmission in the single tone case in accordance with aspects of the present disclosure.

[0059] Referring to Figure 3, it is assumed that the uplink data is a NPUSCH format 1 transmission in the single tone case, wherein N_{rep}=4, N_{RU}=2 and N_{slots}^{UL}=16. It is also

assumed that the spread factor is Mocc=2, and the length of the multiplexing sequence, e.g., OCC sequence is also 2, e.g., w(0) and w(1). Each segment processed by the multiplexing sequence will be mapped to one slot in the single tone case. The spreaded uplink data will be repeatedly transmitted with a repetition number e.g., $M_{rep} = N_{rep}/M_{occ}=2$, and the length of each subblock with the number of uplink slots, e.g., Block#1 and Block#2 for RV cycling or switching in the pattern [0, 2] will be $N_{rv,subblock}=M_{occ}\,N_{RU}N_{slots}^{UL}=2*2*16=64$ slots.

[0060] Figure 4 is also an example of a NPUSCH transmission in the single tone case in accordance with aspects of the present disclosure.

[0061] Referring to Figure 4, it is assumed that the uplink data is a NPUSCH format 1 transmission in the single tone case, wherein $N_{rep}=4$, $N_{RU}=2$ and $N_{slots}^{UL}=16$. It is also assumed that the spread factor is 4, and the length of the multiplexing sequence, e.g., OCC sequence is also 4, e.g., w(0)…w(3). Each segment processed by the multiplexing sequence will be mapped to one slot in the single tone case. The the spreaded uplink data will be repeatedly transmitted with a repetition number e.g., $M_{rep} = N_{rep}/M_{occ}=1$, and there will be only RV0 will be applied to the spreaded uplink data, e.g., Block#1, $N_{rv,subblock}=M_{occ}\,N_{RU}N_{slots}^{UL}=4*2*16=128$ slots

[0062] Figure 5 is an example of a NPUSCH transmission in the multi-tone case in accordance with aspects of the present disclosure.

[0063] Referring to Figure 5, it is assumed that the uplink data is a NPUSCH format 1 transmission in a 12-tone case, wherein $N_{rep}=16$, $N_{RU}=2$ and $N_{slots}^{UL}=2$. It is also assumed that the spread factor is Mocc=4, and the length of the multiplexing sequence, e.g., OCC sequence is also 4. Each segment processed by the multiplexing sequence will be mapped to 2 slots. The spreaded uplink data will be repeatedly transmitted with a repetition number e.g., $M_{rep} = N_{rep}/4=4$, and the length of each subblock, e.g., Block#1 to Block#4 for RV cycling or switching in the pattern [0, 2] will be $N_{rv,subblock}=4\,N_{RU}N_{slots}^{UL}=4*2*2=16$ slots.

[0064] Figure 6 is also an example of a NPUSCH transmission in the multi-tone case in accordance with aspects of the present disclosure.

[0065] Referring to Figure 6, it is assumed that the uplink data is a NPUSCH format 1 transmission in a 12-tone case, wherein N_{rep}=16, N_{RU}=2 and N_{slots}^{UL}=2. It is also assumed that the spread factor is Mocc=2, and the length of the multiplexing sequence, e.g., OCC sequence is also 2. Each segment processed by the multiplexing sequence will be mapped to 2 slots. The spreaded uplink data will be repeatedly transmitted with a repetition number e.g., $M_{rep} = N_{rep}/4$=4, and the length of each subblock, e.g., Block#1 to Block#4 for RV cycling or switching in the pattern [0, 2] will be $N_{rv,subblock}$=4 $N_{RU}N_{slots}^{UL}$=4*2*2=16 slots.

[0066] In some cases, the uplink data may include multiple TBs, e.g., scheduled by single DCI. For example, for multiple interleaved transmitted TBs, the NB-IoT UL slot, $n_{g(cN_{TB}+r)+l}$, $l = 0,1,\ldots,g-1$, $c = 0,1,\ldots,\frac{Nrep}{C}-1$, $g = CN_{RU}N_{slots}^{UL}$, r = 0, 1, … N_{TB}-1 is associated with TB_r where NBIoT UL slot n_i is the UL slot index i, $C = 1$ in the single tone case and $C = 4$ in the multi-tone case. TB_r is the r_{th} TB among the 2 scheduled TBs for NBIoT PUSCH format 1.

[0067] In order to support the multiplexing sequence, e.g., OCC sequence based multiplexing for single tone and multiple tone uplink transmission, the uplink slot allocated for each TB will be updated based on the multiplexing sequence scheme. UE will transmit the multiple TBs by an interleaved way, wherein each TB spans a duration of a number of slots determined by the spreading factor. For example, in the multiple tone case, the maximal OCC length is no larger than 4, and the subblock for each TB will be $CN_{RU}N_{slots}^{UL}$, $C = 4$ as scheme without OCC multiplexing. For the single tone case, the subblock for each TB will be determined by the spreading factor, e.g., $M_{occ}N_{RU}N_{slots}^{UL}$ with the introduction of OCC multiplexing for the NPUSCH format 1.

[0068] Figure 7 is an example of multiple TB interleaved transmission in the single tone case in accordance with aspects of the present disclosure.

[0069] Referring to Figure 7, it is assumed that two TBs, e.g., TB#1 and TB#2 are interleaved transmitted in the single tone case, wherein N_{rep}=4, N_{RU}=2 and N_{slots}^{UL}=16.

[0070] In case (a), no multiplexing sequence is applied, the subblock for each TB will be $CN_{RU}N_{slots}^{UL}$= 1*2*16= 32 uplink slots, and for each subblock of a TB with a repetition

number of 4, N_{rep}=4. Thus, 4 subblocks of TB#1, e.g., 4 TB#1a will be cyclically repeated, 4 subblocks of TB#2, e.g., 4 TB#2a will be cyclically repeated, and each subblock of TB#1 and TB#2 will be interleaved with each other.

[0071] In case (b), a multiplexing sequence, e.g., an OCC sequence is applied for each TB. It is also assumed that the spread factor is Mocc = 4, and the length of the multiplexing sequence, e.g., an OCC sequence is also 4. The transmission duration for subblocks of each TB will be determined by the spreading factor, e.g., $M_{occ}N_{RU}N_{slots}^{UL}$=4*2*16=128 slots, and the repetition number is N_{rep}/M_{OCC}=1 for each TB (e.g., TB1, TB2). Thus, in case (b) TB#1 includes 1 subblock, e.g., TB#1b and TB#2 includes 1 subsblock, e.g., TB#2b.

[0072] Figure 8 is another example of multiple TB interleaved transmission in the single tone case in accordance with aspects of the present disclosure.

[0073] Referring to Figure 8, it is also assumed that two TBs, e.g., TB#1 and TB#2 are interleaved transmitted in the single tone case, wherein N_{rep}=4, N_{RU}=2 and N_{slots}^{UL}=16.

[0074] In case (a), no multiplexing sequence is applied, the duration for subblock of each TB will be $CN_{RU}N_{slots}^{UL}$= 1*2*16= 32 slots, and for each subblock of a TB, N_{rep}=4. Thus, TB#1 will include 4 subblocks, e.g., 4 TB#1a and TB#2 will include 4 subblocks, e.g., 4 TB#2b. In addition, RV in the pattern [0, 2] will be cyclically applied to each subblock, that is, RV will switch every 32slots.

[0075] In case (b), a multiplexing sequence, e.g., an OCC sequence is applied for each TB. It is also assumed that the spread factor is Mocc = 2 in case (b), and the length of the multiplexing sequence, e.g., an OCC sequence is 2. The duration for subblock of each TB will be determined by the spreading factor, e.g., $M_{occ}N_{RU}N_{slots}^{UL}$=2*2*16=64 slots. Thus, in case (b), for each subblock of each TB, the repetition numbered will be $\frac{N_{rep}}{M_{OCC}}$ =2. Accordingly, TB#1 includes 2 repeated subblock, e.g., 2 TB#1b and TB#2 includes 2 repeated subsblocks, e.g., 2 TB#2b with each subblock of 64 slots

[0076] Figure 9 illustrates an example of a UE 900 in accordance with aspects of the present disclosure. The UE 900 may include a processor 902, a memory 904, a controller 906, and a transceiver 908. The processor 902, the memory 904, the controller 906, or the

transceiver 908, 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.

[0077] The processor 902, the memory 904, the controller 906, or the transceiver 908, 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.

[0078] The processor 902 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 902 may be configured to operate the memory 904. In some other implementations, the memory 904 may be integrated into the processor 902. The processor 902 may be configured to execute computer-readable instructions stored in the memory 904 to cause the UE 900 to perform various functions of the present disclosure.

[0079] The memory 904 may include volatile or non-volatile memory. The memory 904 may store computer-readable, computer-executable code including instructions when executed by the processor 902 cause the UE 900 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 904 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.

[0080] In some implementations, the processor 902 and the memory 904 coupled with the processor 902 may be configured to cause the UE 900 to perform one or more of the functions described herein (e.g., executing, by the processor 902, instructions stored in the memory 904). For example, the processor 902 may support wireless communication at the UE 900 in accordance with examples as disclosed herein. The UE 900 may be configured to

support a means for receiving an uplink configuration; a means for applying a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and a means for transmitting the processed uplink data in physical resources based on the uplink configuration.

[0081] The controller 906 may manage input and output signals for the UE 900. The controller 906 may also manage peripherals not integrated into the UE 900. In some implementations, the controller 906 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 906 may be implemented as part of the processor 902.

[0082] In some implementations, the UE 900 may include at least one transceiver 908. In some other implementations, the UE 900 may have more than one transceiver 908. The transceiver 908 may represent a wireless transceiver. The transceiver 908 may include one or more receiver chains 910, one or more transmitter chains 912, or a combination thereof.

[0083] A receiver chain 910 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 910 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 910 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 910 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 910 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0084] A transmitter chain 912 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 912 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 912 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 912 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0085] Figure 10 illustrates an example of a processor 1000 in accordance with aspects of the present disclosure. The processor 1000 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 1000 may include a controller 1002 configured to perform various operations in accordance with examples as described herein. The processor 1000 may optionally include at least one memory 1004, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 1000 may optionally include one or more arithmetic-logic units (ALUs) 1006. 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).

[0086] The processor 1000 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 1000) 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).

[0087] The controller 1002 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 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. For example, the controller 1002 may operate as a control unit of the processor 1000, generating control signals that manage the operation of various components of the processor 1000. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0088] The controller 1002 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 1004 and determine subsequent instruction(s) to be executed to cause the processor 1000 to support various operations in accordance with examples as described herein. The controller 1002 may be configured to track memory address of instructions associated with the memory 1004. The controller 1002 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 1002 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 1000 to cause the processor 1000 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 1002 may be configured to manage flow of data within the processor 1000. The controller 1002 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 1000.

[0089] The memory 1004 may include one or more caches (e.g., memory local to or included in the processor 1000 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 1004 may reside within or on a processor chipset (e.g., local to the processor 1000). In some other implementations, the memory 1004 may reside external to the processor chipset (e.g., remote to the processor 1000).

[0090] The memory 1004 may store computer-readable, computer-executable code including instructions that, when executed by the processor 1000, cause the processor 1000 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 1002 and/or the processor 1000 may be configured to execute computer-readable instructions stored in the memory 1004 to cause the processor 1000 to perform various functions. For example, the processor 1000 and/or the controller 1002 may be coupled with or to the memory 1004, the processor 1000, the controller 1002, and the memory 1004 may be configured to perform various functions described herein. In some examples, the processor 1000 may include multiple processors and the memory 1004 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.

[0091] The one or more ALUs 1006 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 1006 may reside within or on a processor chipset (e.g., the processor 1000). In some other implementations, the one or more ALUs 1006 may reside external to the processor chipset (e.g., the processor 1000). One or more ALUs 1006 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 1006 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 1006 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 1006 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 1006 to handle conditional operations, comparisons, and bitwise operations.

[0092] The processor 1000 may support wireless communication in accordance with examples as disclosed herein. The processor 1000 may be configured to or operable to support a means for receiving an uplink configuration; a means for applying a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and a means for transmitting the processed uplink data in physical resources based on the uplink configuration.

[0093] Figure 11 illustrates an example of a NE 1100 in accordance with aspects of the present disclosure. The NE 1100 may include a processor 1102, a memory 1104, a controller 1106, and a transceiver 1108. The processor 1102, the memory 1104, the controller 1106, or the transceiver 1108, 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.

[0094] The processor 1102, the memory 1104, the controller 1106, or the transceiver 1108, 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.

[0095] The processor 1102 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 1102 may be configured to operate the memory 1104. In some other implementations, the memory 1104 may be integrated into the processor 1102. The processor 1102 may be configured to execute computer-readable instructions stored in the memory 1104 to cause the NE 1100 to perform various functions of the present disclosure.

[0096] The memory 1104 may include volatile or non-volatile memory. The memory 1104 may store computer-readable, computer-executable code including instructions when executed by the processor 1102 cause the NE 1100 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 1104 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.

[0097] In some implementations, the processor 1102 and the memory 1104 coupled with the processor 1102 may be configured to cause the NE 1100 to perform one or more of the functions described herein (e.g., executing, by the processor 1102, instructions stored in the memory 1104). For example, the processor 1102 may support wireless communication at the NE 1100 in accordance with examples as disclosed herein. The NE 1100 may be configured to support a means for transmitting an uplink configuration; and a means for receiving uplink data in physical resources based on the uplink configuration, wherein the uplink data is processed by applying a multiplexing sequence based on the uplink configuration, and the multiplexing sequence is associated with a spreading factor.

[0098] The controller 1106 may manage input and output signals for the NE 1100. The controller 1106 may also manage peripherals not integrated into the NE 1100. In some

implementations, the controller 1106 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 1106 may be implemented as part of the processor 1102.

[0099] In some implementations, the NE 1100 may include at least one transceiver 1108. In some other implementations, the NE 1100 may have more than one transceiver 1108. The transceiver 1108 may represent a wireless transceiver. The transceiver 1108 may include one or more receiver chains 1110, one or more transmitter chains 1112, or a combination thereof.

[0100] A receiver chain 1110 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 1110 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 1110 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 1110 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 1110 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0101] A transmitter chain 1112 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 1112 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 1112 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 1112 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0102] 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 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.

[0103] At step 1201, the method may include receiving an uplink configuration. The operations of step 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 UE as described with reference to Figure 9.

[0104] At step 1203, the method may include applying a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor. The operations of step 1203 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1203 may be performed by a UE as described with reference to Figure 9.

[0105] At step 1205, the method may include transmitting the processed uplink data in physical resources based on the uplink configuration. The operations of step 1205 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1205 may be performed by a UE as described with reference to Figure 9.

[0106] 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.

[0107] Figure 13 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.

[0108] At step 1301, the method may include transmitting an uplink configuration. The operations of step 1301 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1301 may be performed by a NE as described with reference to Figure 11.

[0109] At step 1303, the method may include receiving uplink data in physical resources based on the uplink configuration, wherein the uplink data is processed by applying a multiplexing sequence based on the uplink configuration. The operations of step 1303 may be performed in accordance with examples as described herein. In some implementations,

aspects of the operations of step 1303 may be performed by a NE as described with reference to Figure 11.

[0110] 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.

[0111] 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 an uplink configuration;

apply a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and

transmit the processed uplink data in physical resources based on the uplink configuration.

2. The UE of claim 1, wherein applying the multiplexing sequence to process the uplink data comprises:

dividing samples of each transport block (TB) of the uplink data into a number of segments; and

applying the multiplexing sequence to process each segment of the uplink data, wherein each processed segment is spreaded with the spreading factor in time domain.

3. The UE of claim 2, wherein the number of segments is based on one or more of uplink data frequency domain allocation, a resource unit number or a slot number per each resource unit.

4. The UE of claim 2, wherein applying the multiplexing sequence to process each segment is based on a single slot level, a multi-slot level, a single sample level, a multi-sample level, a single symbol level or a multi-symbol level.

5. The UE of claim 1, wherein transmitting the processed uplink data in physical resources comprises:

repeatedly transmitting the processed uplink data with a first repetition number in a plurality of slots.

6. The UE of claim 5, wherein the first repetition number is based on a configured repetition number and the spreading factor.

7. The UE of claim 5, wherein transmitting the processed uplink data in physical resources comprises:

cyclically adopting two redundancy versions (RVs) across subblocks of the plurality of slots, wherein a length of each subblock is based on one or more of uplink data frequency domain allocation, a resource unit number, a slot number per each resource unit or the spreading factor.

8. The UE of claim 1, wherein the spreading factor is based on one or more of uplink data frequency domain allocation, a configured repetition number or a preconfigured spreading factor.

9. The UE of claim 1, wherein the uplink data comprises multiple transport blocks (TBs), and the at least one processor is configured to cause the UE to:

transmit the multiple TBs by an interleaved way, wherein each TB spans a duration of a number of slots determined by the spreading factor.

10. 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 an uplink configuration;

apply a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and

transmit the processed uplink data in physical resources based on the uplink configuration.

11. 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 an uplink configuration; and

receive uplink data in physical resources based on the uplink configuration, wherein the uplink data is processed by applying a multiplexing sequence based on the uplink configuration, and the multiplexing sequence is associated with a spreading factor.

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

receiving an uplink configuration;

applying a multiplexing sequence to process uplink data based on the uplink configuration, wherein the multiplexing sequence is associated with a spreading factor; and

transmitting the processed uplink data in physical resources based on the uplink configuration.