

METHOD AND APPARATUS OF UPLINK TRANSMISSIONS

TECHNICAL FIELD

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

BACKGROUND

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

SUMMARY

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

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

[0004] Some implementations of the methods and apparatuses described herein may further include a UE for wireless communication, which 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; and perform an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

[0005] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: apply, to the uplink transmission, the multiplexing sequence or each element of the multiplexing sequence beginning from a reference time slot.

[0006] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to: determine the applied duration based on a reference duration, wherein the reference duration configured by a high layer signaling.

[0007] In some implementations of the methods and apparatuses described herein, the uplink transmission includes one or more of a physical uplink shared channel (PUSCH) transmission or an uplink reference signal transmission, and wherein the at least one processor is configured to cause the UE to: determine the applied duration based on one or more of a repetition number of the uplink transmission, a number of resource unit of the uplink transmission, or a number of slots per resource unit of the uplink transmission.

[0008] In some implementations of the methods and apparatuses described herein, the applied duration includes a maximum value of the reference duration scaled by a first factor $1/M1$ and smaller than or equal to a total duration of the uplink transmission.

[0009] In some implementations of the methods and apparatuses described herein, M1 is a length of the multiplexing sequence or maximum multiplexing number of devices or a multiple of the length of the multiplexing sequence or maximum multiplexing number of devices.

[0010] In some implementations of the methods and apparatuses described herein, the applied duration includes a maximum value of the reference duration scaled by a first factor $1/M1$ and smaller than or equal to a total duration of the uplink transmission scaled by a second factor $1/M2$.

[0011] In some implementations of the methods and apparatuses described herein, M1 is equal to a length or multiplexing number of the multiplexing sequence or a multiple of the length or multiplexing number of the multiplexing sequence, and M2 is larger than one.

[0012] In some implementations of the methods and apparatuses described herein, the applied duration is equal to the reference duration.

[0013] In some implementations of the methods and apparatuses described herein, the uplink transmission is a PUSCH transmission, and the at least one processor is configured to cause the UE to receive a control signal scheduling or activating the uplink transmission, wherein a time offset between the control signal and the uplink transmission is determined by a delay field in the control signal.

[0014] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to postpone the uplink transmission to a slot of latest boundary of the multiplexing sequence or latest boundary of any element of multiplexing sequence based on the time offset.

[0015] In some implementations of the methods and apparatuses described herein, the time offset is associated with a unit of the applied duration of the multiplexing sequence or each element of the multiplexing sequence, or associated with a unit of the reference duration for determining the applied duration.

[0016] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to determine an index of the multiplexing

sequence applied to the uplink transmission based on a high layer parameter, or a UE identifier (ID) related information, or a sequence index offset value indicated by a control signal scheduling or activating the uplink transmission.

[0017] In some implementations of the methods and apparatuses described herein, the sequence index offset value is indicated by a field of the control signal.

[0018] In some implementations of the methods and apparatuses described herein, the reference duration is based on a resource unit of the uplink transmission.

[0019] In some implementations of the methods and apparatuses described herein, the uplink transmission is an uplink preamble, wherein the applied duration includes the reference duration, and wherein the reference duration is configured as duration of a repetition number of the uplink preamble scaled by a factor, or duration of one or more repetitions of the uplink preamble, or duration of one or more symbol groups of the uplink preamble.

[0020] In some implementations of the methods and apparatuses described herein, the at least one processor is configured to cause the UE to start or restart the multiplexing sequence during each physical random access channel (PRACH) period or each N_p PRACH period, wherein N_p is configured by a high layer signaling.

[0021] In some implementations of the methods and apparatuses described herein, the multiplexing sequence is cyclically applied to the uplink transmission.

[0022] Some implementations of the methods and apparatuses described herein may further include a processor for wireless communication, which may include: at least one controller coupled with at least one memory and configured to cause the at least one processor to: receive an uplink configuration; and perform an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

[0023] 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 perform an uplink reception based on the uplink configuration and a multiplexing sequence applied to the uplink reception, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink reception for an applied duration.

[0024] Some implementations of the methods and apparatuses described herein may further include a method performed by a UE, which may include: receiving an uplink configuration; and performing an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

BRIEF DESCRIPTION OF THE DRAWINGS

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

[0026] Figure 2 is an example of uplink transmissions in accordance with aspects of the present disclosure.

[0027] Figure 3 is another example of uplink transmissions in accordance with aspects of the present disclosure.

[0028] Figure 4 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0029] Figure 5 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0030] Figure 6 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0031] Figure 7 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0032] Figure 8 illustrates an example of a UE in accordance with aspects of the present disclosure.

[0033] Figure 9 illustrates an example of a processor in accordance with aspects of the present disclosure.

[0034] Figure 10 illustrates an example of a NE in accordance with aspects of the present disclosure.

[0035] Figure 11 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0036] Figure 12 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0037] 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.

[0038] 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 a 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 perform an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration. The multiplexing sequence may differentiate between UEs multiplexed at a same time-frequency resource, which may result in improvement of throughput (e.g., capacity) in an uplink.

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

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

[0041] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE

104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

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

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

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

[0045] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations,

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

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

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

[0048] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the

NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0049] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) 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.

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

[0051] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$,

$\mu=4$) 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.

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

[0053] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), 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.

[0054] In accordance with aspects of the present disclosure, uplink transmissions 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 will be applied for the uplink transmissions (cyclically if necessary) to differentiate UEs, e.g., beginning from a reference time slot (or an absolute slot, e.g., slot#0). 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.

[0055] An exemplary uplink transmission for which a multiplexing sequence is applied may include one or more of PUSCH transmission (or referred to as PUSCH or the like); or an uplink reference signal transmission, e.g., demodulation reference signals (DMRSs) for PUSCH, or an uplink preamble, e.g., a preamble of random access channel (RACH) (or physical random access channels (PRACH)) etc. Taking IoT NTN especially for narrowband (NB) IoT (NB-IoT) as an example, an uplink transmission may be a NB-IoT PUSCH (NPUSCH), e.g., NPUSCH format 1 (which is for uplink data not for feedback information), or a NB-IoT PRACH (NPRACH), e.g., the preamble of NPRACH, or a NPUSCH DMRS, which is a special type of physical layer signal which functions as a reference signal for decoding NPUSCH.

[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. An exemplary multiplexing sequence has a length of 2, 4, or 8. 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).

[0057] In order to avoid potential collision in PUSCH transmissions or the like, the network side, e.g., gNB may adjust the multiplexing sequence index for UE by a sequence index offset, e.g., Δ (indicated in a control signal or signaling) to avoid the potential collision with other UEs (with the same sequence index based on the predefined rule or UE ID related information). For example, the network side may dynamically adjust the multiplexing sequence index for UE by a sequence index offset Δ by a field in DCI scheduling or activating an uplink transmission, e.g., a PUSCH transmission or the like.

[0058] In some implementations of the present disclosure, the existing field of DCI, e.g., redundancy version (RV) field in DCI format N0 may be used for indicating a value of the sequence index offset applied to the multiplexing sequence index, especially for the uplink transmission with a repetition number larger than 2. An exemplary RV field may indicate the RV as legacy LTE NB-IoT system and sequence index offset value, or the RV field may only indicate the sequence index offset value where RV is default as RV0 (e.g., in the case of the repetition number being 2, that is the RV field functions as the sequence index offset indication). An exemplary indication of sequence index offset values in the case of the repetition number being larger than 1 is: (RV0, RV2, RV0, RV2...) or {RV2, RV0, RV2, RV0 ...}, which are cyclically applied for a NPUSCH transmission where RV field indication only determines RV0 first or RV2 first, and the RV indication seems not necessary.

[0059] Table 1 is an exemplary Hadamard sequence for generation of a multiplexing sequence, which is based on a 4*4 matrix. It is supposed $a=(C-RNTI + \Delta)$ mode 4, wherein "a" is the sequence index for generating the multiplexing sequence, sequence index offset value Δ is 0 or 1. For example, in the case that the RV field or the like in the DCI scheduling or activating the uplink transmission indicates 0, it means $\Delta=0$, and in the case that the RV field or the like indicates 1, it means $\Delta=1$. Besides the RV field, other fields such as modulation and coding scheme (MCS), new data indicator (NDI), or repetition number field or some combination above can also reuse to indicate the sequence index offset value with certain conditions. $v(0)$, $v(1)$, $v(2)$ and $v(3)$ are elements of the multiplexing sequence $v(a)$, wherein $v(0)$ is the first element of the multiplexing sequence $v(a)$.

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

[0060] Each element of the multiplexing sequence adopted to the uplink transmission will last for a duration (hereinafter, an applied duration), e.g., V . For simplification, either "each element of the multiplexing sequence" or "multiplexing sequence" will be used, wherein the corresponding applied duration based on the multiplexing sequence is 4 multiple of that based on the element of the multiplexing sequence in the case of the length of the multiplexing sequence being 4. In addition, the duration may be absolute time, e.g., 20ms or 30ms, or 20 uplink slots or 30 uplink subframes; or may be the transmission time of a number of, e.g., 20 available uplink subframes or slots. Regarding the available uplink subframes or slots, it means the subframes or slots for uplink transmission configured by gNB excluding those configured as "invalid" or "reserved." That is, the multiplexing sequence is also based on the applied duration. The applied duration may be dynamically changed, e.g., due to channel condition changes and/or uplink transmission duration changes etc., and it is difficult to pre-configure the value of the applied duration by eNB before uplink transmission. Considering that, in accordance with aspects of the present disclosure, UE will determine the applied duration based on a reference duration, e.g., V_{ref} , which may be configured by high layer signaling, e.g., RRC signaling. The applied duration may be the same as or different from the reference duration. In the case that the UE is in persistent or semi-persistent state, e.g., moving at low speed, the channel conditions will be deemed as stable and the uplink transmission time is relatively stable. Accordingly, the applied duration will be equal to be the reference time and does not need dynamic changes. More details on the applied duration and reference duration will be illustrated in the follow respectively in view of exemplary

uplink shared data transmission, e.g., PUSCH transmission and/or uplink reference signal transmission, and exemplary uplink preamble transmission, e.g., NPRACH transmission.

[0061] In the case that the uplink transmission is a PUSCH transmission or an uplink reference signal transmission or the like, an exemplary reference duration may be based on a resource unit (RU) of the uplink transmission. For example, there are multiple candidate sets based on a resource unit of the uplink transmission, e.g., Set 1: 2^x , or Set 2: $3 \cdot 2^x$, or Set 3: $5 \cdot 2^x$, x is a nature number larger than 1, e.g., $x=1, 2, 3 \dots$ considering that the number of resource unit, e.g., $N_{ru} = \{1, 2, 3, 4, 5, 6, 8, 10\}$, and the reference duration will be configured as a set from the multiple candidate sets. For example, if N_{ru} configured for UE is 5 or 10, then the gNB will configure the reference duration from Set 3: $5 \cdot 2^x$. The network side, e.g., gNB will try to schedule the UE with a proper N_{ru} to make UEs with the same reference duration multiplexed in the same physical resource. In some other implementations of the present disclosure, the reference duration may be configured in other manners.

[0062] Based on the reference duration, UE may determine the applied duration further based on one or more of a repetition number of the uplink transmission, e.g., N_{rep} , the number of RU of the uplink transmission, e.g., N_{ru} , or the number of slots per resource unit of the uplink transmission, e.g., N_{slot} .

[0063] For example, in some implementations of the present disclosure, the applied duration is the maximum value of the reference duration scaled by a factor $1/MI$, which is smaller than or equal to the total duration of the uplink transmission, e.g., $V = V_{ref}/MI \leq N_{rep} \cdot N_{ru} \cdot N_{slot}$. MI is the length of the multiplexing sequence, e.g., L or the maximum multiplexing number of devices (e.g., UE), or a multiple of the length of the multiplexing sequence or maximum multiplexing number of devices. That is, $MI = L \cdot N$, N is the multiple, $N \geq 1$ in the case of MI based on the length of the multiplexing sequence. Optionally MI can be configured by higher layer or predefined as other parameters. In some cases, the applied duration is equals to the reference duration, e.g., in the case that the reference duration is smaller than or equal to the total uplink transmission duration. That is, the reference duration is not scaled or it is assumed that the scale factor $1/MI$ is equal to 1.

[0064] Figure 2 is an example of uplink transmissions in accordance with aspects of the present disclosure.

[0065] Referring to Figure 2, it is assumed that the multiplexing sequences applied to the uplink transmissions from UE1 and UE2 are the OCC sequences shown in Table 1, wherein the length of the multiplexing sequence, e.g., L is 4. Both UE1 and UE2 are configured with a reference duration, e.g., $V_{ref}=2048$ slots, for a PUSCH transmission, e.g., by higher parameters. It is assumed that all the 2048 slots are valid. In the case that each slot is 0.5ms for 15KHz system, the 2048 slots will be 1024ms. However, the applied duration of uplink transmission from UE1 is equal to the reference duration because the uplink transmission of UE1 is larger than the reference duration, and the applied duration of uplink transmission from UE2 is to be determined based on $V=V_{ref}/M1 \leq N_{rep} \cdot N_{ru} \cdot N_{slot}$. It is assumed that N_{rep} is 2, N_{ru} is 6 and N_{slot} is 16 for the PUSCH transmission of UE2. Thus, the total duration of the PUSCH transmission of UE2 is $N_{rep} \cdot N_{ru} \cdot N_{slot}=192$ slot. Then, the applied duration of UE2 is $V=V_{ref}/M1 \leq N_{rep} \cdot N_{ru} \cdot N_{slot}=192$ slots. In the case that $M1$ is a multiple of the length of the applied multiplexing sequence, $M1=L \cdot N$, $L=4$, $N=2$ will be achieve the maximum value meeting the requirement of smaller than the total uplink transmission.

[0066] In some other implementations of the present disclosure, the total duration of the uplink transmission may also be scaled by a factor, e.g., $1/M2$, which can balance the trade-off early data detection at the network side. The applied duration is the maximum value of the reference duration scaled by the factor $1/M1$, which is smaller than or equal to the total duration of the uplink transmission scaled by the factor $1/M2$. $M2$ is larger than one, e.g., $V=V_{ref}/M1 \leq N_{rep} \cdot N_{ru} \cdot N_{slot}/M2$.

[0067] Figure 3 is another example of uplink transmissions in accordance with aspects of the present disclosure.

[0068] Referring to Figure 3, it is also assumed that the multiplexing sequences applied to the uplink transmissions from UE1 and UE2 are the OCC sequences shown in Table 1, wherein the length of the multiplexing sequence, e.g., L is 4. Both UE1 and UE2 are configured with a reference duration, e.g., $V_{ref}=2048$ slots, for a PUSCH transmission, e.g., by higher parameters. However, the applied duration of uplink transmission from UE1 is equal to the reference duration, and the applied duration of uplink transmission from UE2 is to be determined based on $V=V_{ref}/M1 \leq N_{rep} \cdot N_{ru} \cdot N_{slot}/M2$. It is assumed that N_{rep} is 2,

N_{ru} is 6 and N_{slot} is 16 for the PUSCH transmission of UE2, and $M2$ is 4. Thus, the scaled total duration of the PUSCH transmission of UE2 is $N_{rep} * N_{ru} * N_{slot} / 4 = 48$ slots. Then, the applied duration of UE2 is $V = V_{ref} / M1 \leq N_{rep} * N_{ru} * N_{slot} / 4 = 48$ slots. In the case that $M1$ is a multiple of the length of the applied multiplexing sequence, $M1 = L^N$, $L=4$, $N=3$ will achieve the maximum value meeting the requirement of smaller than the total uplink transmission scaled by the factor $1/M2$.

[0069] In the case that the UL transmission is an uplink preamble, e.g., RACH preamble, all UEs in the configured RACH resource transmit the uplink preamble with the same repetition number. It does not need to consider the lattice structure of multiplexing UEs. The applied duration V is equal to V_{ref} , and is configured as the duration of a repetition number of the uplink preamble scaled by a factor, e.g., $1/M3$, or duration of one or more repetitions of the uplink preamble, or duration of one or more symbol groups of the uplink preamble (e.g., about 1.4 or 1.6ms). For example, for coverage level 0, the preamble repetition number is configured as 16, the scaling factor $1/M3$ is configured as $1/2$, and then the applied duration V will be 8 repetitions and each element of the multiplexing sequence applied to the preamble with 2 repetitions. The multiplexing sequence will start or restarted in each NPRACH period or each N_p PRACH period, wherein N_p is configured by higher layer parameter.

[0070] Figure 4 and Figure 5 are respectively yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0071] Referring to Figures 4 and 5, it is also assumed that the multiplexing sequences applied to the uplink transmissions from UE1 and UE2 are the OCC sequences shown in Table 1. In Figure 4, the scaling factor $1/M3$ is $1/3$, and the multiplexing sequence cyclically applied to the preambles will start in each NPRACH period. In Figure 5, the scaling factor $1/M3$ is $1/5$, and the multiplexing sequence cyclically applied to the preambles will start in the first NPRACH period and restart in each following NPRACH period.

[0072] In some scenarios, in order to align the uplink transmissions of multiplexing UEs, e.g., to avoid the orthogonality of OCC sequences applied to different UEs, the time offset between the control signal scheduling or activating the uplink transmission and the corresponding uplink transmission, e.g., PDCCH scheduling or activating the PUSCH and the scheduled or activated PUSCH will be enhanced in accordance with aspects of the present

disclosure. An exemplary time offset is indicated in a field (hereinafter, a delay field) in the control signal, e.g., in a field of DCI of the PDCCH.

[0073] In some implementations of the present disclosure, based on the time offset, UE will postpone the PUSCH transmission to the slot of the latest boundary of the multiplexing sequence or the latest boundary of any element of the multiplexing sequence. The boundary of the multiplexing sequence or the boundary of any element of the multiplexing sequence will assume the multiplexing sequence starts from a reference slot (e.g., slot 0), and the multiplex sequence will be cyclically in all valid slot.

[0074] Figure 6 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0075] Referring to Figure 6, it is also assumed that the multiplexing sequences applied to the uplink transmissions from UE1, UE2 and UE3 are the OCC sequences shown in Table 1. All of UE1, UE2 and UE3 will receive the DCI scheduling a PUSCH transmission in a reference slot, e.g., slot#0 or subframe #0, and the PUSCHs scheduled by DCI will start in slot #0 plus a time offset indicated in the corresponding DCI. Since based on the scheduled time offset, the PUSCHs from UE1 will not start the boundary of any element of the multiplexing sequence, UE1 will postpone the PUSCH transmission to the latest boundary of element (e.g., boundary of $v(1)$) of the multiplexing sequence. Similarly, UE2 will also postpone the PUSCH transmission to the start boundary of element of $v(1)$ of the corresponding multiplexing sequence, and UE3 will postpone the PUSCH transmission to the start boundary of element of $v(2)$ of the corresponding multiplexing sequence.

[0076] In some other implementations of the present disclosure, the time offset between the control signal and the corresponding uplink transmission, e.g., the time offset between the PDCCH and the PUSCH scheduled or activated by the PUCCH is associated with the unit of the applied duration of the multiplexing sequence or each element of the multiplexing sequence, or associated with the unit of the reference duration. An exemplary time offset will be indicated by the DCI of the PDCCH, e.g., by using 2 bits, which indicates the scheduling delay, e.g., I_{Delay} of the k^{th} applied duration after the end of the DCI plus a fixed time duration (e.g., 8ms) as illustrated in Table 2. For example, "00" may be used to indicate I_{Delay} is "0"

for $k^{th}=0$, "01" may be used to indicate I_{Delay} is "1" for $k^{th}=2$, "10" may be used to indicate I_{Delay} is "2" for $k^{th}=4$, and "11" may be used to indicate I_{Delay} is "3" for $k^{th}=8$.

Table 2

I_{Delay}	k^{th}
0	1
1	2
2	4
3	8

[0077] Figure 7 is yet another example of uplink transmissions in accordance with aspects of the present disclosure.

[0078] Referring to Figure 7, it is also assumed that the multiplexing sequences applied to the uplink transmissions from UE1, UE2 and UE3 are the OCC sequences shown in Table 1. The time offset in DCI for UE1 may indicate the scheduling delay of the $k^{th}=1^{st}$ applied duration of 8ms after the end of DCI, the time offset in DCI for UE2 may indicate the scheduling delay of the $k^{th}=2^{nd}$ applied duration of 8ms after the end of DCI, and the time offset in DCI for UE3 may also indicate the scheduling delay of the $k^{th}=1^{st}$ applied duration of 8ms after the end of DCI. Accordingly, UE1 will postpone the PUSCH from UE1 to the start boundary of $v(1)$ of the corresponding multiplexing sequence, UE2 will postpone the PUSCH from UE2 to the start boundary of $v(2)$ of the corresponding multiplexing sequence, and UE3 will postpone the PUSCH from UE3 to the start boundary of $v(2)$ of the corresponding multiplexing sequence.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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 an uplink configuration, and means for supporting performing an uplink transmission based on the uplink configuration and a multiplexing sequence

applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

[0084] 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.

[0085] 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.

[0086] 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.

[0087] 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.

[0088] 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).

[0089] 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).

[0090] 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.

[0091] 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.

[0092] 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).

[0093] 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.

[0094] 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.

[0095] 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 a means for receiving an uplink configuration, and means for supporting performing an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

[0096] 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.

[0097] 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.

[0098] 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.

[0099] 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.

[0100] 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 an uplink configuration; and means for performing an uplink reception based on the uplink configuration and a multiplexing sequence applied to the uplink reception, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink reception for an applied duration.

[0101] 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.

[0102] 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.

[0103] 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.

[0104] 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.

[0105] 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.

[0106] At step 1101, the method may include receiving an uplink configuration. The operations of step 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.

[0107] At step 1103, the method may include performing an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration. The operations of step 1103 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of step 1103 may be performed by a UE as described with reference to Figure 8.

[0108] 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.

[0109] 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.

[0110] At step 1201, the method may include transmitting 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 step 1201 may be performed by a NE as described with reference to Figure 10.

[0111] At step 1203, the method may include perform an uplink reception based on the uplink configuration and a multiplexing sequence applied to the uplink reception, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink reception for an applied duration. 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 NE as described with reference to Figure 10.

[0112] 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.

[0113] 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; and
 - perform an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.
2. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
 - apply, to the uplink transmission, the multiplexing sequence or each element of the multiplexing sequence beginning from a reference time slot.
3. The UE of claim 1, wherein the at least one processor is configured to cause the UE to:
 - determine the applied duration based on a reference duration,
 - wherein the reference duration configured by a high layer signaling.
4. The UE of claim 3, wherein, the uplink transmission comprises one or more of a physical uplink shared channel (PUSCH) transmission or an uplink reference signal transmission, and wherein the at least one processor is configured to cause the UE to:
 - determine the applied duration based on one or more of a repetition number of the uplink transmission, a number of resource unit of the uplink transmission, or a number of slots per resource unit of the uplink transmission.

5. The UE of claim 4, wherein the applied duration comprises a maximum value of the reference duration scaled by a first factor $1/M1$ and smaller than or equal to a total duration of the uplink transmission.

6. The UE of claim 5, wherein $M1$ is a length of the multiplexing sequence or maximum multiplexing number of devices or a multiple of the length of the multiplexing sequence or maximum multiplexing number of devices.

7. The UE of claim 4, wherein the applied duration comprises a maximum value of the reference duration scaled by a first factor $1/M1$ and smaller than or equal to a total duration of the uplink transmission scaled by a second factor $1/M2$.

8. The UE of claim 7, wherein $M1$ is equal to a length or multiplexing number of the multiplexing sequence or a multiple of the length or multiplexing number of the multiplexing sequence, and $M2$ is larger than one.

9. The UE of claim 4, wherein the applied duration is equal to the reference duration.

10. The UE of claim 1, wherein the uplink transmission is a physical uplink shared channel (PUSCH) transmission, and the at least one processor is configured to cause the UE to receive a control signal scheduling or activating the uplink transmission, wherein a time offset between the control signal and the uplink transmission is determined by a delay field in the control signal.

11. The UE of claim 10, wherein the at least one processor is configured to cause the UE to postpone the uplink transmission to a slot of latest boundary of the multiplexing sequence or latest boundary of any element of multiplexing sequence based on the time offset.

12. The UE of claim 10, wherein the time offset is associated with a unit of the applied duration of the multiplexing sequence or each element of the multiplexing sequence, or associated with a unit of the reference duration for determining the applied duration.

13. The UE of claim 1, wherein the at least one processor is configured to cause the UE to determine an index of the multiplexing sequence applied to the uplink transmission based on a high layer parameter, or a UE identifier (ID) related information, or a sequence index offset value indicated by a control signal scheduling or activating the uplink transmission.

14. The UE of claim 13, wherein the sequence index offset value is indicated by a field of the control signal.

15. The UE of claim 3, wherein the uplink transmission is an uplink preamble, wherein the applied duration comprises the reference duration, and wherein the reference duration is configured as duration of a repetition number of the uplink preamble scaled by a factor, or duration of one or more repetitions of the uplink preamble, or duration of one or more symbol groups of the uplink preamble.

16. The UE of claim 15, wherein the at least one processor is configured to cause the UE to start or restart the multiplexing sequence during each physical random access channel (PRACH) period or each N_p PRACH period, wherein N_p is configured by a high layer signaling.

17. The UE of claim 1, wherein the multiplexing sequence is cyclically applied to the uplink transmission.

18. 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; and

perform an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.

19. A network equipment (NE) for wireless communication, comprising:
at least one memory; and
at least one processor coupled with the at least one memory and configured to cause the NE to:

transmit an uplink configuration; and

perform an uplink reception based on the uplink configuration and a multiplexing sequence applied to the uplink reception, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink reception for an applied duration.

20. A method performed by a user equipment (UE), comprising:
receiving an uplink configuration; and
performing an uplink transmission based on the uplink configuration and a multiplexing sequence applied to the uplink transmission, wherein the multiplexing sequence or each element of the multiplexing sequence is applicable to the uplink transmission for an applied duration.