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Inventor(s)	MAAMARI; Diana et al.

VISIBLE INTERRUPTION LENGTH CONSIDERATIONS FOR CONFIGURED GRANT TRANSMISSION OCCASIONS

Abstract

Methods, systems, and devices for wireless communications are described. The techniques herein relate to visible interruption length considerations for configured grant (CG) transmission occasions (TOs). A user equipment (UE) receives a control message indicating a CG configuration, the CG configuration includes multiple uplink TOs within a time period. The UE transmits, using at least one of the multiple uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the multiple uplink TOs. The indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality uplink TOs that at least partially overlap with one or more interruption durations associated with a measurement duration.

Inventors: **MAAMARI; Diana (San Diego, CA), XU; Huilin (Temecula, CA), HE; Linhai (San Diego, CA), KADIRI; Prasad Reddy (San Diego, CA)**

Applicant: **QUALCOMM Incorporated** (San Diego, CA)

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Background/Summary

FIELD OF TECHNOLOGY

[0001] The following relates to wireless communications, including visible interruption length considerations for configured grant transmission occasions.

BACKGROUND

[0002] Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (e.g., time, frequency, and power). Examples of such multiple-access systems include fourth generation (4G) systems such as Long Term Evolution (LTE) systems, LTE-Advanced (LTE-A) systems, or LTE-A Pro systems, and fifth generation (5G) systems which may be referred to as New Radio (NR) systems. These systems may employ technologies such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), or discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM). A wireless multiple-access communications system may include one or more base stations, each supporting wireless communication for communication devices, which may be known as user equipment (UE).

SUMMARY

[0003] The described techniques relate to improved methods, systems, devices, and apparatuses that support visible interruption length (VIL) considerations for configured grant (CG) transmission occasions (TOs). In some aspects, the described techniques provide for efficiently reducing overhead associated with signaling an indication of unused TOs. For example, the UE may receive a control message indicating a CG configuration that is associated with multiple uplink physical uplink shared channel (PUSCH) TOs. The UE may define one or more of the PUSCH TOs that collide with (e.g., at least partially overlap with) one or more visible interruption lengths (VILs) (e.g., interruption periods) as invalid. By defining the colliding PUSCH TOs as invalid, the UE may remove bits that would otherwise be used to indicate such PUSCH TOs in uplink control information (UCI) as unused TOs (e.g., via an unused TO indicated by uplink control information (UTO-UCI)), thereby reducing a size of the UCI message and reducing signaling overhead. Put another way, the UTO-UCI may exclude one or more uplink TOs that at least partially overlap with a VIL. Further, a UE may exclude such invalid occasions when determining a hybrid automatic repeat request (HARQ) identifier (ID) of one or more feedback processes to increase an efficiency in HARQ ID management.

[0004] A method for wireless communication by a user UE is described. The method may include receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period and transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an UCI message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

[0005] A UE for wireless communication is described. The UE may include one or more memories storing processor executable code, and one or more processors coupled with the one or more memories. The one or more processors may individually or collectively be operable to execute the code to cause the UE to receive a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period and transmit, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an UCI message including an indication of a quantity of unused uplink TOs of the set of multiple uplink

TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.
[0006] Another UE for wireless communication is described. The UE may include means for receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period and means for transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an UCI message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.
[0007] A non-transitory computer-readable medium storing code for wireless communication is described. The code may include instructions executable by one or more processors to receive a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period and transmit, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an UCI message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.
[0008] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting one or more acknowledgment or negative acknowledgment messages in accordance with an ID, the ID may be based on a first uplink shared channel occasion corresponding to a first uplink TO of the set of multiple uplink TOs, where the ID may be further based on the quantity of unused uplink TOs excluded from the indication.
[0009] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for receiving a second control message indicating a configuration of a measurement gap pattern, where the one or more interruption durations may be based on the measurement gap pattern.
[0010] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the one or more interruption durations include one or more VILs associated with a network controlled small gap.
[0011] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the UCI message may be multiplexed with each of one or more uplink shared channel messages that may be transmitted during one or more valid uplink TOs.
[0012] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the one or more interruption durations may be associated with inter-band measurements or intra-band measurement in a time division duplexing band.
[0013] Some examples of the method, UEs, and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for determining to exclude the one or more invalid uplink TOs based on a collision of the one or more uplink TOs with the one or more interruption durations, and where the measurement duration corresponds to a synchronization signal measurement timing configuration window.
[0014] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the one or more uplink TOs partially overlap or completely overlap with the one or more interruption durations in a time domain.
[0015] In some examples of the method, UEs, and non-transitory computer-readable medium described herein, the UCI message includes a bitmap indicating exclusion of the one or more invalid uplink TOs.
[0016] In some examples of the method, UEs, and non-transitory computer-readable medium

described herein, the UCI message includes a bitmap including one or more first bits indicating a first subset of the set of multiple uplink TOs including the quantity of unused uplink TOs and one or more second bits indicating a second subset of the set of multiple uplink TOs including a quantity of used uplink TOs.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** shows an example of a wireless communications system that supports visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0018] FIG. **2** shows an example of a wireless communications system that supports visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0019] FIG. **3** shows an example of a process flow that supports visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0020] FIGS. **4** and **5** show block diagrams of devices that support visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0021] FIG. **6** shows a block diagram of a communications manager that supports visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0022] FIG. **7** shows a diagram of a system including a device that supports visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

[0023] FIGS. **8** through **11** show flowcharts illustrating methods that support visible interruption length considerations for configured grant transmission occasions in accordance with one or more aspects of the present disclosure.

DETAILED DESCRIPTION

[0024] A network entity may indicate multiple physical uplink shared channel (PUSCH) occasions during a configured grant (CG) period in which a UE may transmit uplink signaling (e.g., one or more uplink CG PUSCH transmission occasions (TOs)). However, the UE may not have enough pending data to use all of the PUSCH TOs, in which case the UE may transmit an uplink control information (UCI) message including a bitmap indicating which PUSCH TOs are unused (e.g., skipped) by the UE. This may be referred to as an unused TO indicated by uplink control information (UTO-UCI) and may enable enhanced resource usage in the network, for example, when the network reallocates unused resources for other communications. Additionally, the UE and the network entity may consider some PUSCH occasions as invalid (e.g., due to collisions with other signaling). Because both the UE and the network entity can determine which PUSCH occasions are invalid, the UE may not include the invalid resources in the bitmap, reducing the size of the bitmap and reducing signaling overhead. This may result in improved throughput, decreased signaling overhead, among other advantages. However, additional scenarios may also render the PUSCH occasions invalid. For example, a network entity may configure measurements that include interruption periods associated with measurement gaps (e.g., visible interruption length (VIL) durations that correspond to a measurement length for network-controlled small gap (NCSG) configurations), such that the UE may not transmit (e.g., uplink messages in the scheduled PUSCH TOs) during these interruption periods.

[0025] As described herein, a UE may support techniques for defining PUSCH TOs that collide with VILs (e.g., interruption periods) as invalid. By defining such colliding TOs as invalid, the UE may remove bits that would otherwise indicate such PUSCH TOs in UCI (e.g., UTO-UCI), reducing a size of the UCI message, as well as reducing signaling overhead. That is, the UE may exclude one or more PUSCH TOs that collide with (e.g., at least partially overlap with) respective VILs from a UTO-UCI transmission. Further, a UE may exclude such invalid occasions when determining a hybrid automatic repeat request (HARQ) identifier (ID) of one or more feedback processes to increase an efficiency in HARQ ID management.

[0026] Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects of the disclosure are further illustrated by and described with reference to process flows, apparatus diagrams, system diagrams, and flowcharts that relate to VIL considerations for CG TOs.

[0027] FIG. **1** shows an example of a wireless communications system **100** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The wireless communications system **100** may include one or more devices, such as one or more network devices (e.g., network entities **105**), one or more UEs **115**, and a core network **130**. In some examples, the wireless communications system **100** may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an LTE-A Pro network, a New Radio (NR) network, or a network operating in accordance with other systems and radio technologies, including future systems and radio technologies not explicitly mentioned herein.

[0028] The network entities **105** may be dispersed throughout a geographic area to form the wireless communications system **100** and may include devices in different forms or having different capabilities. In various examples, a network entity **105** may be referred to as a network element, a mobility element, a radio access network (RAN) node, or network equipment, among other nomenclature. In some examples, network entities **105** and UEs **115** may wirelessly communicate via communication link(s) **125** (e.g., a radio frequency (RF) access link). For example, a network entity **105** may support a coverage area **110** (e.g., a geographic coverage area) over which the UEs **115** and the network entity **105** may establish the communication link(s) **125**. The coverage area **110** may be an example of a geographic area over which a network entity **105** and a UE **115** may support the communication of signals according to one or more radio access technologies (RATs).

[0029] The UEs **115** may be dispersed throughout a coverage area **110** of the wireless communications system **100**, and each UE **115** may be stationary, or mobile, or both at different times. The UEs **115** may be devices in different forms or having different capabilities. Some example UEs **115** are illustrated in FIG. **1**. The UEs **115** described herein may be capable of supporting communications with various types of devices in the wireless communications system **100** (e.g., other wireless communication devices, including UEs **115** or network entities **105**), as shown in FIG. **1**.

[0030] As described herein, a node of the wireless communications system **100**, which may be referred to as a network node, or a wireless node, may be a network entity **105** (e.g., any network entity described herein), a UE **115** (e.g., any UE described herein), a network controller, an apparatus, a device, a computing system, one or more components, or another suitable processing entity configured to perform any of the techniques described herein. For example, a node may be a UE **115**. As another example, a node may be a network entity **105**. As another example, a first node may be configured to communicate with a second node or a third node. In one aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a UE **115**. In another aspect of this example, the first node may be a UE **115**, the second node may be a network entity **105**, and the third node may be a network entity **105**. In yet other aspects of this example, the first, second, and third nodes may be different relative to these examples. Similarly, reference to a UE **115**, network entity **105**, apparatus, device, computing system, or the like may include disclosure of the UE **115**, network entity **105**, apparatus, device, computing system, or the like being a node. For example, disclosure that a UE **115** is configured to receive information from a network entity **105** also discloses that a first node is configured to receive information from a second node.

[0031] In some examples, network entities **105** may communicate with a core network **130**, or with one another, or both. For example, network entities **105** may communicate with the core network **130** via backhaul communication link(s) **120** (e.g., in accordance with an S1, N2, N3, or other interface protocol). In some examples, network entities **105** may communicate with one another via backhaul communication link(s) **120** (e.g., in accordance with an X2, Xn, or other interface protocol) either directly (e.g., directly between network entities **105**) or indirectly (e.g., via the core network **130**). In some examples, network entities **105** may communicate with one another via a midhaul communication link **162** (e.g., in accordance with a midhaul interface protocol) or a fronthaul communication link **168** (e.g., in accordance with a fronthaul interface protocol), or any combination thereof. The backhaul communication link(s) **120**, midhaul communication links **162**, or fronthaul communication links **168** may be or include one or more wired links (e.g., an electrical link, an optical fiber link) or one or more wireless links (e.g., a radio link, a wireless optical link), among other examples or various combinations thereof. A UE **115** may communicate with the core network **130** via a communication link **155**.

[0032] One or more of the network entities **105** or network equipment described herein may include or may be referred to as a base station **140** (e.g., a base transceiver station, a radio base station, an NR base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation NodeB or giga-NodeB (either of which may be referred to as a gNB), a 5G NB, a next-generation eNB (ng-eNB), a Home NodeB, a Home eNodeB, or other suitable terminology). In some examples, a network entity **105** (e.g., a base station **140**) may be implemented in an aggregated (e.g., monolithic, standalone) base station architecture, which may be configured to utilize a protocol stack that is physically or logically integrated within one network entity (e.g., a network entity **105** or a single RAN node, such as a base station **140**).

[0033] In some examples, a network entity **105** may be implemented in a disaggregated architecture (e.g., a disaggregated base station architecture, a disaggregated RAN architecture), which may be configured to utilize a protocol stack that is physically or logically distributed among multiple network entities (e.g., network entities **105**), such as an integrated access and backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity **105** may include one or more of a central unit (CU), such as a CU **160**, a distributed unit (DU), such as a DU **165**, a radio unit (RU), such as an RU **170**, a RAN Intelligent Controller (RIC), such as an RIC **175** (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, such as an SMO system **180**, or any combination thereof. An RU **170** may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities **105** in a disaggregated RAN architecture may be co-located, or one or more components of the network entities **105** may be located in distributed locations (e.g., separate physical locations). In some examples, one or more of the network entities **105** of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0034] The split of functionality between a CU **160**, a DU **165**, and an RU **170** is flexible and may support different functionalities depending on which functions (e.g., network layer functions, protocol layer functions, baseband functions, RF functions, or any combinations thereof) are performed at a CU **160**, a DU **165**, or an RU **170**. For example, a functional split of a protocol stack may be employed between a CU **160** and a DU **165** such that the CU **160** may support one or more layers of the protocol stack and the DU **165** may support one or more different layers of the protocol stack. In some examples, the CU **160** may host upper protocol layer (e.g., layer 3 (L3), layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU **160** (e.g., one or more CUs) may be connected to a DU **165** (e.g., one or more DUs) or an RU **170** (e.g., one or more RUs), or some combination thereof, and the DUs **165**, RUs **170**, or both may host lower protocol layers, such as layer 1 (L1) (e.g., physical (PHY) layer) or L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU **160**. Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU **165** and an RU **170** such that the DU **165** may support one or more layers of the protocol stack and the RU **170** may support one or more different layers of the protocol stack. The DU **165** may support one or multiple different cells (e.g., via one or multiple different RUs, such as an RU **170**). In some cases, a functional split between a CU **160** and a DU **165** or between a DU **165** and an RU **170** may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU **160**, a DU **165**, or an RU **170**, while other functions of the protocol layer are performed by a different one of the CU **160**, the DU **165**, or the RU **170**). A CU **160** may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU **160** may be connected to a DU **165** via a midhaul communication link **162** (e.g., F1, F1-c, F1-u), and a DU **165** may be connected to an RU **170** via a fronthaul communication link **168** (e.g., open fronthaul (FH) interface). In some examples, a midhaul communication link **162** or a fronthaul communication link **168** may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities (e.g., one or more of the network entities **105**) that are in communication via such communication links.

[0035] In some wireless communications systems (e.g., the wireless communications system **100**), infrastructure and spectral resources for radio access may support wireless backhaul link capabilities to supplement wired backhaul connections, providing an IAB network architecture (e.g., to a core network **130**). In some cases, in an IAB network, one or more of the network entities **105** (e.g., network entities **105** or IAB node(s) **104**) may be partially controlled by each other. The IAB node(s) **104** may be referred to as a donor entity or an IAB donor. A DU **165** or an RU **170** may be partially controlled by a CU **160** associated with a network entity **105** or base station **140** (such as a donor network entity or a donor base station). The one or more donor entities (e.g., IAB donors) may be in communication with one or more additional devices (e.g., IAB node(s) **104**) via supported access and backhaul links (e.g., backhaul communication link(s) **120**). IAB node(s) **104** may include an IAB mobile termination (IAB-MT) controlled (e.g., scheduled) by one or more DUs (e.g., DUs **165**) of a coupled IAB donor. An IAB-MT may be equipped with an independent set of antennas for relay of communications with UEs **115** or may share the same antennas (e.g., of an RU **170**) of IAB node(s) **104** used for access via the DU **165** of the IAB node(s) **104** (e.g., referred to as virtual IAB-MT (vIAB-MT)). In some examples, the IAB node(s) **104** may include one or more DUs (e.g., DUs **165**) that support communication links with additional entities (e.g., IAB node(s) **104**, UEs **115**) within the relay chain or configuration of the access network (e.g., downstream). In such cases, one or more components of the disaggregated RAN architecture (e.g., the IAB node(s) **104** or components of the IAB node(s) **104**) may be configured to operate according to the techniques described herein.

[0036] In the case of the techniques described herein applied in the context of a disaggregated RAN architecture, one or more components of the disaggregated RAN architecture may be configured to support test as described herein. For example, some operations described as being performed by a UE **115** or a network entity **105** (e.g., a base station **140**) may additionally, or alternatively, be performed by one or more components of the disaggregated RAN architecture (e.g., components such as an IAB node, a DU **165**, a CU **160**, an RU **170**, an RIC **175**, an SMO system **180**).

[0037] A UE **115** may include or may be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, where the “device” may also be referred to as a unit, a station, a terminal, or a client, among other examples. A UE **115** may also include or may be referred to as a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE **115** may include or be referred to as a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or a machine type communications (MTC) device, among other examples, which may be implemented in various objects such as appliances, vehicles, or meters, among other examples.

[0038] The UEs **115** described herein may be able to communicate with various types of devices, such as UEs **115** that may sometimes operate as relays, as well as the network entities **105** and the network equipment including macro eNBs or gNBs, small cell eNBs or gNBs, or relay base stations, among other examples, as shown in FIG. **1**.

[0039] The UEs **115** and the network entities **105** may wirelessly communicate with one another via the communication link(s) **125** (e.g., one or more access links) using resources associated with one or more carriers. The term “carrier” may refer to a set of RF spectrum resources having a defined PHY layer structure for supporting the communication link(s) **125**. For example, a carrier used for the communication link(s) **125** may include a portion of an RF spectrum band (e.g., a bandwidth part (BWP)) that is operated according to one or more PHY layer channels for a given RAT (e.g., LTE, LTE-A, LTE-A Pro, NR). Each PHY layer channel may carry acquisition signaling (e.g., synchronization signals, system information), control signaling that coordinates operation for the carrier, user data, or other signaling. The wireless communications system **100** may support communication with a UE **115** using carrier aggregation or multi-carrier operation. A UE **115** may be configured with multiple downlink component carriers and one or more uplink component carriers according to a carrier aggregation configuration. Carrier aggregation may be used with both frequency division duplexing (FDD) and time division duplexing (TDD) component carriers. Communication between a network entity **105** and other devices may refer to communication between the devices and any portion (e.g., entity, sub-entity) of a network entity **105**. For example, the terms “transmitting,” “receiving,” or “communicating,” when referring to a network entity **105**, may refer to any portion of a network entity **105** (e.g., a base station **140**, a CU **160**, a DU **165**, a RU **170**) of a RAN communicating with another device (e.g., directly or via one or more other network entities, such as one or more of the network entities **105**).

[0040] In some examples, such as in a carrier aggregation configuration, a carrier may have acquisition signaling or control signaling that coordinates operations for other carriers. A carrier may be associated with a frequency channel (e.g., an evolved universal mobile telecommunication system terrestrial radio access (E-UTRA) absolute RF channel number (EARFCN)) and may be identified according to a channel raster for discovery by the UEs **115**. A carrier may be operated in a standalone mode, in which case initial acquisition and connection may be conducted by the UEs **115** via the carrier, or the carrier may be operated in a non-standalone mode, in which case a connection is anchored using a different carrier (e.g., of the same or a different RAT).

[0041] The communication link(s) **125** of the wireless communications system **100** may include downlink transmissions (e.g., forward link transmissions) from a network entity **105** to a UE **115**, uplink transmissions (e.g., return link transmissions) from a UE **115** to a network entity **105**, or both, among other configurations of transmissions. Carriers may carry downlink or uplink communications (e.g., in an FDD mode) or may be configured to carry downlink and uplink communications (e.g., in a TDD mode).

[0042] A carrier may be associated with a particular bandwidth of the RF spectrum and, in some examples, the carrier bandwidth may be referred to as a “system bandwidth” of the carrier or the wireless communications system **100**. For example, the carrier bandwidth may be one of a set of bandwidths for carriers of a particular RAT (e.g., 1.4, 3, 5, 10, 15, 20, 40, or 80 megahertz (MHz)). Devices of the wireless communications system **100** (e.g., the network entities **105**, the UEs **115**, or both) may have hardware configurations that support communications using a particular carrier bandwidth or may be configurable to support communications using one of a set of carrier bandwidths. In some examples, the wireless communications system **100** may include network entities **105** or UEs **115** that support concurrent communications using carriers associated with multiple carrier bandwidths. In some examples, each served UE **115** may be configured for operating using portions (e.g., a sub-band, a BWP) or all of a carrier bandwidth.

[0043] Signal waveforms transmitted via a carrier may be made up of multiple subcarriers (e.g., using multi-carrier modulation (MCM) techniques such as orthogonal frequency division multiplexing (OFDM) or discrete Fourier transform spread OFDM (DFT-S-OFDM)). In a system employing MCM techniques, a resource element may refer to resources of one symbol period (e.g., a duration of one modulation symbol) and one subcarrier, in which case the symbol period and subcarrier spacing may be inversely related. The quantity of bits carried by each resource element may depend on the modulation scheme (e.g., the order of the modulation scheme, the coding rate of the modulation scheme, or both), such that a relatively higher quantity of resource elements (e.g., in a transmission duration) and a relatively higher order of a modulation scheme may correspond to a relatively higher rate of communication. A wireless communications resource may refer to a combination of an RF spectrum resource, a time resource, and a spatial resource (e.g., a spatial layer, a beam), and the use of multiple spatial resources may increase the data rate or data integrity for communications with a UE **115**.

[0044] One or more numerologies for a carrier may be supported, and a numerology may include a subcarrier spacing (Δf) and a cyclic prefix. A carrier may be divided into one or more BWPs having the same or different numerologies. In some examples, a UE **115** may be configured with multiple BWPs. In some examples, a single BWP for a carrier may be active at a given time and communications for the UE **115** may be restricted to one or more active BWPs.

[0045] The time intervals for the network entities **105** or the UEs **115** may be expressed in multiples of a basic time unit which may, for example, refer to a sampling period of $T_s=1/(\Delta f_{max} \cdot N_f)$ seconds, for which Δf_{max} may represent a supported subcarrier spacing, and N_f may represent a supported discrete Fourier transform (DFT) size. Time intervals of a communications resource may be organized according to radio frames each having a specified duration (e.g., 10 milliseconds (ms)). Each radio frame may be identified by a system frame number (SFN) (e.g., ranging from 0 to 1023).

[0046] Each frame may include multiple consecutively-numbered subframes or slots, and each subframe or slot may have the same duration. In some examples, a frame may be divided (e.g., in the time domain) into subframes, and each subframe may be further divided into a quantity of slots. Alternatively, each frame may include a variable quantity of slots, and the quantity of slots may depend on subcarrier spacing. Each slot may include a quantity of symbol periods (e.g., depending on the length of the cyclic prefix prepended to each symbol period). In some wireless communications systems, such as the wireless communications system **100**, a slot may further be divided into multiple mini-slots associated with one or more symbols. Excluding the cyclic prefix, each symbol period may be associated with one or more (e.g., N_f) sampling periods. The duration of a symbol period may depend on the subcarrier spacing or frequency band of operation.

[0047] A subframe, a slot, a mini-slot, or a symbol may be the smallest scheduling unit (e.g., in the time domain) of the wireless communications system **100** and may be referred to as a transmission time interval (TTI). In some examples, the TTI duration (e.g., a quantity of symbol periods in a TTI) may be variable. Additionally, or alternatively, the smallest scheduling unit of the wireless communications system **100** may be dynamically selected (e.g., in bursts of shortened TTIs (STTIs)).

[0048] Physical channels may be multiplexed for communication using a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed for signaling via a downlink carrier, for example, using one or more of time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM

techniques. A control region (e.g., a control resource set (CORESET)) for a physical control channel may be defined by a set of symbol periods and may extend across the system bandwidth or a subset of the system bandwidth of the carrier. One or more control regions (e.g., CORESETs) may be configured for a set of the UEs **115**. For example, one or more of the UEs **115** may monitor or search control regions for control information according to one or more search space sets, and each search space set may include one or multiple control channel candidates in one or more aggregation levels arranged in a cascaded manner. An aggregation level for a control channel candidate may refer to an amount of control channel resources (e.g., control channel elements (CCEs)) associated with encoded information for a control information format having a given payload size. Search space sets may include common search space sets configured for sending control information to UEs **115** (e.g., one or more UEs) or may include UE-specific search space sets for sending control information to a UE **115** (e.g., a specific UE).
[0049] In some examples, a network entity **105** (e.g., a base station **140**, an RU **170**) may be movable and therefore provide communication coverage for a moving coverage area, such as the coverage area **110**. In some examples, coverage areas **110** (e.g., different coverage areas) associated with different technologies may overlap, but the coverage areas **110** (e.g., different coverage areas) may be supported by the same network entity (e.g., a network entity **105**). In some other examples, overlapping coverage areas, such as a coverage area **110**, associated with different technologies may be supported by different network entities (e.g., the network entities **105**). The wireless communications system **100** may include, for example, a heterogeneous network in which different types of the network entities **105** support communications for coverage areas **110** (e.g., different coverage areas) using the same or different RATs.
[0050] The wireless communications system **100** may support synchronous or asynchronous operation. For synchronous operation, network entities **105** (e.g., base stations **140**) may have similar frame timings, and transmissions from different network entities (e.g., different ones of the network entities **105**) may be approximately aligned in time. For asynchronous operation, network entities **105** may have different frame timings, and transmissions from different network entities (e.g., different ones of network entities **105**) may, in some examples, not be aligned in time. The techniques described herein may be used for either synchronous or asynchronous operations.
[0051] Some UEs **115**, such as MTC or IoT devices, may be relatively low cost or low complexity devices and may provide for automated communication between machines (e.g., via Machine-to-Machine (M2M) communication). M2M communication or MTC may refer to data communication technologies that allow devices to communicate with one another or a network entity **105** (e.g., a base station **140**) without human intervention. In some examples, M2M communication or MTC may include communications from devices that integrate sensors or meters to measure or capture information and relay such information to a central server or application program that uses the information or presents the information to humans interacting with the application program. Some UEs **115** may be designed to collect information or enable automated behavior of machines or other devices. Examples of applications for MTC devices include smart metering, inventory monitoring, water level monitoring, equipment monitoring, healthcare monitoring, wildlife monitoring, weather and geological event monitoring, fleet management and tracking, remote security sensing, physical access control, and transaction-based business charging.
[0052] Some UEs **115** may be configured to employ operating modes that reduce power consumption, such as half-duplex communications (e.g., a mode that supports one-way communication via transmission or reception, but not transmission and reception concurrently). In some examples, half-duplex communications may be performed at a reduced peak rate. Other power conservation techniques for the UEs **115** may include entering a power saving deep sleep mode when not engaging in active communications, operating using a limited bandwidth (e.g., according to narrowband communications), or a combination of these techniques. For example, some UEs **115** may be configured for operation using a narrowband protocol type that is associated

with a defined portion or range (e.g., set of subcarriers or resource blocks (RBs)) within a carrier, within a guard-band of a carrier, or outside of a carrier.

[0053] The wireless communications system **100** may be configured to support ultra-reliable communications or low-latency communications, or various combinations thereof. For example, the wireless communications system **100** may be configured to support ultra-reliable low-latency communications (URLLC). The UEs **115** may be designed to support ultra-reliable, low-latency, or critical functions. Ultra-reliable communications may include private communication or group communication and may be supported by one or more services such as push-to-talk, video, or data. Support for ultra-reliable, low-latency functions may include prioritization of services, and such services may be used for public safety or general commercial applications. The terms ultra-reliable, low-latency, and ultra-reliable low-latency may be used interchangeably herein.

[0054] In some examples, a UE **115** may be configured to support communicating directly with other UEs (e.g., one or more of the UEs **115**) via a device-to-device (D2D) communication link, such as a D2D communication link **135** (e.g., in accordance with a peer-to-peer (P2P), D2D, or sidelink protocol). In some examples, one or more UEs **115** of a group that are performing D2D communications may be within the coverage area **110** of a network entity **105** (e.g., a base station **140**, an RU **170**), which may support aspects of such D2D communications being configured by (e.g., scheduled by) the network entity **105**. In some examples, one or more UEs **115** of such a group may be outside the coverage area **110** of a network entity **105** or may be otherwise unable to or not configured to receive transmissions from a network entity **105**. In some examples, groups of the UEs **115** communicating via D2D communications may support a one-to-many (**1**: M) system in which each UE **115** transmits to one or more of the UEs **115** in the group. In some examples, a network entity **105** may facilitate the scheduling of resources for D2D communications. In some other examples, D2D communications may be carried out between the UEs **115** without an involvement of a network entity **105**.

[0055] The core network **130** may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network **130** may be an evolved packet core (EPC) or 5G core (5GC), which may include at least one control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management function (AMF)) and at least one 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)). The control plane entity may manage non-access stratum (NAS) functions such as mobility, authentication, and bearer management for the UEs **115** served by the network entities **105** (e.g., base stations **140**) associated with the core network **130**. User IP packets may be transferred through the user plane entity, which may provide IP address allocation as well as other functions. The user plane entity may be connected to IP services **150** for one or more network operators. The IP services **150** may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched Streaming Service.

[0056] The wireless communications system **100** may operate using one or more frequency bands, which may be in the range of 300 megahertz (MHz) to 300 gigahertz (GHz). Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band because the wavelengths range from approximately one decimeter to one meter in length. UHF waves may be blocked or redirected by buildings and environmental features, which may be referred to as clusters, but the waves may penetrate structures sufficiently for a macro cell to provide service to the UEs **115** located indoors. Communications using UHF waves may be associated with smaller antennas and shorter ranges (e.g., less than one hundred kilometers) compared to communications using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

[0057] The wireless communications system **100** may also operate using a super high frequency

(SHF) region, which may be in the range of 3 GHz to 30 GHz, also known as the centimeter band, or using an extremely high frequency (EHF) region of the spectrum (e.g., from 30 GHz to 300 GHz), also known as the millimeter band. In some examples, the wireless communications system **100** may support millimeter wave (mmW) communications between the UEs **115** and the network entities **105** (e.g., base stations **140**, RUs **170**), and EHF antennas of the respective devices may be smaller and more closely spaced than UHF antennas. In some examples, such techniques may facilitate using antenna arrays within a device. The propagation of EHF transmissions, however, may be subject to even greater attenuation and shorter range than SHF or UHF transmissions. The techniques disclosed herein may be employed across transmissions that use one or more different frequency regions, and designated use of bands across these frequency regions may differ by country or regulating body.

[0058] The wireless communications system **100** may utilize both licensed and unlicensed RF spectrum bands. For example, the wireless communications system **100** may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) RAT, or NR technology using an unlicensed band such as the 5 GHz industrial, scientific, and medical (ISM) band. While operating using unlicensed RF spectrum bands, devices such as the network entities **105** and the UEs **115** may employ carrier sensing for collision detection and avoidance. In some examples, operations using unlicensed bands may be based on a carrier aggregation configuration in conjunction with component carriers operating using a licensed band (e.g., LAA). Operations using unlicensed spectrum may include downlink transmissions, uplink transmissions, P2P transmissions, or D2D transmissions, among other examples.

[0059] A network entity **105** (e.g., a base station **140**, an RU **170**) or a UE **115** may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. The antennas of a network entity **105** or a UE **115** may be located within one or more antenna arrays or antenna panels, which may support MIMO operations or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some examples, antennas or antenna arrays associated with a network entity **105** may be located at diverse geographic locations. A network entity **105** may include an antenna array with a set of rows and columns of antenna ports that the network entity **105** may use to support beamforming of communications with a UE **115**. Likewise, a UE **115** may include one or more antenna arrays that may support various MIMO or beamforming operations. Additionally, or alternatively, an antenna panel may support RF beamforming for a signal transmitted via an antenna port.

[0060] Beamforming, which may also be referred to as spatial filtering, directional transmission, or directional reception, is a signal processing technique that may be used at a transmitting device or a receiving device (e.g., a network entity **105**, a UE **115**) to shape or steer an antenna beam (e.g., a transmit beam, a receive beam) along a spatial path between the transmitting device and the receiving device. Beamforming may be achieved by combining the signals communicated via antenna elements of an antenna array such that some signals propagating along particular orientations with respect to an antenna array experience constructive interference while others experience destructive interference. The adjustment of signals communicated via the antenna elements may include a transmitting device or a receiving device applying amplitude offsets, phase offsets, or both to signals carried via the antenna elements associated with the device. The adjustments associated with each of the antenna elements may be defined by a beamforming weight set associated with a particular orientation (e.g., with respect to the antenna array of the transmitting device or receiving device, or with respect to some other orientation).

[0061] The wireless communications system **100** may be a packet-based network that operates according to a layered protocol stack. In the user plane, communications at the bearer or PDCP layer may be IP-based. An RLC layer may perform packet segmentation and reassembly to communicate via logical channels. A MAC layer may perform priority handling and multiplexing of logical channels into transport channels. The MAC layer also may implement error detection techniques, error correction techniques, or both to support retransmissions to improve link efficiency. In the control plane, an RRC layer may provide establishment, configuration, and maintenance of an RRC connection between a UE **115** and a network entity **105** or a core network **130** supporting radio bearers for user plane data. A PHY layer may map transport channels to physical channels.

[0062] The UEs **115** and the network entities **105** may support retransmissions of data to increase the likelihood that data is received successfully. Hybrid automatic repeat request (HARQ) feedback is one technique for increasing the likelihood that data is received correctly via a communication link (e.g., the communication link(s) **125**, a D2D communication link **135**). HARQ may include a combination of error detection (e.g., using a cyclic redundancy check (CRC)), forward error correction (FEC), and retransmission (e.g., automatic repeat request (ARQ)). HARQ may improve throughput at the MAC layer in relatively poor radio conditions (e.g., low signal-to-noise conditions). In some examples, a device may support same-slot HARQ feedback, in which case the device may provide HARQ feedback in a specific slot for data received via a previous symbol in the slot. In some other examples, the device may provide HARQ feedback in a subsequent slot, or according to some other time interval.

[0063] In some examples, the network entity **105** may indicate multiple PUSCH TOs during a CG period in which the UE **115** may transmit uplink signaling (e.g., one or more uplink CG PUSCH TOs. However, the UE **115** may not have enough pending data to use all of the PUSCH TOs, in which case the UE **115** may transmit a UCI message including a bitmap indicating which PUSCH TOs are unused (e.g., skipped) by the UE **115**. This may be referred to as a PUSCH UTO-UCI and may enable enhanced resource usage in the network, for example, when the network reallocates unused resources for other communications.

[0064] Additionally, the UE **115** and the network entity **105** may consider some PUSCH TOs as invalid (e.g., due to collisions with other signaling). Because both the UE **115** and the network entity **105** may determine which PUSCH TOs are invalid, the UE **115** may not include the invalid resources in the bitmap, reducing the size of the bitmap and reducing signaling overhead. This may result in improved throughput, decreased signaling overhead, etc. However, additional scenarios may also render the PUSCH TOs invalid. For example, the UE **115** may perform measurements (e.g., configured by the network) that include interruption periods associated with measurement gaps (e.g., VIL durations that correspond to a measurement length for network-controlled small gap NCSG configurations), such that the UE **115** may not communicate (e.g., uplink messages in the scheduled PUSCH TOs) during these interruption periods.

[0065] In the wireless communications system **100**, a UE **115** may define PUSCH TOs that collide with VILs (e.g., interruption periods) as invalid. By defining the colliding TOs as invalid, the UE **115** may remove bits from UCI that would otherwise indicate these PUSCH TOs (e.g., UTO-UCI), reducing a size of the UCI message, as well as reducing signaling overhead. Further, a UE **115** may exclude such invalid TOs when determining a HARQ ID of one or more feedback processes to increase an efficiency in HARQ ID management.

[0066] FIG. **2** shows an example of a wireless communications system **200** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The wireless communications system **200** may implement aspects of or may be implemented by aspects of the wireless communications system **100**. For example, the wireless communications system **200** includes a UE **115-*a*** and a network entity **105-*a***, which may be examples of a UE **115** and a network entity **105** described with respect to FIG. **1**.

[0067] In some examples, the UE **115-*a*** and the network entity **105-*a*** may consider some PUSCH TOs as invalid (e.g., due to collisions with other signaling), and the UE **115-*a*** may not include the invalid resources in the UCI to the network entity **105-*a*** to reduce the size of the UCI and reduce signaling overhead. This may result in improved throughput, decreased signaling overhead, or the like. However, additional scenarios may also render the PUSCH TOs invalid, and it may be desirable to define techniques such that these additional invalid PUSCH TOs may not be included in the UCI.

[0068] In some cases, applications, such as game rendering applications communicating with an extended reality (XR) headset, may have strict system conditions associated with data rate, latency, and power consumption. For example, the system conditions may include low latency and high reliability, such that 99% packets of XR traffic are to be delivered within packet delay budget (PDB) requirement (e.g., 10 ms). The system conditions may include low power consumption, such that a discontinuous reception (DRX) operation is implemented to save power consumption of multimedia devices executing the application. An enhanced connected mode discontinuous reception (eCDRX) may be implemented to align a DRX cycle with the multimedia devices. In some cases, a radio resource management (RRM) measurement gap may be a condition for mobile devices (e.g., UEs **115**, multimedia devices) to operate in multifrequency cellular networks, resulting in increased packet delay of real-time multimedia traffic. Accordingly, an enhanced solution for an RRM measurement gap may be implemented to improve the user experience for XR applications.

[0069] In some cases, various CG enhancements may be implemented, where the enhancement includes multiple PUSCH TOs in each CG period for licensed spectrum or a UCI that indicates unused CG PUSCH TOS (UTO-UCI). These enhancements for preconfigured CG resources may be used to reduce uplink transmission latency otherwise caused by a scheduling request (SR) and/or a buffer status report (BSR) that are associated with a resource request. The resource request may be for uplink high data rate and low latency periodic traffic. The network (e.g., via the network entity **105-***a*) may configure (e.g., preconfigure) multiple CG PUSCH TOs in each cycle of uplink traffic. The UE **115-***a* may immediately starting transmitting PUSCHs on the CG PUSCH TOs when data arrives in the uplink data buffer. The UE **115-***a* may indicate the unused CG PUSCH TOs that are not used for uplink data transmission in UTO-UCI so that the network entity **105-***a* may reallocate these resources to other UEs **115**.

[0070] In some examples, the multiple CG PUSCH TOs may be allocated in each CG period, where the beginning of the CG period is aligned with the data (e.g., augmented reality (AR) uplink video) in a generation cycle. The network entity **105-***a* may configure the UE **115-***a* to send the UTO-UCI for the CG configuration, where the UTO-UCI is sent in each transmitted PUSCH of the CG.

[0071] In some examples, invalid CG PUSCH TO may be defined for the multi-PUSCH CG and UTO-UCI. For unpaired spectrum (e.g., TDD), a CG PUSCH TO may be considered as invalid if it collides with one or more downlink symbol(s) indicated by a configuration (e.g., TDD-UL-DL-ConfigurationCommon or TDD-UL-DL-ConfigurationDedicated), or if the CG PUSCH TO collides with one or more symbol(s) of a synchronization signal block (SSB) or a physical broadcast channel (PBCH) block (e.g., with index provided by an SBB burst, such as an SSB-PositionsInBurst signal). The collision condition may also include SSBs for intercell multiple transmission-reception points (TRPs). In some cases, dynamic collision and dynamic cancellation of a CG PUSCH TO may not be considered as an invalid CG PUSCH TO.

[0072] In some cases, invalid CG PUSCH TOs may be used in HARQ ID determination for CG PUSCH TOs and UTO-UCI indication for unused CG PUSCH TOs. For example, HARQ ID may be determined for the first configured CG PUSCH TO (valid or invalid) within the multi-PUSCH CG period and subsequent valid CG PUSCH occasions within a CG period. The UTO-UCI may not indicate an unused or used (e.g., reserved) status for invalid CG PUSCH TOs. Invalid CG PUSCH TOs may be excluded from HARQ ID determinations and UTO-UCI for more efficient HARQ ID management and reduced UTO-UCI payload size.

[0073] In some examples, the UE **115-***a* may perform measurements on neighboring cells (e.g., target cells) and other carrier components using different frequencies. However, the UE **115**-*a* may not perform the inter-frequency measurements while maintaining data traffic with serving cell, for example, due to using a single RF module to reduce manufacturing costs of the UE **115**-*a* and/or form factor size considerations. Accordingly, the UE **115**-*a* may not receive a physical downlink shared channel (PDSCH), a physical downlink control channel (PDCCH), and/or a channel state interference reference signal (CSI-RS) from the serving cell during a measurement gap period (e.g., measurement gap occasion). Moreover, the UE **115**-*a* may not transmit a physical uplink control channel (PUCCH), a PUSCH, or a sounding reference signal (SRS) to the serving cell (e.g., the network entity **105**-*a*) during the measurement gap period. Scheduling restrictions associated with communicating with the serving cell during the measurement gap period may be reduced as discussed herein.

[0074] In some examples, the wireless communications system **200** may involve NCSG configurations of a NCSG pattern that includes two interruptions (e.g., VILs) and a measurement portion (e.g., measurement length). For example, the NCSG pattern may include a first VIL (VIL 1), followed by a measurement length, followed by a second VIL (VIL2). In some cases, the NCSG pattern may include a visible interruption repetition period (VIRP) including one or more VILs. A relatively short VIL duration may be associated with the UE **115**-*a* activating hardware or RF resources of the UE **115**-*a* for measuring and/or communicating (e.g., receiving signals) during the measurement length. The relatively short VIL may also impact throughput gain that is recovered. A scheduling restriction may not occur during the measurement length, but a scheduling restriction may occur during each of the VILs (e.g., VIL 1 and VIL 2).

[0075] In an NCSG pattern, an interruption (e.g., VIL 1) may occur over a quantity of slots (e.g., two slots) before measurements (e.g., having a duration of 1 ms) and over a quantity of slots (e.g., two slots) after measurements (e.g., VIL 2 having a duration of 1 ms), and the duration between the two interruptions may be used for measurements (e.g., measurement length having a duration of 4 ms). In some examples, the network entity **105**-*a* may configure the UE **115**-*a* with a 6 ms measurement gap, and for the NCSG pattern, the 6 ms may be divided into 1 ms interruption, 4 ms measurement length (e.g., data may be scheduled here at least for a first frequency (FR1)), and another 1 ms interruption. Other configurations for the measurement and VILs (e.g., interruptions) may be possible.

[0076] The CG enhancements discussed herein may be categorized as dedicated RRC configuration for uplink. However, the UE **115**-*a* may not be configured with CG for PUSCH transmission. For example, when a collision with a dynamically scheduled downlink transmission occurs, a CG PUSCH may not be transmitted by the UE **115**-*a*. Also, the CG PUSCH may not be transmitted due to a collision with an SSB. In some examples, invalid CG PUSCH may include semi-static condition for TDD in an unpaired spectrum. For intra-band or inter-band measurements (e.g., and where the UE **115**-*a* has spare RF), the NCSG pattern with the interruption may include two VIL slots before measurements (e.g., 1 ms) and two VIL slots after measurements (e.g., 1 ms) and the duration between the two interruptions (e.g., 4 ms) may be used for measurements. During a VIL, the UE **115**-*a* may not transmit PUSCH, PUCCH, and/or SRS since the UE **115**-*a* may be RF tuning to another frequency (FR2) to measure the target cell. If the UE **115**-*a* is configured with CG PUSCH occasions and the UTO-UCI unused indication (e.g., unused indication), indicating CG PUSCH occasions that fall within the VIL may be an inefficient transmission of bits in the indication since the UE **115**-*a* may not use these resources. In some examples, a UTO-UCI bitmap size may be RRC configured with a bitmap size between 3 and 8 bits.

[0077] As described herein, UE **115**-*a* may define PUSCH TOs that collide with VILs (e.g., interruption periods) as invalid to remove bits that would otherwise indicate such PUSCH TOs in the UCI. For example, the network entity **105**-*a* may communicate with the UE **115**-*a* using a communication link **125**. In some examples, the communication link **125** may include a first channel **225**-*a* for transmitting data from the UE **115**-*a* to the network entity **105**-*a* and a second channel **225**-*b* for transmitting data from the network entity **105**-*a* to the UE **115**-*a*. The communication link **125** may be an example of an NR or LTE link between the UE **115**-*a* and the network entity **105**-*a*. The communication link **125** may include a bi-directional link that enables both uplink and downlink communications, for example, via the channels **225**.

[0078] The UE **115**-*a* may transmit uplink messages **245** (e.g., uplink transmissions), such as uplink control signals or uplink data signals, to the network entity **105**-*a* using the first channel **225**-*a* (e.g., of the communication link **125**) and the network entity **105**-*a* may transmit downlink messages **250** (e.g., downlink transmissions), such as downlink control signals or downlink data signals, to the UE **115**-*a* using the second channel **225**-*b* (e.g., of the communication link **125**). In some examples, the downlink messages **250** may be part of control signaling transmitted from the network entity **105**-*a*. In some examples, the multiple messages outputted via multiple downlink messages **250**, respectively, may be outputted in a single downlink message **250**, and the multiple messages transmitted via multiple uplink messages **245**, respectively, may be outputted in a single uplink message **245**.

[0079] In an example, the network entity **105**-*a* may output a first downlink message **250**-*a*, which includes a control message indicating a CG configuration (e.g., an uplink CG configuration, a semi-persistent scheduling (SPS) configuration), where the CG configuration includes multiple uplink TOs within a time period. The UE **115**-*a* may transmit, using at least one of multiple uplink TOs in accordance with the CG configuration, a first uplink message **245**-*a* including a control information message. The control information message may include an indication of a quantity of unused uplink TOs of the multiple uplink TOs. The indication may exclude one or more invalid uplink TOs that correspond to one or more uplink TOs of the multiple TOs that at least partially overlap with one or more interruption durations (e.g., VIL duration) associated with a measurement duration (e.g., measurement gap duration).

[0080] To illustrate, a measurement gap **230** in a measurement period may include a pattern of VILs **240** and measurement lengths **260**. In some examples, the measurement gap **230** may include time and frequency resources, such as eight first frequency slots **220**-*a* (e.g., slot i+1 through slot i+6) at a first frequency (e.g., a first serving carrier) and eight second frequency slots **220**-*b* (e.g., slot j+1 through slot j+6) at a second frequency (e.g., a second serving carrier).

[0081] The measurement gap **230** may include a first VIL **240**-*a* (VIL 1) in a single slot **220** for both frequencies (e.g., slot i+1 and slot j+1). The measurement gap **230** may include a measurement length **260** of four slots **220** after the first VIL **240** at both frequencies (e.g., i+2, i+2, i+4, i+5 in the first serving carrier and j+2, j+3, j+4, j+5 in the second serving carrier). The measurement gap **230** may include a second VIL **240**-*b* in a single slot for both frequencies (e.g., slot i+6 and slot j+6) after the measurement length **260**. The slots **220** in which the VILs **240** occur, a CG PUSCH TOs may be invalid due to collision with a VIL. The slots in which the VILs **240** do not occur, such as during the measurement length **260**, the CG PUSCH TO may be valid within the measurement gap **230**. Accordingly, the UE **115**-*a* may determine a HARQ ID based on incrementing for valid CG PUSCH TOs (e.g., i+2, i+2, i+4, i+5 in the first serving carrier and j+2, j+3, j+4, j+5 in the second serving carrier) after the first configured CG PUSCH TO in a CG period. Similarly, UTO-UCI may not include an indication for invalid CG PUSCH TOs. A CG PUSCH TO colliding the VIL for RF tuning and/or RF switching is also invalid and may not be included in an indication from the UE **115**-*a*.

[0082] In some examples, the UE **115**-*a* may transmit a second uplink message **245**-*b*, which includes one or more acknowledgment (ACK) or negative acknowledgment (NACK) messages in accordance with an ID. The ID may be based at least on a first CG PUSCH occasion corresponding to a first uplink TO of the multiple TOs, where the ID is further based on the quantity of unused uplink TOs excluded from the indication. The network entity **105**-*a* may output a second downlink message **250**-*b*, which includes a control message indicating a configuration of a measurement gap pattern (e.g., of the measurement gap **230**), where the one or more interruption durations are based on the measurement gap pattern.

[0083] In some examples, when the UE **115**-*a* performs inter-frequency or intra-frequency measurements with NCSG in a TDD band, the UE **115**-*a* may consider the CG PUSCH that partially or fully overlaps with the VIL as invalid, as discussed with respect to the measurement gap **230**. These CG PUSCH TOs may be excluded from the bitmap of a UTO-UCI that indicates unused (e.g., skipping over) CG PUSCH TOs. Similarly, when the UE performs inter-frequency or intra-frequency measurements with NCSG in a TDD band, the UE **115**-*a* may not increment the HARQ ID for multiple CG PUSCHs when a CG PUSCH partially or fully overlaps with a VIL, unless the overlap is for a first CG PUSCH occasion when incrementing HARQ IDs (e.g., slots i and j). Not incrementing the HARQ ID for multiple CG PUSCHs when a CG PUSCH partially or fully overlaps with a VIL may facilitate efficient HARQ ID management and reduce UTO-UCI size.

[0084] In some examples, the UTO-UCI indication may be applicable to valid CG PUSCH TOs. For the UE **115**-*a* configured with NCSG, in the UTO-UCI, OUTO-UCI CG PUSCH TOs may exclude invalid ones where a UE **115**-*a* does not transmit a PUSCH TO due to collision of the PUSCH with the VIL of NCSG before and after a signal measurement timing configuration (SMTC) window (e.g., the measurement length **260**). For example, a bit value of ‘0’ may indicate that the UE **115**-*a* may transmit CG PUSCH, and a bit value of ‘1’ may indicate that the UE **115**-*a* may not transmit CG PUSCH, in a corresponding CG-PUSCH TO. When the UE **115**-*a* indicates by UTO-UCI a value of ‘1’ for a CG-PUSCH TO, the UE **115**-*a* may continue to indicate the value of ‘1’ for the CG PUSCH TO by UTO-UCI multiplexed in subsequent CG-PUSCH transmissions, and the UE **115**-*a* may not transmit CG PUSCH in the CG PUSCH TO. Additionally, in some examples, the HARQ ID for CG PUSCH TOs after the first configured HARQ ID in the CG period is determined for valid CG PUSCH TOs. For example, the HARQ ID for a K valid configured PUSCH grant, where 1<K≤quantity of slots in CG period, excludes invalid configured PUSCH grant(s) that are not transmitted due to collision with downlink symbol(s) indicated by TDD uplink or downlink configuration (e.g., TDD-UL-DL-ConfigurationCommon or TDD-UL-DL-ConfigurationDedicated), or symbol(s) of an SSB or PBCH block with index provided by SBB burst, or due to overlap with a VIL of an NCSG if the UE **115**-*a* is configured with NCSG.

[0085] FIG. **3** shows an example of a process flow **300** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The process flow **300** may implement aspects of or may be implemented by aspects of the wireless communications systems **100** and **200**. For example, the process flow **300** may include a UE **115**-*b*, which may be an example of a UE **115** as described herein. The process flow **300** may include a network entity **105**-*b*, which may be an example of a network entity **105** as described herein. In the following description of the process flow **300**, the operations performed by the UE **115**-*b* and the network entity **105**-*b* may be performed in different orders or at different times than the exemplary order shown. Some operations may also be omitted from the process flow **300**, or other operations may be added to the process flow **300**. Further, while operations in the process flow **300** are illustrated as being performed by the UE **115**-*b* and the network entity **105**-*b*, the examples herein are not to be construed as limiting, as the described features may be associated with any quantity of different devices.

[0086] At **305**, the UE **115**-*b* may receive a control message indicating a CG configuration, the CG configuration including multiple uplink TOs (e.g., CG PUSCH TOs) within a time period. In some examples, at **310**, the UE **115**-*b* may receive a second control message indicating a configuration of a measurement gap pattern. One or more interruption durations may be based on a measurement gap pattern. In some examples, at **315**, the UE **115**-*b* may transmit one or more ACK or NACK messages in accordance with an ID. The ID may be based at on a first uplink shared channel occasion (e.g., PUSCH TO) corresponding to a first uplink TO of the multiple uplink TOs. The ID may further be based on the quantity of unused uplink TOs excluded from the indication. The one or more interruption durations may include one or more VILs associated with a NCSG. The one or more interruption durations may be associated with inter-band measurements or intra-band measurement in a TDD band.

[0087] At **320**, the UE **115**-*b* may transmit, using at least one of the multiple uplink TOs in accordance with the CG configuration, a UCI message including an indication of a quantity of unused uplink TOs of the multiple uplink TOs. The indication may exclude one or more invalid uplink TOs that correspond to one or more uplink TOs of the multiple uplink TOs that at least partially overlap with the one or more interruption durations associated with the measurement duration. The UCI may be multiplexed with each of one or more uplink shared channel messages that are transmitted during one or more valid uplink TOs. In some examples, the UE **115**-*b* may determine to exclude the one or more invalid uplink TOs based on a collision of the one or more uplink TOs with the one or more interruption durations. The measurement duration may correspond to a SMTC window. In some examples, the one or more uplink TOs partially overlap or completely overlap with the one or more interruption durations in a time domain. The UCI message may include a bitmap indicating exclusion of the one or more invalid uplink TOs. The UCI message may include a bitmap including one or more first bits indicating a first subset of the multiple uplink TOs including the quantity of unused uplink TOs and one or more second bits indicating a second subset of the multiple uplink TOs including a quantity of used uplink TOs.

[0088] FIG. **4** shows a block diagram **400** of a device **405** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The device **405** may be an example of aspects of a UE **115** as described herein. The device **405** may include a receiver **410**, a transmitter **415**, and a communications manager **420**. The device **405**, or one or more components of the device **405** (e.g., the receiver **410**, the transmitter **415**, the communications manager **420**), may include at least one processor, which may be coupled with at least one memory, to, individually or collectively, support or enable the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0089] The receiver **410** may provide a means for receiving information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to VIL considerations for CG TOs). Information may be passed on to other components of the device **405**. The receiver **410** may utilize a single antenna or a set of multiple antennas.

[0090] The transmitter **415** may provide a means for transmitting signals generated by other components of the device **405**. For example, the transmitter **415** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to VIL considerations for CG TOs). In some examples, the transmitter **415** may be co-located with a receiver **410** in a transceiver module. The transmitter **415** may utilize a single antenna or a set of multiple antennas.

[0091] The communications manager **420**, the receiver **410**, the transmitter **415**, or various combinations or components thereof may be examples of means for performing various aspects of VIL considerations for CG TOs as described herein. For example, the communications manager **420**, the receiver **410**, the transmitter **415**, or various combinations or components thereof may be capable of performing one or more of the functions described herein.

[0092] In some examples, the communications manager **420**, the receiver **410**, the transmitter **415**, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include at least one of a processor, a digital signal processor (DSP), a central processing unit (CPU), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a microcontroller, discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure. In some examples, at least one processor and at least one memory coupled with the at least one processor may be configured to perform one or more of the functions described herein (e.g., by one or more processors, individually or collectively, executing instructions stored in the at least one memory).

[0093] Additionally, or alternatively, the communications manager **420**, the receiver **410**, the transmitter **415**, or various combinations or components thereof may be implemented in code (e.g., as communications management software or firmware) executed by at least one processor (e.g., referred to as a processor-executable code). If implemented in code executed by at least one processor, the functions of the communications manager **420**, the receiver **410**, the transmitter **415**, or various combinations or components thereof may be performed by a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, a microcontroller, or any combination of these or other programmable logic devices (e.g., configured as or otherwise supporting, individually or collectively, a means for performing the functions described in the present disclosure).

[0094] In some examples, the communications manager **420** may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **410**, the transmitter **415**, or both. For example, the communications manager **420** may receive information from the receiver **410**, send information to the transmitter **415**, or be integrated in combination with the receiver **410**, the transmitter **415**, or both to obtain information, output information, or perform various other operations as described herein.

[0095] The communications manager **420** may support wireless communication in accordance with examples as disclosed herein. For example, the communications manager **420** is capable of, configured to, or operable to support a means for receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period. The communications manager **420** is capable of, configured to, or operable to support a means for transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

[0096] By including or configuring the communications manager **420** in accordance with examples as described herein, the device **405** (e.g., at least one processor controlling or otherwise coupled with the receiver **410**, the transmitter **415**, the communications manager **420**, or a combination thereof) may support techniques for reducing a size of the UCI message, as well as for reducing signaling overhead, thereby improving resource utilization and system efficiency.

[0097] FIG. **5** shows a block diagram **500** of a device **505** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The device **505** may be an example of aspects of a device **405** or a UE **115** as described herein. The device **505** may include a receiver **510**, a transmitter **515**, and a communications manager **520**. The device **505**, or one or more components of the device **505** (e.g., the receiver **510**, the transmitter **515**, the communications manager **520**), may include at least one processor, which may be coupled with at least one memory, to support the described techniques. Each of these components may be in communication with one another (e.g., via one or more buses).

[0098] The receiver **510** may provide a means for receiving information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to VIL considerations for CG TOs). Information may be passed on to other components of the device **505**. The receiver **510** may utilize a single antenna or a set of multiple antennas.

[0099] The transmitter **515** may provide a means for transmitting signals generated by other components of the device **505**. For example, the transmitter **515** may transmit information such as packets, user data, control information, or any combination thereof associated with various information channels (e.g., control channels, data channels, information channels related to VIL considerations for CG TOs). In some examples, the transmitter **515** may be co-located with a receiver **510** in a transceiver module. The transmitter **515** may utilize a single antenna or a set of multiple antennas.

[0100] The device **505**, or various components thereof, may be an example of means for performing various aspects of VIL considerations for CG TOs as described herein. For example, the communications manager **520** may include a control message reception manager **525** a control message transmission manager **530**, or any combination thereof. The communications manager **520** may be an example of aspects of a communications manager **420** as described herein. In some examples, the communications manager **520**, or various components thereof, may be configured to perform various operations (e.g., receiving, obtaining, monitoring, outputting, transmitting) using or otherwise in cooperation with the receiver **510**, the transmitter **515**, or both. For example, the communications manager **520** may receive information from the receiver **510**, send information to the transmitter **515**, or be integrated in combination with the receiver **510**, the transmitter **515**, or both to obtain information, output information, or perform various other operations as described herein.

[0101] The communications manager **520** may support wireless communication in accordance with examples as disclosed herein. The control message reception manager **525** is capable of, configured to, or operable to support a means for receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period. The control message transmission manager **530** is capable of, configured to, or operable to support a means for transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

[0102] FIG. **6** shows a block diagram **600** of a communications manager **620** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The communications manager **620** may be an example of aspects of a communications manager **420**, a communications manager **520**, or both, as described herein. The communications manager **620**, or various components thereof, may be an example of means for performing various aspects of VIL considerations for CG TOs as described herein. For example, the communications manager **620** may include a control message reception manager **625**, a control message transmission manager **630**, a feedback message manager **635**, an invalid uplink transmission manager **640**, or any combination thereof. Each of these components, or components or subcomponents thereof (e.g., one or more processors, one or more memories), may communicate, directly or indirectly, with one another (e.g., via one or more buses).

[0103] The communications manager **620** may support wireless communication in accordance with examples as disclosed herein. The control message reception manager **625** is capable of, configured to, or operable to support a means for receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period. The control message transmission manager **630** is capable of, configured to, or operable to support a means for transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

[0104] In some examples, the feedback message manager **635** is capable of, configured to, or operable to support a means for transmitting one or more ACK or NACK messages in accordance with an ID, the ID is based on a first uplink shared channel occasion corresponding to a first uplink

TO of the set of multiple uplink TOs, where the ID is further based on the quantity of unused uplink TOs excluded from the indication.

[0105] In some examples, the control message reception manager **625** is capable of, configured to, or operable to support a means for receiving a second control message indicating a configuration of a measurement gap pattern, where the one or more interruption durations are based on the measurement gap pattern.

[0106] In some examples, the one or more interruption durations include one or more VILs associated with an NCSG. In some examples, the uplink control information message is multiplexed with each of one or more uplink shared channel messages (e.g., PUSCH transmissions) that are transmitted during one or more valid uplink TOs. In some examples, the one or more interruption durations are associated with inter-band measurements and/or intra-band measurement in a TDD band.

[0107] In some examples, the invalid uplink transmission manager **640** is capable of, configured to, or operable to support a means for determining to exclude the one or more invalid uplink TOs based on a collision of the one or more uplink TOs with the one or more interruption durations, and where the measurement duration corresponds to a synchronization SMTC window.

[0108] In some examples, the one or more uplink TOs partially overlap or completely overlap with the one or more interruption durations in a time domain. In some examples, the uplink control information message includes a bitmap indicating exclusion of the one or more invalid uplink TOs.

[0109] In some examples, the uplink control information message includes a bitmap including one or more first bits indicating a first subset of the set of multiple uplink TOs including the quantity of unused uplink TOs and one or more second bits indicating a second subset of the set of multiple uplink TOs including a quantity of used uplink TOs.

[0110] FIG. **7** shows a diagram of a system **700** including a device **705** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The device **705** may be an example of or include components of a device **405**, a device **505**, or a UE **115** as described herein. The device **705** may communicate (e.g., wirelessly) with one or more other devices (e.g., network entities **105**, UEs **115**, or a combination thereof). The device **705** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, such as a communications manager **720**, an input/output (I/O) controller, such as an I/O controller **710**, a transceiver **715**, one or more antennas **725**, at least one memory **730**, code **735**, and at least one processor **740**. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more buses (e.g., a bus **745**).

[0111] The I/O controller **710** may manage input and output signals for the device **705**. The I/O controller **710** may also manage peripherals not integrated into the device **705**. In some cases, the I/O controller **710** may represent a physical connection or port to an external peripheral. In some cases, the I/O controller **710** may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. Additionally, or alternatively, the I/O controller **710** may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some cases, the I/O controller **710** may be implemented as part of one or more processors, such as the at least one processor **740**. In some cases, a user may interact with the device **705** via the I/O controller **710** or via hardware components controlled by the I/O controller **710**.

[0112] In some cases, the device **705** may include a single antenna. However, in some other cases, the device **705** may have more than one antenna, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver **715** may communicate bi-directionally via the one or more antennas **725** using wired or wireless links as described herein. For example, the transceiver **715** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **715** may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas **725** for transmission, and to demodulate packets received from the one or more antennas **725**. The transceiver **715**, or the transceiver **715** and one or more antennas **725**, may be an example of a transmitter **415**, a transmitter **515**, a receiver **410**, a receiver **510**, or any combination thereof or component thereof, as described herein.

[0113] The at least one memory **730** may include random access memory (RAM) and read-only memory (ROM). The at least one memory **730** may store computer-readable, computer-executable, or processor-executable code, such as the code **735**. The code **735** may include instructions that, when executed by the at least one processor **740**, cause the device **705** to perform various functions described herein. The code **735** may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some cases, the code **735** may not be directly executable by the at least one processor **740** but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some cases, the at least one memory **730** may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0114] The at least one processor **740** may include one or more intelligent hardware devices (e.g., one or more general-purpose processors, one or more DSPs, one or more central processing units (CPUs), one or more graphics processing units (GPUs), one or more neural processing units (NPUs) (also referred to as neural network processors or deep learning processors (DLPs)), one or more microcontrollers, one or more ASICs, one or more FPGAs, one or more programmable logic devices, discrete gate or transistor logic, one or more discrete hardware components, or any combination thereof). In some cases, the at least one processor **740** may be configured to operate a memory array using a memory controller. In some other cases, a memory controller may be integrated into the at least one processor **740**. The at least one processor **740** may be configured to execute computer-readable instructions stored in a memory (e.g., the at least one memory **730**) to cause the device **705** to perform various functions (e.g., functions or tasks supporting VIL considerations for CG TOs). For example, the device **705** or a component of the device **705** may include at least one processor **740** and at least one memory **730** coupled with or to the at least one processor **740**, the at least one processor **740** and the at least one memory **730** configured to perform various functions described herein. In some examples, the at least one processor **740** may include multiple processors and the at least one memory **730** 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 described herein. In some examples, the at least one processor **740** may be a component of a processing system, which may refer to a system (such as a series) of machines, circuitry (including, for example, one or both of processor circuitry (which may include the at least one processor **740**) and memory circuitry (which may include the at least one memory **730**)), or components, that receives or obtains inputs and processes the inputs to produce, generate, or obtain a set of outputs. The processing system may be configured to perform one or more of the functions described herein. For example, the at least one processor **740** or a processing system including the at least one processor **740** may be configured to, configurable to, or operable to cause the device **705** to perform one or more of the functions described herein. Further, as described herein, being “configured to,” being “configurable to,” and being “operable to” may be used interchangeably and may be associated with a capability, when executing code **735** (e.g., processor-executable code) stored in the at least one memory **730** or otherwise, to perform one or more of the functions described herein.

[0115] The communications manager **720** may support wireless communication in accordance with examples as disclosed herein. For example, the communications manager **720** is capable of, configured to, or operable to support a means for receiving a control message indicating a CG configuration, the CG configuration including a set of multiple uplink TOs within a time period. The communications manager **720** is capable of, configured to, or operable to support a means for transmitting, using at least one of the set of multiple uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the set of multiple uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

[0116] By including or configuring the communications manager **720** in accordance with examples as described herein, the device **705** may support techniques for reducing a size of UCI signaling, as well as for reducing signaling overhead. In particular, the examples described herein may be associated with rules for identifying invalid uplink TOs, which may enable a UE to refrain from including such invalid uplink TOs from a UTO-UCI that is transmitted to the network. As such, a size of the UTO-UCI may be relatively reduced (e.g., by excluding bits that would have otherwise been included) and therefore enable enhanced resource usage.

[0117] In some examples, the communications manager **720** may be configured to perform various operations (e.g., receiving, monitoring, transmitting) using or otherwise in cooperation with the transceiver **715**, the one or more antennas **725**, or any combination thereof. Although the communications manager **720** is illustrated as a separate component, in some examples, one or more functions described with reference to the communications manager **720** may be supported by or performed by the at least one processor **740**, the at least one memory **730**, the code **735**, or any combination thereof. For example, the code **735** may include instructions executable by the at least one processor **740** to cause the device **705** to perform various aspects of VIL considerations for CG TOs as described herein, or the at least one processor **740** and the at least one memory **730** may be otherwise configured to, individually or collectively, perform or support such operations.

[0118] FIG. **8** shows a flowchart illustrating a method **800** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The operations of the method **800** may be implemented by a UE or its components as described herein. For example, the operations of the method **800** may be performed by a UE **115** as described with reference to FIGS. **1** through **7**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0119] At **805**, the method may include receiving a control message indicating a CG configuration, the CG configuration including a plurality of uplink TOs within a time period. The operations of **805** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **805** may be performed by a control message reception manager **625** as described with reference to FIG. **6**.

[0120] At **810**, the method may include transmitting, using at least one of the plurality of uplink TOs in accordance with the CG configuration, an uplink control information message including an indication of a quantity of unused uplink TOs of the plurality of uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration. The operations of **810** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **810** may be performed by a control message transmission manager **630** as described with reference to FIG. **6**.

[0121] FIG. **9** shows a flowchart illustrating a method **900** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The operations of the method **900** may be implemented by a UE or its components as described herein. For example, the operations of the method **900** may be performed by a UE **115** as described with reference to FIGS. **1** through **7**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0122] At **905**, the method may include receiving a control message indicating a CG configuration, the CG configuration including a plurality of uplink TOs within a time period. The operations of **905** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **905** may be performed by a control message reception manager **625** as described with reference to FIG. **6**.

[0123] At **910**, the method may include transmitting one or more ACK or NACK messages in accordance with an ID, the ID is based at least in part on a first uplink shared channel occasion corresponding to a first uplink TO of the plurality of uplink TOs, wherein the ID is further based at least in part on the quantity of unused uplink TOs excluded from the indication. The operations of **910** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **910** may be performed by a feedback message manager **635** as described with reference to FIG. **6**.

[0124] At **915**, the method may include transmitting, using at least one of the plurality of uplink TOs in accordance with the CG configuration, an uplink control information message comprising an indication of a quantity of unused uplink TOs of the plurality of uplink TOs, wherein the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration. The operations of **915** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **915** may be performed by a control message transmission manager **630** as described with reference to FIG. **6**.

[0125] FIG. **10** shows a flowchart illustrating a method **1000** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The operations of the method **1000** may be implemented by a UE or its components as described herein. For example, the operations of the method **1000** may be performed by a UE **115** as described with reference to FIGS. **1** through **7**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.

[0126] At **1005**, the method may include receiving a control message indicating a CG configuration, the CG configuration including a plurality of uplink TOs within a time period. The operations of **1005** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1005** may be performed by a control message reception manager **625** as described with reference to FIG. **6**.

[0127] At **1010**, the method may include receiving a second control message indicating a configuration of a measurement gap pattern. The operations of **1010** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1010** may be performed by a control message reception manager **625** as described with reference to FIG. **6**.

[0128] At **1015**, the method may include transmitting, using at least one of the plurality of multiple uplink TOs in accordance with the CG configuration, an uplink control information message comprising an indication of a quantity of unused uplink TOs of the plurality of uplink TOs, wherein the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration, and wherein the one or more interruption durations are based at least in part on the measurement gap pattern. The operations of **1015** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1015** may be performed by a control message transmission manager **630** as described with reference to FIG. **6**.

[0129] FIG. **11** shows a flowchart illustrating a method **1100** that supports VIL considerations for CG TOs in accordance with one or more aspects of the present disclosure. The operations of the method **1100** may be implemented by a UE or its components as described herein. For example, the operations of the method **1100** may be performed by a UE **115** as described with reference to FIGS. **1** through **7**. In some examples, a UE may execute a set of instructions to control the functional

elements of the UE to perform the described functions. Additionally, or alternatively, the UE may perform aspects of the described functions using special-purpose hardware.
[0130] At **1105**, the method may include receiving a control message indicating a CG configuration, the CG configuration comprising a plurality of uplink TOs within a time period. The operations of **1105** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1105** may be performed by a control message reception manager **625** as described with reference to FIG. **6**.
[0131] At **1110**, the method may include determining to exclude one or more invalid uplink TOs based at least in part on a collision of the one or more uplink TOs with one or more interruption durations. The operations of **1110** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1110** may be performed by an invalid uplink transmission manager **640** as described with reference to FIG. **6**.
[0132] At **1115**, the method may include transmitting, using at least one of the plurality of uplink TOs in accordance with the CG configuration, an uplink control information message comprising an indication of a quantity of unused uplink TOs of the plurality of uplink TOs, where the indication excludes one or more invalid uplink TOs that correspond to the one or more uplink TOs of the plurality that at least partially overlap with the one or more interruption durations associated with a measurement duration, and wherein the measurement duration corresponds to a synchronization SMTC window. The operations of **1115** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **1115** may be performed by a control message transmission manager **630** as described with reference to FIG. **6**.
[0133] The following provides an overview of aspects of the present disclosure:
[0134] Aspect 1: A method for wireless communication by a UE, comprising: receiving a control message indicating a CG configuration, the CG configuration comprising a plurality of uplink TOs within a time period; and transmitting, using at least one of the plurality of uplink TOs in accordance with the CG configuration, an UCI message comprising an indication of a quantity of unused uplink TOs of the plurality of uplink TOs, wherein the indication excludes one or more invalid uplink TOs that correspond to one or more uplink TOs of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.
[0135] Aspect 2: The method of aspect 1, further comprising: transmitting one or more acknowledgment or negative acknowledgment messages in accordance with an ID, the ID is based at least in part on a first uplink shared channel occasion corresponding to a first uplink TO of the plurality of uplink TOs, wherein the ID is further based at least in part on the quantity of unused uplink TOs excluded from the indication.
[0136] Aspect 3: The method of any of aspects 1 through 2, further comprising: receiving a second control message indicating a configuration of a measurement gap pattern, wherein the one or more interruption durations are based at least in part on the measurement gap pattern.
[0137] Aspect 4: The method of any of aspects 1 through 3, wherein the one or more interruption durations comprise one or more VILs associated with a NCSG.
[0138] Aspect 5: The method of any of aspects 1 through 4, wherein the UCI message is multiplexed with each of one or more uplink shared channel messages that are transmitted during one or more valid uplink TOs.
[0139] Aspect 6: The method of any of aspects 1 through 5, wherein the one or more interruption durations are associated with inter-band measurements or intra-band measurement in a time division duplexing band.
[0140] Aspect 7: The method of any of aspects 1 through 6, further comprising: determining to exclude the one or more invalid uplink TOs based at least in part on a collision of the one or more uplink TOs with the one or more interruption durations, and wherein the measurement duration corresponds to a SMTC window.
[0141] Aspect 8: The method of any of aspects 1 through 7, wherein the one or more uplink TOs

partially overlap or completely overlap with the one or more interruption durations in a time domain.

[0142] Aspect 9: The method of any of aspects 1 through 8, wherein the UCI message comprises a bitmap indicating exclusion of the one or more invalid uplink TOs.

[0143] Aspect 10: The method of any of aspects 1 through 9, wherein the UCI message comprises a bitmap comprising one or more first bits indicating a first subset of the plurality of uplink TOs comprising the quantity of unused uplink TOs and one or more second bits indicating a second subset of the plurality of uplink TOs comprising a quantity of used uplink TOs.

[0144] Aspect 11: A UE for wireless communication, comprising one or more memories storing processor-executable code, and one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the UE to perform a method of any of aspects 1 through 10.

[0145] Aspect 12: A UE for wireless communication, comprising at least one means for performing a method of any of aspects 1 through 10.

[0146] Aspect 13: A non-transitory computer-readable medium storing code for wireless communication, the code comprising instructions executable by one or more processors to perform a method of any of aspects 1 through 10.

[0147] It should be noted that the methods described herein describe possible implementations. The operations and the steps may be rearranged or otherwise modified and other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0148] Although aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE, LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR networks. For example, the described techniques may be applicable to various other wireless communications systems such as Ultra Mobile Broadband (UMB), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, as well as other systems and radio technologies not explicitly mentioned herein.

[0149] Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0150] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed using a general-purpose processor, a DSP, an ASIC, a CPU, a graphics processing unit (GPU), a neural processing unit (NPU), an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor but, in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration). Any functions or operations described herein as being capable of being performed by a processor may be performed by multiple processors that, individually or collectively, are capable of performing the described functions or operations.

[0151] The functions described herein may be implemented using hardware, software executed by a processor, firmware, or any combination thereof. If implemented using software executed by a processor, the functions may be stored as or transmitted using one or more instructions or code of a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0152] 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 location to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, and not limitation, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of computer-readable medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray disc. Disks may reproduce data magnetically, and discs may reproduce data optically using lasers. Combinations of the above are also included within the scope of computer-readable media. Any functions or operations described herein as being capable of being performed by a memory may be performed by multiple memories that, individually or collectively, are capable of performing the described functions or operations.

[0153] 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") 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."

[0154] As used herein, including in the claims, the article "a" before a noun is open-ended and understood to refer to "at least one" of those nouns or "one or more" of those nouns. Thus, the terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. For example, if a claim recites "a component" that performs one or more functions, each of the individual functions may be performed by a single component or by any combination of multiple components. Thus, the term "a component" having characteristics or performing functions may refer to "at least one of one or more components" having a particular characteristic or performing a particular function. Subsequent reference to a component introduced with the article "a" using the terms "the" or "said" may refer to any or all of the one or more components. For example, a component introduced with the article "a" may be understood to mean "one or more components," and referring to "the component" subsequently in the claims may be understood to be equivalent to referring to "at least one of the one or more components." Similarly, subsequent reference to a component introduced as "one or more components" using the terms "the" or "said" may refer to any or all of the one or more components. For example, referring to "the one or more components" subsequently in the claims may be understood to be equivalent to referring to "at least one of the one or more components."

[0155] The term "determine" or "determining" encompasses a variety of actions and, therefore, "determining" can include calculating, computing, processing, deriving, investigating, looking up (such as via looking up in a table, a database, or another data structure), ascertaining, and the like. Also, “determining” can include receiving (e.g., receiving information), accessing (e.g., accessing data stored in memory), and the like. Also, “determining” can include resolving, obtaining, selecting, choosing, establishing, and other such similar actions.

[0156] In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label or other subsequent reference label.

[0157] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term “example” used herein means “serving as an example, instance, or illustration” and not “preferred” or “advantageous over other examples.” The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some figures, known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0158] 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

1. A user equipment (UE), comprising: one or more memories storing processor-executable code; and one or more processors coupled with the one or more memories and individually or collectively operable to execute the code to cause the UE to: receive a control message indicating a configured grant configuration, the configured grant configuration comprising a plurality of uplink transmission occasions within a time period; and transmit, using at least one of the plurality of uplink transmission occasions in accordance with the configured grant configuration, an uplink control information message comprising an indication of a quantity of unused uplink transmission occasions of the plurality of uplink transmission occasions, wherein the indication excludes one or more invalid uplink transmission occasions that correspond to one or more uplink transmission occasions of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.

2. The UE of claim 1, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to: transmit one or more acknowledgment or negative acknowledgment messages in accordance with an identifier, the identifier is based at least in part on a first uplink shared channel occasion corresponding to a first uplink transmission occasion of the plurality of uplink transmission occasions, wherein the identifier is further based at least in part on the quantity of unused uplink transmission occasions excluded from the indication.

3. The UE of claim 1, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to: receive a second control message indicating a configuration of a measurement gap pattern, wherein the one or more interruption durations are based at least in part on the measurement gap pattern.

4. The UE of claim 1, wherein the one or more interruption durations comprise one or more visible interruption lengths associated with a network controlled small gap.

5. The UE of claim 1, wherein the uplink control information message is multiplexed with each of one or more uplink shared channel messages that are transmitted during one or more valid uplink transmission occasions.
6. The UE of claim 1, wherein the one or more interruption durations are associated with inter-band measurements or intra-band measurement in a time division duplexing band.
7. The UE of claim 1, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to: determine to exclude the one or more invalid uplink transmission occasions based at least in part on a collision of the one or more uplink transmission occasions with the one or more interruption durations, and wherein the measurement duration corresponds to a synchronization signal measurement timing configuration (SMTC) window.
8. The UE of claim 1, wherein the one or more uplink transmission occasions partially overlap or completely overlap with the one or more interruption durations in a time domain.
9. The UE of claim 1, wherein the uplink control information message comprises a bitmap indicating exclusion of the one or more invalid uplink transmission occasions.
10. The UE of claim 1, wherein the uplink control information message comprises a bitmap comprising one or more first bits indicating a first subset of the plurality of uplink transmission occasions comprising the quantity of unused uplink transmission occasions and one or more second bits indicating a second subset of the plurality of uplink transmission occasions comprising a quantity of used uplink transmission occasions.
11. A method for wireless communication by a user equipment (UE), comprising: receiving a control message indicating a configured grant configuration, the configured grant configuration comprising a plurality of uplink transmission occasions within a time period; and transmitting, using at least one of the plurality of uplink transmission occasions in accordance with the configured grant configuration, an uplink control information message comprising an indication of a quantity of unused uplink transmission occasions of the plurality of uplink transmission occasions, wherein the indication excludes one or more invalid uplink transmission occasions that correspond to one or more uplink transmission occasions of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.
12. The method of claim 11, further comprising: transmitting one or more acknowledgment or negative acknowledgment messages in accordance with an identifier, the identifier is based at least in part on a first uplink shared channel occasion corresponding to a first uplink transmission occasion of the plurality of uplink transmission occasions, wherein the identifier is further based at least in part on the quantity of unused uplink transmission occasions excluded from the indication.
13. The method of claim 11, further comprising: receiving a second control message indicating a configuration of a measurement gap pattern, wherein the one or more interruption durations are based at least in part on the measurement gap pattern.
14. The method of claim 11, wherein the one or more interruption durations comprise one or more visible interruption lengths associated with a network controlled small gap.
15. The method of claim 11, wherein the uplink control information message is multiplexed with each of one or more uplink shared channel messages that are transmitted during one or more valid uplink transmission occasions.
16. The method of claim 11, wherein the one or more interruption durations are associated with inter-band measurements or intra-band measurement in a time division duplexing band.
17. The method of claim 11, further comprising: determining to exclude the one or more invalid uplink transmission occasions based at least in part on a collision of the one or more uplink transmission occasions with the one or more interruption durations, and wherein the measurement duration corresponds to a synchronization signal measurement timing configuration (SMTC) window.
18. The method of claim 11, wherein the one or more uplink transmission occasions partially

overlap or completely overlap with the one or more interruption durations in a time domain.

19. The method of claim 11, wherein the uplink control information message comprises a bitmap indicating exclusion of the one or more invalid uplink transmission occasions.

20. A non-transitory computer-readable medium storing code for wireless communication, the code comprising instructions executable by one or more processors to: receive a control message indicating a configured grant configuration, the configured grant configuration comprising a plurality of uplink transmission occasions within a time period; and transmit, using at least one of the plurality of uplink transmission occasions in accordance with the configured grant configuration, an uplink control information message comprising an indication of a quantity of unused uplink transmission occasions of the plurality of uplink transmission occasions, wherein the indication excludes one or more invalid uplink transmission occasions that correspond to one or more uplink transmission occasions of the plurality that at least partially overlap with one or more interruption durations associated with a measurement duration.