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Patent Public Search | Text View

United States Patent Application Publication

20250260971

Kind Code

A1

Publication Date

August 14, 2025

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TECHNIQUES FOR RESOLVING UPLINK AND DOWNLINK COLLISIONS IN NON-TERRESTRIAL NETWORKS

Abstract

Methods, systems, and devices for wireless communications are described. A user equipment (UE) may receive, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. The UE may receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The UE may transmit a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The UE may drop the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

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Family ID: 94633710

Appl. No.: 18/441230

Filed: February 14, 2024

Publication Classification

Int. Cl.: H04W8/22 (20090101); H04L5/16 (20060101); H04W56/00 (20090101); H04W72/1273 (20230101)

U.S. Cl.:

Background/Summary

FIELD OF TECHNOLOGY

[0001] The following relates to wireless communications, including techniques for resolving uplink and downlink collisions in non-terrestrial networks.

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).

[0003] In some wireless communications systems, a wireless device may operate in association with a non-terrestrial network. However, such approaches may be improved.

SUMMARY

[0004] The described techniques relate to improved methods, systems, devices, and apparatuses that support techniques for resolving uplink and downlink collisions in non-terrestrial networks. For example, a user equipment (UE) may receive, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. The UE may receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The UE may transmit a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The UE may drop the uplink transmission or the reception of the downlink transmission based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0005] A method for wireless communications by a user equipment (UE) is described. The method may include receiving, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources, receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources, transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the first report indicating a timing advance value associated with the uplink transmission, and dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0006] A UE for wireless communications 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, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources, receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources, transmit a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the first report indicating a timing advance value associated with the uplink transmission, and drop the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0007] Another UE for wireless communications is described. The UE may include means for receiving, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources, means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources, means for transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the first report indicating a timing advance value associated with the uplink transmission, and means for dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0008] A non-transitory computer-readable medium storing code for wireless communications is described. The code may include instructions executable by one or more processors to receive, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources, receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources, transmit a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the first report indicating a timing advance value associated with the uplink transmission, and drop the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0009] Some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting a UE-specific report associated with operation of reduced capability (RedCap) UEs in non-terrestrial networks, the second report indicating a timing advance value associated with the uplink transmission, where dropping the uplink transmission or the downlink reception may be based on the timing advance value.

[0010] In some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein, a resolution of a set of multiple candidate timing advance values from which the timing advance value may be selected may be less than one millisecond.

[0011] In some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein, a resolution of a set of multiple candidate timing advance values from which the timing advance value may be selected may be based on a subcarrier spacing value.

[0012] Some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for transmitting, via the second report, an indication of a drift rate of the timing advance, where the drift rate may be associated with operation of the UE in association with a non-terrestrial network.

[0013] In some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein, the second report may be transmitted in accordance with a

reporting periodicity, in response to receiving a request to transmit the second report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.

[0014] Some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein may further include operations, features, means, or instructions for dropping communication of the uplink transmission or the downlink reception based on a dropping rule configured for the UE by a network entity associated with the non-terrestrial network.

[0015] In some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein, the dropping rule may be configured on a per-UE basis or a per-cell basis.

[0016] In some examples of the method, user equipment (UEs), and non-transitory computer-readable medium described herein, the half-duplex RedCap communications capability of the UE includes support for wireless communications over one or more new radio (NR) non-terrestrial network bands, transmission of the UE-common report, transmission of a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, or any combination thereof.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 shows an example of a wireless communications system that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0018] FIG. 2 shows an example of a wireless communications system that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0019] FIG. 3 shows an example of a process flow that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0020] FIGS. 4 and 5 show block diagrams of devices that support techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0021] FIG. 6 shows a block diagram of a communications manager that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0022] FIG. 7 shows a diagram of a system including a device that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0023] FIGS. 8 and 9 show flowcharts illustrating methods that support techniques for resolving uplink and downlink collisions in non-terrestrial networks.

DETAILED DESCRIPTION

[0024] In wireless communications, reduced capability (RedCap) user equipments (UEs) may operate in half-duplex modes on a frequency-division duplexing (FDD) band in which they may not transmit and receive communications simultaneously. As such, a network entity may schedule uplink and downlink communications in accordance with such half-duplex operation. However, in non-terrestrial networks such scheduling may be more complicated due to increased latency or delays resulting from increased distances. The increased distances may introduce increased uncertainty regarding the timing of uplink communications as well as a timing advance (TA) values used to coordinate uplink and downlink transmissions. As such, collisions between uplink and downlink communications may be more likely to occur in a non-terrestrial network (as compared with a terrestrial network). In some approaches (e.g., those associated with terrestrial networks), such collisions result in error conditions and ambiguity in operation. However, if such ambiguities and error conditions are present in non-terrestrial networks, channel usage may be reduced significantly, as other approaches to avoiding such collisions result in excessive cancelation of time resources, resulting in increased communications latency and reduced communications quality.

[0025] Techniques for RedCap UE operation in non-terrestrial networks in cases of uplink and downlink collision may be employed. For example, a UE may receive control signaling that may schedule an uplink transmission and a downlink transmission in a non-terrestrial network. In some cases, the uplink transmission and the downlink transmission may conflict or overlap, and the UE may apply a dropping rule to determine which transmission is to be dropped and which transmission is to be communicated in efforts to avoid a conflict. In some examples, such a dropping rule may be configured by a network entity for a particular UE or for an entire cell. In some examples, it may be mandatory for the UE to transmit a timing advance report. In some examples, the UE may transmit another report that may include more detailed timing advance information (e.g., that reports the timing advance information with a finer resolution or granularity). In some examples, the UE may report a timing advance drift rate to the network entity. By employing these and other techniques described herein, channel usage and communications quality may be increased and communications latency may be decreased.

[0026] Aspects of the disclosure are initially described in the context of wireless communications systems. Aspects of the disclosure are then described with reference to a wireless communications system and a process flow. Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0027] FIG. 1 shows an example of a wireless communications system **100** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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 adaptation 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] For instance, an access network (AN) or RAN may include communications between access

nodes (e.g., an IAB donor), IAB node(s) **104**, and one or more UEs **115**. The IAB donor may facilitate connection between the core network **130** and the AN (e.g., via a wired or wireless connection to the core network **130**). That is, an IAB donor may refer to a RAN node with a wired or wireless connection to the core network **130**. The IAB donor may include one or more of a CU **160**, a DU **165**, and an RU **170**, in which case the CU **160** may communicate with the core network **130** via an interface (e.g., a backhaul link). The IAB donor and IAB node(s) **104** may communicate via an F1 interface according to a protocol that defines signaling messages (e.g., an F1 AP protocol). Additionally, or alternatively, the CU **160** may communicate with the core network **130** via an interface, which may be an example of a portion of a backhaul link, and may communicate with other CUs (e.g., including a CU **160** associated with an alternative IAB donor) via an Xn-C interface, which may be an example of another portion of a backhaul link.

[0037] IAB node(s) **104** may refer to RAN nodes that provide IAB functionality (e.g., access for UEs **115**, wireless self-backhauling capabilities). A DU **165** may act as a distributed scheduling node towards child nodes associated with the IAB node(s) **104**, and the IAB-MT may act as a scheduled node towards parent nodes associated with IAB node(s) **104**. That is, an IAB donor may be referred to as a parent node in communication with one or more child nodes (e.g., an IAB donor may relay transmissions for UEs through other IAB node(s) **104**). Additionally, or alternatively, IAB node(s) **104** may also be referred to as parent nodes or child nodes to other IAB node(s) **104**, depending on the relay chain or configuration of the AN. The IAB-MT entity of IAB node(s) **104** may provide a Uu interface for a child IAB node (e.g., the IAB node(s) **104**) to receive signaling from a parent IAB node (e.g., the IAB node(s) **104**), and a DU interface (e.g., a DU **165**) may provide a Uu interface for a parent IAB node to signal to a child IAB node or UE **115**.

[0038] For example, IAB node(s) **104** may be referred to as parent nodes that support communications for child IAB nodes, or may be referred to as child IAB nodes associated with IAB donors, or both. An IAB donor may include a CU **160** with a wired or wireless connection (e.g., backhaul communication link(s) **120**) to the core network **130** and may act as a parent node to IAB node(s) **104**. For example, the DU **165** of an IAB donor may relay transmissions to UEs **115** through IAB node(s) **104**, or may directly signal transmissions to a UE **115**, or both. The CU **160** of the IAB donor may signal communication link establishment via an F1 interface to IAB node(s) **104**, and the IAB node(s) **104** may schedule transmissions (e.g., transmissions to the UEs **115** relayed from the IAB donor) through one or more DUs (e.g., DUs **165**). That is, data may be relayed to and from IAB node(s) **104** via signaling via an NR Uu interface to MT of IAB node(s) **104** (e.g., other IAB node(s)). Communications with IAB node(s) **104** may be scheduled by a DU **165** of the IAB donor or of IAB node(s) **104**.

[0039] 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**).

[0040] 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.

[0041] 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.

[0042] 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**).

[0043] 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).

[0044] 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).

[0045] 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.

[0046] 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**.

[0047] 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.

[0048] 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 $T_{\text{sub.s}} = 1/(\Delta f_{\text{sub.max}} \cdot N_{\text{sub.f}})$ seconds, for which $\Delta f_{\text{sub.max}}$ may represent a supported subcarrier spacing, and $N_{\text{sub.f}}$ 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).

[0049] 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., $N_{\text{sub.f}}$) sampling periods. The duration of a symbol period may depend on the subcarrier spacing or frequency band of operation. [0050] 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)).

[0051] 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).

[0052] A network entity **105** may provide communication coverage via one or more cells, for example a macro cell, a small cell, a hot spot, or other types of cells, or any combination thereof. The term “cell” may refer to a logical communication entity used for communication with a network entity **105** (e.g., using a carrier) and may be associated with an identifier for distinguishing neighboring cells (e.g., a physical cell identifier (PCID), a virtual cell identifier (VCID)). In some examples, a cell also may refer to a coverage area **110** or a portion of a coverage area **110** (e.g., a sector) over which the logical communication entity operates. Such cells may range from smaller areas (e.g., a structure, a subset of structure) to larger areas depending on various factors such as the capabilities of the network entity **105**. For example, a cell may be or include a building, a subset of a building, or exterior spaces between or overlapping with coverage areas **110**, among other examples.

[0053] A macro cell generally covers a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by the UEs **115** with service subscriptions with the network provider supporting the macro cell. A small cell may be associated with a network entity **105** operating with lower power (e.g., a base station **140** operating with lower power) relative to a macro cell, and a small cell may operate using the same or different (e.g., licensed, unlicensed) frequency bands as macro cells. Small cells may provide unrestricted access to the UEs **115** with service subscriptions with the network provider or may provide restricted access to the UEs **115** having an association with the small cell (e.g., the UEs **115** in a closed subscriber group (CSG), the UEs **115** associated with users in a home or office). A network entity **105** may support one or more cells and may also support communications via the one or more cells using one or multiple component carriers.

[0054] In some examples, a carrier may support multiple cells, and different cells may be configured according to different protocol types (e.g., MTC, narrowband IoT (NB-IoT), enhanced mobile broadband (eMBB)) that may provide access for different types of devices.

[0055] 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.

[0056] 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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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**.

[0061] In some systems, a D2D communication link **135** may be an example of a communication channel, such as a sidelink communication channel, between vehicles (e.g., UEs **115**). In some examples, vehicles may communicate using vehicle-to-everything (V2X) communications, vehicle-to-vehicle (V2V) communications, or some combination of these. A vehicle may signal information related to traffic conditions, signal scheduling, weather, safety, emergencies, or any other information relevant to a V2X system. In some examples, vehicles in a V2X system may communicate with roadside infrastructure, such as roadside units, or with the network via one or more network nodes (e.g., network entities **105**, base stations **140**, RUs **170**) using vehicle-to-

network (V2N) communications, or with both.

[0062] 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.

[0063] 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] The network entities **105** or the UEs **115** may use MIMO communications to exploit multipath signal propagation and increase spectral efficiency by transmitting or receiving multiple signals via different spatial layers. Such techniques may be referred to as spatial multiplexing. The multiple signals may, for example, be transmitted by the transmitting device via different antennas or different combinations of antennas. Likewise, the multiple signals may be received by the receiving device via different antennas or different combinations of antennas. Each of the multiple signals may be referred to as a separate spatial stream and may carry information associated with the same data stream (e.g., the same codeword) or different data streams (e.g., different codewords). Different spatial layers may be associated with different antenna ports used for channel measurement and reporting. MIMO techniques include single-user MIMO (SU-MIMO), for which multiple spatial layers are transmitted to the same receiving device, and multiple-user MIMO (MU-MIMO), for which multiple spatial layers are transmitted to multiple devices.

[0068] 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).

[0069] A network entity **105** or a UE **115** may use beam sweeping techniques as part of beamforming operations. For example, a network entity **105** (e.g., a base station **140**, an RU **170**) may use multiple antennas or antenna arrays (e.g., antenna panels) to conduct beamforming operations for directional communications with a UE **115**. Some signals (e.g., synchronization signals, reference signals, beam selection signals, or other control signals) may be transmitted by a network entity **105** multiple times along different directions. For example, the network entity **105** may transmit a signal according to different beamforming weight sets associated with different directions of transmission. Transmissions along different beam directions may be used to identify (e.g., by a transmitting device, such as a network entity **105**, or by a receiving device, such as a UE **115**) a beam direction for later transmission or reception by the network entity **105**.

[0070] Some signals, such as data signals associated with a particular receiving device, may be transmitted by a transmitting device (e.g., a network entity **105** or a UE **115**) along a single beam direction (e.g., a direction associated with the receiving device, such as another network entity **105** or UE **115**). In some examples, the beam direction associated with transmissions along a single beam direction may be determined based on a signal that was transmitted along one or more beam

directions. For example, a UE **115** may receive one or more of the signals transmitted by the network entity **105** along different directions and may report to the network entity **105** an indication of the signal that the UE **115** received with a highest signal quality or an otherwise acceptable signal quality.

[0071] In some examples, transmissions by a device (e.g., by a network entity **105** or a UE **115**) may be performed using multiple beam directions, and the device may use a combination of digital precoding or beamforming to generate a combined beam for transmission (e.g., from a network entity **105** to a UE **115**). The UE **115** may report feedback that indicates precoding weights for one or more beam directions, and the feedback may correspond to a configured set of beams across a system bandwidth or one or more sub-bands. The network entity **105** may transmit a reference signal (e.g., a cell-specific reference signal (CRS), a channel state information reference signal (CSI-RS)), which may be precoded or unprecoded. The UE **115** may provide feedback for beam selection, which may be a precoding matrix indicator (PMI) or codebook-based feedback (e.g., a multi-panel type codebook, a linear combination type codebook, a port selection type codebook). Although these techniques are described with reference to signals transmitted along one or more directions by a network entity **105** (e.g., a base station **140**, an RU **170**), a UE **115** may employ similar techniques for transmitting signals multiple times along different directions (e.g., for identifying a beam direction for subsequent transmission or reception by the UE **115**) or for transmitting a signal along a single direction (e.g., for transmitting data to a receiving device).

[0072] A receiving device (e.g., a UE **115**) may perform reception operations in accordance with multiple receive configurations (e.g., directional listening) when receiving various signals from a transmitting device (e.g., a network entity **105**), such as synchronization signals, reference signals, beam selection signals, or other control signals. For example, a receiving device may perform reception in accordance with multiple receive directions by receiving via different antenna subarrays, by processing received signals according to different antenna subarrays, by receiving according to different receive beamforming weight sets (e.g., different directional listening weight sets) applied to signals received at multiple antenna elements of an antenna array, or by processing received signals according to different receive beamforming weight sets applied to signals received at multiple antenna elements of an antenna array, any of which may be referred to as “listening” according to different receive configurations or receive directions. In some examples, a receiving device may use a single receive configuration to receive along a single beam direction (e.g., when receiving a data signal). The single receive configuration may be aligned along a beam direction determined based on listening according to different receive configuration directions (e.g., a beam direction determined to have a highest signal strength, highest signal-to-noise ratio (SNR), or otherwise acceptable signal quality based on listening according to multiple beam directions).

[0073] 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.

[0074] 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.

[0075] In some implementations, a UE **115** and a network entity **105** may support resolution of uplink and downlink collisions in NTN. For example, the UE **115** may be a RedCap UE and may operate with a half-duplex communications capability. A network entity **105** may schedule both an uplink transmission and a downlink transmission for the UE **115**. However, due to the operation in the NTN, the delay in the communications between the network entity **105** and the UE **115** (or one or more other factors) may cause the uplink transmission and the downlink transmission to collide or overlap. The UE **115** may then apply a dropping rule to drop either the uplink transmission or the downlink transmission (e.g., depending on the rule). In some examples, the UE **115** may also transmit a UE-common report that may include or indicate a TA value that may aid in correcting or preventing such situations of uplink-downlink collision or overlap. In this way, overlap or collision scenarios may be reduced and, in cases in which overlaps or collisions do occur, UE **115** behavior is defined according to the dropping rule, reducing latency, improving communications quality and reliability.

[0076] FIG. 2 shows an example of a wireless communications system **200** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks.

[0077] The wireless communications system **200** may include the network entity **105-a**, which may be an example of one or more network entities discussed in relation to other figures. The wireless communications system **200** may include the UE **115-a**, which may be an example of UEs discussed in relation to other figures. The wireless communications system **200** may be an NTN, in which case the network entity **105-a** may be associated with a satellite or other element of an NTN. The UE **115-a** may be a RedCap device, employing a reduced set of capabilities that may aid in power savings or other operational characteristics due to the reduced set of capabilities. In some examples, the UE **115-a** may be a wearable device. In some examples, the UE **115-a** may operate in accordance with a half-duplex capability, in which the UE **115-a** may not be capable of both transmitting and receiving communications simultaneously or in an overlapping manner.

[0078] In some examples, collision or overlapping rules may be employed that may determine or designate UE **115-a** behavior to resolve such collision or overlapping. For example, in some cases, the reception of the downlink transmission may be dropped or the uplink transmission may be canceled. Such rules or procedures may depend or be based on the characteristics or types of the uplink and downlink transmissions. However, in some approaches, such rules may designate some collision or overlap cases or combinations of characteristics to be error cases, in which no behavior is defined or designated. In such cases, a UE may perform one or more operations without regard to a rule or procedure, which may increase latency and reduce communications quality and reliability.

[0079] Further, in some cases, channel usage may be reduced due to existing approaches to avoid such collision or overlap scenarios, further increasing latency and reducing communications quality and reliability. For example, given a typical beam size for NTN communications in low earth orbit, existing TA reports may not be helpful in narrowing the uncertainty region in which a “true” or more accurate TA may lie. Supposing that a network entity configures a UE to report a UE-specific TA in response to a change in the TA (e.g., 0.5 ms or 1 ms). In such cases, the network entity may appropriately determine that the “true” TA may lie between 0 and 1 ms. However, without TA reporting, the uncertainty of the “true” TA may be found anywhere between an upper TA threshold (e.g., a maximum TA) and a lower TA threshold (e.g., a minimum TA), where such thresholds are thresholds or values associated with a cell of the NTN. For example, given a 600 km orbit, a 100 km diameter footprint, and a 30 degree elevation angle, a range between an upper TA threshold and

a lower TA threshold may be approximately 0.5 ms.

[0080] Thus, in some cases, an uncertainty of a “true” TA may be within a range of 0 to 1 ms when TA report is transmitted or more when TA report is not transmitted and the beam footprint is large. This may result in cases in which one uplink slot may overlap with two downlink slots (e.g., from the perspective of the network entity **105**) in situations in which a TA report is transmitted by the UE **115-a** (e.g., with 1 ms triggering in which a change in the TA of 1 ms or greater triggers such reporting). Additionally, or alternatively, in cases in which the difference between the upper TA threshold and the lower TA threshold is less than 1 ms and a TA report is not transmitted, the one uplink slot may overlap with two or three downlink slots. In situations in which no TA report is transmitted, similar or same scheduling restraints may be applied to multiple UEs.

[0081] Therefore, without considering uplink transmission repetitions, channel usages of the uplink and downlink channels for a half-duplex UE may satisfy the following equation, where U_{subD} corresponds to the downlink channel usage and where U_u corresponds to the uplink channel usage.

[00001]
$$U_D + 2U_U \leq 1 \quad (1)$$

Thus, uncertainty about TA values for the UE may increase the difficulty of avoiding uplink and downlink overlap or collision without conservative scheduling, which results in further loss of channel usage.

[0082] As such, the UE **115-a** and the network entity **105-a** may operate in accordance with one or more overlap/collision rules (e.g., dropping rules) to resolve ambiguity in operation, reduce latency, and increase communications quality and reliability. For example, the network entity **105-a** may transmit the first control signaling **220** that may schedule transmission of the downlink transmission **240**. The network entity **105-a** may also transmit the second control signaling **225** that may schedule the uplink transmission **245**. The UE **115-a** may determine that the downlink transmission **240** and the uplink transmission **245** will overlap or collide, and the UE **115-a** may, as a result, drop either the reception of the downlink transmission **240** or the uplink transmission **245** based on the overlap or collision. In some examples, the UE **115-a** may drop the reception of the downlink transmission **240** or the uplink transmission **245** based on a dropping rule that may be configured by the network entity **105-a**. In some examples, the network entity **105-a** may configure the dropping rule for the UE **115-a** (e.g., on an individual UE basis) or on a cell basis (e.g., in the first control signaling **220**, which may be SIB signaling, such as SIB1 signaling).

[0083] As described herein, in some cases, a UE may not transmit a TA report to a network entity, resulting in increased ambiguity as to a “true” or most helpful TA value (e.g., to compensate for delays present in NTN operation). As such, in some examples, the UE **115-a** may transmit the first report **230** which may include or indicate a TA value **250** or multiple such TA values **250**. In some examples, transmission of the first report **230** by the UE **115-a** may be mandatory or may be transmitted in response to a request from the network entity. In some examples, transmission of the first report **230** by the UE **115-a** may be mandatory for a UE (e.g., a RedCap UE, a half-duplex RedCap UE, a full-duplex RedCap UE, a non-RedCap UE, or any combination thereof) operating in association with an NTN.

[0084] In some examples, the UE **115-a** may transmit the second report **235**. The second report **235** may be distinct from the first report **230**. The second report **235** may include or indicate the TA value **250-a**, but the resolution or granularity of the TA value **250-b** may be finer than the resolution or granularity of the TA value **250-a**. For example, a resolution associated with candidate values for the TA value **250-b** may be less than 1 ms, which is the resolution associated with the TA value **250-a**. Further, in some examples, the resolution associated with candidate values for the TA value **250-b** may be based on a subcarrier spacing associated with operation of the network entity **105-a** and the UE **115-a**. In some examples, the second report **235** may include or indicate a reference to a time period or one or more transmissions with which the included TA value **250-b** is associated. For example, the included TA value **250-b** may be a TA value for the uplink

transmission that carries the second report **235**.

[0085] In some examples, the second report **235** may further include or indicate a TA drift value **255**. The TA drift value **255** may indicate an amount of drift of the TA value that may occur over time (e.g., due to movement of the UE **115-a** or other changes in relative positions of the UE **115-a** and the network entity **105-a**, such as an orbit path of the network entity **105-a**).

[0086] In some examples, the UE **115-a** may transmit the second report **235** on a periodic or semi-periodic basis. For example, the network entity **105-a** may configure periodic transmission of the second report **235** for the UE **115-a** individually or for a cell. Additionally, or alternatively, the UE **115-a** may transmit the second report **235** in response to receiving a request from the network entity **105-a**.

[0087] FIG. **3** shows an example of a process flow **300** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. The process flow **300** may implement various aspects of the present disclosure described herein. The elements described in the process flow **300** (e.g., UE **115-b** and network entity **105-b**) may be examples of similarly named elements described herein. In the following description of the process flow **300**, the operations between the various entities or elements may be performed in different orders or at different times. Some operations may also be left out of the process flow **300**, or other operations may be added.

Although the various entities or elements are shown performing the operations of the process flow **300**, some aspects of some operations may also be performed by other entities or elements of the process flow **300** or by entities or elements that are not depicted in the process flow, or any combination thereof.

[0088] At **320**, the UE **115-b** may receive, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources.

[0089] At **325**, the UE **115-b** may receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. In some examples, the half-duplex RedCap communications capability of the UE may include support for wireless communications over one or more new radio non-terrestrial network bands, transmission of the UE-common report, transmission of a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, or any combination thereof. For example, a communications capability of the UE may include a capability to transmit one or more reports (e.g., the UE-common report, the UE-specific report, or both) that may include or indicate a TA value. In some examples, such a capability may be presented, relevant, indicated, or employed in situations in which such reporting is not mandatory. In some examples, the UE **115-b** may transmit an indication of such a communications capability to the network entity **105-b** and the network entity **105-b** may respond with an indication that the UE **115-b** is to provide the report indicating the TA value. The UE **115-a** may transmit the report indicating the TA value in response to receiving the network entity **105-b** signaling.

[0090] At **330**, the UE **115-b** may transmit a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission.

[0091] At **335**, the UE **115-b** may transmit a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value associated with the uplink transmission and dropping the uplink transmission or the downlink reception is based on the timing advance value. In some examples, a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is less than one millisecond. Additionally, or alternatively, in some examples, a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is based on a subcarrier spacing value. In some examples, the UE **115-b** may transmit, via the UE-specific report,

an indication of a drift rate of the timing advance and the drift rate is associated with operation of the UE in association with a non-terrestrial network. In some examples, the UE-specific report is transmitted in accordance with a reporting periodicity, in response to receiving a request to transmit the UE-specific report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.

[0092] At **340**, the UE **115-b** may drop the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value. For example, the UE **115-b** may not transmit the uplink transmission or may not engage in one or more operations to receive the downlink transmission (e.g., even if the downlink transmission is transmitted by the network entity **105-b**). In some examples, the UE **115-b** may drop communication of the uplink transmission or the downlink transmission based on a dropping rule configured for the UE by a network entity **105-b** associated with the non-terrestrial network. In some examples, the dropping rule is configured on a per-UE basis or a per-cell basis.

[0093] FIG. **4** shows a block diagram **400** of a device **405** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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).

[0094] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks). 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.

[0095] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks). 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.

[0096] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks 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.

[0097] 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).

[0098] 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).

[0099] 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.

[0100] Additionally, or alternatively, the communications manager **420** may support wireless communications 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, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. The communications manager **420** is capable of, configured to, or operable to support a means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The communications manager **420** is capable of, configured to, or operable to support a means for transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The communications manager **420** is capable of, configured to, or operable to support a means for dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0101] 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 reduced processing, reduced power consumption, more efficient utilization of communication resources, or any combination thereof.

[0102] FIG. 5 shows a block diagram **500** of a device **505** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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).

[0103] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks). 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.

[0104] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks). 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.

[0105] The device **505**, or various components thereof, may be an example of means for performing various aspects of techniques for resolving uplink and downlink collisions in non-terrestrial networks as described herein. For example, the communications manager **520** may include a control signaling component **525**, a reporting component **530**, a transmission management component **535**, 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.

[0106] The communications manager **520** may support wireless communications in accordance with examples as disclosed herein. The control signaling component **525** is capable of, configured to, or operable to support a means for receiving, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. The control signaling component **525** is capable of, configured to, or operable to support a means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The reporting component **530** is capable of, configured to, or operable to support a means for transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The transmission management component **535** is capable of, configured to, or operable to support a means for dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0107] FIG. **6** shows a block diagram **600** of a communications manager **620** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks as described herein. For example, the communications manager **620** may include a control signaling component **625**, a reporting component **630**, a transmission management component **635**, a dropping rule component **640**, a capability component **645**, a resolution component **650**, a draft rate component **655**, a reporting trigger component **660**, 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).

[0108] Additionally, or alternatively, the communications manager **620** may support wireless communications in accordance with examples as disclosed herein. The control signaling

component **625** is capable of, configured to, or operable to support a means for receiving, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. In some examples, the control signaling component **625** is capable of, configured to, or operable to support a means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The reporting component **630** is capable of, configured to, or operable to support a means for transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The transmission management component **635** is capable of, configured to, or operable to support a means for dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0109] In some examples, the reporting component **630** is capable of, configured to, or operable to support a means for transmitting a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, where dropping the uplink transmission or the downlink reception is based on the timing advance value.

[0110] In some examples, a resolution of a set of multiple candidate timing advance values from which the timing advance value is selected is less than one millisecond.

[0111] In some examples, a resolution of a set of multiple candidate timing advance values from which the timing advance value is selected is based on a subcarrier spacing value.

[0112] In some examples, the draft rate component **655** is capable of, configured to, or operable to support a means for transmitting, via the UE-specific report, an indication of a drift rate of the timing advance value, where the drift rate is associated with operation of the UE in association with a non-terrestrial network.

[0113] In some examples, the UE-specific report is transmitted in accordance with a reporting periodicity, in response to receiving a request to transmit the UE-specific report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.

[0114] In some examples, the dropping rule component **640** is capable of, configured to, or operable to support a means for dropping communication of the uplink transmission or the downlink transmission based on a dropping rule configured for the UE by a network entity associated with a non-terrestrial network.

[0115] In some examples, the dropping rule is configured on a per-UE basis or a per-cell basis.

[0116] In some examples, the half-duplex RedCap communications capability of the UE includes support for wireless communications over one or more new radio (NR) non-terrestrial network bands, transmission of the UE-common report, transmission of a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, or any combination thereof.

[0117] FIG. 7 shows a diagram of a system **700** including a device **705** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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**).

[0118] 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**.

[0119] 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.

[0120] 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.

[0121] 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 (NPU)s (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 techniques for resolving uplink and downlink collisions in non-terrestrial networks). 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.

[0122] Additionally, or alternatively, the communications manager **720** may support wireless communications 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, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. The communications manager **720** is capable of, configured to, or operable to support a means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. The communications manager **720** is capable of, configured to, or operable to support a means for transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The communications manager **720** is capable of, configured to, or operable to support a means for dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0123] By including or configuring the communications manager **720** in accordance with examples as described herein, the device **705** may support techniques for improved communication reliability, reduced latency, improved user experience related to reduced processing, reduced power consumption, more efficient utilization of communication resources, improved coordination between devices, longer battery life, improved utilization of processing capability, or any combination thereof.

[0124] 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 techniques for resolving uplink and downlink collisions in non-terrestrial networks 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.

[0125] FIG. **8** shows a flowchart illustrating a method **800** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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.

[0126] At **805**, the method may include receiving, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. 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 signaling component **625** as described with reference to FIG. 6.

[0127] At **810**, the method may include receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. 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 signaling component **625** as described with reference to FIG. 6.

[0128] At **815**, the method may include transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. The operations of **815** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **815** may be performed by a reporting component **630** as described with reference to FIG. 6.

[0129] At **820**, the method may include dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value. The operations of **820** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **820** may be performed by a transmission management component **635** as described with reference to FIG. 6.

[0130] FIG. 9 shows a flowchart illustrating a method **900** that supports techniques for resolving uplink and downlink collisions in non-terrestrial networks. 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.

[0131] At **905**, the method may include receiving, in accordance with a half-duplex RedCap communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources. 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 signaling component **625** as described with reference to FIG. 6.

[0132] At **910**, the method may include receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources. 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 control signaling component **625** as described with reference to FIG. 6.

[0133] At **915**, the method may include transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the UE-common report indicating a timing advance value associated with the uplink transmission. 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 reporting component **630** as described with reference to FIG. 6.

[0134] At **920**, the method may include transmitting a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, where dropping the uplink transmission or the downlink reception is based on the timing advance value. The operations of **920** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **920** may be performed by a reporting component **630** as described with reference to FIG. 6.

[0135] At **925**, the method may include dropping the uplink transmission or the downlink reception based on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value. The operations of **925** may be performed in accordance with examples as disclosed herein. In some examples, aspects of the operations of **925** may be performed by a transmission management component **635** as described with reference to FIG. 6.

[0136] The following provides an overview of aspects of the present disclosure:

[0137] Aspect 1: A method for wireless communications at a UE, the method comprising: receiving, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources; receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources; transmitting a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, the first report indicating a timing advance value associated with the uplink transmission; and dropping the uplink transmission or the downlink reception based at least in part on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission and the timing advance value.

[0138] Aspect 2: The method of aspect 1, further comprising: transmitting a UE-specific report associated with operation of reduced capability (RedCap) UEs in non-terrestrial networks, the second report indicating a timing advance value associated with the uplink transmission, wherein dropping the uplink transmission or the downlink reception is based at least in part on the timing advance value.

[0139] Aspect 3: The method of aspect 2, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is less than one millisecond.

[0140] Aspect 4: The method of any of aspects 2 through 3, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is based at least in part on a subcarrier spacing value.

[0141] Aspect 5: The method of any of aspects 2 through 4, further comprising: transmitting, via the second report, an indication of a drift rate of the timing advance, wherein the drift rate is associated with operation of the UE in association with a non-terrestrial network.

[0142] Aspect 6: The method of any of aspects 2 through 5, wherein the second report is transmitted in accordance with a reporting periodicity, in response to receiving a request to transmit the second report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.

[0143] Aspect 7: The method of any of aspects 1 through 6, further comprising: dropping communication of the uplink transmission or the downlink reception based at least in part on a dropping rule configured for the UE by a network entity associated with the non-terrestrial network.

[0144] Aspect 8: The method of aspect 7, wherein the dropping rule is configured on a per-UE basis or a per-cell basis.

[0145] Aspect 9: The method of any of aspects 1 through 8, wherein the half-duplex RedCap communications capability of the UE comprises support for wireless communications over one or more new radio (NR) non-terrestrial network bands, transmission of the UE-common report, transmission of a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating the timing advance value, or any combination thereof.

[0146] Aspect 10: A UE for wireless communications, 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 9.

[0147] Aspect 11: A UE for wireless communications, comprising at least one means for performing a method of any of aspects 1 through 9.

[0148] Aspect 12: A non-transitory computer-readable medium storing code for wireless communications, the code comprising instructions executable by one or more processors to perform a method of any of aspects 1 through 9.

[0149] 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.

[0150] 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.

[0151] 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.

[0152] 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.

[0153] 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.

[0154] 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.

[0155] 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.”

[0156] 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.”

[0157] 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.

[0158] 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.

[0159] 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.

[0160] 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, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources; receive, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources; drop the uplink transmission or the downlink reception based at least in part on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission.
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 a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value, wherein dropping the uplink transmission or the downlink reception is based at least in part on the timing advance value.
3. The UE of claim 2, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is less than one millisecond.
4. The UE of claim 2, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is based at least in part on a subcarrier spacing value.
5. The UE of claim 2, wherein the one or more processors are individually or collectively further operable to execute the code to cause the UE to: transmit, via the UE-specific report, an indication of a drift rate of the timing advance value, wherein the drift rate is associated with operation of the UE in association with a non-terrestrial network.
6. The UE of claim 2, wherein the UE-specific report is transmitted in accordance with a reporting periodicity, in response to receiving a request to transmit the UE-specific report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.
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: drop communication of the uplink transmission or the downlink reception based at least in part on a dropping rule configured for the UE by a network entity associated with a non-terrestrial network.
8. The UE of claim 7, wherein the dropping rule is configured on a per-UE basis or a per-cell basis.
9. The UE of claim 1, wherein: the half-duplex RedCap communications capability of the UE comprises support for wireless communications over one or more new radio (NR) non-terrestrial network bands, transmission of a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, transmission of a UE-specific report associated with operation of RedCap

UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value, or any combination thereof.

10. A method for wireless communications at a user equipment (UE), the method comprising: receiving, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources; receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources; dropping the uplink transmission or the downlink reception based at least in part on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission.

11. The method of claim 10, further comprising: transmitting a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value, wherein dropping the uplink transmission or the downlink reception is based at least in part on the timing advance value.

12. The method of claim 11, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is less than one millisecond.

13. The method of claim 11, wherein a resolution of a plurality of candidate timing advance values from which the timing advance value is selected is based at least in part on a subcarrier spacing value.

14. The method of claim 11, further comprising: transmitting, via the UE-specific report, an indication of a drift rate of the timing advance value, wherein the drift rate is associated with operation of the UE in association with a non-terrestrial network.

15. The method of claim 11, wherein the UE-specific report is transmitted in accordance with a reporting periodicity, in response to receiving a request to transmit the UE-specific report, or in response to the timing advance value differing from a previous timing advance value by at least a threshold amount after transmitting a previous report associated with the previous timing advance value.

16. The method of claim 10, further comprising: dropping communication of the uplink transmission or the downlink transmission based at least in part on a dropping rule configured for the UE by a network entity associated with a non-terrestrial network.

17. The method of claim 16, wherein the dropping rule is configured on a per-UE basis or a per-cell basis.

18. The method of claim 10, wherein the half-duplex RedCap communications capability of the UE comprises support for wireless communications over one or more new radio (NR) non-terrestrial network bands, transmission of a UE-common report associated with operation of RedCap UEs in non-terrestrial networks, transmission of a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value, or any combination thereof.

19. A user equipment (UE) for wireless communications, comprising: means for receiving, in accordance with a half-duplex reduced capability (RedCap) communications capability of the UE, first control signaling scheduling reception of a downlink transmission in first time resources; means for receiving, in accordance with the half-duplex RedCap communications capability of the UE, second control signaling scheduling an uplink transmission in second time resources; means for dropping the uplink transmission or the downlink reception based at least in part on at least a portion of the uplink transmission overlapping in time with at least a portion of the downlink transmission.

20. The UE of claim 19, further comprising: means for transmitting a UE-specific report associated with operation of RedCap UEs in non-terrestrial networks, the UE-specific report indicating a timing advance value, wherein dropping the uplink transmission or the downlink reception is based at least in part on the timing advance value.

