US Patent & Trademark Office
Patent Public Search | Text View

United States Patent Application Publication	20250264580
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	REN; Yuwei et al.

DYNAMIC POWER CONTROL FOR SENSING

Abstract

Disclosed are systems, apparatuses, processes, and computer-readable media for wireless communications. For example, an example of a process may include receiving, at a network device, reflection signals generated based on a plurality of sensing signals reflecting from a target object. The plurality of sensing signals may be configured in a plurality of resources, with each resource of the plurality of resources being associated with a different respective power level. The process may further include determining, at the network device, a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

Inventors:	**REN; Yuwei (Beijing, CN), DUAN; Weimin (San Diego, CA), XU; Huilin (Temecula, CA)**
Applicant:	**QUALCOMM Incorporated** (San Diego, CA)

Family ID:	**1000008577377**
Appl. No.:	**18/866028**
Filed (or PCT Filed):	**July 22, 2022**
PCT No.:	**PCT/CN2022/107298**

Publication Classification

Int. Cl.: **G01S7/40** (20060101); **G01S7/00** (20060101); **G01S13/86** (20060101); **H04W52/38** (20090101)

U.S. Cl.:

CPC **G01S7/4013** (20210501); **G01S7/006** (20130101); **G01S13/86** (20130101); **H04W52/38** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application for patent is a 371 of international Patent Application PCT/CN2022/107298, filed Jul. 22, 2022, which is hereby incorporated by referenced in its entirety and for all purposes.

FIELD OF THE DISCLOSURE
[0002] The present disclosure generally relates to joint communications and sensing. For example, aspects of the present disclosure relate to dynamic power control for performing sensing (e.g., with limited resource costs) of one or more target objects.
BACKGROUND OF THE DISCLOSURE
[0003] Wireless communications systems are widely deployed to provide various types of communication content, such as voice, video, packet data, messaging, and broadcast. 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 or one or more network access nodes, each simultaneously supporting communication for multiple communication devices, which may be otherwise known as user equipment (UE). Some wireless communications systems may support communications between UEs, which may involve direct transmissions between two or more UEs.
[0004] Due to larger bandwidths being allocated for wireless cellular communications systems (e.g., including 5G and 5G beyond) and more use cases being introduced into the cellular communications systems, multiplexing sensing and communication signals for joint communications and sensing can be an essential feature for existing or future wireless communication systems, such as to enhance the overall spectral efficiency of the wireless communication networks.
SUMMARY
[0005] The following presents a simplified summary relating to one or more aspects disclosed herein. Thus, the following summary should not be considered an extensive overview relating to all contemplated aspects, nor should the following summary be considered to identify key or critical elements relating to all contemplated aspects or to delineate the scope associated with any particular aspect. Accordingly, the following summary has the sole purpose to present certain concepts relating to one or more aspects relating to the mechanisms disclosed herein in a simplified form to precede the detailed description presented below.
[0006] Systems and techniques are described for wireless communications. According to at least

one example, a method is provided for wireless communications. The method includes: receiving, at the network device, reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determining, at the network device, a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

[0007] In another example, an apparatus for wireless communications is provided that includes at least one memory and at least one processor (e.g., implemented in circuitry) coupled to the at least one memory. The at least one processor is configured to: receive reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determine a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

[0008] In another example, a non-transitory computer-readable medium is provided that has stored thereon instructions that, when executed by one or more processors, cause the one or more processors to: receive reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determine a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

[0009] In another example, an apparatus for wireless communications is provided. The apparatus includes: means for receiving reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and means for determining a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

[0010] In some aspects, the apparatus is, is part of, and/or includes a UE, such as a wearable device, a mobile device (e.g., a mobile telephone and/or mobile handset and/or so-called “smart phone” or other mobile device), an extended reality (XR) device (e.g., a virtual reality (VR) device, an augmented reality (AR) device, or a mixed reality (MR) device, which may include a head-mounted display (HMD) device or glasses), a vehicle or a computing device or component of a vehicle, a wireless communication device, a camera, a personal computer, a laptop computer, a server computer, another device, or a combination thereof. In some aspects, the apparatus includes a camera or multiple cameras for capturing one or more images. In some aspects, the apparatus further includes a display for displaying one or more images, notifications, and/or other displayable data. In some aspects, the apparatuses described above can include one or more sensors (e.g., one or more inertial measurement units (IMUs), such as one or more gyroscopes, one or more gyrometers, one or more accelerometers, any combination thereof, and/or other sensor).

[0011] This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this patent, any or all drawings, and each claim.

[0012] The foregoing, together with other features and aspects, will become more apparent upon referring to the following specification, claims, and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings are presented to aid in the description of various aspects of the disclosure and are provided solely for illustration of the aspects and not limitation thereof.

[0014] FIG. **1** is a diagram illustrating an example wireless communications system, which may be employed by the disclosed systems and techniques for dynamic power control in sensing, in accordance with some aspects of the present disclosure.

[0015] FIG. **2** is a diagram illustrating an example of a disaggregated base station architecture, which may be employed by the disclosed systems and techniques for dynamic power control in sensing, in accordance with some aspects of the present disclosure.

[0016] FIG. **3** is a diagram illustrating an example of a frame structure, which may be employed by the disclosed systems and techniques for dynamic power control in sensing, in accordance with some aspects of the present disclosure.

[0017] FIG. **4** is a block diagram illustrating an example of a computing system of an electronic device that may be employed by the disclosed systems and techniques for dynamic power control in sensing, in accordance with some aspects of the present disclosure.

[0018] FIG. **5** is a diagram illustrating an example of a wireless device utilizing radio frequency (RF) monostatic sensing techniques, which may be employed by the disclosed systems and techniques described herein to determine one or more characteristics of a target object, in accordance with some aspects of the present disclosure.

[0019] FIG. **6** is a diagram illustrating an example of a receiver utilizing RF bistatic sensing techniques with one transmitter, which may be employed by the disclosed systems and techniques described herein to determine one or more characteristics of a target object, in accordance with some aspects of the present disclosure.

[0020] FIG. **7** is a diagram illustrating an example of a receiver utilizing RF bistatic sensing techniques with multiple transmitters, which may be employed by the disclosed systems and techniques described herein to determine one or more characteristics of a target object, in accordance with some aspects of the present disclosure.

[0021] FIG. **8** is a diagram illustrating an example geometry for bistatic (or monostatic) sensing, in accordance with some aspects of the present disclosure.

[0022] FIG. **9** is a diagram illustrating a bistatic range of bistatic sensing, in accordance with some aspects of the present disclosure.

[0023] FIG. **10** is a diagram illustrating an example of a system for dynamic power control in sensing, in accordance with some aspects of the present disclosure.

[0024] FIG. **11** is a diagram illustrating an example of a network device experiencing interference from an aggressor device, in accordance with some aspects of the present disclosure.

[0025] FIG. **12**A is a diagram illustrating an example of a network device performing monostatic sensing of a target, in accordance with some aspects of the present disclosure.

[0026] FIG. **12**B is a diagram illustrating an example of network devices performing bistatic sensing of a target, in accordance with some aspects of the present disclosure.

[0027] FIG. **12**C is a graph illustrating an example of typical radar cross section (RSC) values for different types of targets, in accordance with some aspects of the present disclosure.

[0028] FIG. **13**A is a diagram illustrating an example of a network device transmitting sensing signals with an initial power level, in accordance with some aspects of the present disclosure.

[0029] FIG. **13**B is a diagram illustrating an example of a network device transmitting sensing signals with an increased power level, in accordance with some aspects of the present disclosure.

[0030] FIG. **13**C is a diagram illustrating an example of a network device transmitting sensing signals with a further increased power level, in accordance with some aspects of the present

disclosure.
[0031] FIG. **14** is a diagram illustrating an example of a system for dynamic power control in sensing, where a network device of the system sends an acknowledge message, in accordance with some aspects of the present disclosure.
[0032] FIG. **15**A is a diagram illustrating an example of sensing resources associated with different power levels, in accordance with some aspects of the present disclosure.
[0033] FIG. **15**B is a graph illustrating the power levels associated with the different sensing resources of FIG. **15**A, in accordance with some aspects of the present disclosure.
[0034] FIG. **16** is a diagram illustrating an example of a system for dynamic power control in sensing, where a network device of the system sends a reverse transmission in an optimum resource, in accordance with some aspects of the present disclosure.
[0035] FIG. **17**A is a diagram illustrating an example of a system for dynamic power control in sensing performing power control by utilizing signals, in accordance with some aspects of the present disclosure.
[0036] FIG. **17**B is a graph illustrating an example of power levels for the signals of FIG. **17**A, in accordance with some aspects of the present disclosure.
[0037] FIG. **18** is a flow chart illustrating an example of a process for wireless communications utilizing dynamic power control in sensing, in accordance with some aspects of the present disclosure.
[0038] FIG. **19** is a block diagram illustrating an example of a computing system, which may be employed by the disclosed systems and techniques for dynamic power control in sensing, in accordance with some aspects of the present disclosure.
DETAILED DESCRIPTION
[0039] Certain aspects of this disclosure are provided below for illustration purposes. Alternate aspects may be devised without departing from the scope of the disclosure. Additionally, well-known elements of the disclosure will not be described in detail or will be omitted so as not to obscure the relevant details of the disclosure. Some of the aspects described herein may be applied independently and some of them may be applied in combination as would be apparent to those of skill in the art. In the following description, for the purposes of explanation, specific details are set forth in order to provide a thorough understanding of aspects of the application. However, it will be apparent that various aspects may be practiced without these specific details. The figures and description are not intended to be restrictive.
[0040] The ensuing description provides example aspects, and is not intended to limit the scope, applicability, or configuration of the disclosure. Rather, the ensuing description of the example aspects will provide those skilled in the art with an enabling description for implementing an example aspect. It should be understood that various changes may be made in the function and arrangement of elements without departing from the scope of the application as set forth in the appended claims.
[0041] Radar sensing systems use radio frequency (RF) waveforms to perform RF sensing (also referred to as radar sensing) to determine or estimate one or more characteristics of a target object, such as the distance, angle, and/or velocity of the target object. A target object may include a vehicle, an obstruction, a user, a building, or other object. A typical radar system includes at least one transmitter, at least one receiver, and at least one processor. A radar sensing system may perform monostatic sensing when one receiver is employed that is co-located with a transmitter. A radar system may perform bistatic sensing when one receiver of a first device is employed that is located remote from a transmitter of a second device. Similarly, a radar system may perform multi-static sensing when multiple receivers of multiple devices are employed that are all located remotely from at least one transmitter of at least one device.
[0042] During operation of a radar sensing system, a transmitter transmits an electromagnetic (EM) signal in the RF domain towards a target object. The signal reflects off of the target object to

produce one or more reflection signals, which provides information or properties regarding the target, such as target object's location and speed. At least one receiver receives the one or more reflection signals and at least one processor, which may be associated with at least one receiver, utilizes the information from the one or more reflection signals to determine information or properties of the target object. A target object can also be referred herein as a target.

[0043] Generally, RF sensing involves monitoring moving targets with different motions (e.g., a moving car or pedestrian, a body motion of a person, such as breathing, and/or other micro-motions related to a target). Doppler, which measures the phase variation in a signal and is indicative of motion, is an important characteristic for sensing of a target.

[0044] In some cases, the radar sensing signals, which can be referred to as radar reference signals (RSs), may be designed for and used for sensing purposes. Radar RSs do not contain any communications information. Conversely, communication RSs, such as demodulation reference signals (DMRSs) and sounding reference signals (SRSs), are typically designed for and solely used for communications purposes, such as estimating channel parameters for communications.

[0045] Cellular communications systems are designed to transmit communication signals on designated communication frequency bands (e.g., 23 gigahertz (GHz), 3.5 GHz, etc. for 5G/NR, 2.2 GHz for LTE, among others). RF sensing systems are designed to transmit RF sensing signals on designated radar RF frequency bands (e.g., 77 GHz for autonomous driving). The spectrum for communications and sensing is very likely to be shared in future cellular communication systems, in which case the communications and sensing should be jointly considered.

[0046] In some cases, due to larger bandwidths being allocated for wireless communications systems (e.g., including cellular communications systems such as 4G/LTE, 5G/NR, and beyond) and more use cases being introduced into the wireless communications systems, sensing and communication signals may be multiplexed (e.g., multiplexed using time division multiplexing (TDM)) for joint communications and sensing.

[0047] Radar or RF sensing (e.g., monostatic sensing or bistatic sensing) is inherently susceptible to interference generated by nearby aggressor sensing devices, since the interference signals from the aggressor sensing devices' transmissions are typically much larger than a reflected target sensing signal. Aggressor sensing devices are other sensing devices that are not associated with the sensing radar (e.g., sensing transmitter and/or receiver) experiencing the interference.

[0048] Currently, there are some solutions to mitigate and/or reduce the generated interference. These solutions include, but are not limited to, specific waveform designs, signal variation designs, and designs that repair the reflected target sensing signals. An effective solution involves power control of the transmitted sensing signals. Power control of the transmitted sensing signals should be able to satisfy the target detection by the sensing receiver, while reducing the interference generated from aggressor sensing devices.

[0049] Power control is one common solution in communications applications. However, in the traditional sensing domain, which typically has constraints to message exchanges amongst clients, power control is often not available. Generally, sensing is performed using a maximum, or predefined, fixed power level (setting) for transmission of the sensing signals to ensure an accurate detection of the target. Such a power setting can be acceptable for use in sparce sensing scenarios, but can be problematic to employ in dense sensing scenarios because it can cause unwanted interference.

[0050] In some aspects of the present disclosure, systems, apparatuses, methods (also referred to as processes), and computer-readable media (collectively referred to herein as “systems and techniques”) are described herein that provide dynamic power control in for performing sensing (e.g., radar or RF sensing) of one or more target objects. In one or more examples, power control messages may be exchanged between radar sensing devices (e.g., sensing transmitter and/or receiver) to implement power control in the transmission of the sensing signals. Power control in the transmission of the sensing signals can provide for a reduction in interference to other sensing devices, while still allowing for accurate detection of the one or more target objects (e.g., detection of a location of the one or more target objects). In some examples, power control messages can be transmitted between the radar sensing devices in integrated sensing and communication (ISAC) systems, where communications is enabled within sensing.

[0051] Additional aspects of the present disclosure are described in more detail below.

[0052] As used herein, the terms "user equipment" (UE) and "network entity" are not intended to be specific or otherwise limited to any particular radio access technology (RAT), unless otherwise noted. In general, a UE may be any wireless communication device (e.g., a mobile phone, router, tablet computer, laptop computer, and/or tracking device, etc.), wearable (e.g., smartwatch, smart-glasses, wearable ring, and/or an extended reality (XR) device such as a virtual reality (VR) headset, an augmented reality (AR) headset or glasses, or a mixed reality (MR) headset), vehicle (e.g., automobile, motorcycle, bicycle, etc.), and/or Internet of Things (IoT) device, etc., used by a user to communicate over a wireless communications network. A UE may be mobile or may (e.g., at certain times) be stationary, and may communicate with a radio access network (RAN). As used herein, the term "UE" may be referred to interchangeably as an "access terminal" or "AT," a "client device," a "wireless device," a "subscriber device," a "subscriber terminal," a "subscriber station," a "user terminal" or "UT," a "mobile device," a "mobile terminal," a "mobile station," or variations thereof. Generally, UEs can communicate with a core network via a RAN, and through the core network the UEs can be connected with external networks such as the Internet and with other UEs. Of course, other mechanisms of connecting to the core network and/or the Internet are also possible for the UEs, such as over wired access networks, wireless local area network (WLAN) networks (e.g., based on IEEE 802.11 communication standards, etc.) and so on.

[0053] A network entity can be implemented in an aggregated or monolithic base station architecture, or alternatively, in a disaggregated base station architecture, and may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC), or a Non-Real Time (Non-RT) RIC. A base station (e.g., with an aggregated/monolithic base station architecture or disaggregated base station architecture) may operate according to one of several RATs in communication with UEs depending on the network in which it is deployed, and may be alternatively referred to as an access point (AP), a network node, a NodeB (NB), an evolved NodeB (eNB), a next generation eNB (ng-eNB), a New Radio (NR) Node B (also referred to as a gNB or gNodeB), etc. A base station may be used primarily to support wireless access by UEs, including supporting data, voice, and/or signaling connections for the supported UEs. In some systems, a base station may provide edge node signaling functions while in other systems it may provide additional control and/or network management functions. A communication link through which UEs can send signals to a base station is called an uplink (UL) channel (e.g., a reverse traffic channel, a reverse control channel, an access channel, etc.). A communication link through which the base station can send signals to UEs is called a downlink (DL) or forward link channel (e.g., a paging channel, a control channel, a broadcast channel, or a forward traffic channel, etc.). The term traffic channel (TCH), as used herein, can refer to either an uplink, reverse or downlink, and/or a forward traffic channel.

[0054] The term "network entity" or "base station" (e.g., with an aggregated/monolithic base station architecture or disaggregated base station architecture) may refer to a single physical Transmission-Reception Point (TRP) or to multiple physical Transmission-Reception Points (TRPs) that may or may not be co-located. For example, where the term "network entity" or "base station" refers to a single physical TRP, the physical TRP may be an antenna of the base station corresponding to a cell (or several cell sectors) of the base station. Where the term "network entity" or "base station" refers to multiple co-located physical TRPs, the physical TRPs may be an array of antennas (e.g., as in a multiple-input multiple-output (MIMO) system or where the base station employs beamforming) of the base station. Where the term "base station" refers to multiple non-co-located physical TRPs, the physical TRPs may be a distributed antenna system (DAS) (a network of spatially separated antennas connected to a common source via a transport medium) or a remote radio head (RRH) (a remote base station connected to a serving base station). Alternatively, the non-co-located physical TRPs may be the serving base station receiving the measurement report from the UE and a neighbor base station whose reference radio frequency (RF) signals (or simply “reference signals”) the UE is measuring. Because a TRP is the point from which a base station transmits and receives wireless signals, as used herein, references to transmission from or reception at a base station are to be understood as referring to a particular TRP of the base station.

[0055] In some implementations that support positioning of UEs, a network entity or base station may not support wireless access by UEs (e.g., may not support data, voice, and/or signaling connections for UEs), but may instead transmit reference signals to UEs to be measured by the UEs, and/or may receive and measure signals transmitted by the UEs. Such a base station may be referred to as a positioning beacon (e.g., when transmitting signals to UEs) and/or as a location measurement unit (e.g., when receiving and measuring signals from UEs).

[0056] An RF signal includes an electromagnetic wave of a given frequency that transports information through the space between a transmitter and a receiver. As used herein, a transmitter may transmit a single “RF signal” or multiple “RF signals” to a receiver. However, the receiver may receive multiple “RF signals” corresponding to each transmitted RF signal due to the propagation characteristics of RF signals through multipath channels. The same transmitted RF signal on different paths between the transmitter and receiver may be referred to as a “multipath” RF signal. As used herein, an RF signal may also be referred to as a “wireless signal” or simply a “signal” where it is clear from the context that the term “signal” refers to a wireless signal or an RF signal.

[0057] According to various aspects, FIG. **1** illustrates an exemplary wireless communications system **100**, which may be employed by the disclosed systems and techniques described herein for dynamic power control in sensing. The wireless communications system **100** (which may also be referred to as a wireless wide area network (WWAN)) can include various base stations **102** and various UEs **104**. In some aspects, the base stations **102** may also be referred to as “network entities” or “network nodes.” One or more of the base stations **102** can be implemented in an aggregated or monolithic base station architecture. Additionally or alternatively, one or more of the base stations **102** can be implemented in a disaggregated base station architecture, and may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC), or a Non-Real Time (Non-RT) RIC. The base stations **102** can include macro cell base stations (high power cellular base stations) and/or small cell base stations (low power cellular base stations). In an aspect, the macro cell base station may include eNBs and/or ng-eNBs where the wireless communications system **100** corresponds to a long term evolution (LTE) network, or gNBs where the wireless communications system **100** corresponds to a NR network, or a combination of both, and the small cell base stations may include femtocells, picocells, microcells, etc.

[0058] The base stations **102** may collectively form a RAN and interface with a core network **170** (e.g., an evolved packet core (EPC) or a 5G core (5GC)) through backhaul links **122**, and through the core network **170** to one or more location servers **172** (which may be part of core network **170** or may be external to core network **170**). In addition to other functions, the base stations **102** may perform functions that relate to one or more of transferring user data, radio channel ciphering and deciphering, integrity protection, header compression, mobility control functions (e.g., handover, dual connectivity), inter-cell interference coordination, connection setup and release, load balancing, distribution for non-access stratum (NAS) messages, NAS node selection, synchronization, RAN sharing, multimedia broadcast multicast service (MBMS), subscriber and equipment trace, RAN information management (RIM), paging, positioning, and delivery of warning messages. The base stations **102** may communicate with each other directly or indirectly (e.g., through the EPC or 5GC) over backhaul links **134**, which may be wired and/or wireless.

[0059] The base stations **102** may wirelessly communicate with the UEs **104**. Each of the base stations **102** may provide communication coverage for a respective geographic coverage area **110**. In an aspect, one or more cells may be supported by a base station **102** in each coverage area **110**. A "cell" is a logical communication entity used for communication with a base station (e.g., over some frequency resource, referred to as a carrier frequency, component carrier, carrier, band, or the like), and may be associated with an identifier (e.g., a physical cell identifier (PCI), a virtual cell identifier (VCI), a cell global identifier (CGI)) for distinguishing cells operating via the same or a different carrier frequency. In some cases, different cells may be configured according to different protocol types (e.g., machine-type communication (MTC), narrowband IoT (NB-IoT), enhanced mobile broadband (eMBB), or others) that may provide access for different types of UEs. Because a cell is supported by a specific base station, the term "cell" may refer to either or both of the logical communication entity and the base station that supports it, depending on the context. In addition, because a TRP is typically the physical transmission point of a cell, the terms "cell" and "TRP" may be used interchangeably. In some cases, the term "cell" may also refer to a geographic coverage area of a base station (e.g., a sector), insofar as a carrier frequency can be detected and used for communication within some portion of geographic coverage areas **110**.
[0060] While neighboring macro cell base station **102** geographic coverage areas **110** may partially overlap (e.g., in a handover region), some of the geographic coverage areas **110** may be substantially overlapped by a larger geographic coverage area **110**. For example, a small cell base station **102**′ may have a coverage area **110**′ that substantially overlaps with the coverage area **110** of one or more macro cell base stations **102**. A network that includes both small cell and macro cell base stations may be known as a heterogeneous network. A heterogeneous network may also include home eNBs (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG).
[0061] The communication links **120** between the base stations **102** and the UEs **104** may include uplink (also referred to as reverse link) transmissions from a UE **104** to a base station **102** and/or downlink (also referred to as forward link) transmissions from a base station **102** to a UE **104**. The communication links **120** may use MIMO antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links **120** may be through one or more carrier frequencies. Allocation of carriers may be asymmetric with respect to downlink and uplink (e.g., more or less carriers may be allocated for downlink than for uplink).
[0062] The wireless communications system **100** may further include a WLAN AP **150** in communication with WLAN stations (STAs) **152** via communication links **154** in an unlicensed frequency spectrum (e.g., 5 Gigahertz (GHz)). When communicating in an unlicensed frequency spectrum, the WLAN STAs **152** and/or the WLAN AP **150** may perform a clear channel assessment (CCA) or listen before talk (LBT) procedure prior to communicating in order to determine whether the channel is available. In some examples, the wireless communications system **100** can include devices (e.g., UEs, etc.) that communicate with one or more UEs **104**, base stations **102**, APs **150**, etc. utilizing the ultra-wideband (UWB) spectrum. The UWB spectrum can range from 3.1 to 10.5 GHz.
[0063] The small cell base station **102**′ may operate in a licensed and/or an unlicensed frequency spectrum. When operating in an unlicensed frequency spectrum, the small cell base station **102**′ may employ LTE or NR technology and use the same 5 GHz unlicensed frequency spectrum as used by the WLAN AP **150**. The small cell base station **102**′, employing LTE and/or 5G in an unlicensed frequency spectrum, may boost coverage to and/or increase capacity of the access network. NR in unlicensed spectrum may be referred to as NR-U. LTE in an unlicensed spectrum may be referred to as LTE-U, licensed assisted access (LAA), or MulteFire.
[0064] The wireless communications system **100** may further include a millimeter wave (mmW) base station **180** that may operate in mmW frequencies and/or near mmW frequencies in communication with a UE **182**. The mmW base station **180** may be implemented in an aggregated

or monolithic base station architecture, or alternatively, in a disaggregated base station architecture (e.g., including one or more of a CU, a DU, a RU, a Near-RT RIC, or a Non-RT RIC). Extremely high frequency (EHF) is part of the RF in the electromagnetic spectrum. EHF has a range of 30 GHz to 300 GHz and a wavelength between 1 millimeter and 10 millimeters. Radio waves in this band may be referred to as a millimeter wave. Near mmW may extend down to a frequency of 3 GHz with a wavelength of 100 millimeters. The super high frequency (SHF) band extends between 3 GHz and 30 GHz, also referred to as centimeter wave. Communications using the mmW and/or near mmW radio frequency band have high path loss and a relatively short range. The mmW base station **180** and the UE **182** may utilize beamforming (transmit and/or receive) over an mmW communication link **184** to compensate for the extremely high path loss and short range. Further, it will be appreciated that in alternative configurations, one or more base stations **102** may also transmit using mmW or near mmW and beamforming. Accordingly, it will be appreciated that the foregoing illustrations are merely examples and should not be construed to limit the various aspects disclosed herein.

[0065] Transmit beamforming is a technique for focusing an RF signal in a specific direction. Traditionally, when a network node or entity (e.g., a base station) broadcasts an RF signal, it broadcasts the signal in all directions (omni-directionally). With transmit beamforming, the network node determines where a given target device (e.g., a UE) is located (relative to the transmitting network node) and projects a stronger downlink RF signal in that specific direction, thereby providing a faster (in terms of data rate) and stronger RF signal for the receiving device(s). To change the directionality of the RF signal when transmitting, a network node can control the phase and relative amplitude of the RF signal at each of the one or more transmitters that are broadcasting the RF signal. For example, a network node may use an array of antennas (referred to as a “phased array” or an “antenna array”) that creates a beam of RF waves that can be “steered” to point in different directions, without actually moving the antennas. Specifically, the RF current from the transmitter is fed to the individual antennas with the correct phase relationship so that the radio waves from the separate antennas add together to increase the radiation in a desired direction, while canceling to suppress radiation in undesired directions.

[0066] Transmit beams may be quasi-collocated, meaning that they appear to the receiver (e.g., a UE) as having the same parameters, regardless of whether or not the transmitting antennas of the network node themselves are physically collocated. In NR, there are four types of quasi-collocation (QCL) relations. Specifically, a QCL relation of a given type means that certain parameters about a second reference RF signal on a second beam can be derived from information about a source reference RF signal on a source beam. Thus, if the source reference RF signal is QCL Type A, the receiver can use the source reference RF signal to estimate the Doppler shift, Doppler spread, average delay, and delay spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type B, the receiver can use the source reference RF signal to estimate the Doppler shift and Doppler spread of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type C, the receiver can use the source reference RF signal to estimate the Doppler shift and average delay of a second reference RF signal transmitted on the same channel. If the source reference RF signal is QCL Type D, the receiver can use the source reference RF signal to estimate the spatial receive parameter of a second reference RF signal transmitted on the same channel.

[0067] In receiving beamforming, the receiver uses a receive beam to amplify RF signals detected on a given channel. For example, the receiver can increase the gain setting and/or adjust the phase setting of an array of antennas in a particular direction to amplify (e.g., to increase the gain level of) the RF signals received from that direction. Thus, when a receiver is said to beamform in a certain direction, it means the beam gain in that direction is high relative to the beam gain along other directions, or the beam gain in that direction is the highest compared to the beam gain of other beams available to the receiver. This results in a stronger received signal strength, (e.g., reference signal received power (RSRP), reference signal received quality (RSRQ), signal-to-interference-plus-noise ratio (SINR), etc.) of the RF signals received from that direction.

[0068] Receive beams may be spatially related. A spatial relation means that parameters for a transmit beam for a second reference signal can be derived from information about a receive beam for a first reference signal. For example, a UE may use a particular receive beam to receive one or more reference downlink reference signals (e.g., positioning reference signals (PRS), tracking reference signals (TRS), phase tracking reference signal (PTRS), cell-specific reference signals (CRS), channel state information reference signals (CSI-RS), primary synchronization signals (PSS), secondary synchronization signals (SSS), synchronization signal blocks (SSBs), etc.) from a network node or entity (e.g., a base station). The UE can then form a transmit beam for sending one or more uplink reference signals (e.g., uplink positioning reference signals (UL-PRS), sounding reference signal (SRS), demodulation reference signals (DMRS), PTRS, etc.) to that network node or entity (e.g., a base station) based on the parameters of the receive beam.

[0069] Note that a “downlink” beam may be either a transmit beam or a receive beam, depending on the entity forming it. For example, if a network node or entity (e.g., a base station) is forming the downlink beam to transmit a reference signal to a UE, the downlink beam is a transmit beam. If the UE is forming the downlink beam, however, it is a receive beam to receive the downlink reference signal. Similarly, an “uplink” beam may be either a transmit beam or a receive beam, depending on the entity forming it. For example, if a network node or entity (e.g., a base station) is forming the uplink beam, it is an uplink receive beam, and if a UE is forming the uplink beam, it is an uplink transmit beam.

[0070] In 5G, the frequency spectrum in which wireless network nodes or entities (e.g., base stations **102**/**180**, UEs **104**/**182**) operate is divided into multiple frequency ranges, FR1 (from 450 to 6000 Megahertz (MHz)), FR2 (from 24250 to 52600 MHZ), FR3 (above 52600 MHz), and FR4 (between FR1 and FR2). In a multi-carrier system, such as 5G, one of the carrier frequencies is referred to as the “primary carrier” or “anchor carrier” or “primary serving cell” or “PCell,” and the remaining carrier frequencies are referred to as “secondary carriers” or “secondary serving cells” or “SCells.” In carrier aggregation, the anchor carrier is the carrier operating on the primary frequency (e.g., FR1) utilized by a UE **104**/**182** and the cell in which the UE **104**/**182** either performs the initial radio resource control (RRC) connection establishment procedure or initiates the RRC connection re-establishment procedure. The primary carrier carries all common and UE-specific control channels, and may be a carrier in a licensed frequency (however, this is not always the case). A secondary carrier is a carrier operating on a second frequency (e.g., FR2) that may be configured once the RRC connection is established between the UE **104** and the anchor carrier and that may be used to provide additional radio resources. In some cases, the secondary carrier may be a carrier in an unlicensed frequency. The secondary carrier may contain only necessary signaling information and signals, for example, those that are UE-specific may not be present in the secondary carrier, since both primary uplink and downlink carriers are typically UE-specific. This means that different UEs **104**/**182** in a cell may have different downlink primary carriers. The same is true for the uplink primary carriers. The network is able to change the primary carrier of any UE **104**/**182** at any time. This is done, for example, to balance the load on different carriers. Because a “serving cell” (whether a PCell or an SCell) corresponds to a carrier frequency and/or component carrier over which some base station is communicating, the term “cell,” “serving cell,” “component carrier,” “carrier frequency,” and the like can be used interchangeably.

[0071] For example, still referring to FIG. **1**, one of the frequencies utilized by the macro cell base stations **102** may be an anchor carrier (or “PCell”) and other frequencies utilized by the macro cell base stations **102** and/or the mmW base station **180** may be secondary carriers (“SCells”). In carrier aggregation, the base stations **102** and/or the UEs **104** may use spectrum up to Y MHz (e.g., 5, 10, 15, 20, 100 MHz) bandwidth per carrier up to a total of Yx MHz (x component carriers) for transmission in each direction. The component carriers may or may not be adjacent to each other on the frequency spectrum. Allocation of carriers may be asymmetric with respect to the downlink and uplink (e.g., more or less carriers may be allocated for downlink than for uplink). The simultaneous transmission and/or reception of multiple carriers enables the UE **104**/**182** to significantly increase its data transmission and/or reception rates. For example, two 20 MHZ aggregated carriers in a multi-carrier system would theoretically lead to a two-fold increase in data rate (i.e., 40 MHz), compared to that attained by a single 20 MHz carrier.

[0072] In order to operate on multiple carrier frequencies, a base station **102** and/or a UE **104** is equipped with multiple receivers and/or transmitters. For example, a UE **104** may have two receivers, "Receiver 1" and "Receiver 2," where "Receiver 1" is a multi-band receiver that can be tuned to band (i.e., carrier frequency) 'X' or band 'Y,' and "Receiver 2" is a one-band receiver tuneable to band 'Z' only. In this example, if the UE **104** is being served in band 'X,' band 'X' would be referred to as the PCell or the active carrier frequency, and "Receiver 1" would need to tune from band 'X' to band 'Y' (an SCell) in order to measure band 'Y' (and vice versa). In contrast, whether the UE **104** is being served in band 'X' or band 'Y,' because of the separate "Receiver 2," the UE **104** can measure band 'Z' without interrupting the service on band 'X' or band 'Y.'

[0073] The wireless communications system **100** may further include a UE **164** that may communicate with a macro cell base station **102** over a communication link **120** and/or the mmW base station **180** over an mmW communication link **184**. For example, the macro cell base station **102** may support a PCell and one or more SCells for the UE **164** and the mmW base station **180** may support one or more SCells for the UE **164**.

[0074] The wireless communications system **100** may further include one or more UEs, such as UE **190**, that connects indirectly to one or more communication networks via one or more device-to-device (D2D) peer-to-peer (P2P) links (referred to as "sidelinks"). In the example of FIG. **1**, UE **190** has a D2D P2P link **192** with one of the UEs **104** connected to one of the base stations **102** (e.g., through which UE **190** may indirectly obtain cellular connectivity) and a D2D P2P link **194** with WLAN STA **152** connected to the WLAN AP **150** (through which UE **190** may indirectly obtain WLAN-based Internet connectivity). In an example, the D2D P2P links **192** and **194** may be supported with any well-known D2D RAT, such as LTE Direct (LTE-D), Wi-Fi Direct (Wi-Fi-D), Bluetooth®, and so on. As noted above, UE **104** and UE **190** can be configured to communicate using sidelink communications. In some cases, a sidelink transmission can include a request for feedback (e.g., a hybrid automatic repeat request (HARQ)) from the receiving UE.

[0075] FIG. **2** is a diagram illustrating an example of a disaggregated base station architecture, which may be employed by the disclosed systems and techniques for dynamic power control in sensing. Deployment of communication systems, such as 5G NR systems, may be arranged in multiple manners with various components or constituent parts. In a 5G NR system, or network, a network node, a network entity, a mobility element of a network, a radio access network (RAN) node, a core network node, a network element, or a network equipment, such as a base station (BS), or one or more units (or one or more components) performing base station functionality, may be implemented in an aggregated or disaggregated architecture. For example, a BS (such as a Node B (NB), evolved NB (eNB), NR BS, 5G NB, AP, a transmit receive point (TRP), or a cell, etc.) may be implemented as an aggregated base station (also known as a standalone BS or a monolithic BS) or a disaggregated base station.

[0076] An aggregated base station may be configured to utilize a radio protocol stack that is physically or logically integrated within a single RAN node. A disaggregated base station may be configured to utilize a protocol stack that is physically or logically distributed among two or more units (such as one or more central or centralized units (CUs), one or more distributed units (DUs), or one or more radio units (RUS)). In some aspects, a CU may be implemented within a RAN node, and one or more DUs may be co-located with the CU, or alternatively, may be geographically or virtually distributed throughout one or multiple other RAN nodes. The DUs may be implemented to communicate with one or more RUs. Each of the CU, DU and RU also can be implemented as virtual units, i.e., a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU).

[0077] Base station-type operation or network design may consider aggregation characteristics of base station functionality. For example, disaggregated base stations may be utilized in an integrated access backhaul (IAB) network, an open radio access network (O-RAN (such as the network configuration sponsored by the O-RAN Alliance)), or a virtualized radio access network (vRAN, also known as a cloud radio access network (C-RAN)). Disaggregation may include distributing functionality across two or more units at various physical locations, as well as distributing functionality for at least one unit virtually, which can enable flexibility in network design. The various units of the disaggregated base station, or disaggregated RAN architecture, can be configured for wired or wireless communication with at least one other unit.

[0078] As previously mentioned, FIG. **2** shows a diagram illustrating an example disaggregated base station **201** architecture. The disaggregated base station **201** architecture may include one or more central units (CUs) **211** that can communicate directly with a core network **223** via a backhaul link, or indirectly with the core network **223** through one or more disaggregated base station units (such as a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC) **227** via an E2 link, or a Non-Real Time (Non-RT) RIC **217** associated with a Service Management and Orchestration (SMO) Framework **207**, or both). A CU **211** may communicate with one or more distributed units (DUs) **231** via respective midhaul links, such as an F1 interface. The DUs **231** may communicate with one or more radio units (RUs) **241** via respective fronthaul links. The RUs **241** may communicate with respective UEs **221** via one or more RF access links. In some implementations, the UE **221** may be simultaneously served by multiple RUs **241**.

[0079] Each of the units, i.e., the CUS **211**, the DUs **231**, the RUs **241**, as well as the Near-RT RICs **227**, the Non-RT RICs **217** and the SMO Framework **207**, may include one or more interfaces or be coupled to one or more interfaces configured to receive or transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to the communication interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or transmit signals over a wired transmission medium to one or more of the other units. Additionally, the units can include a wireless interface, which may include a receiver, a transmitter or transceiver (such as an RF transceiver), configured to receive or transmit signals, or both, over a wireless transmission medium to one or more of the other units.

[0080] In some aspects, the CU **211** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **211**. The CU **211** may be configured to handle user plane functionality (i.e., Central Unit-User Plane (CU-UP)), control plane functionality (i.e., Central Unit-Control Plane (CU-CP)), or a combination thereof. In some implementations, the CU **211** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bidirectionally with the CU-CP unit via an interface, such as the E1 interface when implemented in an O-RAN configuration. The CU **211** can be implemented to communicate with the DU **231**, as necessary, for network control and signaling.

[0081] The DU **231** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **241**. In some aspects, the DU **231** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation and demodulation, or the like) depending, at least in part, on a functional split, such as those defined by the 3rd Generation Partnership Project (3GPP). In some aspects, the DU **231** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **231**, or with the control functions hosted by the CU **211**.

[0082] Lower-layer functionality can be implemented by one or more RUs **241**. In some deployments, an RU **241**, controlled by a DU **231**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer functions (such as performing fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **241** can be implemented to handle over the air (OTA) communication with one or more UEs **221**. In some implementations, real-time and non-real-time aspects of control and user plane communication with the RU(s) **241** can be controlled by the corresponding DU **231**. In some scenarios, this configuration can enable the DU(s) **231** and the CU **211** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

[0083] The SMO Framework **207** may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **207** may be configured to support the deployment of dedicated physical resources for RAN coverage requirements which may be managed via an operations and maintenance interface (such as an O1 interface). For virtualized network elements, the SMO Framework **207** may be configured to interact with a cloud computing platform (such as an open cloud (O-Cloud) **291**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface (such as an O2 interface). Such virtualized network elements can include, but are not limited to, CUs **211**, DUs **231**, RUs **241** and Near-RT RICs **227**. In some implementations, the SMO Framework **207** can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **213**, via an O1 interface. Additionally, in some implementations, the SMO Framework **207** can communicate directly with one or more RUs **241** via an O1 interface. The SMO Framework **207** also may include a Non-RT RIC **217** configured to support functionality of the SMO Framework **207**.

[0084] The Non-RT RIC **217** may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, Artificial Intelligence/Machine Learning (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the Near-RT RIC **227**. The Non-RT RIC **217** may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC **227**. The Near-RT RIC **227** may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs **211**, one or more DUs **231**, or both, as well as an O-eNB **213**, with the Near-RT RIC **227**.

[0085] In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC **227**, the Non-RT RIC **217** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **227** and may be received at the SMO Framework **207** or the Non-RT RIC **217** from non-network data sources or from network functions. In some examples, the Non-RT RIC **217** or the Near-RT RIC **227** may be configured to tune RAN behavior or performance. For example, the Non-RT RIC **217** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **207** (such as reconfiguration via **01**) or via creation of RAN management policies (such as A1 policies).

[0086] Various radio frame structures may be used to support downlink, uplink, and sidelink transmissions between network nodes (e.g., base stations and UEs). FIG. **3** is a diagram **300** illustrating an example of a frame structure, which may be employed by the disclosed systems and techniques for dynamic power control in sensing. Other wireless communications technologies may have different frame structures and/or different channels.

[0087] NR (and LTE) utilizes OFDM on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the uplink. Unlike LTE, however, NR has an option to use OFDM on the uplink as well. OFDM and SC-FDM partition the system bandwidth into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, etc. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, the spacing of the subcarriers may be 15 kHz and the minimum resource allocation (resource block) may be 12 subcarriers (or 180 kHz). Consequently, the nominal fast Fourier transform (FFT) size may be equal to 128, 256, 512, 1024, or 2048 for system bandwidth of 1.25, 2.5, 5, 10, or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into subbands. For example, a subband may cover 1.08 MHz (i.e., 6 resource blocks), and there may be 1, 2, 4, 8, or 16 subbands for system bandwidth of 1.25, 2.5, 5, 10, or 20 MHz, respectively.

[0088] LTE supports a single numerology (subcarrier spacing, symbol length, etc.). In contrast, NR may support multiple numerologies (u). For example, subcarrier spacing (SCS) of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz or greater may be available. Table 1 provided below lists some various parameters for different NR numerologies.

TABLE-US-00001 TABLE 1 Max. nominal Slot Symbol system BW SCS Symbols/ Slots/ Slots/ Duration Duration (MHz) with (kHz) Sot Subframe Frame (ms) (μs) 4K FFT size 0 15 14 1 10 1 66.7 50 1 30 14 2 20 0.5 33.3 100 2 60 14 4 40 0.25 16.7 100 3 120 14 8 80 0.125 8.33 400 4 240 14 16 160 0.0625 4.17 800

[0089] In one example, a numerology of 15 kHz is used. Thus, in the time domain, a 10 millisecond (ms) frame is divided into 10 equally sized subframes of 1 ms each, and each subframe includes one time slot. In FIG. **3**, time is represented horizontally (e.g., on the X axis) with time increasing from left to right, while frequency is represented vertically (e.g., on the Y axis) with frequency increasing (or decreasing) from bottom to top.

[0090] A resource grid may be used to represent time slots, each time slot including one or more time-concurrent resource blocks (RBs) (also referred to as physical RBs (PRBs)) in the frequency domain. FIG. **3** illustrates an example of a resource block (RB) **302**. Data or information for joint communications and sensing may be included in one or more RBs **302**. The RB **302** is arranged with the time domain on the horizontal (or x-) axis and the frequency domain on the vertical (or y-) axis. As shown, the RB **302** may be 180 kilohertz (kHz) wide in frequency and one slot long in time (with a slot being 1 milliseconds (ms) in time). In some cases, the slot may include fourteen symbols (e.g., in a slot configuration 0). The RB **302** includes twelve subcarriers (along the y-axis) and fourteen symbols (along the x-axis).

[0091] An intersection of a symbol and subcarrier can be referred to as a resource element (RE) **304** or tone. The RB **302** of FIG. **3** includes multiple REs, including the resource element (RE) **304**. For instance, a RE **304** is 1 subcarrier×1 symbol (e.g., OFDM symbol), and is the smallest discrete part of the subframe. A RE **304** includes a single complex value representing data from a physical channel or signal. The number of bits carried by each RE **304** depends on the modulation scheme.

[0092] In some aspects, some REs **304** can be used to transmit downlink reference (pilot) signals (DL-RS). The DL-RS can include Positioning Reference Signal (PRS), Tracking Reference Signal (TRS), Phase Tracking Reference Signal (PTRS), Channel State Information Reference Signal (CSI-RS), Demodulation Reference Signal (DMRS), Primary Synchronization Signal (PSS), Secondary Synchronization Signal (SSS), etc. The resource grid if FIG. **3** illustrates exemplary locations of REs **304** used to transmit DL-RS (labeled “R”).

[0093] FIG. **4** is a block diagram illustrating an example of a computing system **470** of an electronic device **407**, which may be employed by the disclosed systems and techniques for dynamic power control in sensing. The electronic device **407** is an example of a device that can include hardware and software for the purpose of connecting and exchanging data with other devices and systems using a communications network (e.g., a 3rd Generation Partnership network, such as a 5th Generation (5G)/New Radio (NR) network, a 4th Generation (4G)/Long Term Evolution (LTE) network, a WiFi network, or other communications network). For example, the electronic device **407** can include, or be a part of, a mobile device (e.g., a mobile telephone), a wearable device (e.g., a network-connected or smart watch), an extended reality device (e.g., a virtual reality (VR) device, an augmented reality (AR) device, or a mixed reality (MR) device), a personal computer, a laptop computer, a tablet computer, an Internet-of-Things (IoT) device, a wireless access point, a router, a vehicle or component of a vehicle, a server computer, a robotics device, and/or other device used by a user to communicate over a wireless communications network. In some cases, the device **407** can be referred to as user equipment (UE), such as when referring to a device configured to communicate using 5G/NR, 4G/LTE, or other telecommunication standard. In some cases, the device can be referred to as a station (STA), such as when referring to a device configured to communicate using the Wi-Fi standard.

[0094] The computing system **470** includes software and hardware components that can be electrically or communicatively coupled via a bus **489** (or may otherwise be in communication, as appropriate). For example, the computing system **470** includes one or more processors **484**. The one or more processors **484** can include one or more CPUs, ASICS, FPGAs, APs, GPUs, VPUs, NSPs, microcontrollers, dedicated hardware, any combination thereof, and/or other processing device/s and/or system/s. The bus **489** can be used by the one or more processors **484** to communicate between cores and/or with the one or more memory devices **486**.

[0095] The computing system **470** may also include one or more memory devices **486**, one or more digital signal processors (DSPs) **482**, one or more subscriber identity modules (SIMs) **474**, one or more modems **476**, one or more wireless transceivers **478**, one or more antennas **487**, one or more input devices **472** (e.g., a camera, a mouse, a keyboard, a touch sensitive screen, a touch pad, a keypad, a microphone or a microphone array, and/or the like), and one or more output devices **480** (e.g., a display, a speaker, a printer, and/or the like).

[0096] The one or more wireless transceivers **478** can receive wireless signals (e.g., signal **488**) via antenna **487** from one or more other devices, such as other user devices, network devices (e.g., base stations such as evolved Node Bs (eNBs) and/or gNodeBs (gNBs), WiFi access points (APs) such as routers, range extenders or the like, etc.), cloud networks, and/or the like. In some examples, the computing system **470** can include multiple antennas or an antenna array that can facilitate simultaneous transmit and receive functionality. Antenna **487** can be an omnidirectional antenna such that RF signals can be received from and transmitted in all directions. The wireless signal **488** may be transmitted via a wireless network. The wireless network may be any wireless network, such as a cellular or telecommunications network (e.g., 3G, 4G, 5G, etc.), wireless local area network (e.g., a WiFi network), a Bluetooth™ network, and/or other network. In some examples, the one or more wireless transceivers **478** may include an RF front end including one or more components, such as an amplifier, a mixer (also referred to as a signal multiplier) for signal down conversion, a frequency synthesizer (also referred to as an oscillator) that provides signals to the mixer, a baseband filter, an analog-to-digital converter (ADC), one or more power amplifiers, among other components. The RF front-end can generally handle selection and conversion of the wireless signals **488** into a baseband or intermediate frequency and can convert the RF signals to the digital domain.

[0097] In some cases, the computing system **470** can include a coding-decoding device (or CODEC) configured to encode and/or decode data transmitted and/or received using the one or more wireless transceivers **478**. In some cases, the computing system **470** can include an encryption-decryption device or component configured to encrypt and/or decrypt data (e.g., according to the Advanced Encryption Standard (AES) and/or Data Encryption Standard (DES) standard) transmitted and/or received by the one or more wireless transceivers **478**.

[0098] The one or more SIMs **474** can each securely store an international mobile subscriber identity (IMSI) number and related key assigned to the user of the electronic device **407**. The IMSI and key can be used to identify and authenticate the subscriber when accessing a network provided by a network service provider or operator associated with the one or more SIMs **474**. The one or more modems **476** can modulate one or more signals to encode information for transmission using the one or more wireless transceivers **478**. The one or more modems **476** can also demodulate signals received by the one or more wireless transceivers **478** in order to decode the transmitted information. In some examples, the one or more modems **476** can include a WiFi modem, a 4G (or LTE) modem, a 5G (or NR) modem, and/or other types of modems. The one or more modems **476** and the one or more wireless transceivers **478** can be used for communicating data for the one or more SIMs **474**.

[0099] The computing system **470** can also include (and/or be in communication with) one or more non-transitory machine-readable storage media or storage devices (e.g., one or more memory devices **486**), which can include, without limitation, local and/or network accessible storage, a disk drive, a drive array, an optical storage device, a solid-state storage device such as a RAM and/or a ROM, which can be programmable, flash-updateable and/or the like. Such storage devices may be configured to implement any appropriate data storage, including without limitation, various file systems, database structures, and/or the like.

[0100] In various aspects, functions may be stored as one or more computer-program products (e.g., instructions or code) in memory device(s) **486** and executed by the one or more processor(s) **484** and/or the one or more DSPs **482**. The computing system **470** can also include software elements (e.g., located within the one or more memory devices **486**), including, for example, an operating system, device drivers, executable libraries, and/or other code, such as one or more application programs, which may comprise computer programs implementing the functions provided by various aspects, and/or may be designed to implement methods and/or configure systems, as described herein.

[0101] In some aspects, the electronic device **407** can include means for performing operations described herein. The means can include one or more of the components of the computing system **470**. For example, the means for performing operations described herein may include one or more of input device(s) **472**, SIM(s) **474**, modems(s) **476**, wireless transceiver(s) **478**, output device(s) **480**, DSP(s) **482**, processors **484**, memory device(s) **486**, and/or antenna(s) **487**.

[0102] In some aspects, the electronic device **407** can include means for providing joint communications and sensing as well as a means for providing dynamic power control in sensing. In some examples, any or all of these means can include the one or more wireless transceivers **478**, the one or more modems **476**, the one or more processors **484**, the one or more DSPs **482**, the one or more memory devices **486**, any combination thereof, or other component(s) of the electronic device **407**.

[0103] FIG. **5** is a diagram illustrating an example of a wireless device **500** utilizing RF monostatic sensing technique for determining one or more characteristics (e.g., location, speed or velocity, heading, etc.) of a target object **502**. In particular, FIG. **5** is a diagram illustrating an example of a wireless device **500** (e.g., a transmit/receive sensing node) that utilizes RF sensing techniques (e.g., monostatic sensing) to perform one or more functions, such as detecting a presence and location of a target object **502** (e.g., an object, user, or vehicle), which in this figure is illustrated in the form of a vehicle.

[0104] In some examples, the wireless device **500** can be a mobile phone, a tablet computer, a wearable device, a vehicle, an extending reality (XR) device, a computing device or component of a vehicle, or other device (e.g., device **407** of FIG. **4**) that includes at least one RF interface. In some examples, the wireless device **500** can be a device that provides connectivity for a user device

(e.g., for electronic device **407** of FIG. **4**), such as a base station (e.g., a gNB, eNB, etc.), a wireless access point (AP), or other device that includes at least one RF interface.
[0105] In some aspects, wireless device **500** can include one or more components for transmitting an RF signal. The wireless device **500** can include at least one processor **522** for generating a digital signal or waveform. The wireless device **500** can also include a digital-to-analog converter (DAC) **504** that is capable of receiving the digital signal or waveform from the processor(s) **522** (e.g., a microprocessor), and converting the digital signal or waveform to an analog waveform. The analog signal that is the output of the DAC **504** can be provided to RF transmitter **506** for transmission. The RF transmitter **506** can be a Wi-Fi transmitter, a 5G/NR transmitter, a Bluetooth™ transmitter, or any other transmitter capable of transmitting an RF signal.
[0106] RF transmitter **506** can be coupled to one or more transmitting antennas such as Tx antenna **512**. In some examples, transmit (Tx) antenna **512** can be an omnidirectional antenna that is capable of transmitting an RF signal in all directions. For example, Tx antenna **512** can be an omnidirectional Wi-Fi antenna that can radiate Wi-Fi signals (e.g., 2.4 GHZ, 5 GHZ, 6 GHZ, etc.) in a 360-degree radiation pattern. In another example, Tx antenna **512** can be a directional antenna that transmits an RF signal in a particular direction.
[0107] In some examples, wireless device **500** can also include one or more components for receiving an RF signal. For example, the receiver lineup in wireless device **500** can include one or more receiving antennas such as a receive (Rx) antenna **514**. In some examples, Rx antenna **514** can be an omnidirectional antenna capable of receiving RF signals from multiple directions. In other examples, Rx antenna **514** can be a directional antenna that is configured to receive signals from a particular direction. In further examples, the Tx antenna **512** and/or the Rx antenna **514** can include multiple antennas (e.g., elements) configured as an antenna array (e.g., a phase antenna array).
[0108] Wireless device **500** can also include an RF receiver **510** that is coupled to Rx antenna **514**. RF receiver **510** can include one or more hardware components for receiving an RF waveform such as a Wi-Fi signal, a Bluetooth™ signal, a 5G/NR signal, or any other RF signal. The output of RF receiver **510** can be coupled to an analog-to-digital converter (ADC) **508**. ADC **508** can be configured to convert the received analog RF waveform into a digital waveform. The digital waveform that is the output of the ADC **508** can be provided to the processor(s) **522** for processing. The processor(s) **522** (e.g., a digital signal processor (DSP)) can be configured for processing the digital waveform.
[0109] In one example, wireless device **500** can implement RF sensing techniques, for example monostatic sensing techniques, by causing a Tx waveform **516** to be transmitted from Tx antenna **512**. Although Tx waveform **516** is illustrated as a single line, in some cases, Tx waveform **516** can be transmitted in all directions by an omnidirectional Tx antenna **512**. In one example, Tx waveform **516** can be a Wi-Fi waveform that is transmitted by a Wi-Fi transmitter in wireless device **500**. In some cases, Tx waveform **516** can correspond to a Wi-Fi waveform that is transmitted at or near the same time as a Wi-Fi data communication signal or a Wi-Fi control function signal (e.g., a beacon transmission). In some examples, Tx waveform **516** can be transmitted using the same or a similar frequency resource as a Wi-Fi data communication signal or a Wi-Fi control function signal (e.g., a beacon transmission). In some aspects, Tx waveform **516** can correspond to a Wi-Fi waveform that is transmitted separately from a Wi-Fi data communication signal and/or a Wi-Fi control signal (e.g., Tx waveform **516** can be transmitted at different times and/or using a different frequency resource).
[0110] In some examples, Tx waveform **516** can correspond to a 5G NR waveform that is transmitted at or near the same time as a 5G NR data communication signal or a 5G NR control function signal. In some examples, Tx waveform **516** can be transmitted using the same or a similar frequency resource as a 5G NR data communication signal or a 5G NR control function signal. In some aspects, Tx waveform **516** can correspond to a 5G NR waveform that is transmitted

separately from a 5G NR data communication signal and/or a 5G NR control signal (e.g., Tx waveform **516** can be transmitted at different times and/or using a different frequency resource).

[0111] In some aspects, one or more parameters associated with Tx waveform **516** can be modified that may be used to increase or decrease RF sensing resolution. The parameters may include frequency, bandwidth, number of spatial streams, the number of antennas configured to transmit Tx waveform **516**, the number of antennas configured to receive a reflected RF signal (e.g., Rx waveform **518**) corresponding to Tx waveform **516**, the number of spatial links (e.g., number of spatial streams multiplied by number of antennas configured to receive an RF signal), the sampling rate, or any combination thereof. The transmitted waveform (e.g., Tx waveform **516**) and the received waveform (e.g., Rx waveform **518**) can include one or more RF sensing signals, which are also referred to as radar reference signals (RSS).

[0112] In further examples, Tx waveform **516** can be implemented to have a sequence that has perfect or almost perfect autocorrelation properties. For instance, Tx waveform **516** can include single carrier Zadoff sequences or can include symbols that are similar to orthogonal frequency-division multiplexing (OFDM) Long Training Field (LTF) symbols. In some cases, Tx waveform **516** can include a chirp signal, as used, for example, in a Frequency-Modulated Continuous-Wave (FM-CW) radar system. In some configurations, the chirp signal can include a signal in which the signal frequency increases and/or decreases periodically in a linear and/or an exponential manner.

[0113] In some aspects, wireless device **500** can implement RF sensing techniques by performing alternating transmit and receive functions (e.g., performing a half-duplex operation). For example, wireless device **500** can alternately enable its RF transmitter **506** to transmit the Tx waveform **516** when the RF receiver **510** is not enabled to receive (i.e. not receiving), and enable its RF receiver **510** to receive the Rx waveform **518** when the RF transmitter **506** is not enabled to transmit (i.e. not transmitting). When the wireless device **500** is performing a half-duplex operation, the wireless device **500** may transmit Tx waveform **516**, which may be a radar RS (e.g., sensing signal).

[0114] In other aspects, wireless device **500** can implement RF sensing techniques by performing concurrent transmit and receive functions (e.g., performing a sub-band or full-band full-duplex operation). For example, wireless device **500** can enable its RF receiver **510** to receive at or near the same time as it enables RF transmitter **506** to transmit Tx waveform **516**. When the wireless device **500** is performing a full-duplex operation (e.g., either sub-band full-duplex or full-band full-duplex), the wireless device **500** may transmit Tx waveform **516**, which may be a radar RS (e.g., sensing signal).

[0115] In some examples, transmission of a sequence or pattern that is included in Tx waveform **516** can be repeated continuously such that the sequence is transmitted a certain number of times or for a certain duration of time. In some examples, repeating a pattern in the transmission of Tx waveform **516** can be used to avoid missing the reception of any reflected signals if RF receiver **510** is enabled after RF transmitter **506**. In one example implementation, Tx waveform **516** can include a sequence having a sequence length L that is transmitted two or more times, which can allow RF receiver **510** to be enabled at a time less than or equal to L in order to receive reflections corresponding to the entire sequence without missing any information.

[0116] By implementing alternating or simultaneous transmit and receive functionality (e.g. half-duplex or full-duplex operation), wireless device **500** can receive signals that correspond to Tx waveform **516**. For example, wireless device **500** can receive signals that are reflected from objects or people that are within range of Tx waveform **516**, such as Rx waveform **518** reflected from target object **502**. Wireless device **500** can also receive leakage signals (e.g., Tx leakage signal **520**) that are coupled directly from Tx antenna **512** to Rx antenna **514** without reflecting from any objects. For example, leakage signals can include signals that are transferred from a transmitter antenna (e.g., Tx antenna **512**) on a wireless device to a receive antenna (e.g., Rx antenna **514**) on the wireless device without reflecting from any objects. In some cases, Rx waveform **518** can include multiple sequences that correspond to multiple copies of a sequence that are included in Tx waveform **516**. In some examples, wireless device **500** can combine the multiple sequences that are received by RF receiver **510** to improve the signal to noise ratio (SNR).

[0117] Wireless device **500** can further implement RF sensing techniques by obtaining RF sensing data associated with each of the received signals corresponding to Tx waveform **516**. In some examples, the RF sensing data can include channel state information (CSI) data relating to the direct paths (e.g., leakage signal **520**) of Tx waveform **516** together with data relating to the reflected paths (e.g., Rx waveform **518**) that correspond to Tx waveform **516**.

[0118] In some aspects, RF sensing data (e.g., CSI data) can include information that can be used to determine the manner in which an RF signal (e.g., Tx waveform **516**) propagates from RF transmitter **506** to RF receiver **510**. RF sensing data can include data that corresponds to the effects on the transmitted RF signal due to scattering, fading, and/or power decay with distance, or any combination thereof. In some examples, RF sensing data can include imaginary data and real data (e.g., I/Q components) corresponding to each tone in the frequency domain over a particular bandwidth.

[0119] In some examples, RF sensing data can be used by the processor(s) **522** to calculate distances and angles of arrival that correspond to reflected waveforms, such as Rx waveform **518**. In further examples, RF sensing data can also be used to detect motion, determine location, detect changes in location or motion patterns, or any combination thereof. In some cases, the distance and angle of arrival of the reflected signals can be used to identify the size, position, movement, and/or orientation of target objects (e.g., target object **502**) in the surrounding environment in order to detect a presence/proximity of a target object.

[0120] The processor(s) **522** of the wireless device **500** can calculate distances and angles of arrival corresponding to reflected waveforms (e.g., the distance and angle of arrival corresponding to Rx waveform **518**) by utilizing signal processing, machine learning algorithms, any other suitable technique, or any combination thereof. In other examples, wireless device **500** can transmit or send the RF sensing data to at least one processor of another computing device, such as a server or base station, that can perform the calculations to obtain the distance and angle of arrival corresponding to Rx waveform **518** or other reflected waveforms.

[0121] In one example, the distance of Rx waveform **518** can be calculated by measuring the difference in time from reception of the leakage signal to the reception of the reflected signals. For example, wireless device **500** can determine a baseline distance of zero that is based on the difference from the time the wireless device **500** transmits Tx waveform **516** to the time it receives leakage signal **520** (e.g., propagation delay). The processor(s) **522** of the wireless device **500** can then determine a distance associated with Rx waveform **518** based on the difference from the time the wireless device **500** transmits Tx waveform **516** to the time it receives Rx waveform **518** (e.g., time of flight, which is also referred to as round trip time (RTT)), which can then be adjusted according to the propagation delay associated with leakage signal **520**. In doing so, the processor(s) **522** of the wireless device **500** can determine the distance traveled by Rx waveform **518** which can be used to determine the presence and movement of a target (e.g., target object **502**) that caused the reflection.

[0122] In further examples, the angle of arrival of Rx waveform **518** can be calculated by the processor(s) **522** by measuring the time difference of arrival of Rx waveform **518** between individual elements of a receive antenna array, such as antenna **514**. In some examples, the time difference of arrival can be calculated by measuring the difference in received phase at each element in the receive antenna array.

[0123] In some cases, the distance and the angle of arrival of Rx waveform **518** can be used by processor(s) **522** to determine the distance between wireless device **500** and target object **502** as well as the position of the target object **502** relative to the wireless device **500**. The distance and the angle of arrival of Rx waveform **518** can also be used to determine presence, movement, proximity, identity, or any combination thereof, of target object **502**. For example, the processor(s) **522** of the wireless device **500** can utilize the calculated distance and angle of arrival corresponding to Rx waveform **518** to determine that the target object **502** is moving towards wireless device **500**.

[0124] As noted above, wireless device **500** can include mobile devices (e.g., IoT devices, smartphones, laptops, tablets, etc.) or other types of devices. In some examples, wireless device **500** can be configured to obtain device location data and device orientation data together with the RF sensing data. In some instances, device location data and device orientation data can be used to determine or adjust the distance and angle of arrival of a reflected signal such as Rx waveform **518**. For example, wireless device **500** may be set on the ground facing the sky as a target object **502** (e.g., a vehicle) moves towards it during the RF sensing process. In this instance, wireless device **500** can use its location data and orientation data together with the RF sensing data to determine the direction that the target object **502** is moving.

[0125] In some examples, device position data can be gathered by wireless device **500** using techniques that include RTT measurements, time of arrival (TOA) measurements, time difference of arrival (TDOA) measurements, passive positioning measurements, angle of arrival (AOA) measurements, angle of departure (AoD) measurements, received signal strength indicator (RSSI) measurements, CSI data, using any other suitable technique, or any combination thereof. In further examples, device orientation data can be obtained from electronic sensors on the wireless device **500**, such as a gyroscope, an accelerometer, a compass, a magnetometer, a barometer, any other suitable sensor, or any combination thereof.

[0126] FIG. **6** is a diagram illustrating an example of a receiver **604** utilizing RF bistatic sensing techniques with one transmitter **600** for determining one or more characteristics (e.g., location, speed or velocity, heading, etc.) of a target object **602**. For example, the receiver **604** can use the RF bistatic sensing to detect a presence and location of a target object **602** (e.g., an object, user, or vehicle), which is illustrated in the form of a vehicle in FIG. **6**. In one example, the receiver **604** may be in the form of a base station, such as a gNB.

[0127] The bistatic radar system of FIG. **6** includes a transmitter **600** (e.g., a transmit sensing node), which in this figure is depicted to be in the form of a base station (e.g., gNB), and a receiver **604** (e.g., a receive sensing node) that are separated by a distance comparable to the expected distance target object. As compared to the monostatic system of FIG. **5**, the transmitter **600** and the receiver **604** of the bistatic radar system of FIG. **6** are located remote from one another. Conversely, monostatic radar is a radar system (e.g., the system of FIG. **5**) comprising a transmitter (e.g., the RF transmitter **506** of wireless device **500** of FIG. **5**) and a receiver (e.g., the RF receiver **510** of wireless device **500** of FIG. **5**) that are co-located with one another.

[0128] An advantage of bistatic radar (or more generally, multistatic radar, which has more than one receiver) over monostatic radar is the ability to collect radar returns reflected from a scene at angles different than that of a transmitted pulse. This can be of interest to some applications (e.g., vehicle applications, scenes with multiple objects, military applications, etc.) where target objects may reflect the transmitted energy in many directions (e.g., where target objects are specifically designed to reflect in many directions), which can minimize the energy that is reflected back to the transmitter. It should be noted that, in one or more examples, a monostatic system can coexist with a multistatic radar system, such as when the transmitter also has a co-located receiver.

[0129] In some examples, the transmitter **600** and/or the receiver **604** of FIG. **6** can be a mobile phone, a tablet computer, a wearable device, a vehicle, or other device (e.g., device **407** of FIG. **4**) that includes at least one RF interface. In some examples, the transmitter **600** and/or the receiver **604** can be a device that provides connectivity for a user device (e.g., for IoT device **407** of FIG. **4**), such as a base station (e.g., a gNB, eNB, etc.), a wireless access point (AP), or other device that includes at least one RF interface.

[0130] In some aspects, transmitter **600** can include one or more components for transmitting an RF signal. The transmitter **600** can include at least one processor (e.g., the at least one processor **522** of FIG. **5**) that is capable of determining signals (e.g., determining the waveforms for the signals) to be transmitted. The transmitter **600** can also include an RF transmitter (e.g., the RF transmitter **506** of FIG. **5**) for transmission of a Tx signal comprising Tx waveform **616**. The RF transmitter can be a transmitter configured to transmit cellular or telecommunication signals (e.g., a transmitter configured to transmit 5G/NR signals, 4G/LTE signals, or other cellular/telecommunication signals, etc.), a Wi-Fi transmitter, a Bluetooth™ transmitter, any combination thereof, or any other transmitter capable of transmitting an RF signal.

[0131] The RF transmitter can be coupled to one or more transmitting antennas, such as a Tx antenna (e.g., the TX antenna **512** of FIG. **5**). In some examples, a Tx antenna can be an omnidirectional antenna that is capable of transmitting an RF signal in all directions, or a directional antenna that transmits an RF signal in a particular direction. In some examples, the Tx antenna may include multiple antennas (e.g., elements) configured as an antenna array.

[0132] The receiver **604** can include one or more components for receiving an RF signal. For example, the receiver **604** may include one or more receiving antennas, such as an Rx antenna (e.g., the Rx antenna **514** of FIG. **5**). In some examples, an Rx antenna can be an omnidirectional antenna capable of receiving RF signals from multiple directions, or a directional antenna that is configured to receive signals from a particular direction. In further examples, the Rx antenna can include multiple antennas (e.g., elements) configured as an antenna array.

[0133] The receiver **604** may also include an RF receiver (e.g., RF receiver **510** of FIG. **5**) coupled to the Rx antenna. The RF receiver may include one or more hardware components for receiving an RF waveform such as a Wi-Fi signal, a Bluetooth™ signal, a 5G/NR signal, or any other RF signal. The output of the RF receiver can be coupled to at least one processor (e.g., the at least one processor **522** of FIG. **5**). The processor(s) may be configured to process a received waveform (e.g., Rx waveform **618**).

[0134] In one or more examples, transmitter **600** can implement RF sensing techniques, for example bistatic sensing techniques, by causing a Tx waveform **616** to be transmitted from a Tx antenna. It should be noted that although the Tx waveform **616** is illustrated as a single line, in some cases, the Tx waveform **616** can be transmitted in all directions by an omnidirectional Tx antenna.

[0135] In one or more aspects, one or more parameters associated with the Tx waveform **616** may be used to increase or decrease RF sensing resolution. The parameters may include frequency, bandwidth, number of spatial streams, the number of antennas configured to transmit Tx waveform **616**, the number of antennas configured to receive a reflected RF signal (e.g., Rx waveform **618**) corresponding to the Tx waveform **616**, the number of spatial links (e.g., number of spatial streams multiplied by number of antennas configured to receive an RF signal), the sampling rate, or any combination thereof. The transmitted waveform (e.g., Tx waveform **616**) and the received waveform (e.g., the Rx waveform **618**) can include one or more radar RF sensing signals (also referred to as RF sensing RSs).

[0136] During operation, the receiver **604** (e.g., which operates as a receive sensing node) can receive signals that correspond to Tx waveform **616**, which is transmitted by the transmitter **600** (e.g., which operates as a transmit sensing node). For example, the receiver **604** can receive signals that are reflected from objects or people that are within range of the Tx waveform **616**, such as Rx waveform **618** reflected from target object **602**. In some cases, the Rx waveform **618** can include multiple sequences that correspond to multiple copies of a sequence that are included in the Tx waveform **616**. In some examples, the receiver **604** may combine the multiple sequences that are received to improve the SNR.

[0137] In some examples, RF sensing data can be used by at least one processor within the receiver **604** to calculate distances, angles of arrival, or other characteristics that correspond to reflected waveforms, such as the Rx waveform **618**. In other examples, RF sensing data can also be used to detect motion, determine location, detect changes in location or motion patterns, or any combination thereof. In some cases, the distance and angle of arrival of the reflected signals can be used to identify the size, position, movement, and/or orientation of targets (e.g., target object **602**) in the surrounding environment in order to detect target object presence/proximity.

[0138] The processor(s) of the receiver **604** can calculate distances and angles of arrival corresponding to reflected waveforms (e.g., the distance and angle of arrival corresponding to the Rx waveform **618**) by using signal processing, machine learning algorithms, any other suitable technique, or any combination thereof. In other examples, the receiver **604** can transmit or send the RF sensing data to at least one processor of another computing device, such as a server, that can perform the calculations to obtain the distance and angle of arrival corresponding to the Rx waveform **618** or other reflected waveforms.

[0139] In one or more examples, the angle of arrival of the Rx waveform **618** can be calculated by a processor(s) of the receiver **604** by measuring the time difference of arrival of the Rx waveform **618** between individual elements of a receive antenna array of the receiver **604**. In some examples, the time difference of arrival can be calculated by measuring the difference in received phase at each element in the receive antenna array.

[0140] In some cases, the distance and the angle of arrival of the Rx waveform **618** can be used by the processor(s) of the receiver **604** to determine the distance between the receiver **604** and the target object **602** as well as the position of target object **602** relative to the receiver **604**. The distance and the angle of arrival of the Rx waveform **618** can also be used to determine presence, movement, proximity, identity, or any combination thereof, of the target object **602**. For example, the processor(s) of the receiver **604** may use the calculated distance and angle of arrival corresponding to the Rx waveform **618** to determine that the target object **602** is moving towards the receiver **604**.

[0141] FIG. **7** is a diagram illustrating an example of a receiver **704**, in the form of a smart phone, utilizing RF bistatic sensing techniques with multiple transmitters (including a transmitter **700***a*, a transmitter **700***b*, and a transmitter **700***c*), which may be employed to determine one or more characteristics (e.g., location, velocity or speed, heading, etc.) of a target object **702**. For example, the receiver **704** may use RF bistatic sensing to detect a presence and location of a target object **702** (e.g., an object, user, or vehicle). The target object **702** is depicted in FIG. **7** in the form of an object that does not have communications capabilities (which can be referred to as a device-free object), such as a person, a vehicle (e.g., a vehicle without the ability to transmit and receive messages, such as using C-V2X or dedicated short range communication (DSRC) protocols), or other device-free object. The bistatic radar system of FIG. **7** is similar to the bistatic radar system of FIG. **6**, except that the bistatic radar system of FIG. **7** has multiple transmitters **700***a*, **700***b*, **700***c*, while the bistatic radar system of FIG. **6** has only one transmitter **600**.

[0142] The bistatic radar system of FIG. **7** includes multiple transmitters **700***a*, **700***b*, **700***c* (e.g., transmit sensing nodes), which are illustrated to be in the form of base stations. The bistatic radar system of FIG. **7** also includes a receiver **704** (e.g., a receive sensing node), which is depicted in the form of a smart phone. The each of the transmitters **700***a*, **700***b*, **700***c* is separated from the receiver **704** by a distance comparable to the expected distance from the target object **702**. Similar to the bistatic system of FIG. **6**, the transmitters **700***a*, **700***b*, **700***c* and the receiver **704** of the bistatic radar system of FIG. **7** are located remote from one another.

[0143] In one or more examples, the transmitters **700***a*, **700***b*, **700***c* and/or the receiver **704** may each be a mobile phone, a tablet computer, a wearable device, a vehicle (e.g., a vehicle configured to transmit and receive communications according to C-V2X, DSRC, or other communication protocol), or other device (e.g., device **407** of FIG. **4**) that includes at least one RF interface. In some examples, the transmitters **700***a*, **700***b*, **700***c* and/or the receiver **704** may each be a device that provides connectivity for a user device (e.g., for IoT device **407** of FIG. **4**), such as a base station (e.g., a gNB, eNB, etc.), a wireless access point (AP), or other device that includes at least one RF interface.

[0144] The transmitters **700***a*, **700***b*, **700***c* may include one or more components for transmitting an

RF signal. Each of the transmitters **700***a*, **700***b*, **700***c* may include at least one processor (e.g., the processor(s) **522** of FIG. **5**) that is capable of determining signals (e.g., determining the waveforms for the signals) to be transmitted. Each of the transmitters **700***a*, **700***b*, **700***c* can also include an RF transmitter (e.g., the RF transmitter **506** of FIG. **5**) for transmission of Tx signals comprising Tx waveforms **716***a*, **716***b*, **716***c*, **720***a*, **720***b*, **720***c*. In one or more examples, Tx waveforms **716***a*, **716***b*, **716***c* are RF sensing signals, and Tx waveforms **720***a*, **720***b*, **720***c* are communications signals. In one or more examples, the Tx waveforms **720***a*, **720***b*, **720***c* are communications signals that may be used for scheduling transmitters (e.g., transmitters **700***a*, **700***b*, **700***c*) and receivers (e.g., receiver **704**) for performing RF sensing of a target object (e.g., target object **702**) to obtain location information regarding the target object. The RF transmitter can be a transmitter configured to transmit cellular or telecommunication signals (e.g., a transmitter configured to transmit 5G/NR signals, 4G/LTE signals, or other cellular/telecommunication signals, etc.), a Wi-Fi transmitter, a Bluetooth™ transmitter, any combination thereof, or any other transmitter capable of transmitting an RF signal.

[0145] The RF transmitter may be coupled to one or more transmitting antennas, such as a Tx antenna (e.g., the TX antenna **512** of FIG. **5**). In one or more examples, a Tx antenna can be an omnidirectional antenna that is capable of transmitting an RF signal in all directions, or a directional antenna that transmits an RF signal in a particular direction. The Tx antenna may include multiple antennas (e.g., elements) configured as an antenna array.

[0146] The receiver **704** of FIG. **7** may include one or more components for receiving an RF signal. For example, the receiver **704** can include one or more receiving antennas, such as an Rx antenna (e.g., the Rx antenna **514** of FIG. **5**). In one or more examples, an Rx antenna can be an omnidirectional antenna capable of receiving RF signals from multiple directions, or a directional antenna that is configured to receive signals from a particular direction. In some examples, the Rx antenna may include multiple antennas (e.g., elements) configured as an antenna array (e.g., a phase antenna array).

[0147] The receiver **704** can also include an RF receiver (e.g., RF receiver **510** of FIG. **5**) coupled to the Rx antenna. The RF receiver may include one or more hardware components for receiving an RF waveform such as a Wi-Fi signal, a Bluetooth™ signal, a 5G/NR signal, or any other RF signal. The output of the RF receiver can be coupled to at least one processor (e.g., the processor(s) **522** of FIG. **5**). The processor(s) may be configured to process a received waveform (e.g., Rx waveform **718**, which is a reflection (echo) RF sensing signal).

[0148] In some examples, the transmitters **700***a*, **700***b*, **700***c* can implement RF sensing techniques, for example bistatic sensing techniques, by causing Tx waveforms **716***a*, **716***b*, **716***c* (e.g., radar sensing signals) to be transmitted from a Tx antenna associated with each of the transmitters **700***a*, **700***b*, **700***c*. Although the Tx waveforms **716***a*, **716***b*, **716***c* are illustrated as single lines, in some cases, the Tx waveforms **716***a*, **716***b*, **716***c* may be transmitted in all directions (e.g., by an omnidirectional Tx antenna associated with each of the transmitters **700***a*, **700***b*, **700***c*).

[0149] In one or more aspects, one or more parameters associated with the Tx waveforms **716***a*, **716***b*, **716***c* may be used to increase or decrease RF sensing resolution. The parameters can include, but are not limited to, frequency, bandwidth, number of spatial streams, the number of antennas configured to transmit Tx waveforms **716***a*, **716***b*, **716***c*, the number of antennas configured to receive a reflected (echo) RF signal (e.g., Rx waveform **718**) corresponding to each of the Tx waveforms **716***a*, **716***b*, **716***c*, the number of spatial links (e.g., number of spatial streams multiplied by number of antennas configured to receive an RF signal), the sampling rate, or any combination thereof. The transmitted waveforms (e.g., Tx waveforms **716***a*, **716***b*, **716***c*) and the received waveforms (e.g., the Rx waveform **718**) may include one or more radar RF sensing signals (also referred to as RF sensing RSs). It should be noted that although only one reflected sensing signal (e.g., Rx waveform **718**) is shown in FIG. **7**, it is understood that a separate reflection (echo) sensing signal will be generated by each sensing signal (e.g., Tx waveforms **716***a*, **716***b*, **716***c*) reflecting off of the target object **702**.

[0150] During operation of the system of FIG. **7**, the receiver **704** (e.g., which operates as a receive sensing node) can receive signals that correspond to Tx waveforms **716***a*, **716***b*, **716***c*, which are transmitted by the transmitters **700***a*, **700***b*, **700***c* (e.g., which each operate as a transmit sensing node). The receiver **704** can receive signals that are reflected from objects or people that are within range of the Tx waveforms **716***a*, **716***b*, **716***c*, such as Rx waveform **718** reflected from the target object **702**. In one or more examples, the Rx waveform **718** may include multiple sequences that correspond to multiple copies of a sequence that are included in its corresponding Tx waveform **716***a*, **716***b*, **716***c*. In some examples, the receiver **704** may combine the multiple sequences that are received to improve the SNR.

[0151] In some examples, RF sensing data can be used by at least one processor within the receiver **704** to calculate distances, angles of arrival (AOA), TDOA, angle of departure (AoD), or other characteristics that correspond to reflected waveforms (e.g., Rx waveform **718**). In further examples, RF sensing data can also be used to detect motion, determine location, detect changes in location or motion patterns, or any combination thereof. In one or more examples, the distance and angle of arrival of the reflected signals can be used to identify the size, position, movement, and/or orientation of target objects (e.g., target object **702**) in order to detect target object presence/proximity.

[0152] The processor(s) of the receiver **704** can calculate distances and angles of arrival corresponding to reflected waveforms (e.g., the distance and angle of arrival corresponding to the Rx waveform **718**) by using signal processing, machine learning algorithms, any other suitable technique, or any combination thereof. In one or more examples, the receiver **704** can transmit or send the RF sensing data to at least one processor of another computing device, such as a server, that can perform the calculations to obtain the distance and angle of arrival corresponding to the Rx waveform **718** or other reflected waveforms (not shown).

[0153] In one or more examples, a processor(s) of the receiver **704** can calculate the angle of arrival (AOA) of the Rx waveform **718** by measuring the TDOA of the Rx waveform **718** between individual elements of a receive antenna array of the receiver **704**. In some examples, the TDOA can be calculated by measuring the difference in received phase at each element in the receive antenna array. In one illustrative example, to determine TDOA, the processor(s) can determine the difference time of arrival of the Rx waveform **718** to the receive antenna array elements, using one of them as a reference. The time difference is proportional to distance differences.

[0154] In some cases, the processor(s) of the receiver **704** can use the distance, the AOA, the TDOA, other measured information (e.g., AoD, etc.), any combination thereof, of the Rx waveform **718** to determine the distance between the receiver **704** and the target object **702**, and determine the position of target object **702** relative to the receiver **704**. In one example, the processor(s) can apply a multilateration or other location-based algorithm using the distance, AOA, and/or TDOA information as input to determine a position (e.g., 3D position) of the target object **702**. In other examples, the processor(s) can use the distance, the AOA, and/or the TDOA of the Rx waveform **718** to determine a presence, movement (e.g., velocity or speed, heading or direction or movement, etc.), proximity, identity, any combination thereof, or other characteristic of the target object **702**. For instance, the processor(s) of the receiver **704** may use the distance, the AOA, and/or the TDOA corresponding to the Rx waveform **718** to determine that the target object **702** is moving towards the receiver **704**.

[0155] FIG. **8** is a diagram illustrating geometry for bistatic (or monostatic) sensing. FIG. **8** shows a bistatic radar North-reference coordinate system in two-dimensions. In particular, FIG. **8** shows a coordinate system and parameters defining bistatic radar operation in a plane (referred to as a bistatic plane) containing a transmitter **800**, a receiver **804**, and a target object **802**. A bistatic triangle lies in the bistatic plane. The transmitter **800**, the target object **802**, and the receiver **804** are shown in relation to one another. The transmitter **800** and the receiver **804** are separated by a baseline distance L. The extended baseline is defined as continuing the baseline distance L beyond either the transmitter **800** or the receiver **804**. The target object **802** and the transmitter **800** are separated by a distance RT, and the target object **802** and the receiver **804** are separated by a distance RR.

[0156] Angles θ.sub.T and θ.sub.R are, respectively, the transmitter **800** and receiver **804** look angles, which are taken as positive when measured clockwise from North (N). The angles θτ and θ.sub.R are also referred to as angles of arrival (AOA) or lines of sight (LOS). A bistatic angle (B) is the angle subtended between the transmitter **800**, the target object **802**, and the receiver **804** in the radar. In particular, the bistatic angle is the angle between the transmitter **800** and the receiver **804** with the vertex located at the target object **802**. The bistatic angle is equal to the transmitter **800** look angle minus the receiver **804** look angle θ.sub.R (e.g., β=θ.sub.T−θ.sub.R).

[0157] When the bistatic angle is exactly zero (0), the radar is considered to be a monostatic radar; when the bistatic angle is close to zero, the radar is considered to be pseudo-monostatic; and when the bistatic angle is close to 180 degrees, the radar is considered to be a forward scatter radar. Otherwise, the radar is simply considered to be, and referred to as, a bistatic radar. The bistatic angle (β) can be used in determining the radar cross section of the target object.

[0158] FIG. **9** is a diagram illustrating an example of a bistatic range **910** of bistatic sensing. In this figure, a transmitter (Tx) **900**, a target object **902**, and a receiver (Rx) **904** of a radar are shown in relation to one another. The transmitter **900** and the receiver **904** are separated by a baseline distance L, the target object **902** and the transmitter **900** are separated by a distance Rtx, and the target object **902** and the receiver **904** are separated by a distance Rrx.

[0159] Bistatic range **910** (shown as an ellipse) refers to the measurement range made by radar with a separate transmitter **900** and receiver **904** (e.g., the transmitter **900** and the receiver **904** are located remote from one another). The receiver **904** measures the time of arrival from when the signal is transmitted by the transmitter **900** to when the signal is received by the receiver **904** from the transmitter **900** via the target object **902**. The bistatic range **910** defines an ellipse of constant bistatic range, referred to an iso-range contour, on which the target object **902** lies, with foci centered on the transmitter **900** and the receiver **904**. If the target object **902** is at range Rrx from the receiver **904** and range Rtx from the transmitter **900**, and the receiver **904** and the transmitter **900** are located a distance L apart from one another, then the bistatic range is equal to Rrx+Rtx−L. It should be noted that motion of the target object **902** causes a rate of change of bistatic range, which results in bistatic Doppler shift.

[0160] Generally, constant bistatic range points draw an ellipsoid, with the transmitter **900** and the receiver **904** positions as the focal points. The bistatic iso-range contours are where the ground slices the ellipsoid. When the ground is flat, this intercept forms an ellipse (e.g., bistatic range **910**). Note that except when the two platforms have equal altitude, these ellipses are not centered on a specular point.

[0161] As previously noted, systems and techniques are described herein that apply solutions associated with joint communications and sensing (e.g., monostatic sensing, bistatic sensing, and/or multi-static sensing). FIG. **10** is a diagram illustrating an example of a system **1000** for dynamic power control in sensing. In FIG. **10**, the system **1000** is shown to include a network device **1010** in the form of a UE. The network device **1010** (e.g., UE) can operate as a radar Rx (e.g., sensing Rx) for sensing purposes. Also shown is a network device **1020** in the form of a base station (e.g., gNB or a portion of a gNB, such as a CU, DU, RU, Near-RT RIC, Non-RT RIC, etc.). The network device **1020** (e.g., gNB) can operate as a radar Tx (e.g., sensing Tx) for sensing purposes. The system **1000** also includes a plurality of network entities **1040**, **1050**, where network entity **1040** is in the form of a radar server and network entity **1050** is in the form of a location server.

[0162] The system **1000** may include more or less network devices and/or more or less network entities, than as shown in FIG. **10**. In addition, the system **1000** may include different types of network devices (e.g., vehicles) and/or different types of network entities (e.g., network servers) than as shown in FIG. **10**. Also, a UE may be employed as the radar Tx instead of a base station (e.g., gNB) as is shown in FIG. **10**. In addition, in one or more examples, the network device **1010** (e.g., UE) may be equipped with heterogeneous capability, which may include, but is not limited to, 4G/5G cellular connectivity, GPS capability, camera capability, radar capability, and/or LIDAR capability. The network devices **1010**, **1020** and network entities **1040**, **1050** may be capable of performing wireless communications with each other via communications signals (e.g., signals **1070***a*, **1070***b*, **1070***c*, **1070***d*).

[0163] In one or more examples, the network devices **1010**, **1020** may be capable of transmitting and receiving sensing signals of some kind (e.g., camera, RF sensing signals, optical sensing signals, etc.). In some cases, the network devices **1010**, **1020** may transmit and receive sensing signals (e.g., RF sensing signals **1060***a*, **1060***b*) for using one or more sensors to detect nearby target objects (e.g., target object **1030**, which is in the form of a vehicle). In some cases, the network devices **1010**, **1020** can detect nearby target objects based on one or more images or frames captured using one or more cameras.

[0164] The network device **1020**, which may operate as a radar Tx, may perform RF sensing (e.g., bistatic sensing or monostatic sensing) of at least one target object (e.g., target object **1030**) to obtain RF sensing measurements (e.g., Doppler, RTT, TOA, and/or TDOA measurements) of the target object(s) (e.g., target object **1030**). The RF sensing measurements of the target object(s) (e.g., target object **1030**) can be used (e.g., by at least one processor(s) of at least one of the network devices **1010**, **1020** and/or at least one of the network entities **1040**, **1050**) to determine one or more characteristics (e.g., speed, location, distance, movement, heading, size, and/or other characteristics) of the target object(s) (e.g., target object **1030**).

[0165] As previously mentioned, generally, sensing involves monitoring moving target objects (e.g., target object **1030**) with different motions (e.g., a moving car or pedestrian, a body motion of a person, such as breathing, and/or other micro-motions related to a target). Doppler, which measures the phase variation in a signal and is indicative of motion, is an important characteristic for sensing of a target object (e.g., target object **1030**). As such, in order to obtain an accurate estimation of the motion of the target object, the phase of the signal should be continuous (e.g., the signal should maintain phase continuity).

[0166] During operation of the system **1000**, for example when performing bistatic sensing of a target object (e.g., target object **1030**), a network device **1020** (e.g., base station), operating as a radar Tx, may transmit an RF sensing signal **1060***a* towards the target object (e.g., target object **1030**). The RF sensing signal **1060***a* may include sensing signals, or may include communication signals and sensing signals multiplexed together. The sensing signal **1060***a* can reflect off of the target object (e.g., target object **1030**) to produce an RF reflection sensing signal **1060***b*, which may be reflected towards network device **1010** (e.g., UE). The network device **1010** (e.g., UE), operating as a radar Rx, can receive the reflection sensing signal **1060***b*. After the network device (e.g., UE) receives the reflection sensing signal **1060***b*, the network device (e.g., UE) can obtain measurements (e.g., Doppler, RTT, TOA, and/or TDOA measurements) of the reflection sensing signal **1060***b*. At least one processor (e.g., processor **1910** of FIG. **19**) of at least one of the network devices **1010**, **1020** and/or at least one of the network entities **1040**, **1050** may then determine or compute the characteristics (e.g., speed, location, distance, movement, heading, size, etc.) of the target object (e.g., target object **1030**) by using sensing measurements (e.g., Doppler, RTT, TOA, and/or TDOA measurements) from the received reflection sensing signal **1060***b*.

[0167] In some examples, the network device **1010** (e.g., UE) may transmit the measurements (e.g., Doppler, RTT, TOA, and/or TDOA measurements) and/or determined characteristics (e.g., speed, location, distance, movement, heading, size, etc.) of the target object (e.g., target object **1030**) to the network device **1020** (e.g., base station) and/or network entity **1040** (e.g., radar server) via communication signals **1070***a*, **1070***b*. The network device **1020** (e.g., base station) and/or network entity **1040** (e.g., radar server) may then transmit the measurements (e.g., Doppler, RTT, TOA, and/or TDOA measurements) and/or determined characteristics (e.g., speed, location, distance, movement, heading, size, etc.) of the target object (e.g., target object **1030**) to the network entity **1040** (e.g., radar server) and/or network entity **1050** (e.g., location server) via communication signals **1070***c*, **1070***d*.

[0168] As previously mentioned, radar sensing (e.g., monostatic sensing or bistatic sensing) is inherently susceptible to interference generated by nearby aggressor sensing devices, since the interference signals from the aggressor sensing devices' transmissions are typically much larger than a reflected target object sensing signal. Aggressor sensing devices are other sensing devices that are not associated with the sensing radar (e.g., sensing transmitter and/or receiver) experiencing the interference.

[0169] FIG. **11** is a diagram **1100** illustrating an example of a network device **1110** (as a victim device) experiencing interference (e.g., interference signal **1150**) from an aggressor device **1130**. FIG. **11**, the network device **1110** is operating as a sensing Tx and Rx (e.g., radar Tx and Rx) and is performing monostatic sensing of a target object **1120**. The network device **1110** may be in the form of UE, such as a smart phone, and the target object **1120** may be in the form of a human body, which may be moving.

[0170] During operation, for monostatic sensing, the network device **1110**, while operating as a sensing Tx, may transmit sensing signals **1140***a* towards the target object **1120**. The sensing signals can reflect off of the target object **1120** to produce reflection sensing signals **1140***b*. The network device **1110**, while operating as a sensing Rx, may receive the reflection sensing signals **1140***b*, and process the reflection sensing signals **1140***b* to determine characteristics (e.g., location, type, size, gestures, and motion) of the target object **1120**.

[0171] However, during operation, another network device **1130** (e.g., an aggressor), which is not associated with the network device **1110**, may be transmitting sensing and/or communication signals **1150**. The network device **1110** (e.g., a victim) may receive these signals **1150** as interference. These interference signals **1150** can have much less propagation loss than the reflection sensing signals **1140***b* because the interference signals **1150** are directly transmitted (e.g., not a bi-directional propagation, which is reflected off of a target object) from the network device **1130** (e.g., the aggressor) towards the network device **1110** (e.g., the victim).

[0172] For radar sensing (e.g., monostatic sensing and bistatic sensing), there are a number of related formulas for radar for power control in the different sensing scenarios. For monostatic sensing, the received signal power is:

[00001] $P_{\mathrm{Rx\_mono}} = \frac{P_{\mathrm{TX}} G_{\mathrm{TX}} G_{\mathrm{RX}} \quad ^{2}}{(4*\ )^{3} R_{\mathrm{mono}}^{4}}$ [0173] where σ is the radar cross section (RSC) of the target object, P.sub.TX is the Tx power, G.sub.TX is the Tx gain, G.sub.RX is the Tx gain, A is the wavelength, and R.sub.mono is the range (e.g., distance) from the network device (e.g., sensing Rx and Tx) to the target object.

[0174] FIG. **12**A is a diagram **1200** illustrating an example of a network device **1210** performing monostatic sensing of a target object **1220**. In FIG. **12**A, during operation, the network device **1210** (e.g., in the form of a smart phone), while operating as a sensing Tx, can transmit a sensing signal **1230***a* towards the target object **1220** (e.g., in the form of a building). The sensing signal **1230***a* can reflect off of the target object **1220**, and generate a reflection sensing signal **1230***b*. The reflection sensing signal **1230***b* can be propagated towards the network device **1210**. The network device **1210**, while operating as a sensing Rx, can then receive the reflection sensing signal **1230***b* and process the reflection sensing signal **1230***b* to determine characteristics of the target object **1220**.

[0175] For bistatic sensing, the received signal power is:

[00002] $P_{\mathrm{Rx\_bi}} = \frac{P_{\mathrm{TX}} G_{\mathrm{TX}} G_{\mathrm{RX}} \quad ^{2}}{(4*\ )^{3} R_{bi\text{-}R1}^{2} R_{bi\text{-}R2}^{2}}$

where R.sub.bi-R1 is the range (e.g., distance) from the network device (e.g., sensing Tx) to the target object, and R.sub.bi-R2 is the range (e.g., distance) from the network device (e.g., sensing Rx) to the target object.

[0176] FIG. **12**B is a diagram **1205** illustrating an example of a network devices **1215***a*, **1215***b* performing bistatic sensing of a target object **1225**. In FIG. **12**B, during operation, the network device **1215***a* (e.g., in the form of a smart phone), operating as a sensing Tx, can transmit a sensing signal **1235***a* towards the target object **1225** (e.g., in the form of a building). The sensing signal **1235***a* can reflect off of the target object **1225**, and generate a reflection sensing signal **1235***b*. The reflection sensing signal **1235***b* can be propagated towards the network device **1215***b* (e.g., in the form of a smart phone). The network device **1215***b*, operating as a sensing Rx, can then receive the reflection sensing signal **1235***b*, and process the reflection sensing signal **1235***b* to obtain characteristics of the target object **1225**.

[0177] FIG. **12**C is a graph **1207** illustrating an example of typical radar cross section (RSC) values for different types of target objects. An RCS, which can also be referred to as a radar signature, is a measure of how detectable a target object is by a radar. An object with a large RCS indicates that the object is more easily detected than an object with a smaller RCS. The RCS of a target object can be dependent upon the size, shape, and material of a target object, as well as can be dependent upon the wavelength and incident angle of the electromagnetic waves of the signals.

[0178] In FIG. **12**C, the upper portion of the horizontal axis represents decibels per square meter (dBsm), and the lower portion of the horizontal axis represents the cross-sectional size of a target object in meters squared (m.sup.2). As is shown in the graph **1207**, for example, a person typically has approximately a 1 m.sup.2 cross section.

[0179] As previously mentioned, there are some solutions to mitigate and/or reduce the generated interference. These solutions include, but are not limited to, specific waveform designs, signal variation designs, and designs that repair the reflected target object sensing signals. An effective solution involves power control of the transmitted sensing signals. Power control of the transmitted sensing signals should be able to satisfy the target object detection by the sensing receiver, while reducing the interference generated from aggressor sensing devices.

[0180] Power control is one common solution in communications applications. However, in the traditional sensing domain, which typically has constraints to message exchanges amongst clients, power control is often not available. Generally, sensing is performed using a maximum, or predefined, fixed power level (setting) for transmission of the sensing signals to ensure an accurate detection of the target object. Such a power setting can be fine to use in sparce sensing scenarios, but can be problematic to employ in dense sensing scenarios because it can cause unwanted interference.

[0181] Recently, in integrated sensing and communication (ISAC) where communications is enabled along with the sensing, messages (e.g., power control messages) can be exchanged amongst sensing Tx devices and sensing Rx devices to implement power control. However, if power control is enabled for sensing, there can be some challenges. For example, a diverse sensing setting (e.g., for monostatic or bistatic) may be simultaneously enabled in the same scenario. In such a diverse sensing setting, it may be difficult for the power control to handle this complicated sensing setting. As another example of a challenge, a communication link for sensing may not always be available. For example, a sensing Tx and sensing Rx may be two separate sensing devices (e.g., UEs, base stations, etc.) that do not have any communication links between each other. In another example of a challenge, short-range dense sensing, which is one typical scenario in ISAC sensing, can have multiple potential aggressors, with some aggressors generating strong interference signals. It can be difficult to identify which device(s) is/are real aggressor(s) and to trigger the power control accordingly. As such, based on the above-noted challenges, the systems and techniques described herein provide a series of power control solutions, which can match these different sensing scenarios.

[0182] In one or more aspects, power control may be determined by the following equation, which is the power for the sensing Tx:

[00003] $P_{\text{sensing}} = \min\{P_{\max}, P_{\text{range}}, P_{\text{target}} + PL\}$

[0183] Where P.sub.max is the maximum Tx sensing power, which may be specified by a standard or may be based on the device's self-constraint (e.g., UE-self constraint).
[0184] P.sub.range is the power that covers the maximum range of the sensing. Different sensing services, generally, have different specific sensing requirements. For example, phone-based sensing may only be concerned with target objects located within one (1) meter from the sensing device to determine various characteristics (e.g., hand gestures and/or vital signs) of the target object (e.g., a person). Target objects located outside of the 1 meter range, may not provide valuable information for phone-based sensing. Similarly, constant phase element (CPE)-based sensing may only require power to support a ten (10) meter coverage area. P.sub.range may be configured by the network, standardized, or based on the device's self-implementation (e.g., UE-self implementation).
[0185] For one implementation, for monostatic sensing with N meter coverage, where N=R.sub.mono, P.sub.range can be determined by the following formula:
[00004] $P_{\text{range}} = P_{\text{rx, min}} + P_{\text{Rx\_mono}} +$
where P.sub.rx, min is the minimum received power for the sensing Rx, P.sub.Rx_mono is the power loss from bidirectional propagation, and δ is one delta value, which is not necessary, but may be related to power compensation for power reflection, HW constraints, or other constraints.
[0186] For bistatic sensing with N meter coverage, with a separate sensing Tx and sensing Rx, N≈R.sub.bi-R1+R.sub.bi-R2, and P.sub.range can be determined by the following formula:
[00005] $P_{\text{range}} = P_{\text{rx, min}} + P_{\text{Rx\_bi}} +$
where P.sub.Rx_bi is the power loss from the propagation.
[0187] P.sub.target+PL is the power, which is associated to the target object, and can be the sum of the required reception power (P.sub.target), reflected by the target object and the corresponding power loss (PL) from the propagation (e.g., monostatic or bistatic sensing). The power loss (PL) may have different values for monostatic sensing and bistatic sensing (e.g., the power loss may be one value for monostatic sensing, and may be another value for bistatic sensing).
[0188] In one or more aspects, for power control in monostatic sensing, the power level for the sensing Tx can be subsequently ramped up for power control, until the target object is detected by the sensing Rx or until the maximum power of the sensing Tx is triggered (e.g., is reached), whichever comes first. The maximum power for the sensing Tx can be equal to the min {P.sub.max, P.sub.range}, the initial power level for the sensing Tx is P.sub.min, and the sensing Tx power ramp step is P.sub.Δ.
[0189] During operation, for power control for monostatic sensing, the network device (e.g., operating as a sensing Tx) can enable sensing with an initial power level of P.sub.min. As such, the network device (e.g. operating as a sensing Tx) may transmit sensing signals, with a power level of P.sub.min, towards a target object for sensing. The sensing signals can reflect off of the target object to generate sensing reflection signals. If the network device (e.g., operating as a sensing Rx) cannot detect the reflection sensing signals, the network device (e.g., operating as a sensing Tx) can increase the power level by P.sub.A to P.sub.min+P.sub.Δ. The network device (e.g., operating as a sensing Tx) can continue to increase the power level by P.sub.Δ, until the reflection sensing signals are detected by the network device (e.g., operating as a sensing Rx) or until the maximum power is triggered, whichever comes first.
[0190] FIGS. **13**A, **13**B, and **13**C are diagrams illustrating an example of power control for monostatic sensing. In particular, FIG. **13**A is a diagram illustrating an example of a network device **1310** (e.g., which may be in the form of a UE, such as a smart phone) performing monostatic sensing by transmitting sensing signals **1330***a* with an initial power level (P.sub.min). In FIG. **13**A, the network device **1310** (e.g., operating as a sensing Tx) may be transmitting sensing signals **1330***a*, with a power level of P.sub.min, towards a target object **1320** (e.g., in the form of a hand) for sensing (e.g., for sensing hand gestures). In FIG. **13**A, the sensing signals **1330***a* have a low power level such that the sensing signals **1330***a* are not able to reach the target object **1320** to reflect off of the target object **1320** and produce reflection sensing signals. As such, the network

device **1310** (e.g., operating as a sensing Rx) will not be able to detect any reflection sensing signals.

[0191] Since the network device **1310** (e.g., operating as a sensing Rx) is not be able to detect any reflection sensing signals, the network device **1310** (e.g., operating as a sensing Tx) may increase the power level by P.sub.A to P.sub.min+P.sub.Δ. FIG. **13**B is a diagram illustrating an example of the network device **1310** transmitting sensing signals **1330**_b_ with an increased power level (P.sub.min+P.sub.Δ). In FIG. **13**B, the network device **1310** (e.g., operating as a sensing Tx) may be transmitting sensing signals **1330**_b_, with a power level of P.sub.min+P.sub.Δ, towards the target object **1320** for sensing. In FIG. **13**B, the sensing signals **1330**_b_ have a power level high enough such that the sensing signals **1330**_b_ are able to reach the target object **1320** and reflect off of the target object **1320** to produce reflection sensing signals **1340**_b_. However, the reflection sensing signals **1340**_b_ are not strong enough to reach the network device **1310**. As such, the network device **1310** (e.g., operating as a sensing Rx) cannot detect the reflection sensing signals **1340**_b_.

[0192] Since the network device **1310** (e.g., operating as a sensing Rx) is not be able to detect the reflection sensing signals **1340**_b_, the network device **1310** (e.g., operating as a sensing Tx) may increase the power level by P.sub.Δ to P.sub.min+P.sub.Δ+P.sub.Δ. FIG. **13**C is a diagram illustrating an example of the network device **1310** transmitting sensing signals **1330**_c_ with a further increased power level (P.sub.min+P.sub.Δ+P.sub.Δ). In FIG. **13**C, the network device **1310** (e.g., operating as a sensing Tx) may be transmitting sensing signals **1330**_c_, with a power level of P.sub.min+P.sub.Δ+P.sub.Δ, towards the target object **1320** for sensing. In FIG. **13**B, the sensing signals **1330**_c_ have a power level high enough such that the sensing signals **1330**_c_ are able to reach the target object **1320** and reflect off of the target object **1320** to produce reflection sensing signals **1340**_c_. The reflection sensing signals **1340**_c_ are strong enough to reach the network device **1310**. As such, the network device **1310** (e.g., operating as a sensing Rx) can detect the reflection sensing signals **1340**_c_. Since the network device **1310** (e.g., operating as a sensing Rx) is able to detect the reflection sensing signals **1340**_c_, the network device **1310** (e.g., operating as a sensing Tx) can continue to transmit the sensing signals **1330**_c_ at the current power level of P.sub.min+P.sub.Δ+P.sub.Δ.

[0193] In some aspects, the target object signals (e.g., reflection sensing signals) may have different definitions for different devices or scenarios. For example, for phone-based short-range sensing, the target object signals may be reflected signals reflected from one static object and/or one motion. For another example, for CPE-based sensing, the service may be for the network device to monitor actions within the room, and the reflected signals from static objects may not be meaningful for CPE-based sensing. The target object signals (e.g., reflection sensing signals) may be defined as the reflected signals with some specific Doppler information (e.g., for detected motions, such as body or arm movements).

[0194] In one or more aspects, for power control in bistatic sensing, if there is a communication connection between the sensing Tx and Rx (e.g., which are located separate from one another), the sensing Rx may transmit a power control message to the sensing Tx via the communication link. The power control message can be used by the sensing Rx to acknowledge to the sensing Tx that the current transmit power level for the sensing service is acceptable.

[0195] FIG. **14** is a diagram illustrating an example of a system **1400** for dynamic power control in sensing, where a network device **1410**_b_ (e.g., sensing Rx) of the system **1400** sends (e.g., transmits) an acknowledge message. In FIG. **14**, the system **1400** includes network device **1410**_a_ (e.g., sensing Tx), network device **1410**_b_ (e.g., sensing Rx), and a network device **1450**. Network devices **1410**_a_, **1410**_b_ may be in the form of a UE (e.g., smart phone), and network device **1450** may be in the form of a base station (e.g., gNB). The network devices **1410**_a_, **1410**_b_ may be performing bistatic sensing to detect a target object **1420**, which may be in the form of a walking person.

[0196] During operation, the network device **1410**_a_ (e.g., sensing Tx) may transmit sensing signals **1430** towards the target object **1420**. The sensing signals **1430** can reflect off of the target object

1420 and generate reflection sensing signals that are propagated towards the network device **1410***b*. The network device **1410***b* (e.g., sensing Rx) may receive the reflection signals. After the network device **1410***b* receives the reflection signals, the network device **1410***b* can determine whether the reflection signals have a power level that is acceptable for the sensing of the target object **1420**. The network device **1410***b* can determine that the reflection signals have a power level that is acceptable for the sensing of the target object **1420**, when the reflection signals have an acceptable signal to noise (SNR), which is not too low such that the network device **1410***b* cannot perform an accurate sensing of the target object **1420**, or not too high such that the power is wasted. Different sensing scenarios (e.g., detection of hand gestures, finger movements, running) can have different predefined required SNR values. The network device **1410***a* (e.g., sensing Tx) will continue to ramp up the power level of the sensing signals **1430**, until the network device **1410***a* receives a power control message from network device **1410***b* indicating that the power level is acceptable or until a maximum power level for transmission of the sensing signal **1430** has been triggered (e.g., reached), whichever comes first.
[0197] When the network device **1410***b* determines that the reflection signals have a power level (e.g., SNR level) that is acceptable for determining an accurate sensing of the target object **1420**, the network device **1410***b* may transmit a power control message to the network device **1410***a* including an acknowledge message. The acknowledge message indicates to the network device **1410***a* (e.g., sensing Tx) that the power level (e.g., SNR level) of the sensing signals **1430** is acceptable for the sensing.
[0198] If the network devices **1410***a*, **1410***b* have a communication link with each other via a base station (e.g., network device **1450**), the network device **1410***b* may transmit the power control message to the network device **1410***a* using signals **1440***a*, **1440***b* via the base station (e.g., network device **1450**. If the network devices **1410***a*, **1410***b* do not have a communication link with each other via a base station (e.g., network device **1450**), but are able to communicate directly with each other via sidelink (SL) communications, the network device **1410***b* may transmit the power control message to the network device **1410***a* using SL communications via signal **1460**. The signaling exchange procedure between the network devices **1410***a*, **1410***b* for bistatic sensing may be standardized.
[0199] In one or more aspects, for power control in monostatic sensing, no signaling exchange (e.g., regarding an acceptable power level for the sensing having been reached) between the network devices is needed because the network devices (e.g., sensing Tx and sensing Rx) are collocated together. The procedures and associated parameters for determining whether the sensing signals have an acceptable power level (e.g., SNR) can be standardized for the different sensing scenarios.
[0200] In some aspects, the sensing Tx (e.g., network device **1410***a*) may perform the power ramping together with beam sweeping. For example, for each beam sweep by the sensing Tx, the sensing Tx can ramp up the power level until an acceptable power level for the sensing has been chosen.
[0201] These power ramping methods for sensing can prevent wasting resources. In one or more aspects, in order to prevent a large latency in the system, sensing reference signals (RSS) can be configured in different resources, such as resource elements (e.g., REs), where each resource can be associated with a different power level.
[0202] FIG. **15**A is a diagram **1500** illustrating an example of sensing resources **1510** associated with different power levels. In FIG. **15**A, the sensing resources **1510** are shown to be arranged in a matrix (e.g., similar to resource block **302** of FIG. **3**). For the matrix, the x-axis denotes time, and the y-axis denotes frequency. The sensing resources **1510** include sensing resource 1 **1510***a* having a first power level, sensing resource 2 **1510***b* having a second power level, sensing resource 3 **1510***c* having a third power level, and sensing resource 4 **1510***d* having a fourth power level.
[0203] FIG. **15**B is a graph **1505** illustrating the power levels associated with the different sensing

resources **1510** of FIG. **15**A. In the graph **1505** of FIG. **15**B, the x-axis denotes the resource index, and the y-axis denotes the power level. As shown in the graph **1505**, sensing resource 3 **1510***c* has the lowest power level and sensing resource 1 **1510***a* has the highest power level.

[0204] During operation (e.g., of monostatic sensing or bistatic sensing), the sensing Rx can determine the resource index associated with the sensing RS that has an acceptable power level for the sensing. For example, in FIG. **15**B, sensing resource 4 **1510***d* has a power level (e.g., signal-to-noise ratio (SNR)) that is very close to the required power level for the sensing Rx for the sensing of the target object. As such, the sensing Rx may determine that sensing resource 4 **1510***d* has an acceptable power level.

[0205] For bistatic sensing, after the sensing Rx determines the resource index (e.g., sensing resource 4 **1510***d*) that has an acceptable power level for the sensing, the sensing Rx can feedback (e.g., via a communication link, such as via a base station or via SL communications) that particular resource index (e.g., sensing resource 4 **1510***d*) to the sensing Tx. After the sensing Tx receives the resource index, the sensing Tx can look up that particular resource index (e.g., sensing resource 4 **1510***d*) on a power mapping table to determine the optimum power level for transmission of the sensing RSs. The power mapping table can include a listing of the resource indexes with their associated power levels for the sensing RSs. For example, the power mapping table can indicate that (e.g., as relatively shown in graph **1505**) sensing resource 1 **1510***a* has a power level of 4, sensing resource 2 **1510***b* has a power level of 2, sensing resource 3 **1510***c* has a power level of 1, and sensing resource 4 **1510***d* has a power level of 3.

[0206] For monostatic sensing, after the network device (e.g. operating as a sensing Rx) determines the resource index (e.g., sensing resource 4 **1510***d*) that has an acceptable power level for the sensing, the network device (e.g., operating as a sensing Tx) can look up that particular resource index (e.g., sensing resource 4 **1510***d*) on a power mapping table to determine the optimum power level for transmission of the sensing RSs.

[0207] In one or more aspects, the sensing Tx may transmit sensing signals (e.g., with the same sensing signal sequence on the same frequency resource) multiple times with different transmission power levels on different time domain locations (e.g., at different times) within a sensing signal occasion (e.g., a sensing window of time for sensing a target object). The sensing Rx then only needs to feedback the specific time location(s), which can indicate the corresponding acceptable power level(s).

[0208] In one or more aspects, in bistatic sensing, if there is no communication link available between the sensing Tx and Rx, after the sensing Rx determines the resource index with an accepting power level for the sensing, the sensing Rx may perform a reverse transmission in that particular resource (e.g., a transmission on the frequency band of that particular resource) to the sensing Tx to indicate to the sensing Tx that that particular resource index has an acceptable power level for the sensing.

[0209] FIG. **16** is a diagram illustrating an example of a system **1600** for dynamic power control in sensing, where a network device **1610***c* of the system **1600** sends a reverse transmission in an optimum resource. In FIG. **16**, the system **1600** may include two network devices **1610***a*, **1610***b*, which may each be in the form of a UE, such as a smart phone. During operation for bistatic sensing, for a first step, the sensing Tx **1610***a* can transmit sensing signals towards a target object. The sensing signals can be configured in different resources (e.g., resource 1, 2, 3, and 4), where each resource can be associated with a different power level. The sensing signals can reflect off of the target object and generate reflection sensing signals. The sensing Rx **1610***b* can receive the reflection sensing signals. After the sensing Rx **1610***b* receives the reflection sensing signals, for a second step, the sensing Rx **1610***b* can determine which resource index of the reflection sensing signals has an optimum power level for the sensing of the target object.

[0210] After the sensing Rx **1610***b* determines which resource index (e.g., resource 4) has an optimum power level for the sensing, for a third step, the sensing Rx **1610***b* can perform a reverse transmission in that particular resource (e.g., a transmission on the frequency band of resource 4) to the sensing Tx to indicate to the sensing Tx that that particular resource index (e.g., resource 4) has an acceptable power level for the sensing. The power for the reverse transmission should be large enough (e.g., the maximum transmission power of the sensing Rx) such that the sensing Tx is able to detect the reverse transmission signal transmitted from the sensing Rx.

[0211] After the sensing Tx receives the reverse transmission in that particular resource (e.g., resource 4), for a fourth step, the sensing Tx can look up that particular resource (e.g., resource 4) in a power mapping table to determine the optimum power level (e.g., power level 3) for transmission of the sensing signals.

[0212] In one or more aspects, in some bistatic sensing settings, the sensing Tx and sensing Rx are not in connection with each other. In some cases, the sensing Tx and sensing Rx are not even aware of each other. For example, in distributed sensing, the sensing Rx may not know which sensing Tx can provide the sensing service. The sensing Rx may not even know where the sensing Tx is located. For these cases, power control can be very challenging. One solution for power control, for these cases, can be based on one time arrival (OTA) of the signals.

[0213] In one or more aspects, for bistatic sensing, the power control may be controlled by the sensing Rx using power control signals (e.g., signals RS2_1 and RS2_2). For example, signal RS2_1 can be used for increasing the power level for transmission of the sensing signals, and signal RS2_2 can be used for decreasing the power level for transmission of the sensing signals.

[0214] In some aspects, for bistatic sensing for using signal RS2_1 for increasing the power level for transmission of the sensing signals, the sensing Rx (e.g., network device **1710***b* of FIG. **17**A) may initially transmit signal RS2_1 with a large default power (e.g., a maximum power for the sensing Rx, which can ensure that the sensing Tx can detect the RS2_1 signal). After the sensing Tx (e.g., network device **1710***a* of FIG. **17**A) has detected the RS2_1 signal transmitted by the sensing Rx, the sensing Tx can increase the power for the sensing RS (e.g., RS1 signal) transmission, until the RS2_1 is no longer detected by the sensing Tx. The sensing Rx can keep transmitting the RS2_1 signal, until the received reflection signals (e.g., generated from the RS1 signal reflecting off of a target object) have an acceptable power level (e.g., acceptable SNR) that meets the sensing requirements for sensing the target object. The sensing Tx can determine the optimum power level for transmission of sensing signals (e.g., sensing RSs) by determining the time when the sensing Rx stopped transmitting the RS2_1 signal. The sensing Tx can determine that the power level of the transmission of RS1 at that time is the optimum power level for transmission of the sensing signals.

[0215] In some aspects, for bistatic sensing for using signal RS2_2 for decreasing the power level for transmission of the sensing signals, the sensing Tx (e.g., network device **1710***a* of FIG. **17**A) may initially transmit a sensing RS (e.g., RS1 signal) at a constant power level. After receiving reflection signals (e.g., generated from the RS1 signal reflecting off of a target object), if the sensing Rx (e.g., network device **1710***b* of FIG. **17**A) determines that the reflection signals have a power level that is too high (e.g., which can cause interference to other nearby network devices) for the sensing of the target object, the sensing Rx can transmit the RS2_2 signal with a large default power level (e.g., a maximum power for the sensing Rx, which can ensure that the sensing Tx can detect the RS2_2 signal). After the sensing Tx receives the RS2_2 signal from the sensing Rx, the sensing Tx can decrease the power level for the transmission of the sensing RS (e.g., RS1 signal), until the sensing Tx can no longer detect the RS2_2 signal transmitted from the sensing Rx. The sensing Rx will continue to transmit the sensing RS2_2 signal, until the sensing Rx determines that the reflected signals have an acceptable power level (e.g., acceptable SNR) that meets the sensing requirements for sensing the target object.

[0216] In one or more aspects, for bistatic sensing, the power control may be controlled by the sensing Tx using a sensing signal (e.g., RS1 signal). FIG. **17**A is a diagram illustrating an example of a system **1700** for dynamic power control in sensing performing power control by utilizing signals RS1, RS2. In FIG. **17**A, the system **1700** may include network devices **1710***a*, **1710***b*. The network devices **1710***a*, **1710***b* may each be in the form of a UE, such as a smart phone. Network device **1710***a* may operate as a sensing Tx, and network device **1710***b* may operate as a sensing Rx.

[0217] During operation, for bistatic sensing, for an initial step (e.g., 0.sup.th step), the network device **1710***a* (e.g., operating as a sensing Tx) may initially transmit a sensing RS (e.g., the RS1 signal) with a large default power level (e.g., a maximum power for transmission by the network device **1710***a* such that the network device **1710***b* can detect the RS1 signal). After the network device **1710***b* (e.g., operating as a sensing Rx) has detected reflection signals (e.g., generated from the RS1 signal reflecting off of a target object), for a first step, the network device **1710***b* may transmit the RS2 signal with a large default power (e.g., a maximum power for transmission by the network device **1710***b* such that the network device **1710***a* can detect the RS2 signal). After the network device **1710***a* detects the RS2 signal, for a second step, the network device **1710***a* can decrease the power for the transmission of the sensing RS (e.g., the RS1 signal), until the network device **1710***a* can no longer detect the RS2 signal. The network device **1710***b* can continue to transmit the RS2 signal, until the network device **1710***b* determines that the reflected signals have an acceptable power level (e.g., acceptable SNR) that meets the sensing requirements for sensing the target object.

[0218] FIG. **17**B is a graph **1705** illustrating an example of power levels for the signals RS1, RS2 of FIG. **17**A. In the graph **1705** of FIG. **17**B, the x-axis denotes time, and the y-axis denotes the power level. As is shown in the graph **1705**, the network device **1710***a* (e.g., operating as a sensing Tx) decreases the power level of the RS1 signal, until the network device **1710***a* can no longer detect the RS2 signal because the RS2 signal has a low power level.

[0219] In one or more aspects, for bistatic sensing, the sensing Tx (e.g., network device **1710***a* of FIG. **17**A) may only transmit one sensing signal. The sensing Rx (e.g., network device **1710***b* of FIG. **17**A) may transmit one of multiple power control signals, each having different time, frequency, and/or sequences. Each of these power control signals can indicate a different specific power level adjustment (e.g., −3, −1, 1, or 3 dB). When the sensing Tx detects a power control signal transmitted from the sensing Rx, the sensing Tx can then be aware of the specific power control adjustment (e.g., as specified by the received power control signal) needed for the transmission power of the sensing signal.

[0220] In one or more aspects, for increasing and/or decreasing the power level of the sensing signal transmitted by the sensing Tx, the sensing Rx may utilize power control signals (e.g., signals RS2, RS2_1, RS2_2) to control the transmission power level of the sensing signals by the sensing Tx.

[0221] FIG. **18** is a flow chart illustrating an example of a process **1800** for wireless communications utilizing dynamic power control in sensing. The process **1800** can be performed by a network device, such as a UE (e.g., a mobile device such as a mobile phone, an XR device, a vehicle or component of a vehicle, or other UE), a base station (e.g., a gNB, eNB, an RSU, or other base station), or by a component or system (e.g., a chipset) of the network device or base station. The operations of the process **1800** may be implemented as software components that are executed and run on one or more processors (e.g., processor **1910** of FIG. **19** or other processor(s)). Further, the transmission and reception of signals by the wireless communications device in the process **1800** may be enabled, for example, by one or more antennas and/or one or more transceivers (e.g., wireless transceiver(s)).

[0222] At block **1810**, the network device (or component thereof) may receive reflection signals generated based on a plurality of sensing signals (e.g., sensing reference signals (RSs)) reflecting from a target object. The plurality of sensing signals are configured in a plurality of resources (e.g., resource elements of a resource block or multiple resource blocks), with each resource of the plurality of resources being associated with a different respective power level. In some aspects, the network device (or component thereof) is configured to (and may) transmit the plurality of sensing signals towards the target object. In some cases, the plurality of sensing signals are transmitted by an additional network device (other than the network device). In such cases, the network device (or component thereof) may transmit, to the additional network device, a power control signal indicating a resource index for the resource with the acceptable power level. In some examples, the network device (or component thereof) may transmit the power control signal via a communications link (e.g., a Uu link provided via a base station). In some examples, the network device (or component thereof) may transmit the power control signal via a sidelink communication (e.g., a PC5 interface, a DSRC interface, or other sidelink interface).

[0223] At block **1820**, the network device (or component thereof) may determine a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level. In one illustrative example, the predefined power level is a predefined signal-to-noise ratio (SNR). In some aspects, the network device (or component thereof) may determine a resource index for the resource with the acceptable power level. In some cases, the network device (or component thereof) may determine, from a power mapping table based on the resource index, an optimum transmission power for one or more additional sensing signals. In some examples, the network device (or component thereof) may transmit the one or more additional sensing signals using the optimum transmission power. In some examples, the network device (or component thereof) may transmit an indication of the optimum transmission power to the additional network device (or a network device other than the network device and the additional network device) for transmission of the one or more additional sensing signals.

[0224] FIG. **19** is a block diagram illustrating an example of a computing system **1900**, which may be employed by the disclosed systems and techniques for dynamic power control in sensing. In particular, FIG. **19** illustrates an example of computing system **1900**, which can be, for example, any computing device making up internal computing system, a remote computing system, a camera, or any component thereof in which the components of the system are in communication with each other using connection **1905**. Connection **1905** can be a physical connection using a bus, or a direct connection into processor **1910**, such as in a chipset architecture. Connection **1905** can also be a virtual connection, networked connection, or logical connection.

[0225] In some aspects, computing system **1900** is a distributed system in which the functions described in this disclosure can be distributed within a datacenter, multiple data centers, a peer network, etc. In some aspects, one or more of the described system components represents many such components each performing some or all of the function for which the component is described. In some aspects, the components can be physical or virtual devices.

[0226] Example system **1900** includes at least one processing unit (CPU or processor) **1910** and connection **1905** that communicatively couples various system components including system memory **1915**, such as read-only memory (ROM) **1920** and random access memory (RAM) **1925** to processor **1910**. Computing system **1900** can include a cache **1912** of high-speed memory connected directly with, in close proximity to, or integrated as part of processor **1910**.

[0227] Processor **1910** can include any general purpose processor and a hardware service or software service, such as services **1932**, **1934**, and **1936** stored in storage device **1930**, configured to control processor **1910** as well as a special-purpose processor where software instructions are incorporated into the actual processor design. Processor **1910** may essentially be a completely self-contained computing system, containing multiple cores or processors, a bus, memory controller, cache, etc. A multi-core processor may be symmetric or asymmetric.

[0228] To enable user interaction, computing system **1900** includes an input device **1945**, which can represent any number of input mechanisms, such as a microphone for speech, a touch-sensitive screen for gesture or graphical input, keyboard, mouse, motion input, speech, etc. Computing system **1900** can also include output device **1935**, which can be one or more of a number of output mechanisms. In some instances, multimodal systems can enable a user to provide multiple types of input/output to communicate with computing system **1900**.

[0229] Computing system **1900** can include communications interface **1940**, which can generally govern and manage the user input and system output. The communication interface may perform or facilitate receipt and/or transmission wired or wireless communications using wired and/or wireless transceivers, including those making use of an audio jack/plug, a microphone jack/plug, a universal serial bus (USB) port/plug, an Apple™ Lightning™ port/plug, an Ethernet port/plug, a fiber optic port/plug, a proprietary wired port/plug, 3G, 4G, 5G and/or other cellular data network wireless signal transfer, a Bluetooth™ wireless signal transfer, a Bluetooth™ low energy (BLE) wireless signal transfer, an IBEACON™ wireless signal transfer, a radio-frequency identification (RFID) wireless signal transfer, near-field communications (NFC) wireless signal transfer, dedicated short range communication (DSRC) wireless signal transfer, 802.11 Wi-Fi wireless signal transfer, wireless local area network (WLAN) signal transfer, Visible Light Communication (VLC), Worldwide Interoperability for Microwave Access (WiMAX), Infrared (IR) communication wireless signal transfer, Public Switched Telephone Network (PSTN) signal transfer, Integrated Services Digital Network (ISDN) signal transfer, ad-hoc network signal transfer, radio wave signal transfer, microwave signal transfer, infrared signal transfer, visible light signal transfer, ultraviolet light signal transfer, wireless signal transfer along the electromagnetic spectrum, or some combination thereof.

[0230] The communications interface **1940** may also include one or more range sensors (e.g., LIDAR sensors, laser range finders, RF radars, ultrasonic sensors, and infrared (IR) sensors) configured to collect data and provide measurements to processor **1910**, whereby processor **1910** can be configured to perform determinations and calculations needed to obtain various measurements for the one or more range sensors. In some examples, the measurements can include time of flight, wavelengths, azimuth angle, elevation angle, range, linear velocity and/or angular velocity, or any combination thereof. The communications interface **1940** may also include one or more Global Navigation Satellite System (GNSS) receivers or transceivers that are used to determine a location of the computing system **1900** based on receipt of one or more signals from one or more satellites associated with one or more GNSS systems. GNSS systems include, but are not limited to, the US-based GPS, the Russia-based Global Navigation Satellite System (GLONASS), the China-based BeiDou Navigation Satellite System (BDS), and the Europe-based Galileo GNSS. There is no restriction on operating on any particular hardware arrangement, and therefore the basic features here may easily be substituted for improved hardware or firmware arrangements as they are developed.

[0231] Storage device **1930** can be a non-volatile and/or non-transitory and/or computer-readable memory device and can be a hard disk or other types of computer readable media which can store data that are accessible by a computer, such as magnetic cassettes, flash memory cards, solid state memory devices, digital versatile disks, cartridges, a floppy disk, a flexible disk, a hard disk, magnetic tape, a magnetic strip/stripe, any other magnetic storage medium, flash memory, memristor memory, any other solid-state memory, a compact disc read only memory (CD-ROM) optical disc, a rewritable compact disc (CD) optical disc, digital video disk (DVD) optical disc, a blu-ray disc (BDD) optical disc, a holographic optical disk, another optical medium, a secure digital (SD) card, a micro secure digital (microSD) card, a Memory Stick® card, a smartcard chip, a EMV chip, a subscriber identity module (SIM) card, a mini/micro/nano/pico SIM card, another integrated circuit (IC) chip/card, random access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), flash EPROM (FLASHEPROM), cache memory (e.g., Level 1 (L1) cache, Level 2 (L2) cache, Level 3 (L3) cache, Level 4 (L4) cache, Level 5 (L5) cache, or other (L #) cache), resistive random-access memory (RRAM/ReRAM), phase change memory (PCM), spin transfer torque RAM (STT-RAM), another memory chip or cartridge, and/or a combination thereof.

[0232] The storage device **1930** can include software services, servers, services, etc., that when the code that defines such software is executed by the processor **1910**, it causes the system to perform a function. In some aspects, a hardware service that performs a particular function can include the software component stored in a computer-readable medium in connection with the necessary hardware components, such as processor **1910**, connection **1905**, output device **1935**, etc., to carry out the function. The term "computer-readable medium" includes, but is not limited to, portable or non-portable storage devices, optical storage devices, and various other mediums capable of storing, containing, or carrying instruction(s) and/or data. A computer-readable medium may include a non-transitory medium in which data can be stored and that does not include carrier waves and/or transitory electronic signals propagating wirelessly or over wired connections. Examples of a non-transitory medium may include, but are not limited to, a magnetic disk or tape, optical storage media such as compact disk (CD) or digital versatile disk (DVD), flash memory, memory or memory devices. A computer-readable medium may have stored thereon code and/or machine-executable instructions that may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, or the like.
[0233] Specific details are provided in the description above to provide a thorough understanding of the aspects and examples provided herein, but those skilled in the art will recognize that the application is not limited thereto. Thus, while illustrative aspects of the application have been described in detail herein, it is to be understood that the inventive concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art. Various features and aspects of the above-described application may be used individually or jointly. Further, aspects can be utilized in any number of environments and applications beyond those described herein without departing from the broader scope of the specification. The specification and drawings are, accordingly, to be regarded as illustrative rather than restrictive. For the purposes of illustration, methods were described in a particular order. It should be appreciated that in alternate aspects, the methods may be performed in a different order than that described.
[0234] For clarity of explanation, in some instances the present technology may be presented as including individual functional blocks comprising devices, device components, steps or routines in a method embodied in software, or combinations of hardware and software. Additional components may be used other than those shown in the figures and/or described herein. For example, circuits, systems, networks, processes, and other components may be shown as components in block diagram form in order not to obscure the aspects in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the aspects.
[0235] Further, those of skill in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

[0236] Individual aspects may be described above as a process or method which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed, but could have additional steps not included in a figure. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination can correspond to a return of the function to the calling function or the main function.

[0237] Processes and methods according to the above-described examples can be implemented using computer-executable instructions that are stored or otherwise available from computer-readable media. Such instructions can include, for example, instructions and data which cause or otherwise configure a general purpose computer, special purpose computer, or a processing device to perform a certain function or group of functions. Portions of computer resources used can be accessible over a network. The computer executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, firmware, source code. Examples of computer-readable media that may be used to store instructions, information used, and/or information created during methods according to described examples include magnetic or optical disks, flash memory, USB devices provided with non-volatile memory, networked storage devices, and so on.

[0238] In some aspects the computer-readable storage devices, mediums, and memories can include a cable or wireless signal containing a bitstream and the like. However, when mentioned, non-transitory computer-readable storage media expressly exclude media such as energy, carrier signals, electromagnetic waves, and signals per se.

[0239] Those of skill in the art will appreciate that information and signals 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 above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof, in some cases depending in part on the particular application, in part on the desired design, in part on the corresponding technology, etc.

[0240] The various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented or performed using hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof, and can take any of a variety of form factors. When implemented in software, firmware, middleware, or microcode, the program code or code segments to perform the necessary tasks (e.g., a computer-program product) may be stored in a computer-readable or machine-readable medium. A processor(s) may perform the necessary tasks. Examples of form factors include laptops, smart phones, mobile phones, tablet devices or other small form factor personal computers, personal digital assistants, rackmount devices, standalone devices, and so on. Functionality described herein also can be embodied in peripherals or add-in cards. Such functionality can also be implemented on a circuit board among different chips or different processes executing in a single device, by way of further example.

[0241] The instructions, media for conveying such instructions, computing resources for executing them, and other structures for supporting such computing resources are example means for providing the functions described in the disclosure.

[0242] The techniques described herein may also be implemented in electronic hardware, computer software, firmware, or any combination thereof. Such techniques may be implemented in any of a variety of devices such as general purposes computers, wireless communication device handsets, or integrated circuit devices having multiple uses including application in wireless communication device handsets and other devices. Any features described as modules or components may be implemented together in an integrated logic device or separately as discrete but interoperable logic devices. If implemented in software, the techniques may be realized at least in part by a computer-readable data storage medium comprising program code including instructions that, when executed, performs one or more of the methods, algorithms, and/or operations described above. The computer-readable data storage medium may form part of a computer program product, which may include packaging materials. The computer-readable medium may comprise memory or data storage media, such as random access memory (RAM) such as synchronous dynamic random access memory (SDRAM), read-only memory (ROM), non-volatile random access memory (NVRAM), electrically erasable programmable read-only memory (EEPROM), FLASH memory, magnetic or optical data storage media, and the like. The techniques additionally, or alternatively, may be realized at least in part by a computer-readable communication medium that carries or communicates program code in the form of instructions or data structures and that can be accessed, read, and/or executed by a computer, such as propagated signals or waves.

[0243] The program code may be executed by a processor, which may include one or more processors, such as one or more digital signal processors (DSPs), general purpose microprocessors, an application specific integrated circuits (ASICs), field programmable logic arrays (FPGAs), or other equivalent integrated or discrete logic circuitry. Such a processor may be configured to perform any of the techniques described in this disclosure. A general-purpose processor may be a microprocessor; but in the alternative, the processor may be any conventional 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, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. Accordingly, the term “processor,” as used herein may refer to any of the foregoing structure, any combination of the foregoing structure, or any other structure or apparatus suitable for implementation of the techniques described herein.

[0244] One of ordinary skill will appreciate that the less than (“<”) and greater than (“>”) symbols or terminology used herein can be replaced with less than or equal to (“≤”) and greater than or equal to (“≥”) symbols, respectively, without departing from the scope of this description.

[0245] Where components are described as being “configured to” perform certain operations, such configuration can be accomplished, for example, by designing electronic circuits or other hardware to perform the operation, by programming programmable electronic circuits (e.g., microprocessors, or other suitable electronic circuits) to perform the operation, or any combination thereof.

[0246] The phrase “coupled to” or “communicatively coupled to” refers to any component that is physically connected to another component either directly or indirectly, and/or any component that is in communication with another component (e.g., connected to the other component over a wired or wireless connection, and/or other suitable communication interface) either directly or indirectly.

[0247] Claim language or other language reciting “at least one of” a set and/or “one or more” of a set indicates that one member of the set or multiple members of the set (in any combination) satisfy the claim. For example, claim language reciting “at least one of A and B” or “at least one of A or B” means A, B, or A and B. In another example, claim language reciting “at least one of A, B, and C” or “at least one of A, B, or C” means A, B, C, or A and B, or A and C, or B and C, or A and B and C. The language “at least one of” a set and/or “one or more” of a set does not limit the set to the items listed in the set. For example, claim language reciting “at least one of A and B” or “at least one of A or B” can mean A, B, or A and B, and can additionally include items not listed in the set of A and B.

[0248] Illustrative aspects of the disclosure include:

[0249] Aspect 1. A method for wireless communications at a network device, the method comprising: receiving, at the network device, reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated

with a different respective power level; and determining, at the network device, a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.
[0250] Aspect 2. The method of Aspect 1, further comprising: transmitting the plurality of sensing signals towards the target object.
[0251] Aspect 3. The method of any of Aspects 1 or 2, wherein the plurality of sensing signals are transmitted by an additional network device.
[0252] Aspect 4. The method of Aspect 3, further comprising: transmitting, to the additional network device, a power control signal indicating a resource index for the resource with the acceptable power level.
[0253] Aspect 5. The method of Aspect 4, wherein the power control signal is transmitted via a communications link.
[0254] Aspect 6. The method of Aspect 5, wherein the communications link is provided via a base station.
[0255] Aspect 7. The method of Aspect 4, wherein the power control signal is transmitted via a sidelink communication.
[0256] Aspect 8. The method of any of Aspects 1 to 7, further comprising: determining a resource index for the resource with the acceptable power level.
[0257] Aspect 9. The method of Aspect 8, further comprising: determining, from a power mapping table based on the resource index, an optimum transmission power for one or more additional sensing signals.
[0258] Aspect 10. The method of Aspect 9, further comprising: transmitting the one or more additional sensing signals using the optimum transmission power.
[0259] Aspect 11. The method of any of Aspects 9 or 10, further comprising: transmitting an indication of the optimum transmission power to an additional network device for transmission of the one or more additional sensing signals.
[0260] Aspect 12. The method of any of Aspects 1 to 11, wherein the plurality of sensing signals are sensing reference signals (RSs).
[0261] Aspect 13. The method of any of Aspects 1 to 12, wherein the plurality of resources are resource elements of a resource block.
[0262] Aspect 14. The method of any of Aspects 1 to 13, wherein the predefined power level is a predefined signal-to-noise ratio (SNR).
[0263] Aspect 15. The method of any of Aspects 1 to 14, wherein the network device is one of a user equipment (UE) or a base station.
[0264] Aspect 16. The method of Aspect 15, wherein the UE is one of a mobile device or a vehicle.
[0265] Aspect 17. The method of Aspect 15, wherein the base station is a gNodeB (gNB).
[0266] Aspect 18. An apparatus for wireless communications, comprising: at least one memory; and at least one processor coupled to at least one memory and configured to: receive reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determine a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.
[0267] Aspect 19. The apparatus of Aspect 18, wherein the at least one processor is configured to: output the plurality of sensing signals for transmission.
[0268] Aspect 20. The apparatus of any of Aspects 18 or 19, wherein the plurality of sensing signals are transmitted by a network device.
[0269] Aspect 21. The apparatus of Aspect 20, wherein the at least one processor is configured to: output, for transmission to the network device, a power control signal indicating a resource index for the resource with the acceptable power level.

[0270] Aspect 22. The apparatus of Aspect 21, wherein the at least one processor is configured to output the power control signal for transmission via a communications link.
[0271] Aspect 23. The apparatus of Aspect 22, wherein the communications link is provided via a base station.
[0272] Aspect 24. The apparatus of Aspect 21, wherein the at least one processor is configured to output the power control signal for transmission via a sidelink communication.
[0273] Aspect 25. The apparatus of any of Aspects 18 to 24, wherein the at least one processor is configured to: determine a resource index for the resource with the acceptable power level.
[0274] Aspect 26. The apparatus of Aspect 25, wherein the at least one processor is configured to: determine, from a power mapping table based on the resource index, an optimum transmission power for one or more additional sensing signals.
[0275] Aspect 27. The apparatus of Aspect 26, wherein the at least one processor is configured to: output the one or more additional sensing signals for transmission using the optimum transmission power.
[0276] Aspect 28. The apparatus of any of Aspects 26 or 27, wherein the at least one processor is configured to: output an indication of the optimum transmission power for transmission to a network device for transmission of the one or more additional sensing signals.
[0277] Aspect 29. The apparatus of any of Aspects 18 to 28, wherein the plurality of sensing signals are sensing reference signals (RSS).
[0278] Aspect 30. The apparatus of any of Aspects 18 to 29, wherein the plurality of resources are resource elements of a resource block.
[0279] Aspect 31. The apparatus of any of Aspects 18 to 30, wherein the predefined power level is a predefined signal-to-noise ratio (SNR).
[0280] Aspect 32. The apparatus of any of Aspects 18 to 31, wherein the apparatus is one of a user equipment (UE) or a base station.
[0281] Aspect 33. The apparatus of Aspect 32, wherein the UE is one of a mobile device or a vehicle.
[0282] Aspect 34. The apparatus of Aspect 32, wherein the base station is a gNodeB (gNB).
[0283] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean “one and only one” unless specifically so stated, but rather “one or more.”

Claims

1. A method for wireless communications at a network device, the method comprising: receiving, at the network device, reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determining, at the network device, a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.
2. The method of claim 1, further comprising: transmitting the plurality of sensing signals towards the target object.
3. The method of claim 1, wherein the plurality of sensing signals are transmitted by an additional network device.
4. The method of claim 3, further comprising: transmitting, to the additional network device, a power control signal indicating a resource index for the resource with the acceptable power level.

5. The method of claim 4, wherein the power control signal is transmitted via a communications link provided via a base station.

6. The method of claim 4, wherein the power control signal is transmitted via a sidelink communication.

7. The method of claim 1, further comprising: determining a resource index for the resource with the acceptable power level.

8. The method of claim 7, further comprising: determining, from a power mapping table based on the resource index, an optimum transmission power for one or more additional sensing signals.

9. The method of claim 8, further comprising: transmitting the one or more additional sensing signals using the optimum transmission power.

10. The method of claim 8, further comprising: transmitting an indication of the optimum transmission power to an additional network device for transmission of the one or more additional sensing signals.

11. The method of claim 1, wherein the plurality of sensing signals are sensing reference signals (RSS).

12. The method of claim 1, wherein the plurality of resources are resource elements of a resource block.

13. The method of claim 1, wherein the predefined power level is a predefined signal-to-noise ratio (SNR).

14. An apparatus for wireless communications, comprising: at least one memory; and at least one processor coupled to at least one memory and configured to: receive reflection signals generated based on a plurality of sensing signals reflecting from a target object, wherein the plurality of sensing signals are configured in a plurality of resources, each resource of the plurality of resources being associated with a different respective power level; and determine a power level of a resource associated with a reflection signal is an acceptable power level for performing sensing of the target object based on the power level meeting a predefined power level.

15. The apparatus of claim 14, wherein the at least one processor is configured to: output the plurality of sensing signals for transmission towards the target object.

16. The apparatus of claim 14, wherein the plurality of sensing signals are transmitted by a network device.

17. The apparatus of claim 16, wherein the at least one processor is configured to: output, for transmission to the network device, a power control signal indicating a resource index for the resource with the acceptable power level.

18. The apparatus of claim 17, wherein the at least one processor is configured to output the power control signal for transmission via a communications link.

19. The apparatus of claim 18, wherein the communications link is provided via a base station.

20. The apparatus of claim 17, wherein the at least one processor is configured to output the power control signal for transmission via a sidelink communication.

21. The apparatus of claim 14, wherein the at least one processor is configured to: determine a resource index for the resource with the acceptable power level.

22. The apparatus of claim 21, wherein the at least one processor is configured to: determine, from a power mapping table based on the resource index, an optimum transmission power for one or more additional sensing signals.

23. The apparatus of claim 22, wherein the at least one processor is configured to: output the one or more additional sensing signals for transmission using the optimum transmission power.

24. The apparatus of claim 22, wherein the at least one processor is configured to: output an indication of the optimum transmission power for transmission to a network device for transmission of the one or more additional sensing signals.

25. The apparatus of claim 14, wherein the plurality of sensing signals are sensing reference signals (RSS).

26. The apparatus of claim 14, wherein the plurality of resources are resource elements of a resource block.
27. The apparatus of claim 14, wherein the predefined power level is a predefined signal-to-noise ratio (SNR).
28. The apparatus of claim 14, wherein the apparatus is one of a user equipment (UE) or a base station.
29. The apparatus of claim 28, wherein the UE is one of a mobile device or a vehicle.
30. The apparatus of claim 28, wherein the base station is a gNodeB (gNB).