APPARATUS AND METHOD FOR REFERENCE ANCHOR UE FOR SIDELINK POSITIONING

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to sidelink positioning using a reference anchor UE.

BACKGROUND

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

[0003] The introduction of the sidelink (SL) Positioning framework was approved to support the varying target positioning requirements across different use cases. SL positioning is intended to be applied for a variety of use cases such as vehicle-to-everything (V2X), public safety, industrial internet of things (IIoT) and commercial use cases. The aim of SL positioning is to determine the absolute, relative position of a UE or distance or direction between a pair of UEs by using a variety of SL positioning methods such as SL round trip time (RTT)-type methods including single-sided and double-sided RTT, SL-angle of arrival (AoA), SL-TOA (SL-Time-of-Arrival) and SL- time difference of arrival

(TDOA). SL positioning is enabled using sidelink positioning reference signals (SL-PRS) transmitted over the PC5 (SL) interface and will be supported in multiple coverage scenarios (in-coverage, partial coverage and out-of-coverage scenarios). SL positioning is also supported for network-based, network-assisted and UE-only operational positioning scenarios. The Sidelink Positioning Protocol (SLPP) has also been designed to support the transmission of all relevant SL positioning messages between LMF and UE and between a pair of UEs.

[0004] TDoA is a well-established positioning technique to provide the absolute position of one or more UE and is one of the key supported positioning techniques supported in sidelink, also known as SL-TDoA. To obtain good positioning performance, SL-TDoA requires at least 3 anchor nodes, tight synchronization between anchor nodes (ideally no synchronization error) and a diversified geometric placement of anchor nodes. In practice, these conditions are difficult to guarantee using known techniques.

SUMMARY

[0005] The present disclosure relates to methods, apparatuses, and systems that support identification, selection and configuration of a reference anchor UE to support an optimized SL-TDoA procedure. Embodiments of the present disclosure provide more accurate and efficient sidelink positioning of a target UE.

[0006] Some implementations of the method and apparatuses described herein may further include a user equipment (UE) for wireless communication, comprising at least one memory, and at least one processor coupled with the at least one memory and configured to cause the UE to select a reference anchor UE from a set of active anchor UEs using one or more selection criteria, perform a sidelink measurement for positioning with respect to the selected reference anchor UE, and transmit one or more of a sidelink measurement report, based at least in part on the performed sidelink measurement, or information associated with the reference anchor UE.

[0007] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to cause the UE to receive a list of anchor UEs,

and select a set of active anchor UEs from the list of anchor UEs, wherein the list of anchor UEs is received from a server UE or a Location Management Function (LMF), and wherein one or more of the sidelink measurement report or information associated with the reference anchor UE is transmitted to the server UE or the LMF.

[0008] In some implementations of the method and apparatuses described herein, the list of anchor UEs is received in a message functioning as a container carrying a Sidelink Positioning Protocol (SLPP) message, or the list of anchor UEs is received in the SLPP message.

[0009] In some implementations of the method and apparatuses described herein, the one or more selection criteria include at least one of: a threshold value for a sidelink reference signal, a line-of-sight (LoS) status associated with one or more of the UE or each of at least one active anchor UE of the set of active anchor UEs, a coverage status associated with one or more of the UE or each of at least one active anchor UE of the set of active anchor UEs, whether sidelink time difference of arrival (SL-TDoA) measurement is supported by one or more of the UE or each of at least one active anchor UE of the set of active anchor UEs, whether a location of each of at least one active anchor UE of the set of active anchor UEs in multiple dimensions is available, and Public Land Mobile Network (PLMN) information associated with each active anchor UE of the set of active anchor UEs.

[0010] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to cause the UE to rank each active anchor UE in the list of active anchor UEs and transmit an indication of the ranked active anchor UEs.

[0011] In some implementations of the method and apparatuses described herein, the information associated with the reference anchor UE includes an identifier of the reference anchor UE.

[0012] In some implementations of the method and apparatuses described herein, the information associated with the reference anchor UE includes one or more of: one or more Sidelink Reference Signal Time Difference (SL-RSTD) measurement values, an application layer identifier, a Temporary Mobile Subscriber Identity (TMSI), a source identifier, a

destination identifier, an anchor UE identifier, and a temporary reference anchor UE identifier.

[0013] In some implementations of the method and apparatuses described herein, the selected reference anchor UE is a first reference anchor UE, and the at least one processor is further configured to cause the UE to select a second reference anchor UE for a Sidelink Positioning Protocol (SLPP) session as the first reference anchor UE based at least in part on the one or more selection criteria.

[0014] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to cause the UE to perform one or more Sidelink Reference Signal Time Difference (SL-RSTD) measurements with the first reference anchor UE and the second reference anchor UE, and transmit a report of the SL-RSTD measurements with the first reference UE and the second reference UE, wherein the transmitted report associates each SL-RSTD measurement with one or more of the first reference anchor UE or the second reference anchor UE.

[0015] Some implementations of the method and apparatuses described herein may further include a processor for wireless communication, comprising at least one memory, and a controller coupled with the at least one memory and configured to cause the controller to select a reference anchor UE from a set of active anchor UEs using one or more selection criteria, perform a sidelink measurement for positioning with respect to the selected reference anchor UE, and transmit one or more of a sidelink measurement report, based at least in part on the performed sidelink measurement, or information associated with the reference anchor UE.

[0016] Some implementations of the method and apparatuses described herein may further include an apparatus for performing a network function, the apparatus comprising at least one memory, and at least one processor coupled with the at least one memory and configured to cause the apparatus to transmit a list of initial anchor UEs to a target UE, receive a set of active anchor UEs from the list of initial anchor UEs from the target UE, select a reference anchor UE from the set of active anchor UEs using one or more selection

criteria, receive sidelink positioning measurements from the target UE, and calculate a position of the target UE using the sidelink positioning measurements.

[0017] In some implementations of the method and apparatuses described herein, the apparatus receives a list of candidate UEs from the target UE and generates the list of initial anchor UEs from the list of candidate UEs.

[0018] In some implementations of the method and apparatuses described herein, the list of initial anchor UEs is transmitted in a sidelink positioning protocol (SLPP) message.

[0019] In some implementations of the method and apparatuses described herein, the selection criteria are pre-configured in the apparatus.

[0020] In some implementations of the method and apparatuses described herein, the one or more selection criteria include at least one of: a threshold value for a sidelink reference signal received by the target UE, a line of sight status between the target UE and a respective anchor UE, a coverage status, support for sidelink time difference of arrival (SL-TDoA) measurements, whether a location of the respective anchor UE in two or three dimensions is available, and public land mobile network (PLMN) information of the respective anchor UE.

[0021] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to cause the apparatus to transmit assistance information to the selected reference anchor UE.

[0022] In some implementations of the method and apparatuses described herein, the assistance information includes at least one of a sidelink positioning reference signal (SL-PRS) resource ID, a combsize, SL -PRS periodicity, a combsize offset, a number of symbols, and dedicated SL-PRS or shared resource pool information or related configuration requited to transmit SL-PRS to another UE, e.g., target-UE.

[0023] In some implementations of the method and apparatuses described herein, the position of the target UE is calculated from a set of SL-RSTD measurements, and each of the SL-RSTD measurements is based on a first time-of-arrival measurement between the

target UE and the reference anchor UE and a second time-of-arrival measurement between the target UE and an anchor UE from the set of active anchor UEs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 illustrates an example of a wireless communications system that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0025] FIG. 2 illustrates an example of a processor that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0026] FIG. 3 illustrates an example of beam-based positioning in an NR network.

[0027] FIG. 4 illustrates an example of absolute and relative positioning in wireless cellular networks.

[0028] FIG. 5 illustrates an example of a configuration of SL PRS resources in an SL BWP.

[0029] FIG. 6 illustrates an example of a message flow for a sidelink mobile terminal location request (SL-MT-LR) procedure.

[0030] FIG. 7 illustrates an example of a message flow for a sidelink mobile originating location request (SL-MO-LR) procedure.

[0031] FIG. 8 illustrates an example of a device that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0032] FIG. 9 illustrates an example of signaling and processing operations that support sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0033] FIG. 10A and FIG. 10B illustrate examples of measurements using different reference anchor UEs that support sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0034] FIGs. 11 and 12 illustrate flowcharts of methods that support sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0035] A key issue in sidelink positioning that is yet to be solved relates to the derivation of the SL reference signal time difference measurement for SL-TDoA. A sidelink reference signal time difference (SL-RSTD) is derived based on the time-of-arrival (TOA) difference between one sidelink positioning reference signal (SL-PRS) transmission originating from one anchor device and another SL-PRS transmission originating from another anchor device. This SL-RSTD measurement, which is derived based on a pair of SL-PRS receptions can be challenging to track and manage given the involvement of a number of anchor UEs as well as different pairs of combinations from which to derive the SL-RSTD measurement. In some scenarios, the number of SL-RTSD measurements may be high, and the quality of some SL-RTSD measurements may be low, leading to inefficient and inaccurate position calculations. These problems may be addressed by establishing a reference anchor UE from which a configured set of SL-RSTD measurements are derived and preferentially using measurements from the reference anchor UE when calculating the position of a target UE.

[0036] In the context of SL positioning, a variety of SL positioning techniques may be used to obtain good SL positioning performance. This disclosure addresses a problem of managing one or more sidelink reference anchor UE, which is important for SL-TDoA positioning since SL-RSTD measurements are derived using time-of-arrival ("TOA") measurements based on a pair of received SL-PRS transmissions originating from a pair of anchor UEs. It is therefore helpful to distinguish which of the anchor UEs is an active reference anchor UE in order to associate a set of sidelink reference signal time difference (SL-RSTD) measurements performed by a UE.

[0037] One aspect of this disclosure describes methods and devices to support reference anchor UE procedures in a network-based positioning including involvement of a location server performing a location management function (LMF). Another aspect of this

disclosure describes methods and devices to support reference anchor UE procedures in a UE-only positioning scenario without the direct involvement of a LMF. Reference anchor UE selection criteria and prioritization of reference anchor UEs are described for both network-based and UE-only positioning scenarios. In addition, a method and device to provision dedicated SL-PRS configuration information to reference anchor UEs are also described, as well as additional methods which distinguish the reference anchor UEs in both network-based and UE-only positioning scenarios.

[0038] This disclosure therefore presents systems, apparatuses and methods for identification, selection and configuration of a reference anchor UE to support an optimized SL-TDoA procedure. In one embodiment, a procedure provides identification and selection of reference UEs for network-based positioning scenarios involving a location server associated with a LMF. In another embodiment, a procedure provides identification and selection of reference UEs for UE-only positioning scenarios without involvement of the location server, which is especially relevant in out-of-coverage scenarios.

[0039] Embodiments of the present disclosure provide more accurate and efficient handling of sidelink time difference measurements and positioning of a target UE.

[0040] Aspects of the present disclosure are described in the context of a wireless communications system. Aspects of the present disclosure are further illustrated and described with reference to device diagrams and flowcharts.

[0041] FIG. 1 illustrates an example of a wireless communications system 100 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more network entities 102, one or more UEs 104, a core network 106, and a packet data network 108. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a 5G network, such as an NR network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access

technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0042] The one or more network entities 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the network entities 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a radio access network (RAN), a base transceiver station, an access point, a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. A network entity 102 and a UE 104 may communicate via a communication link 110, which may be a wireless or wired connection. For example, a network entity 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0043] A network entity 102 may provide a geographic coverage area 112 for which the network entity 102 may support services (e.g., voice, video, packet data, messaging, broadcast, etc.) for one or more UEs 104 within the geographic coverage area 112. For example, a network entity 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, a network entity 102 may be moveable, for example, a satellite associated with a non-terrestrial network. In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas 112 may be associated with different network entities 102. Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0044] The one or more UEs 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a mobile device, a wireless device, a remote device, a remote unit, a handheld device, or a subscriber device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples. In some implementations, a UE 104 may be stationary in the wireless communications system 100. In some other implementations, a UE 104 may be mobile in the wireless communications system 100.

[0045] The one or more UEs 104 may be devices in different forms or having different capabilities. Some examples of UEs 104 are illustrated in FIG. 1. A UE 104 may be capable of communicating with various types of devices, such as the network entities 102, other UEs 104, or network equipment (e.g., the core network 106, the packet data network 108, a relay device, an integrated access and backhaul (IAB) node, or another network equipment), as shown in FIG. 1. Additionally, or alternatively, a UE 104 may support communication with other network entities 102 or UEs 104, which may act as relays in the wireless communications system 100.

[0046] A UE 104 may also be able to support wireless communication directly with other UEs 104 over a communication link 114. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0047] A network entity 102 may support communications with the core network 106, or with another network entity 102, or both. For example, a network entity 102 may interface with the core network 106 through one or more backhaul links 116 (e.g., via an S1, N2, or another network interface). The network entities 102 may communicate with each other over the backhaul links 116 (e.g., via an X2, Xn, or another network interface).

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

[0048] In some implementations, a network entity 102 may be configured in a disaggregated architecture, which may be configured to utilize a protocol stack physically or logically distributed among two or more network entities 102, such as an integrated access backhaul (IAB) network, an open RAN (O-RAN) (e.g., a network configuration sponsored by the O-RAN Alliance), or a virtualized RAN (vRAN) (e.g., a cloud RAN (C-RAN)). For example, a network entity 102 may include one or more of a central unit (CU), a distributed unit (DU), a radio unit (RU), a RAN Intelligent Controller (RIC) (e.g., a Near-Real Time RIC (Near-RT RIC), a Non-Real Time RIC (Non-RT RIC)), a Service Management and Orchestration (SMO) system, or any combination thereof.

[0049] An RU may also be referred to as a radio head, a smart radio head, a remote radio head (RRH), a remote radio unit (RRU), or a transmission reception point (TRP). One or more components of the network entities 102 in a disaggregated RAN architecture may be co-located, or one or more components of the network entities 102 may be located in distributed locations (e.g., separate physical locations). In some implementations, one or more network entities 102 of a disaggregated RAN architecture may be implemented as virtual units (e.g., a virtual CU (VCU), a virtual DU (VDU), a virtual RU (VRU)).

[0050] Split of functionality between a CU, a DU, and an RU may be flexible and may support different functionalities depending upon which functions (e.g., network layer functions, protocol layer functions, baseband functions, radio frequency functions, and any combinations thereof) are performed at a CU, a DU, or an RU. For example, a functional split of a protocol stack may be employed between a CU and a DU such that the CU may support one or more layers of the protocol stack and the DU may support one or more

different layers of the protocol stack. In some implementations, the CU may host upper protocol layer (e.g., a layer 3 (L3), a layer 2 (L2)) functionality and signaling (e.g., Radio Resource Control (RRC), service data adaption protocol (SDAP), Packet Data Convergence Protocol (PDCP)). The CU may be connected to one or more DUsor RUs, and the one or more DUs or RUs may host lower protocol layers, such as a layer 1 (L1) (e.g., physical (PHY) layer) or an L2 (e.g., radio link control (RLC) layer, medium access control (MAC) layer) functionality and signaling, and may each be at least partially controlled by the CU 160.

[0051] Additionally, or alternatively, a functional split of the protocol stack may be employed between a DU and an RU such that the DU may support one or more layers of the protocol stack and the RU may support one or more different layers of the protocol stack. The DU may support one or multiple different cells (e.g., via one or more RUs). In some implementations, a functional split between a CU and a DU, or between a DU and an RU may be within a protocol layer (e.g., some functions for a protocol layer may be performed by one of a CU, a DU, or an RU, while other functions of the protocol layer are performed by a different one of the CU, the DU, or the RU).

[0052] A CU may be functionally split further into CU control plane (CU-CP) and CU user plane (CU-UP) functions. A CU may be connected to one or more DUs via a midhaul communication link (e.g., F1, F1-c, F1-u), and a DU may be connected to one or more RUs via a fronthaul communication link (e.g., open fronthaul (FH) interface). In some implementations, a midhaul communication link or a fronthaul communication link may be implemented in accordance with an interface (e.g., a channel) between layers of a protocol stack supported by respective network entities 102 that are in communication via such communication links.

[0053] The core network 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The core network 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a

Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)) or a control and user plane entity, e.g., Location Management Function (LMF), that is responsible for providing location services. In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more network entities 102 associated with the core network 106.

[0054] The core network 106 may communicate with the packet data network 108 over one or more backhaul links 116 (e.g., via an S1, N2, or another network interface). The packet data network 108 may include an application server 118. In some implementations, one or more UEs 104 may communicate with the application server 118. A UE 104 may establish a session (e.g., a protocol data unit (PDU) session, or the like) with the core network 106 via a network entity 102. The core network 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server 118 using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the core network 106 (e.g., one or more network functions of the core network 106).

[0055] In the wireless communications system 100, the network entities 102 and the UEs 104 may use resources of the wireless communication system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the network entities 102 and the UEs 104 may support different resource structures. For example, the network entities 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the network entities 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the network entities 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The network entities 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0056] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first

numerology (e.g., μ=0) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., μ=0) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., μ=1) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., μ=2) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., μ=3) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., μ=4) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0057] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0058] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., μ=0, μ=1, μ=2, μ=3, μ=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively.# Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended

cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., μ=0) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0059] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the network entities 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the network entities 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the network entities 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0060] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., μ=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g., μ=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., μ=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., μ=3), which includes 120 kHz subcarrier spacing.

[0061] FIG. 2 illustrates an example of a processor 200 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. The processor 200 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 200 may include a controller202 configured to perform various operations in accordance with examples as described herein. The processor 200 may optionally include at least one

memory 204, such as L1/L2/L3 cache. Additionally, or alternatively, the processor 200 may optionally include one or more arithmetic-logic units (ALUs) 200. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0062] The processor 200 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 200)) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0063] The controller 202 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 200 to cause the processor 200 to support various operations in accordance with examples as described herein. For example, the controller 202 may operate as a control unit of the processor 200, generating control signals that manage the operation of various components of the processor 200. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0064] The controller 202 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 204 and determine subsequent instruction(s) to be executed to cause the processor 200 to support various operations in accordance with examples as described herein. The controller 202 may be configured to track memory address of instructions associated with the memory 204. The controller 202 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 202 may be configured to interpret the instruction and

determine control signals to be output to other components of the processor 200 to cause the processor 200 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 202 may be configured to manage flow of data within the processor 200. The controller 202 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 200.

[0065] The memory 204 may include one or more caches (e.g., memory local to or included in the processor 200) or other memory, such as RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementation, the memory 204 may reside within or on a processor chipset (e.g., local to the processor 200). In some other implementations, the memory 204 may reside external to the processor chipset (e.g., remote to the processor 200).

[0066] The memory 204 may store computer-readable, computer-executable code including instructions that, when executed by the processor 200, cause the processor 200 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 202 and/or the processor 200 may be configured to execute computer-readable instructions stored in the memory 204 to cause the processor 200 to perform various functions. For example, the processor 200 and/or the controller 202 may be coupled with or to the memory 204, and the processor 200, the controller 202, and the memory 204 may be configured to perform various functions described herein. In some examples, the processor 200 may include multiple processors and the memory 204 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0067] The one or more ALUs 206 may be configured to support various operations in accordance with examples as described herein. In some implementation, the one or more ALUs 206 may reside within or on a processor chipset (e.g., the processor 200). In some other implementations, the one or more ALUs 206 may reside external to the processor chipset (e.g., the processor 200). One or more ALUs 206 may perform one or more

computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 206 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 206 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 206 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 206 to handle conditional operations, comparisons, and bitwise operations.

[0068] The processor 200 may support wireless communication in accordance with examples as disclosed herein. The processor 200 may be configured to or operable to support a means for sidelink positioning using a reference anchor UE.

[0069] An example of supported positioning techniques for RAT-dependent UL-based and DL-based and RAT-independent positioning as of Rel-16 are listed in Table 1 below.

[Table 1]

Method	**UE-based**	**UE-assisted, LMF-based**	**NG-RAN node assisted**	**SUPL**
A-GNSS	Yes	Yes	No	Yes (UE-based and UE-assisted)
OTDOA	No	Yes	No	Yes (UE-assisted)
E-CID	No	Yes	Yes	Yes for E-UTRA (UE-assisted)
Sensor	Yes	Yes	No	No
WLAN	Yes	Yes	No	Yes
Bluetooth	No	Yes	No	No
TBS	Yes	Yes	No	Yes (MBS)
DL-TDOA	Yes	Yes	No	No
DL-AoD	Yes	Yes	No	No
Multi-RTT	No	Yes	Yes	No
NR E-CID	No	Yes	FFS	No
UL-TDOA	No	No	Yes	No
UL-AoA	No	No	Yes	No

[0070] Different positioning techniques as indicated in Table 1 can be currently configured and performed based on the requirements of the LMF and UE capabilities. The transmission of Uu (uplink and downlink) positioning reference signals (PRS) enable a UE to perform UE positioning-related measurements to enable the computation of a UE's absolute location estimate and are configured per Transmission Reception Point (TRP), where a TRP may include a set of one or more beams. A conceptual overview is illustrated in FIG. 3.

[0071] According to Rel-16, the PRS can be transmitted by different base stations (serving and neighboring) using narrow beams over FR1 and FR2 as illustrated in FIG. 3, which is relatively different when compared to LTE where the PRS was transmitted across the whole cell. The PRS can be locally associated with a PRS Resource ID and Resource Set ID for a base station (TRP). Similarly, UE positioning measurements such as Reference Signal Time Difference (RSTD) and PRS RSRP measurements are made between beams (e.g., between a different pair of DL PRS resources or DL PRS resource sets) as opposed to different cells as was the case in LTE.

[0072] In addition, there are additional UL positioning methods for the network to exploit in order to compute the target UE's location. Table 2 and Table 3 show reference signal to measurements mapping for at least some of the supported RAT-dependent positioning techniques at the UE and gNB, respectively. RAT-dependent positioning techniques may involve 3GPP RAT and core network entities to perform the position estimation of the UE, which are differentiated from RAT-independent positioning techniques which rely on GNSS, IMU sensor, WLAN and Bluetooth technologies for performing target device (UE) positioning.

[0073] FIG. 4 is an overview of absolute and relative positioning scenarios using three different coordinate systems: 1) absolute positioning, fixed coordinate systems, 2) relative positioning, variable and moving coordinate systems, and 3) relative positioning, variable coordinate systems.

[Table 2]

DL/UL Reference Signals	**UE Measurements**	**To facilitate support of the following positioning techniques**
Rel.16 DL PRS	DL RSTD	DL-TDOA
Rel.16 DL PRS	DL PRS RSRP	DL-TDOA, DL-AoD, Multi-RTT
Rel.16 DL PRS / Rel.16 SRS for positioning	UE Rx-Tx time difference	Multi-RTT
Rel. 15 SSB / CSI-RS for RRM	SS-RSRP(RSRP for RRM), SS-RSRQ(for RRM), CSI-RSRP (for RRM), CSI-RSRQ (for RRM), SS-RSRPB (for RRM)	E-CID

[Table 3]

DL/UL Reference Signals	**gNB Measurements**	**To facilitate support of the following positioning techniques**
Rel.16 SRS for positioning	UL RTOA	UL-TDOA
Rel.16 SRS for positioning	UL SRS-RSRP	UL-TDOA, UL-AoA, Multi-RTT
Rel.16 SRS for positioning, Rel.16 DL PRS	gNB Rx-Tx time difference	Multi-RTT
Rel.16 SRS for positioning	AoA and ZoA	UL-AoA, Multi-RTT

[0074] RAT-dependent positioning measurements

[0075] Different DL measurements including downlink positioning reference signal-reference signal received power (DL PRS-RSRP), DL RSTD and UE Rx-Tx Time Difference for supported RAT-dependent positioning techniques are shown in Table 4. The

following measurement configurations are specified: 1) 4 Pair of DL RSTD measurements can be performed per pair of cells. Each measurement is performed between a different pair of DL PRS Resources/Resource Sets with a single reference timing. 2) 8 DL PRS RSRP measurements can be performed on different DL PRS resources from the same cell.

[Table 4]

DL PRS reference signal received power (DL PRS-RSRP)	
Definition	DL PRS reference signal received power (DL PRS-RSRP), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry DL PRS reference signals configured for RSRP measurements within the considered measurement frequency bandwidth. For frequency range 1, the reference point for the DL PRS-RSRP shall be the antenna connector of the UE. For frequency range 2, DL PRS-RSRP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch. For frequency range 1 and 2, if receiver diversity is in use by the UE, the reported DL PRS-RSRP value shall not be lower than the corresponding DL PRS-RSRP of any of the individual receiver branches.
Applicable for	RRC_CONNECTED intra-frequency, RRC_CONNECTED inter-frequency
DL reference signal time difference (DL RSTD)	
Definition	DL reference signal time difference (DL RSTD) is the DL relative timing difference between the positioning node *j* and the reference positioning node *i*, defined as $T_{SubframeRxj} - T_{SubframeRxi}$, Where: $T_{SubframeRxj}$ is the time when the UE receives the start of one subframe from positioning node *j*. $T_{SubframeRxi}$ is the time when the UE receives the corresponding start of one subframe from positioning node *i* that is closest in time to the subframe received from positioning node *j*. Multiple DL PRS resources can be used to determine the start of one subframe from a positioning node.

	For frequency range 1, the reference point for the DL RSTD shall be the antenna connector of the UE. For frequency range 2, the reference point for the DL RSTD shall be the antenna of the UE.
Applicable for	RRC_CONNECTED intra-frequency RRC_CONNECTED inter-frequency
UE Rx – Tx time difference	
Definition	The UE Rx – Tx time difference is defined as $T_{UE-RX} - T_{UE-TX}$ Where: T_{UE-RX} is the UE received timing of downlink subframe #*i* from a positioning node, defined by the first detected path in time. T_{UE-TX} is the UE transmit timing of uplink subframe #*j* that is closest in time to the subframe #i received from the positioning node. Multiple DL PRS resources can be used to determine the start of one subframe of the first arrival path of the positioning node. For frequency range 1, the reference point for T_{UE-RX} measurement shall be the Rx antenna connector of the UE and the reference point for T_{UE-TX} measurement shall be the Tx antenna connector of the UE. For frequency range 2, the reference point for T_{UE-RX} measurement shall be the Rx antenna of the UE and the reference point for T_{UE-TX} measurement shall be the Tx antenna of the UE.
Applicable for	RRC_CONNECTED intra-frequency RRC_CONNECTED inter-frequency
DL PRS RSRPP (Reference Signal Received Path Power)	
Definition	DL PRS reference signal received path power (DL PRS-RSRPP), is defined as the power of the linear average of the channel response at the i-th path delay of the resource elements that carry DL PRS signal configured for the measurement, where DL PRS-RSRPP for the 1st path delay is the power contribution corresponding to the first detected path in time. For frequency range 1, the reference point for the DL PRS-RSRPP shall be the antenna connector of the UE. For frequency range 2, DL PRS-RSRPP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch.

Applicable for	RRC_CONNECTED, RRC_INACTIVE

[0076] SL PRS resource configuration and allocation

[0077] SL positioning is based on a SL PRS that is transmitted over the PC5 interface. An SL PRS resource is a pseudo-random sequence that is mapped to time-frequency resources (pairs of OFDM symbol, subcarrier) within a slot of a radio frame used for SL PRS transmission. Multiple SL PRS resources can be configured within an SL BWP by a number of resource pools.

[0078] A resource pool may include of a number of contiguous PRBs and contiguous or non-contiguous slots. In the frequency domain a resource pool is further divided into a number of contiguous subchannels, where a subchannel consists of a group of N consecutive PRBs in a slot. A subchannel represents the smallest unit for SL data transmission or reception. Furthermore, an SL PRS resource pool can be configured as a shared resource pool or as a dedicated resource pool. A shared resource pool can be used for transmission of both SL PRS and Physical Sidelink Shared Channel (PSSCH) whereas a dedicated resource pool may be used only for transmission of SL PRS.

[0079] FIG. 5 illustrates an exemplary configuration of SL PRS resources in an SL BWP. Overall, 3 resource pools for SL PRS are configured within the SL BWP (RP1 to RP3) and the configuration of each resource pool is repeated in time with a given periodicity. For the resource pool RP1, 12 subchannels are defined and each subchannel consists of a group of 10 consecutive PRBs in a slot.

[0080] With respect to resource allocation of SL PRS, the following schemes are supported.

[0081] Scheme 1/Mode l refers to network-controlled SL PRS resource allocation where the gNB manages and schedules the transmission of SL PRS resources. According to this scheme a UE that transmits a SL PRS sends a request for specific SL PRS resource characteristic(s)/SL-PRS resource configuration(s) to a gNB and receives an SL-PRS

resource allocation signaling from gNB through a dynamic grant (provided via DCI), configured grant type 1 (provided via RRC) or configured grant type 2 (provided via PDCCH). The request from UE may be sent to gNB via a L2 MAC control element (CE) or RRC message.

[0082] Scheme 2/Mode 2 refers to UE autonomous SL PRS resource allocation where the UE autonomously selects the SL PRS resources for transmission. According to this scheme the UE firstly defines a selection window (a number of slots) and identifies candidate SL PRS resources within the selection window. Afterwards, the UE senses the identified candidate SL PRS resources during a defined sensing window (a number of slots) to determine which of the SL PRS resources are available. Finally, the UE selects randomly an SL PRS resource among the set of available SL PRS resources. SL PRS transmission can be triggered either by the UE itself or a UE-A can request a UE-B to transmit SL-PRS, either by L1 sidelink control information (SCI) or a L2 MAC CE.

[0083] Scheme 1 is intended for in-coverage and partial coverage scenarios, whereas Scheme 2 is intended for out-of-coverage scenarios. A UE can be configured via broadcast signaling (SIB12) or dedicated signaling (*RRCReconfiguration* message) to perform resource allocation Scheme 1 and/or Scheme 2, applicable to all resource pools (dedicated or shared resource pools).

[0084] Network-based SL positioning

[0085] FIG. 6 shows an exemplary message flow for a sidelink mobile terminal location request (SL-MT-LR) procedure where the network is involved and in which the absolute location of UE1 shall be determined by using SL PRS that is transmitted by UE2 to UEn. The UE1 is the Target UE, and UE2 to UEn are the Anchor UEs. It is assumed that all involved UEs are in-coverage and served by the same gNB.

[0086] At step 0, the AMF receives a request for the current absolute location of UE1 from an external LCS client (not shown in FIG. 6). At step 1, based on the requested LCS QoS in the LCS service request the AMF initiates SL positioning and sends an SL-MT-LR request to UE1. At step 2, based on the received SL-MT-LR request the UE1 initiates SL discovery procedure and attempts to discover other UEs, e.g. UE2 to UEn. At step 3, upon

discovery of UE2 to UEn the UE1 obtains their SL positioning capabilities, e.g. the supported SL positioning modes, positioning methods, UE role (i.e. Anchor UE) and their (pre-)configured (if any) SL PRS resource pools. At step 4, UE1 sends the SL-MT-LR response to the AMF that contains information about the discovered UE2 to UEn and their SL positioning capabilities and (pre-)configured (if any) SL PRS resource pools. The AMF forwards the SL-MT-LR response to LMF.

[0087] At step 5, the LMF triggers SL positioning procedure for the UE1 and the discovered UE2 to UEn. Based on the received SL-MT-LR response, the LMF performs UE-assisted positioning based on SL-TDoA and the UE2 to UEn as Anchor UEs for determining UE1's location. Furthermore, during the procedure the LMF sends SL positioning assistance data to UE1 to UEn. The assistance data to UE1 contains information about the SL PRS resources that can be requested from each UE2 to UEn. The assistance data to each UE2 to UEn contains information about the SL PRS resources that are requested to be transmitted to UE1. In accordance with the received assistance data the UE1 to UEn perform SL positioning for SL-TDoA. UE1 performs SL PRS measurements based on the received SL PRS from UE2 to UEn and sends the measured results to the LMF. At step 6, the LMF then calculates the absolute location of UE1 based on the SL PRS measurements received from UE1 and sends the location estimate to the AMF.

[0088] UE-only based SL positioning

[0089] FIG. 7 shows an exemplary message flow for a sidelink mobile originating location request (SL-MO-LR) procedure where the network is not involved and in which the absolute location of the Target UE is determined by using SL PRS that is transmitted by the Anchor UE1 to UEn. It is assumed that all involved UEs are out-of-coverage and the Target UE has no SL positioning server functionalities that would enable it to perform a location calculation.

[0090] At step 0, the Target UE receives a request for its current absolute location from an external LCS client. At step 1, the Target UE initiates SL positioning based on the requested LCS QoS in the LCS service request and starts the SL discovery procedure to discover Anchor and Server UEs in its vicinity. It is assumed that the Target UE was able to

discover the Anchor UE1 to UEn and one Server UE. At step 2, the Target UE, Anchor UE1 to UEn and Server UE perform SL positioning capability exchange. That means the Target UE obtains the SL positioning capabilities of Anchor UE1 to UEn and Server UE, e.g. the supported SL positioning modes, positioning methods and their pre-configured (if any) SL PRS resource pools.

[0091] At step 3, based on the result of the SL positioning capability exchange in Step 2, the Target UE decides to perform UE-assisted positioning based on SL-TDOA and to use the Server UE for performing the location calculation. The Target UE then sends SL positioning assistance data to the Anchor UEs. The assistance data to each Anchor UE1 to UEn contain information about the SL PRS resources that are requested to be transmitted to the Target UE.

[0092] At step 4, the Anchor UEs transmit SL PRS in accordance with the received assistance data and the Target UE performs SL PRS measurements based on the received SL PRS from the Anchor UEs. At step 5, the Target UE sends the measured results to the Server UE using the SL Provide Location Information message. At step 6, based on the SL PRS measurements received from the Target UE the Server UE then calculates the absolute location of Target UE and sends the location estimate back using the SL Provide Assistance Data message.

[0093] FIG. 8 illustrates an example of a block diagram of a device 802 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. The device 802 may be an example of an LMF server or a UE 104 as described herein. The LMF server may be any physical entity associated with a location function, e.g. an LMF, and may be a network entity 102, a core network server 106, etc. The device 802 may support wireless communication with one or more network entities 102, UEs 104, or any combination thereof. The device 802 may include components for bi-directional communications including components for transmitting and receiving communications, such as a processor 804, a memory 806, a transceiver 808, and an I/O controller 810. These components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0094] The processor 804, the memory 806, the transceiver 808, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. For example, the processor 804, the memory 806, the transceiver 808, or various combinations or components thereof may support a method for performing one or more of the operations described herein.

[0095] In some implementations, the processor 804, the memory 806, the transceiver 808, or various combinations or components thereof may be implemented in hardware (e.g., in communications management circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA) or other programmable logic device, a discrete gate or transistor logic, discrete hardware components, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure. In some implementations, the processor 804 and the memory 806 coupled with the processor 804 may be configured to perform one or more of the functions described herein (e.g., executing, by the processor 804, instructions stored in the memory 806).

[0096] For example, the processor 804 may support wireless communication at the device 802 in accordance with examples as disclosed herein. Processor 804 may be configured as or otherwise support a means for sidelink positioning using a reference anchor UE.

[0097] The processor 804 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor 804 may be configured to operate a memory array using a memory controller. In some other implementations, a memory controller may be integrated into the processor 804. The processor 804 may be configured to execute computer-readable instructions stored in a memory (e.g., the memory 806) to cause the device 802 to perform various functions of the present disclosure.

[0098] The memory 806 may include random access memory (RAM) and read-only memory (ROM). The memory 806 may store computer-readable, computer-executable code including instructions that, when executed by the processor 804 cause the device 802 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. In some implementations, the code may not be directly executable by the processor 804 but may cause a computer (e.g., when compiled and executed) to perform functions described herein. In some implementations, the memory 806 may include, among other things, a basic I/O system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

[0099] The I/O controller 810 may manage input and output signals for the device 802. The I/O controller 810 may also manage peripherals not integrated into the device M02. In some implementations, the I/O controller 810 may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller 810 may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In some implementations, the I/O controller 810 may be implemented as part of a processor, such as the processor 804. In some implementations, a user may interact with the device 802 via the I/O controller 810 or via hardware components controlled by the I/O controller 810.

[0100] In some implementations, the device 802 may include a single antenna 812. However, in some other implementations, the device 802 may have more than one antenna 812 (i.e., multiple antennas), including multiple antenna panels or antenna arrays, which may be capable of concurrently transmitting or receiving multiple wireless transmissions. The transceiver 808 may communicate bi-directionally, via the one or more antennas 812, wired, or wireless links as described herein. For example, the transceiver 808 may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver 808 may also include a modem to modulate the packets, to provide the modulated packets to one or more antennas 812 for transmission, and to demodulate packets received from the one or more antennas 812.

[0101] This disclosure details solutions for selection and configuration of reference anchor UEs to support SL-TDoA configurations. In various embodiments, reference UEs can be selected and managed and locations can be calculated with or without an LMF. The calculation of the location of a target UE and other functions that would otherwise be handled by a LMF may be handled by a server UE instead of an LMF. Accordingly, a server UE is a UE that is provisioned to provide functionality that is similar to that of an LMF for performing SL-TDoA procedures. A server UE may be co-located with a target UE or an anchor UE.

[0102] Embodiments relate to various aspects of SL location measurements, including processes to manage reference UE selection in a network-based SL positioning scenario involving a target-UE, participating SL positioning UEs, e.g., anchor UEs and a location server, e.g., LMF; processes to manage reference UE selection in a UE-only SL positioning scenario involving a target-UE and participating SL positioning UEs, which may be referred to as anchor UEs; processes to enable dedicated SL-PRS configurations for a reference anchor UE; and processes to distinguish a reference anchor UE for both network-based and UE-only positioning operations.

[0103] For purposes of this disclosure, a positioning-related reference signal (PRS) may be referred to as a reference signal used for positioning procedures to estimate a target-UE's location, or based on existing reference signals such as CSI-RS or SRS, and a target-UE may be referred to as the device to be positioned. In various embodiments, the term 'PRS' may refer to a signal such as a reference signal, which may or may not be used primarily for positioning. In addition, the location or positioning of a UE may refer to either an absolute position, relative position with respect to another node, ranging in terms of distance, ranging in terms of direction, or combinations thereof.

[0104] FIG. 9 illustrates an example of a diagram 900 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure.

[0105] On selection of one or more positioning methods comprising SL-TDoA measurements based on one or more SL-RSTD measurements, an active reference anchor UE is selected in a network-based positioning scenario. The network-based positioning

operation for sidelink positioning may involve one or more 5GC functions including an LMF, which handles location service request management as well as providing configuration assistance information and performs the eventual location estimate result calculation. Alternatively, as shown in FIG. 9, the positioning entity may be a server UE instead of an LMF.

[0106] A target-UE may share a list of candidate anchor UEs with the LMF or server UE by signaling 902 such as SLPP or LPP signaling, for example, in a SLPP *RequestAssistanceData* message or in other implementations utilize a supplementary service message, which acts as a container to carry the SLPP or LPP message. The list of candidate anchor UEs may be obtained by the target UE using a set of sidelink positioning discovery procedures performed by the target UE or a server UE.

[0107] Each of the listed candidate anchor UEs 1) may have associated location information or 2) may not have associated location information. The location information may comprise one or more of an absolute horizontal location (2D location), an absolute vertical location (3D location), relative horizontal and/or vertical location, horizontal and/or vertical distance with respect to one or more UEs, and direction with respect to one or more UEs. In the case that location information for one or more UE is not provided at 902, the LMF may prioritize anchor UEs with associated location information. In the case that location information has not been provided with a candidate anchor UE, the LMF may instigate location retrieval procedures of such anchor UEs, e.g., using mobile-terminated location request (MT-LR) procedures and associated LPP signaling. Each of the associated SL positioning capabilities of candidate anchor UEs may also be signaled along with candidate anchor UE information to the LMF at 902.

[0108] In an embodiment, the LMF initiates a legacy location service request of potential anchor UEs, and the LMF receives a response from the potential anchor UEs to participate in a location retrieval procedure. The LMF determines locations of the potential anchor UEs to which the LMF had send a location service request. In this case, the LMF may prioritize anchor UEs based on the time it receives a positive acknowledgement of the location retrieval request from the anchor UE, location proximity of the anchor UE to the

target UE, any received prior Rx measurement information of the anchor UE with respect to the target UE, or any combination thereof.

[0109] When the position calculating entity is a server UE, the server UE may instigate location retrieval procedures of such anchor UEs, e.g., using additional SL positioning procedures based on SLPP signaling. The list of candidate anchor UEs may be obtained using a SL positioning discovery procedure and in addition, each of the associated SL positioning capabilities of candidate anchor UE may also be signaled along with candidate anchor UE information to the server UE via SLPP Capability exchange procedures at 902.

[0110] The LMF, server UE or target UE selects a set of active anchor UEs at 906. There are several possible embodiments for active anchor UE selection. In one embodiment, the LMF or server UE selects initial anchor UEs from the list of candidate anchor UEs received at 902 for a configured SLPP session associated with an SLPP session ID and signals the initial list of anchor UEs to the target UE, e.g., using the SLPP *ProvideAssistanceData* message at 904. The target UE may then select the anchor UEs at 906 based on the initial list provided by the LMF or server UE and these may be considered as the active anchor UEs used for sidelink positioning, e.g., to perform SL-TDoA. In another embodiment, the LMF or server UE may select active anchor UEs from the candidate UEs.

[0111] In another embodiment, the target UE performs final anchor UE selection based on the candidate list of anchor UEs and notifies the LMF or server UE of the final selected anchor UEs from the candidate anchor UE list. The finally selected anchor UEs may be considered as active anchor UEs.

[0112] The finally selected anchor UEs or active anchor UEs may be used throughout the duration of an active SLPP session, unless one or more active anchor UEs is reselected due to reasons such as a change in radio channel conditions, mobility of an anchor UE with respect to the target UE, an anchor UE becomes unreachable via SL (PC5) interface, an anchor UE is out-of-coverage, etc.

[0113] The target UE establishes sidelink connections with the anchor UEs (UE1 to UEn in FIG. 9) at 908 and initiates suitable procedures according to a type of positioning

method, e.g., SL-TDoA. The target UE or LMF or server UE performs reference anchor UE selection and/or derives a reference anchor UE list using one or more selection criteria at 910. For example, the target UE, LMF or server UE may select an active reference anchor UE from the list of active anchor UEs in order to associate a set of reported SL-RSTD measurements within an ongoing SLPP session. In other implementations, the same reference anchor UE may be maintained across different SLPP sessions, based on the applicable conditions. The selection criteria used by the target UE, LMF or server UE to select one or more reference anchor UE may include one or more of the following criteria. When the LMF or server UE selects a reference anchor UE, the reference anchor UE may be selected from a set of active anchor UEs received from the UE at 906.

[0114] A first criteria may be based on prior measured sidelink positioning or reference signal measurements based one or more transmissions from the SL anchor UEs. Examples of the signal measurements are Physical Sidelink Broadcast Channel (PSBCH)-RSRP, PSSCH-RSRP, Physical Sidelink Control Channel (PSCCH)-RSRP from the target device, SL PRS RSRP, SL PRS RSRPP, and SL RSSI measurements. For example, reference anchor UEs may be selected based on configured measurement thresholds such that if the target UE performs a measurement that is above a configured threshold, it is more likely to choose the associated anchor UE as a reference anchor UE.

[0115] A second criteria is based on the line of sight (LOS) status of the SL positioning measurements, which indicates whether the potential reference anchor device has a LOS link with respect to the target UE. The target UE would be more likely to select an anchor UE as a reference anchor UE, which has a LOS measurement.

[0116] A third criteria is based on whether the anchor UE supports time difference procedures. For example, in one embodiment, this criteria includes whether an anchor UE must supports SL-TDoA positioning procedures. In other implementations, this criteria may consider whether the candidate reference anchor UE also supports SL-RToA or SL-ToA methods based on SL-RToA measurements.

[0117] A fourth criteria is based on whether 2D or 3D location information for the anchor UE is known. This criteria may favor UEs for which absolute horizontal and/or

vertical location information is available. If the UEs are too far apart, time synchronization is difficult, and in some cases the reference signals may be invalid/inaccurate when the distance is too great and therefore close location proximity to the target UE may be considered favorable in terms of reference anchor UE selection.

[0118] A fifth criteria is based on the coverage status of the anchor UE. This criteria favors UEs that are within coverage of the same network as the target UE, and may further favor UEs that are within coverage of the same gNB or cell as the target UE. Coverage status may be provided via a flag using SLPP signaling or higher-layer signaling, e.g., from the application layer or Ranging/SL positioning layer or layer that performs UE discovery. Sidelink time difference measurements typically use a synchronization procedure, and synchronization is easier to obtain when the target and reference anchor UEs share coverage and the same synchronization source, e.g., either GNSS, network time (gNB) or same UE synchronization time.

[0119] A sixth criteria is based on public land mobile network (PLMN) related information of the anchor UE. The PLMN information may include at least a PLMN ID, which is a 6 digit identifier including a Mobile Country Code (MCC) and a mobile Network Code (MNC). This criteria may favor UEs with the same PLMN ID as the target UE.

[0120] A seventh criteria is that the candidate reference anchor UE is defined with an anchor UE role and indicates this to the target UE. The indication can be transmitted as part of the UE's capability information or as part of the discovery meta data information.

[0121] At 912, the target UE transmits the identity of the active reference anchor UE and/or a list of reference anchor UEs to the LMF or server UE. The finally selected reference anchor UE may also be referred to as an active reference anchor UE. In some embodiments, the target UE may implement the above selection criteria to provide a list of reference anchor UEs, where the {list of reference anchor UE} ≤ {total number of active anchor UEs}. The selected active reference anchor UE or list of reference anchor UEs may be provided to the LMF or server UE using exemplary signaling such as a SLPP *RequestAssistanceData* message.

[0122] As noted above, in an embodiment, the target UE transmits a list of reference anchor UEs to the LMF or server UE instead of simply transmitting the identity of a single active reference anchor UE. The selection of a reference anchor UE may be dynamic and may not be restricted to a single anchor UE throughout an SLPP session. In addition, the selection of the reference UE may be detailed in order to describe the reference anchor UE selection procedure or in the case of other implementations, in order to enable flexibility, the selection criteria of the reference UE may be left up to a UE implementation. The list of reference anchor UEs may be used by the LMF or server UE to select a different active reference anchor UE at a later time, which may be within the same SLPP session or in a subsequent SLPP session.

[0123] The reference anchor UEs within a list of reference anchor UEs may be ranked according to an explicit priority indicator or an implicit priority indicator. In the case of an implicit priority order, the reference anchor UEs may be ranked in descending order of appearance within the list, which corresponds to a descending priority order, i.e. the first reference anchor UE in the list has the highest priority (and may be the active reference anchor UE), the second reference anchor UE has the second priority and so forth. In another implementation, an ascending priority order may also be utilized. The list of priorities may be determined by the target UE based on the selection criteria described above.

[0124] In another implementation, a reference anchor device flag (indication) may be associated with an anchor UE, where a value ‘0’ indicates that it is not a reference anchor UE or where a value ‘1’ indicates that the anchor UE is a reference anchor UE. This may be signaled to the LMF or server UE by an indication in the signal transmitted at 912, e.g. a SLPP *RequestAssistanceData* message or based on a supplementary service message, e.g., SL-MT-LR.

[0125] The LMF or server UE may provide dedicated assistance data to the active reference anchor UE at 914. In FIG. 9, UE2 is designated as the active reference anchor UE and receives this assistance data. Examples of the data that may be transmitted to the active reference anchor UE are SL-PRS information including SL-PRS resource IDs, SL-PRS periodicity, combsize and combsize offsets, number of symbols, dedicated SL-PRS or

shared resource pool information, i.e., both SL-PRS and PSSCH comprising 2nd stage SCI and/or sidelink shared channel (SL-SCH) data. In another implementation, the serving gNB may also provide dedicated resource grants to the reference anchor UE, e.g., configured Type 1 or Type 2 grants.

[0126] At 916, the target UE performs SL-RSTD measurement(s) based on the active reference anchor UE.

[0127] FIGS. 10A and 10B illustrate exemplary conceptual diagrams of the role of a reference anchor UE for deriving SL-RSTD measurements in a network-based positioning scenario that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. While the reference anchor UE is UE 104a in FIG. 10A at time t1, the reference anchor UE is UE 104c in FIG. 10B at later time t2. Accordingly, as will be explained in more detail below, the reference anchor UE for a target UE 104T can be changed even within the same SLPP session.

[0128] In FIGS. 10A and 10B, target UE 104T receives SL-PRS signals from each of the anchor UEs 104a, 104b and 104c, one of which is designated as the reference anchor UE. The target UE 104T then generates SL-RSTD measurements from the SL-PRS signals and associates the measurements with the respective transmitting UE. In an embodiment, each of the SL-RSTD measurements is based on a first time-of-arrival (ToA) measurement between the target UE 104T and the reference anchor UE and a second ToA measurement between the target UE and an anchor UE from the set of active anchor UEs.

[0129] For example, in FIG. 10A, the UE may generate a first SL-RSTD measurement using ToA measurements for the reference UE 104a and another anchor UE 104b, and a second SL-RSTD measurement using ToA measurements for the reference UE 104a and another anchor UE 104c. Accordingly, each of the SL-RSTD measurements generated by the target UE 104T is based on a ToA measurement of an SL-PRS from the reference anchor UE (UE 104a in FIG. 10A, and UE 104c in FIG. 10B).

[0130] At 918, the target UE reports the SL-RSTD measurements from 916 to a positioning entity 1002, which is an LMF or server UE in FIG. 9. The data reported by the target UE may include reference anchor UE information such as UE IDs associated with the

measurements. Alternatively, for UE-based positioning, the target UE processes the SL-RSTD measurements at 916 and calculates the requested location information as received from an internal LCS client or application within the UE in an example.

[0131] At 920, the target UE performs an updated selection reference anchor UE and/or updates the reference anchor UE list based on in part, the selection criteria described above. Referring again to FIG. 10B, it can be seen that the locations of anchor UEs 104a, 104b and 104c have changed with respect to target UE 104T. Therefore, when the target UE 104T in FIG. 10B re-evaluates the anchor UEs using the selection criteria, the target UE 104T determines that UE 104c is more suitable as a reference anchor UE and designates UE 104c as the new reference anchor UE. In an embodiment, the target UE updates a list of reference anchor UEs using the selection criteria. At 922, the target UE transmits the updated active reference anchor UE and/or the updated reference anchor UE list to the LMF or server UE.

[0132] At 924, the LMF or server UE may provide updated dedicated assistance data to the new reference anchor UE. In FIG. 9, the new reference anchor UE is UE1, while in FIG. 10B the new reference anchor UE is 104c. The updated dedicated assistance data may include one or more of SL-PRS information including SL-PRS resource IDs, SL-PRS periodicity, combsize and combsize offsets, number of symbols, dedicated SL-PRS or shared resource pool information (both SL-PRS and PSSCH comprising 2nd stage SCI and/or SL-SCH Data). In another implementation, the serving gNB may also provide dedicated resource grants to the reference anchor UE, e.g., configured Type 1 or Type 2 grants.

[0133] At 926, the target UE performs SL-RSTD measurements based on the updated active reference anchor UE, which is UE 1 in FIG. 9 and UE 104c in FIG. 10B. This step may be essentially the same as 918 discussed above, except that the reference anchor UE for the SL-RSTD measurements is the updated reference anchor UE from 926 (UE1 in FIG. 9 and UE 104c in FIG. 10B). At 928, the target UE reports the SL-RSTD measurements from 926 to the LMF or server UE according to the active reference anchor UE. Alternatively, for UE-based positioning, the target UE processes the SL-RSTD measurements and calculates the requested location information. The LMF or server UE

calculates the position of the target UE at 930 using the SL-RSTD data received from the UE at 918 or 928. The SL-RSTD data at these two steps represents data collected at two different times, so a position would be calculated at each time.

[0134] Configuration of Reference Anchor UE

[0135] In an embodiment, the network in the case of Mode 1 may configure shared or dedicated SL positioning assistance data for the active reference anchor UEs or in the case of Mode 2 may utilize a shared resource pool for sensing and resource selection or receive a dedicated set of resources from another UE, e.g., a server UE. Table 5 shows an exemplary list of SL-PRS configuration parameters that may be configured to the reference anchor UE, which can be applicable to dedicated SL-PRS resource pool and/or a shared resource pool.

[Table 5]

Parameter	Description
> Dedicated SL PRS resource pool ID	Indicates the dedicated SL PRS resource pool ID
>Shared resource pool ID	Indicates the shared SL PRS resource pool ID
>SL PRS Resource ID	Indicates SL PRS resources in a slot of dedicated SL PRS resource pool along with the the (pre-) configuration of tuple set comprising of Combsize pattern, Starting symbol and comboffset
> Combsize pattern (M,N)	Indicates M symbols with combsize-N for a SL-PRS configuration
>Starting symbol	Indicates the starting symbol of a SL-PRS configuration
>Comb offset	Indicates the comb offset of a SL-PRS configuration
>SL PRS sequence ID	Indicates the SL-PRS sequence ID of a SL-PRS configuration
>SL PRS Time resource	Indicates the bitmap of a SL PRS dedicated resource pool
>StartRB Subchannel	Indicates the lowest RB index of the SL PRS dedicated resource pool with respect to the lowest RB index of the SL BWP
>SL-PRS Periodicity	Indicates the periodicity at which the SL-PRS may be transmitted
>SL-PRS Repetition/Reservation number	Indicates the number of SL-PRS repetitions or resource reservations within one period of a SL-PRS transmission, e.g., 2 or 3 SL-PRS signals may be consecutively repeated or reserved in the case of Mode 2 transmissions.

[0136] In addition, the relative time difference (RTD) information used to mitigate potential synchronization errors may be performed with respect to the selected active reference anchor UE. The relative time difference between a UE i and a reference anchor UE j may be defined as $t_j - t_i$, where t_i and t_j are defined as the time when UE i and reference anchor UE j transmit the start of one sidelink subframe/slot respectively.

[0137] The relative times between anchor UE i and reference anchor UE j may be expressed in terms of an SL-PRS offset which can be signaled to the target UE using one or more of the following parameters:

[0138] 1) System frame number (SFN)#0 slot#0 for in-coverage scenarios, with gNB coverage

[0139] SFN Offset: A parameter *sfn-Offset* may specify the SFN offset at the UE antenna location between the SL positioning assistance data of the reference anchor UE j and anchor UE i. This offset corresponds to the number of full radio frames counted from the beginning of a radio frame #0 of the assistance data reference anchor UE j to the beginning of the closest subsequent radio frame #0 of this anchor UE i.

[0140] Integer Subframe Offset: A parameter *integerSubframeOffset* may specify the frame boundary offset at the UE antenna location between the assistance data reference anchor UE j and another anchor UE i counted in full subframes. This offset corresponds to the number of full subframes counted from the beginning of a subframe #0 of the assistance data reference anchor UE j to the beginning of the closest subsequent subframe #0 of this another anchor UE i.

[0141] 2) Direct Frame Number (DFN)#0 slot#0 for out-of-coverage scenarios, where the DFN, subframe number and slot number within a frame are derived using the current UTC time.

[0142] DFN Offset: A parameter *dfn-Offset* may specify the DFN offset at the UE antenna location between the SL positioning assistance data of the reference anchor UE j and anchor UE i. This offset corresponds to the number of full radio frames counted from the beginning of a radio frame #0 of the assistance data reference anchor UE j to the beginning of the closest subsequent radio frame #0 of this anchor UE i.

[0143] Integer Subframe Offset: A parameter *integerSubframeOffset* may specify the frame boundary offset at the UE antenna location between the assistance data reference anchor UE j and another anchor UE i counted in full subframes. This offset corresponds to the number of full subframes counted from the beginning of a subframe #0 of the assistance data reference anchor UE j to the beginning of the closest subsequent subframe #0 of this another anchor UE i.

[0144] The above RTD as well as relative time offset information between a reference anchor UE and another anchor UE may be signaled as part of the SL positioning assistance, e.g., SLPP *ProvideAssistanceData* from a server UE to the target UE, which is transmitted at 904, 914 and 924 in FIG. 9.

[0145] ID Management of Reference Anchor UE device

[0146] In various embodiments, a number of ID options may be used in order for the LMF or server UE to distinguish a particular reference anchor device in a particular SLPP session for a network-based positioning scenario, where one or more combinations of IDs may be used. In addition, a number of ID options to distinguish a reference anchor UE in a UE-only operation are also provided. The list of ID options are shown below in Table 6.

[Table 6]

Parameter	Description
Network-based Positioning Scenario	
5G TMSI	An ID comprising of a Temporary Mobile Station Identifier
Source ID	Source Layer-2 IDs are always self-assigned by the UE originating the corresponding layer-2 frames
Destination ID	A UE is configured with the destination Layer-2 ID(s) to be used for Ranging/SL positioning services based on the following: • The mapping of SL-PRS/Ranging/SL positioning service type to Destination Layer-2 ID(s) for broadcast. • The mapping of SL-PRS/Ranging/SL positioning service type to Destination Layer-2 ID(s) for groupcast mode communication. • The mapping of SL-PRS/Ranging/SL positioning service type to default Destination

	Layer-2 ID(s) for initial signalling to establish unicast connection.
SLPP Session ID	Identifies a particular SLPP session
Anchor UE ID	Defines an identifier for an Anchor UE
Temporary Reference Anchor UE ID	Defines a temporary identifier for a reference Anchor UE
Application layer ID	An identifier identifying a 5G ProSe-enabled/V2X-enabled UE/Ranging/SL positioning-enabled UE within the context of a specific application
UE-only Positioning Scenario	
Source ID	Source Layer-2 IDs are self-assigned by the UE originating the corresponding layer-2 frames
Destination ID	A UE is configured with the destination Layer-2 ID(s) to be used for Ranging/SL positioning services based on the following: • The mapping of SL-PRS/Ranging/SL positioning service type to Destination Layer-2 ID(s) for broadcast. • The mapping of SL-PRS/Ranging/SL positioning service type to Destination Layer-2 ID(s) for groupcast mode communication. The mapping of SL-PRS/Ranging/SL positioning service type to default Destination Layer-2 ID(s) for initial signalling to establish unicast connection.
SLPP Session ID	Identifies a particular SLPP session
Anchor UE ID	Defines an identifier for an Anchor UE
Temporary Reference Anchor UE ID	Defines a temporary identifier for a reference Anchor UE
Application layer ID	An identifier identifying a 5G ProSe-enabled/V2X-enabled UE/Ranging/SL positioning-enabled UE within the context of a specific application

[0147] In addition, a flag may also be associated with an anchor UE and/or reference anchor UE in order to indicate whether the UE is active. For example, a value ‘0’ may indicate that an anchor UE and/or reference anchor UE is not active, while a value ‘1’ may indicate that an anchor UE and/or reference anchor UE is active.

[0148] In an embodiment, a LMF or AMF may create a mapping of UE IDs such as 5G TMSI IDs with source ID and destination ID or with an Application Layer ID in order to distinguish the different transmission and reception UEs. Since the LMF is unaware of the association of source and destination IDs, this mapping may be provided explicitly via

SLPP signaling or derived implicitly based on temporary identifiers by the LMF and indicated source ID and destination IDs.

[0149] In an embodiment, the active reference anchor UE ID information may be transmitted in the SL positioning measurement report that comprises performed SL-RSTD measurements for a given active reference anchor UE. In a given SLPP session, a UE may report multiple sets of SL-RSTD measurements associated with different reference anchor UEs, e.g., SL-RSTD measurement set 1 associated to reference anchor UE 1, SL-RSTD measurement set 2 associated to reference anchor UE 2 and so forth. The one or more above reference anchor UE information may be used to associate a SL-RSTD measurement set in a SL positioning measurement report. Exemplary signaling of these reference anchor UE IDs may be included in SLPP signaling, e.g., SLPP *ProvideLocationInformation* or SL-TDOA-*SignalMeasurementInformation* message. Referring to FIG. 9, this information may be transmitted at 918 and 928.

[0150] In an embodiment, the above UE ID information may be associated with anchor UEs as part of any of the reported SL-PRS-based positioning measurements including SL-RTOA, UE Rx-Tx time difference and SL-AOA. Exemplary signaling of these reference anchor UE IDs may be included in SLPP signaling, e.g., SLPP *ProvideLocationInformation* message provided at 918 and 928.

[0151] For the above aspects of SL positioning measurement reporting, a SL positioning measurement report comprising one or both of a reference anchor UE and anchor UE ID may be transmitted to LMF for network-based positioning. For UE-only positioning, a SL positioning measurement report containing reference anchor UE and/or anchor UE ID information may be transmitted to another UE, e.g., a server UE, anchor UE or target UE.

[0152] FIG. 11 illustrates a flowchart of a method 1100 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. The operations of the method 1100 may be implemented by a device or its components as described herein. For example, the operations of the method 1100 may be performed by a UE 104 as described with reference to FIGs. 1, 2, 9, 10A and 10B. In some

implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0153] At 1105, the method may include receiving a list of initial anchor UEs. The operations of 1105 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1105 may be performed by a device as described with reference to FIG. 1. The list of initial anchor UEs may be received from an LMF or server UE as explained above with respect to operation 904 of FIG. 9.

[0154] At 1110, the method may include selecting a set of active anchor UEs from the list of initial anchor UEs using one or more selection criteria. The operations of 1110 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1110 may be performed by a device as described with reference to FIG. 1. Selecting a set of active anchor UEs from the list of initial anchor UEs may be performed as explained above with respect to operation 906 of FIG. 9.

[0155] At 1115, the method may include selecting a reference anchor UE from the set of active anchor UEs. The operations of 1115 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1115 may be performed by a device as described with reference to FIG. 1. Selecting a reference anchor UE from the set of active anchor UEs using one or more selection criteria may be performed as explained above with respect to operation 910 of FIG. 9.

[0156] At 1120, the method may include performing one or more sidelink positioning measurement with respect to the reference anchor UE. The operations of 1120 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1120 may be performed by a device as described with reference to FIG. 1. The one or more sidelink positioning measurement with respect to the reference anchor UE may be performed as explained above with respect to operation 916 of FIG. 9.

[0157] At 1125, the method may include transmitting one or more sidelink positioning measurement and information for the reference anchor UE to a position calculation entity. The operations of 1125 may be performed in accordance with examples as described

herein. In some implementations, aspects of the operations of 1125 may be performed by a device as described with reference to FIG. 1. Transmitting one or more sidelink positioning measurement and information for the reference anchor UE to a position calculation entity may be performed as explained above with respect to operations 918 and 928 of FIG. 9.

[0158] FIG. 12 illustrates a flowchart of a method 1200 that supports sidelink positioning using a reference anchor UE in accordance with aspects of the present disclosure. The operations of the method 1200 may be implemented by a device or its components as described herein. For example, the operations of the method 1200 may be performed by an LMF or server UE as described with reference to FIGs. 1, 2, 9, 10A and 10B. In some implementations, the device may execute a set of instructions to control the function elements of the device to perform the described functions. Additionally, or alternatively, the device may perform aspects of the described functions using special-purpose hardware.

[0159] At 1205, the method may include transmitting a list of initial anchor UEs to a target UE. The operations of 1205 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1205 may be performed by a device as described with reference to FIG. 1. The list of initial anchor UEs may be transmitted to the target UE as explained above with respect to operation 904 of FIG. 9.

[0160] At 1210, the method may include receiving a set of active anchor UEs from the list of initial anchor UEs from the target UE. The operations of 1210 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1210 may be performed by a device as described with reference to FIG. 1. Receiving a set of active anchor UEs from the list of initial anchor UEs may be performed as explained above with respect to operation 906 of FIG. 9.

[0161] At 1215, the method may include selecting a reference anchor UE from the set of active anchor UEs. The operations of 1115 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1215 may be performed by a device as described with reference to FIG. 1. Selecting a reference

anchor UE from the set of active anchor UEs using one or more selection criteria may be performed as explained above with respect to operation 910 of FIG. 9.

[0162] At 1220, the method may include receiving sidelink positioning measurements from the target UE. The operations of 1220 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1220 may be performed by a device as described with reference to FIG. 1. Receiving sidelink positioning measurements from the target UE may be performed as explained above with respect to operation 918 of FIG. 9.

[0163] At 1225, the method may include calculating a position of the target UE using the sidelink positioning measurements. The operations of 1225 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 1225 may be performed by a device as described with reference to FIG. 1. calculating a position of the target UE using the sidelink positioning measurements may be performed as explained above with respect to operation 930 of FIG. 9.

[0164] It should be noted that the methods described herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

[0165] The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0166] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations.

[0167] Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer. By way of example, and not limitation, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor.

[0168] Any connection may be properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of computer-readable medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

[0169] As used herein, including in the claims, "or" as used in a list of items (e.g., a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as "based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

[0170] The terms "transmitting," "receiving," or "communicating," when referring to a network entity, may refer to any portion of a network entity (e.g., a base station, a CU, a DU, a RU) of a RAN communicating with another device (e.g., directly or via one or more other network entities).

[0171] The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term "example" used herein means "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, known structures and devices are shown in block diagram form to avoid obscuring the concepts of the described example.

[0172] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.