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(54) SUBSAMPLE CONFIGURATION FOR POSITIONING

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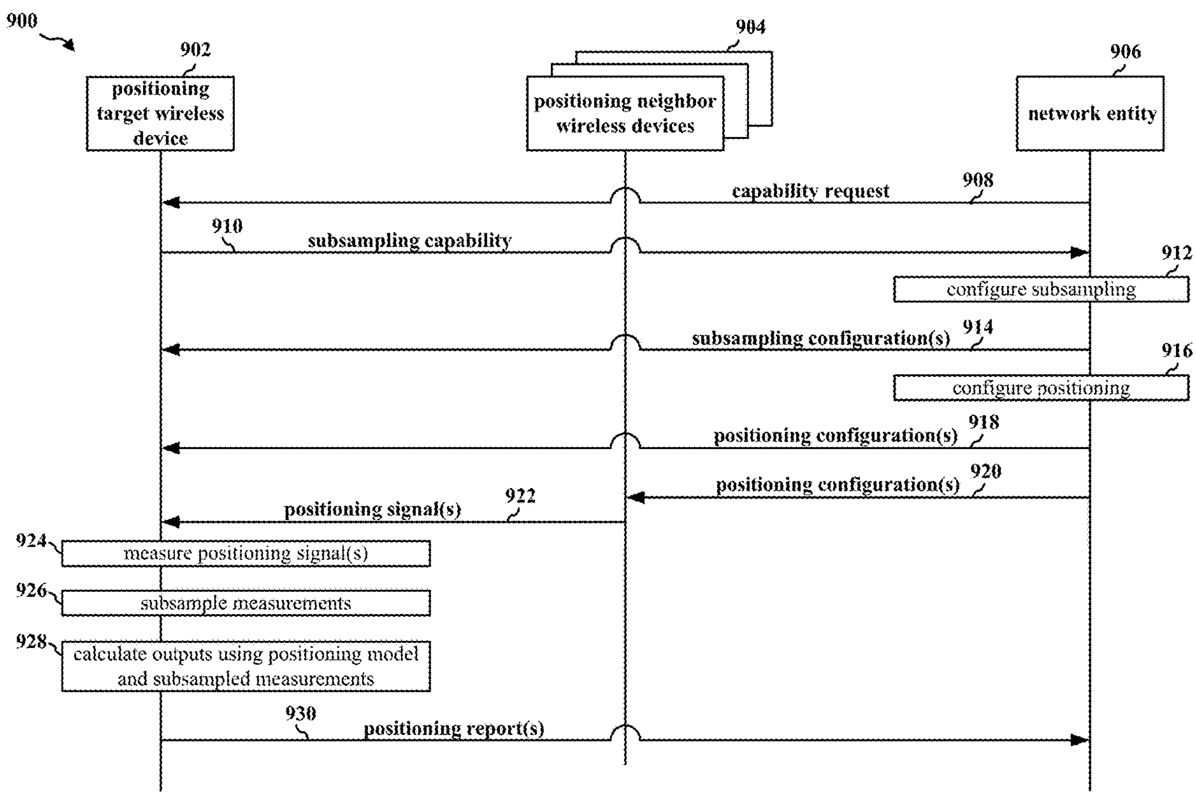
(57) **ABSTRACT**

A network entity, such as a location management function (LMF), may transmit an indicator of a plurality of subsampling configurations. A wireless device, such as a user equipment (UE), a base station, or a transmission reception point (TRP), may receive the indicator of the plurality of subsampling configurations. The wireless device may select a subsampling configuration from a plurality of subsampling configurations. The wireless device may receive a set of positioning signals. The wireless device may measure the received set of positioning signals. The wireless device may calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The wireless device may output the calculated subset of measurements to a positioning model.



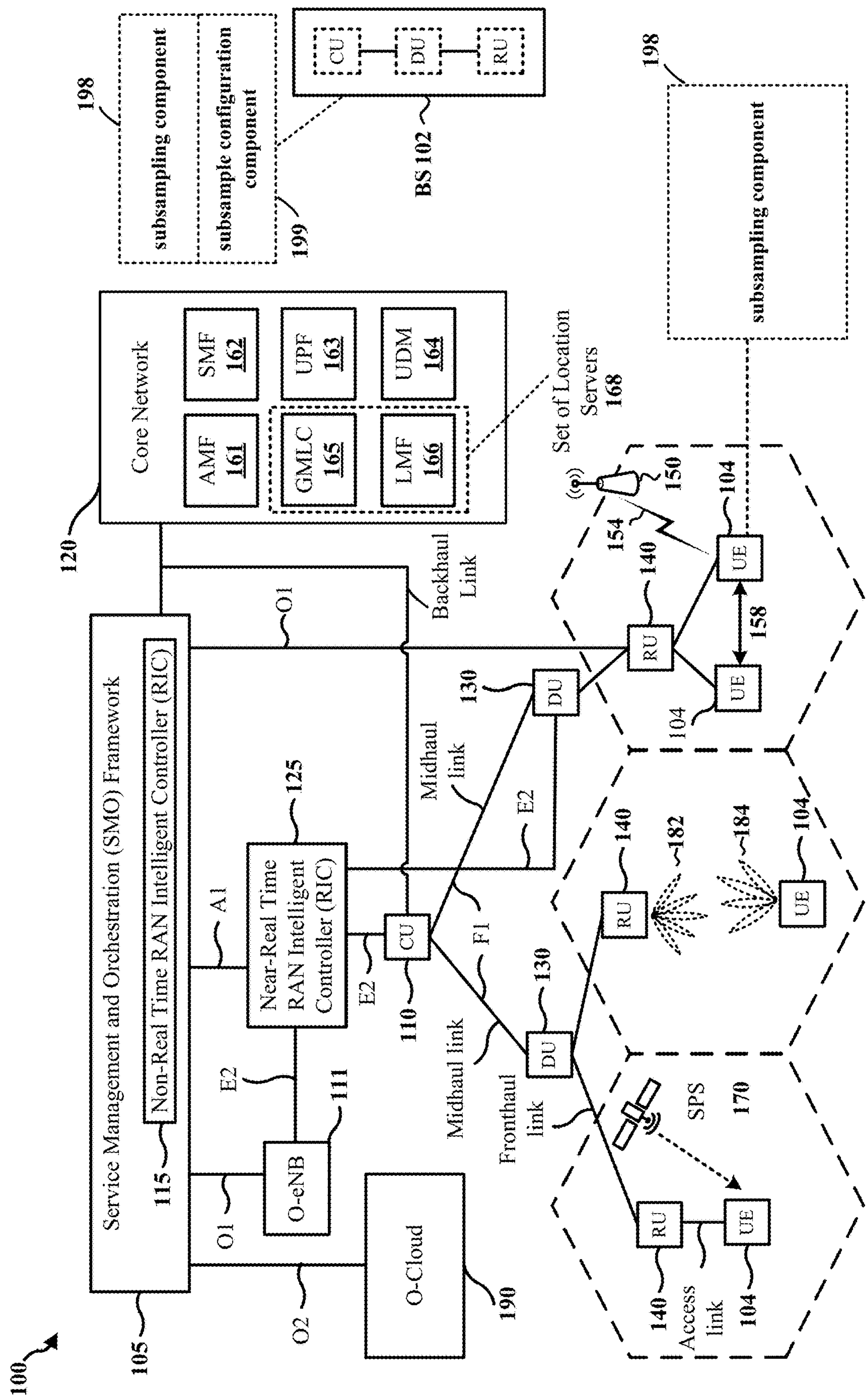

100
Service Management and Orchestration (SMO) Framework
105
Non-Real Time RAN Intelligent Controller (RIC)
115
O1
O2
O-eNB
111
E2
A1
Near-Real Time RAN Intelligent Controller (RIC)
125
O-Cloud
190
CU
110
E2
F1
Midhaul link
Fronthaul link
DU
130
RU
140
UE
104
Access link
SPS
170
182
184
E2
Midhaul link
O1
Backhaul Link
158
150
154
Set of Location Servers
168
Core Network
120
AMF
161
SMF
162
GMLC
165
UPF
163
LMF
166
UDM
164
subsampling component
198
subsample configuration component
199
CU
DU
RU
BS 102

FIG. 1

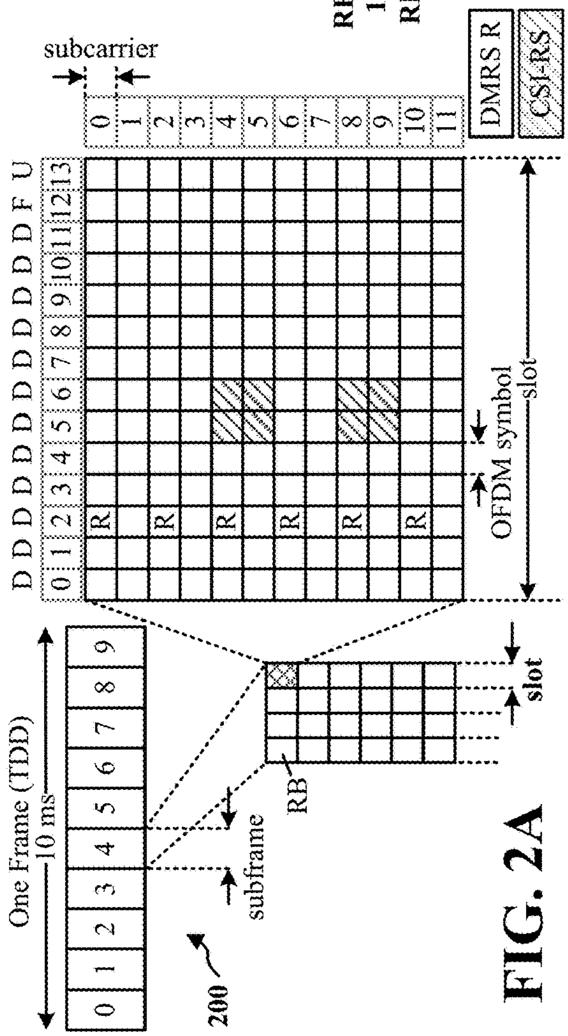


FIG. 2A

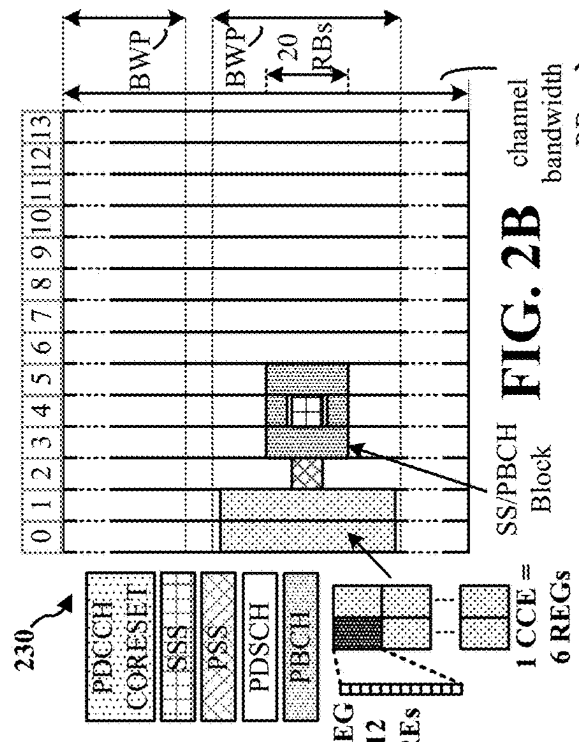


FIG. 2B

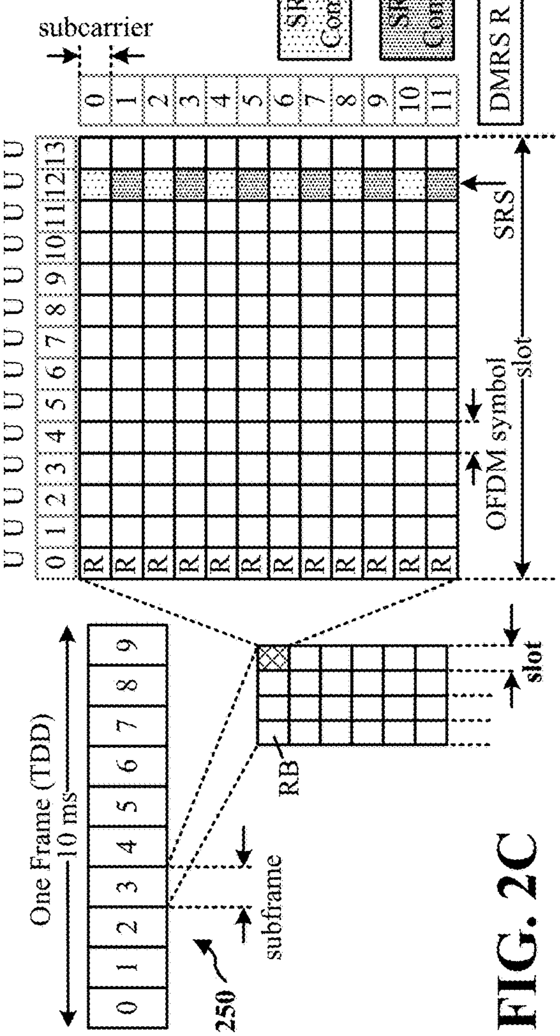


FIG. 2C

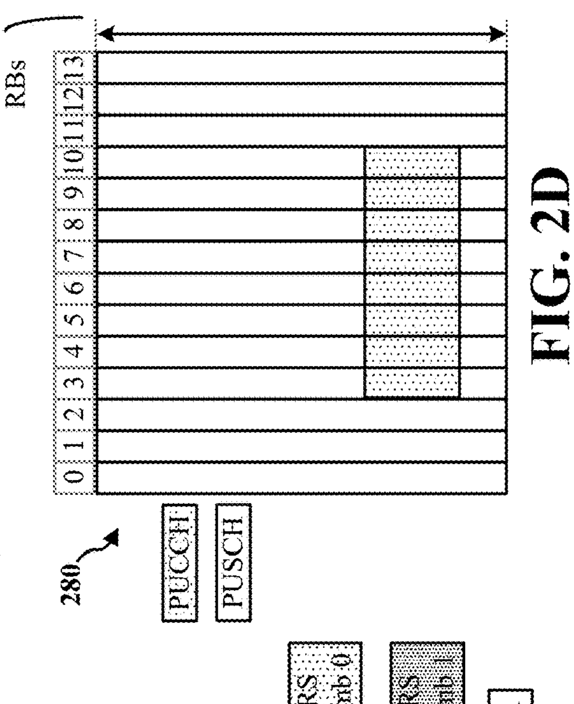


FIG. 2D

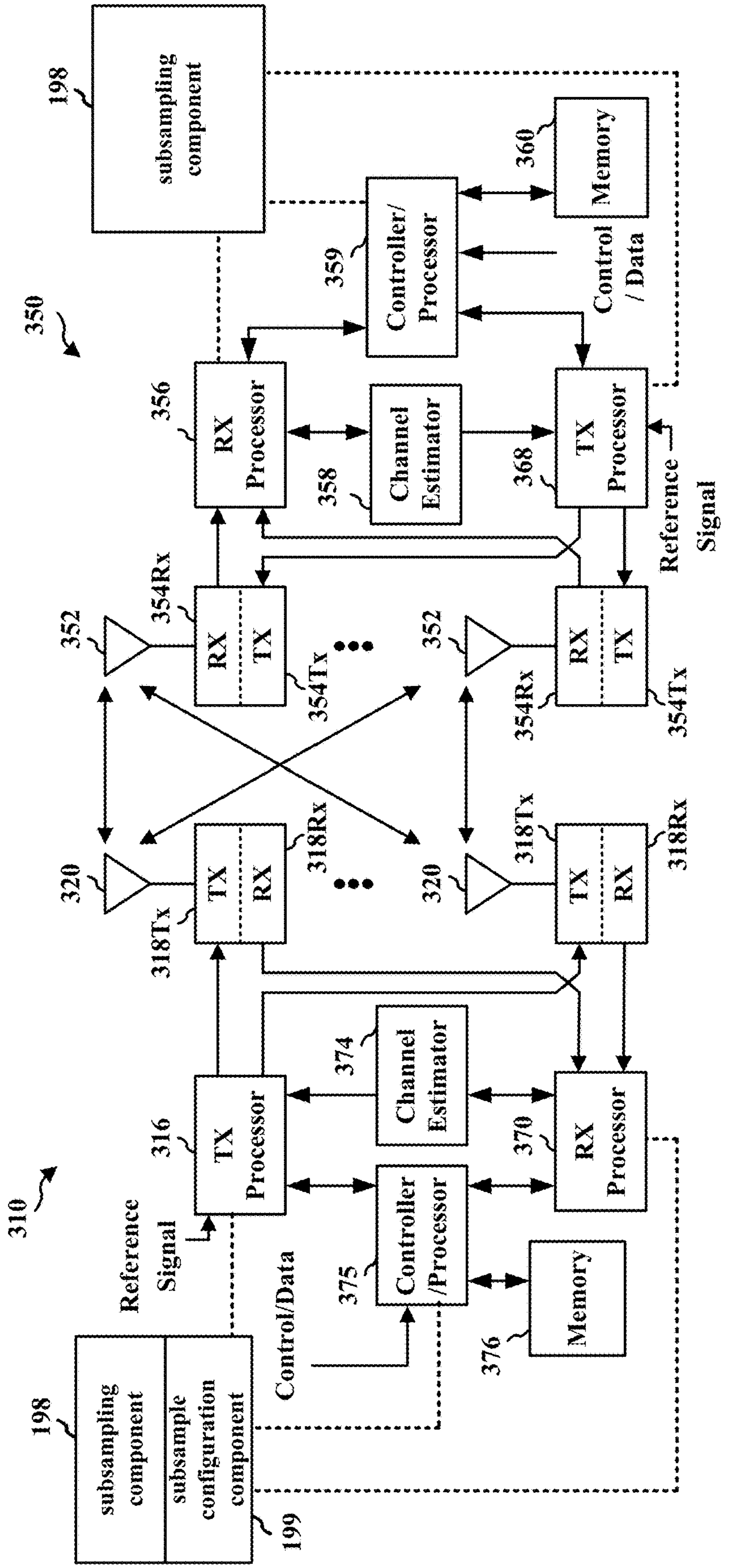

350
198
subsampling component
359
Controller/ Processor
360
Memory
Control / Data
356
RX Processor
358
Channel Estimator
368
TX Processor
Reference Signal
354Rx
352
RX
TX
354Tx
320
318Tx
TX
RX
318Rx
310
316
TX Processor
374
Channel Estimator
370
RX Processor
375
Controller /Processor
376
Memory
Reference Signal
Control/Data
198
subsampling component
subsample configuration component
199

FIG. 3

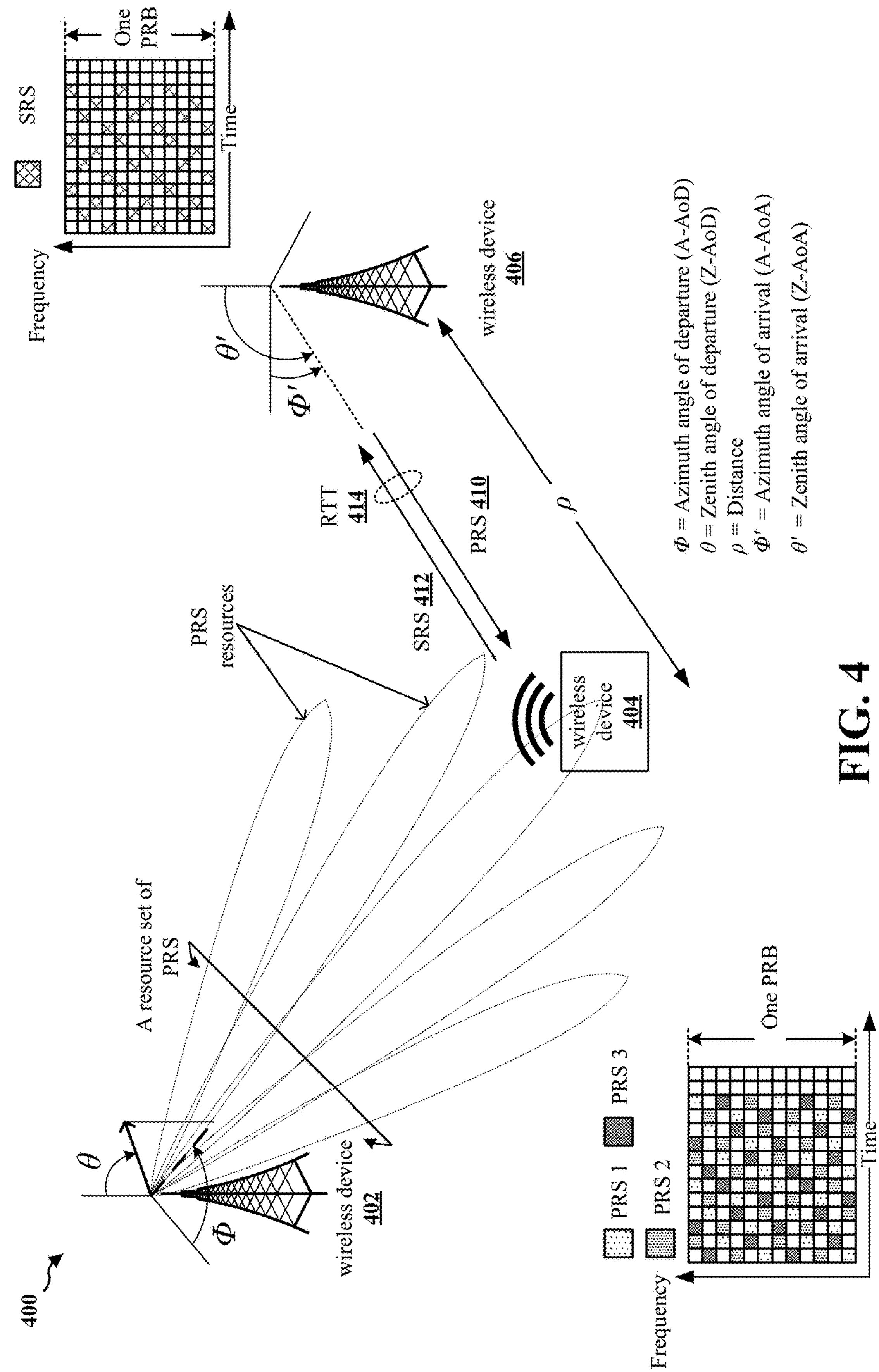

400
SRS
One PRB
Time
Frequency
wireless device 406
θ'
Φ'
RTT 414
PRS 410
SRS 412
ρ
PRS resources
A resource set of PRS
θ
Φ
wireless device 402
wireless device 404
Φ = Azimuth angle of departure (A-AoD)
θ = Zenith angle of departure (Z-AoD)
ρ = Distance
Φ' = Azimuth angle of arrival (A-AoA)
θ' = Zenith angle of arrival (Z-AoA)
PRS 1
PRS 2
PRS 3
One PRB
Time
Frequency

FIG. 4

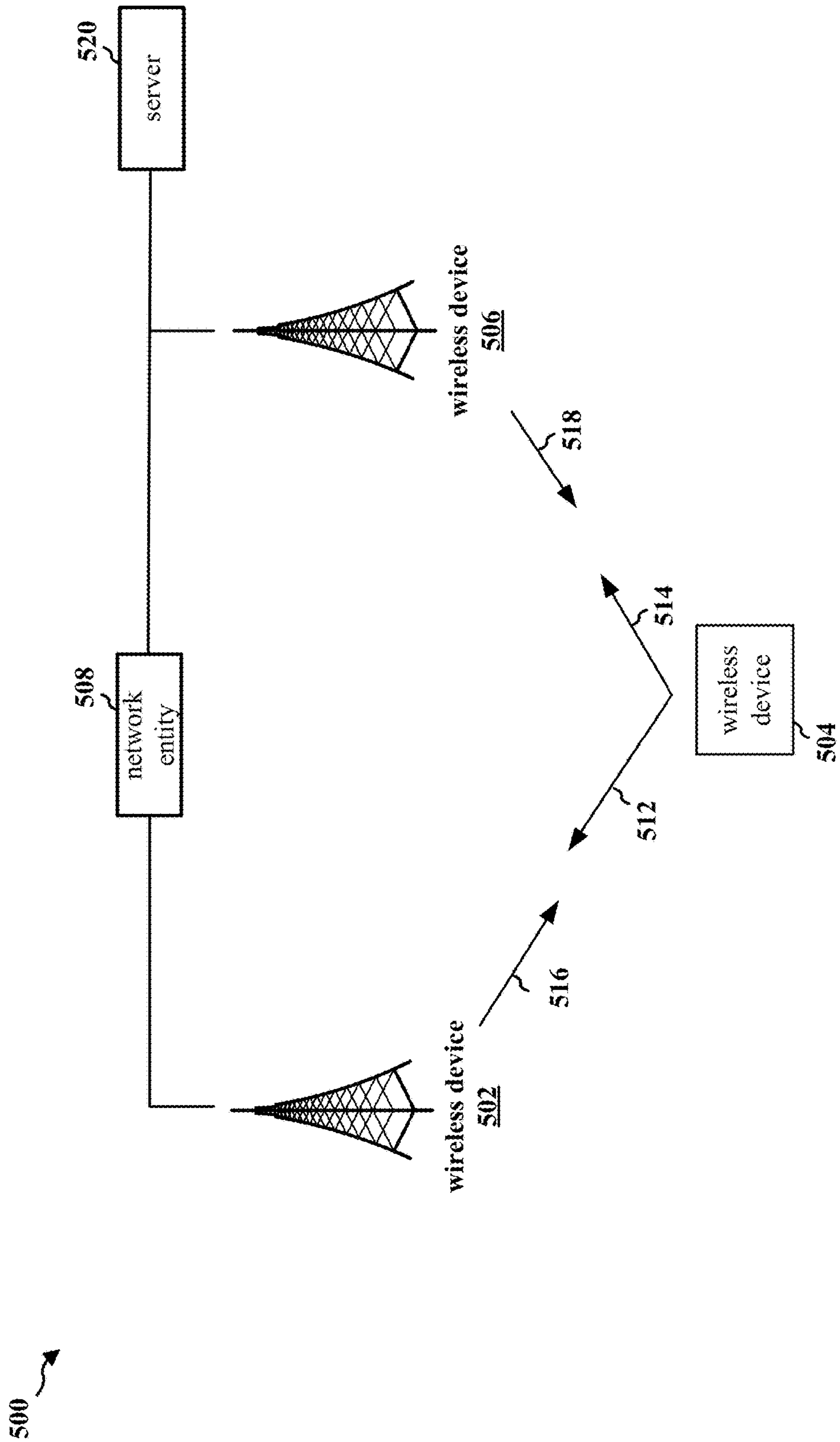

520
server
508
network entity
wireless device
506
518
514
wireless device
504
512
516
wireless device
502
500

FIG. 5

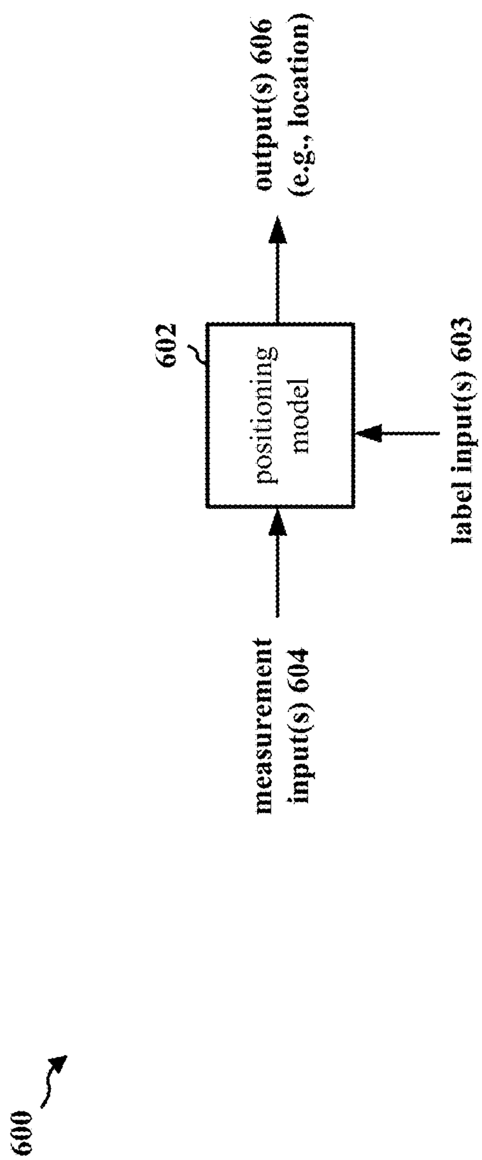

600
measurement input(s) 604
602
positioning model
label input(s) 603
output(s) 606 (e.g., location)

FIG. 6A

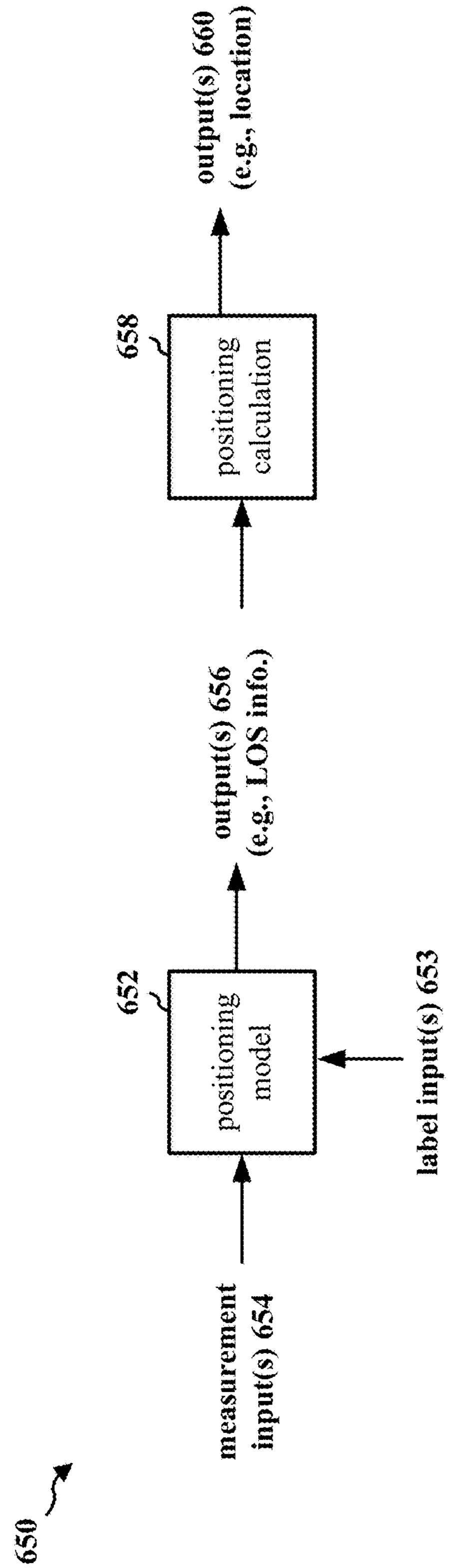

650
measurement input(s) 654
652
positioning model
label input(s) 653
output(s) 656 (e.g., LOS info.)
658
positioning calculation
output(s) 660 (e.g., location)

FIG. 6B

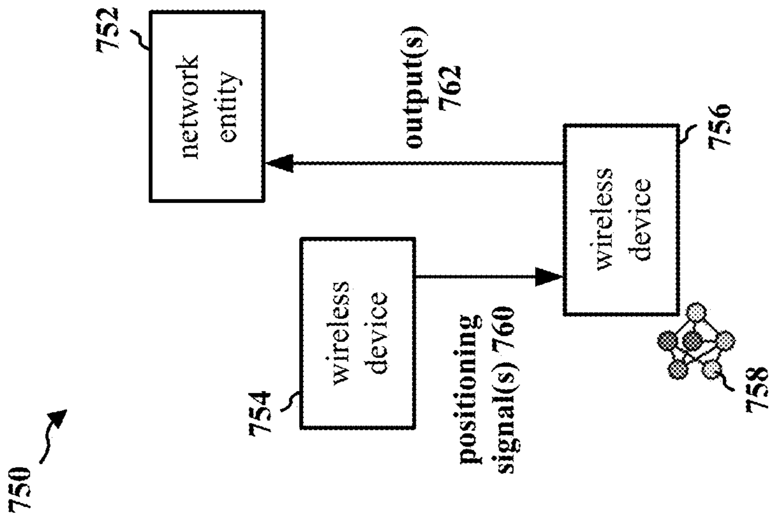

750
752
network entity
output(s) 762
754
wireless device
positioning signal(s) 760
756
wireless device
758

FIG. 7B

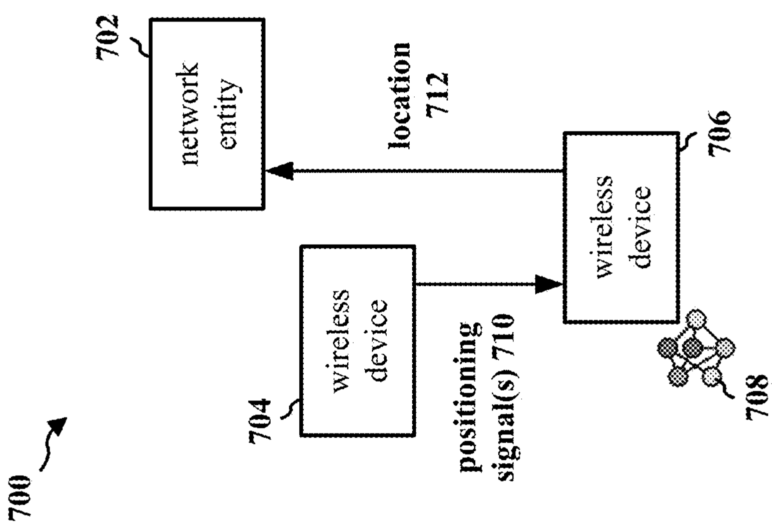

700
702
network entity
location 712
704
wireless device
positioning signal(s) 710
706
wireless device
708

FIG. 7A

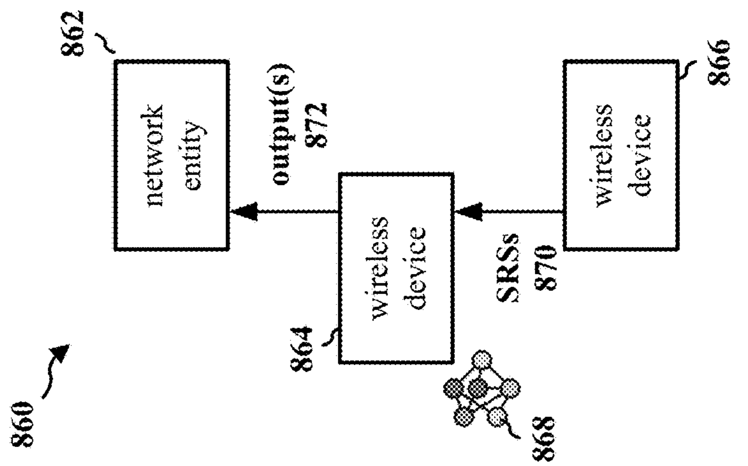


FIG. 8C

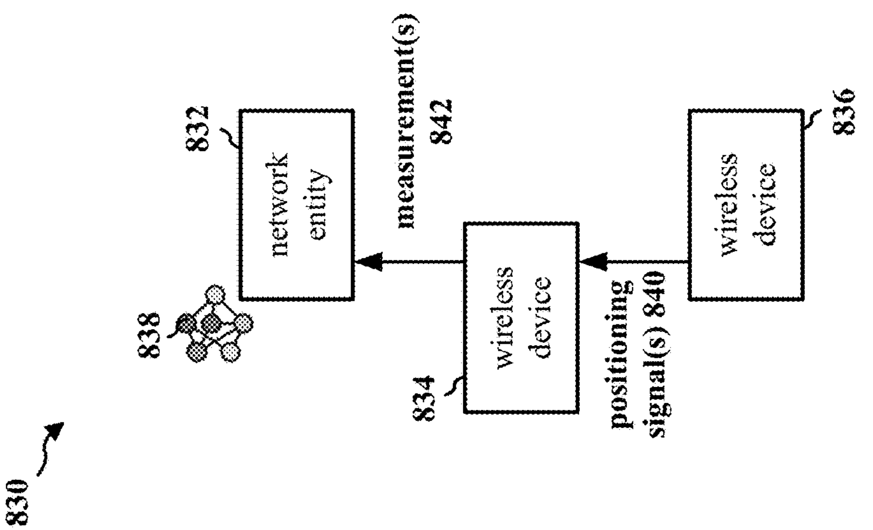


FIG. 8B

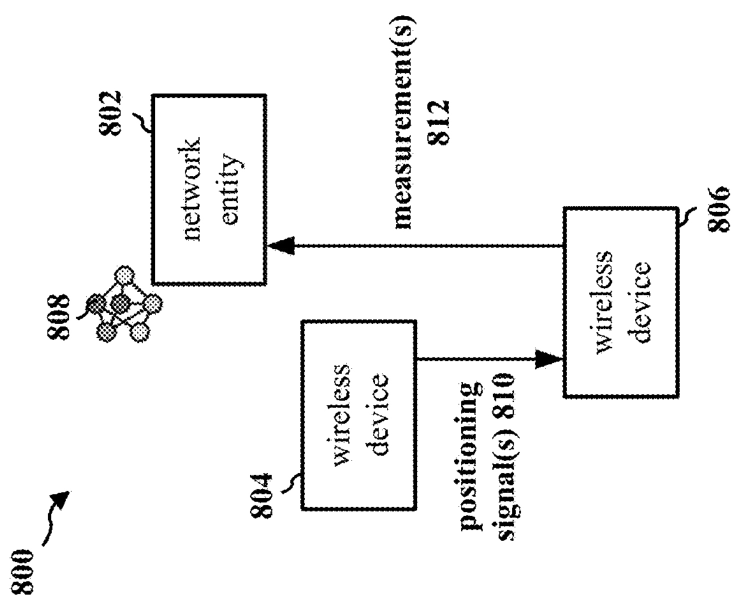


FIG. 8A

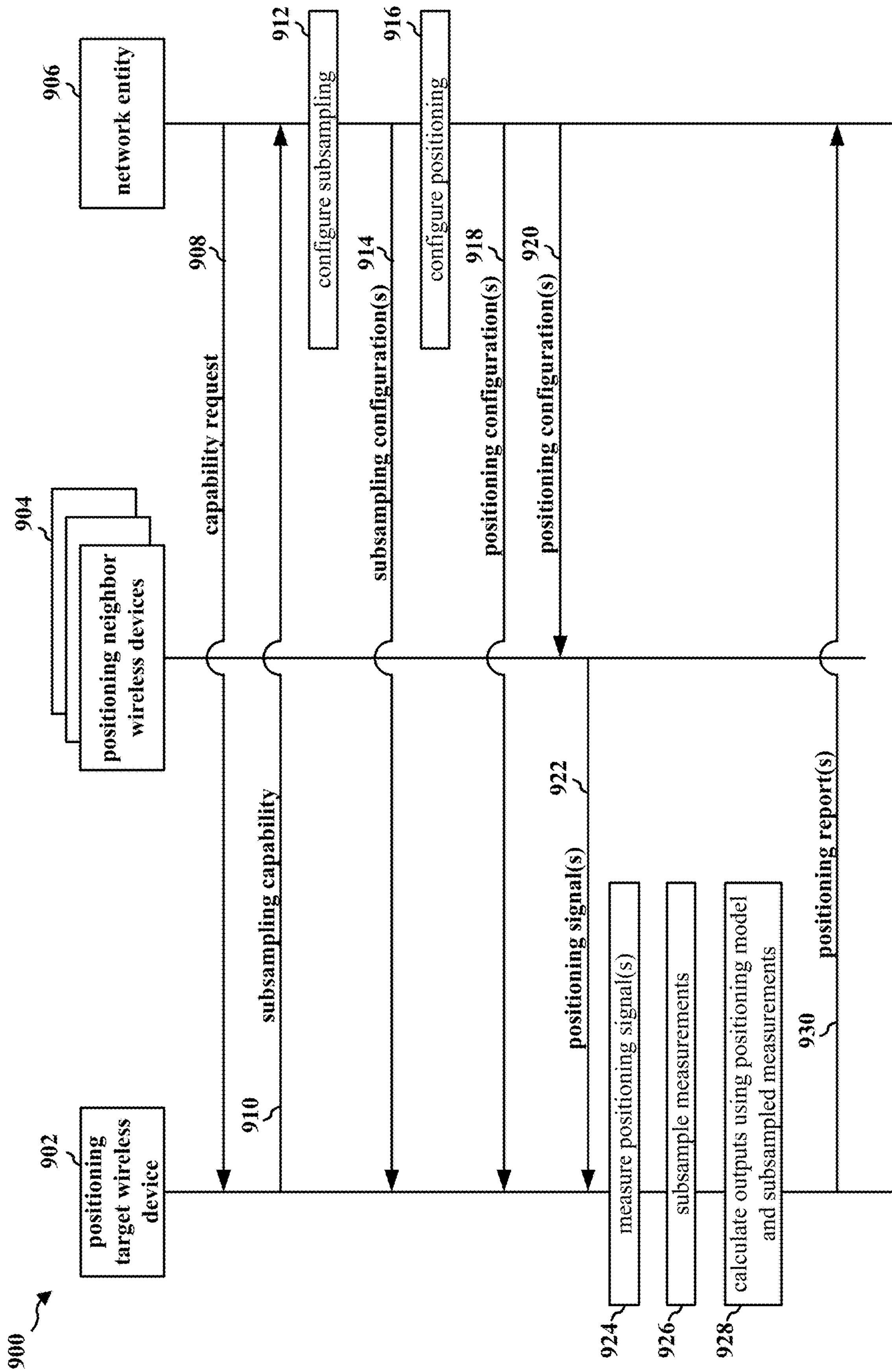

900
902
positioning target wireless device
904
positioning neighbor wireless devices
906
network entity
908
capability request
910
subsampling capability
912
configure subsampling
914
subsampling configuration(s)
916
configure positioning
918
positioning configuration(s)
920
positioning configuration(s)
922
positioning signal(s)
924
measure positioning signal(s)
926
subsample measurements
928
calculate outputs using positioning model and subsampled measurements
930
positioning report(s)

FIG. 9

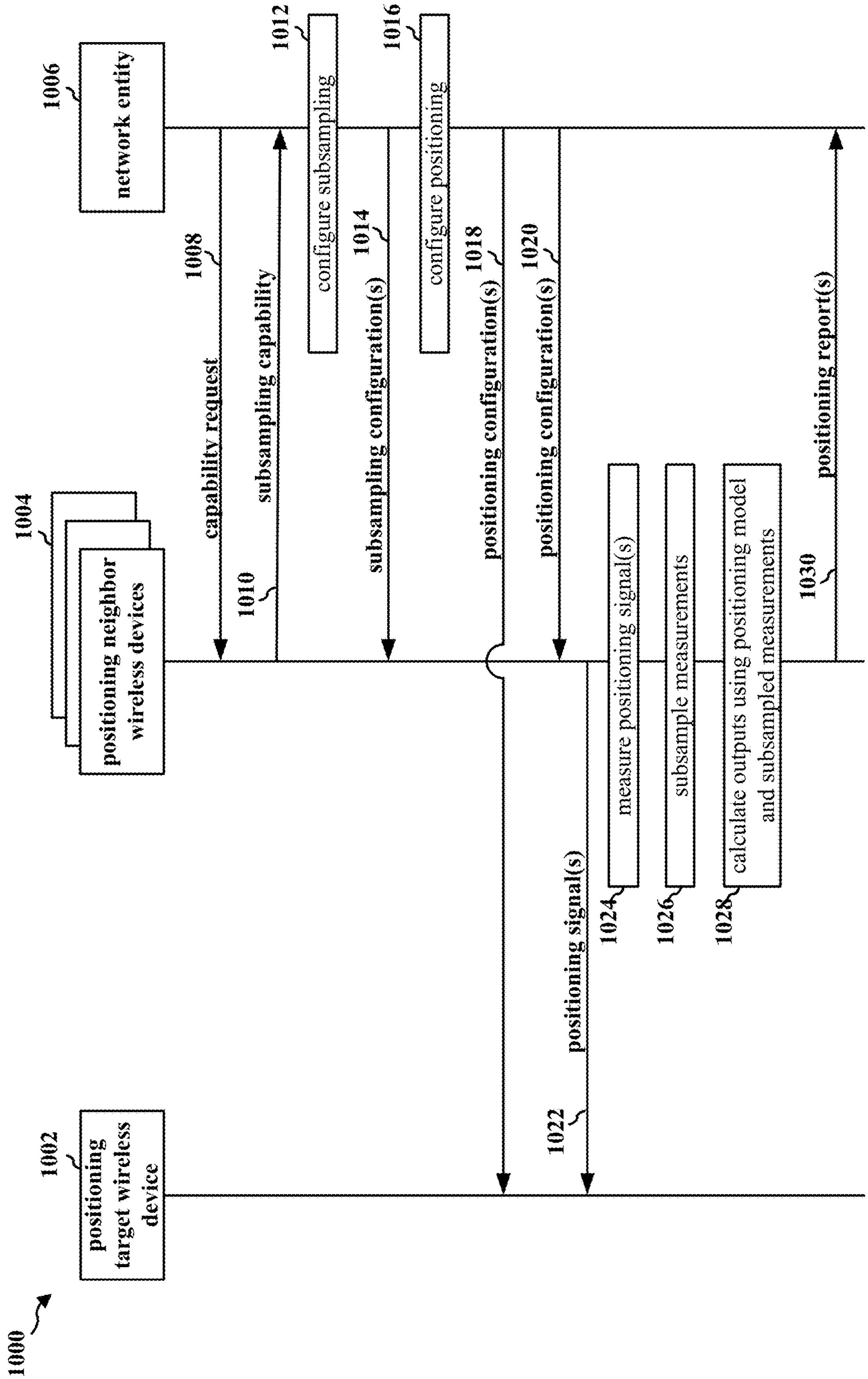

1000
1002
positioning target wireless device
1004
positioning neighbor wireless devices
1006
network entity
1008
capability request
1010
subsampling capability
1012
configure subsampling
1014
subsampling configuration(s)
1016
configure positioning
1018
positioning configuration(s)
1020
positioning configuration(s)
1022
positioning signal(s)
1024
measure positioning signal(s)
1026
subsample measurements
1028
calculate outputs using positioning model and subsampled measurements
1030
positioning report(s)

FIG. 10

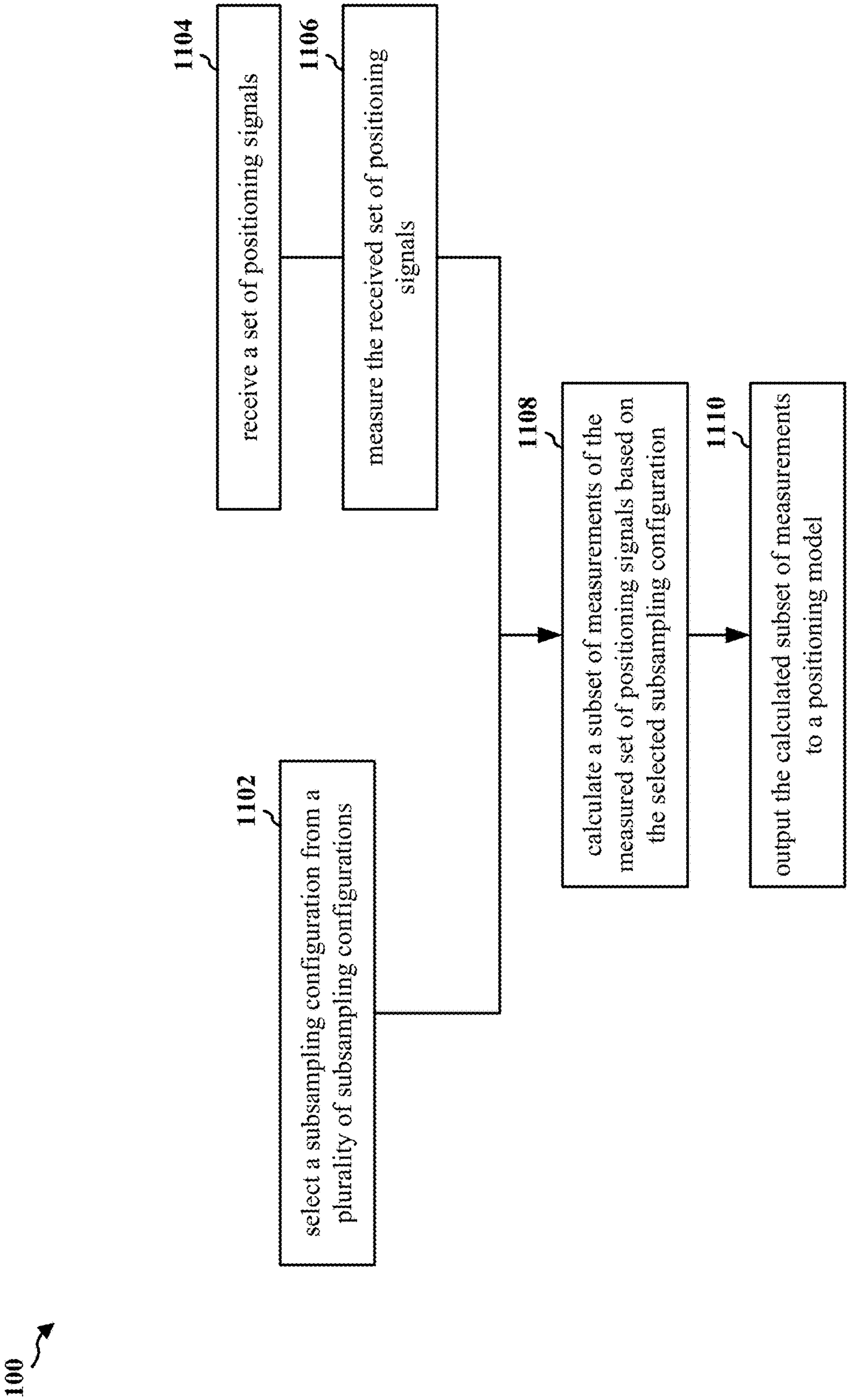

1100
1102
select a subsampling configuration from a plurality of subsampling configurations
1104
receive a set of positioning signals
1106
measure the received set of positioning signals
1108
calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration
1110
output the calculated subset of measurements to a positioning model

FIG. 11

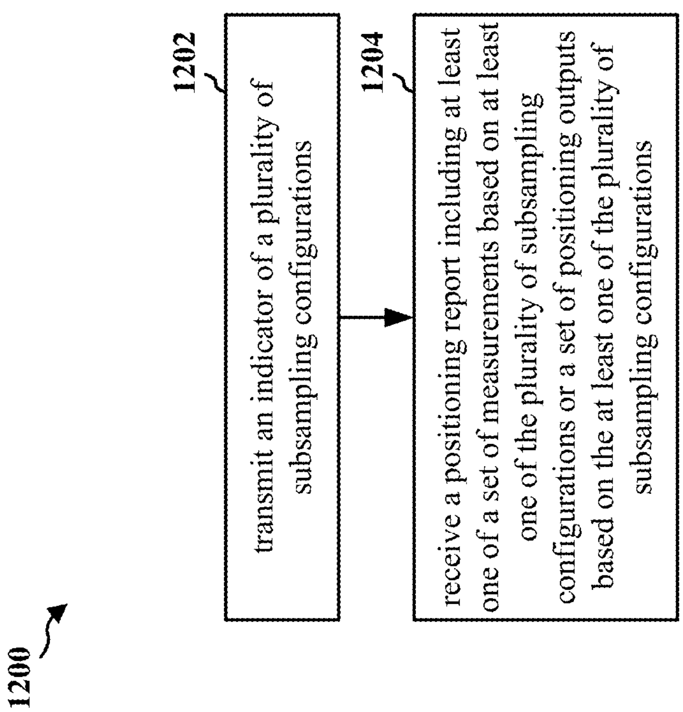

1200
1202
transmit an indicator of a plurality of subsampling configurations
1204
receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations

FIG. 12

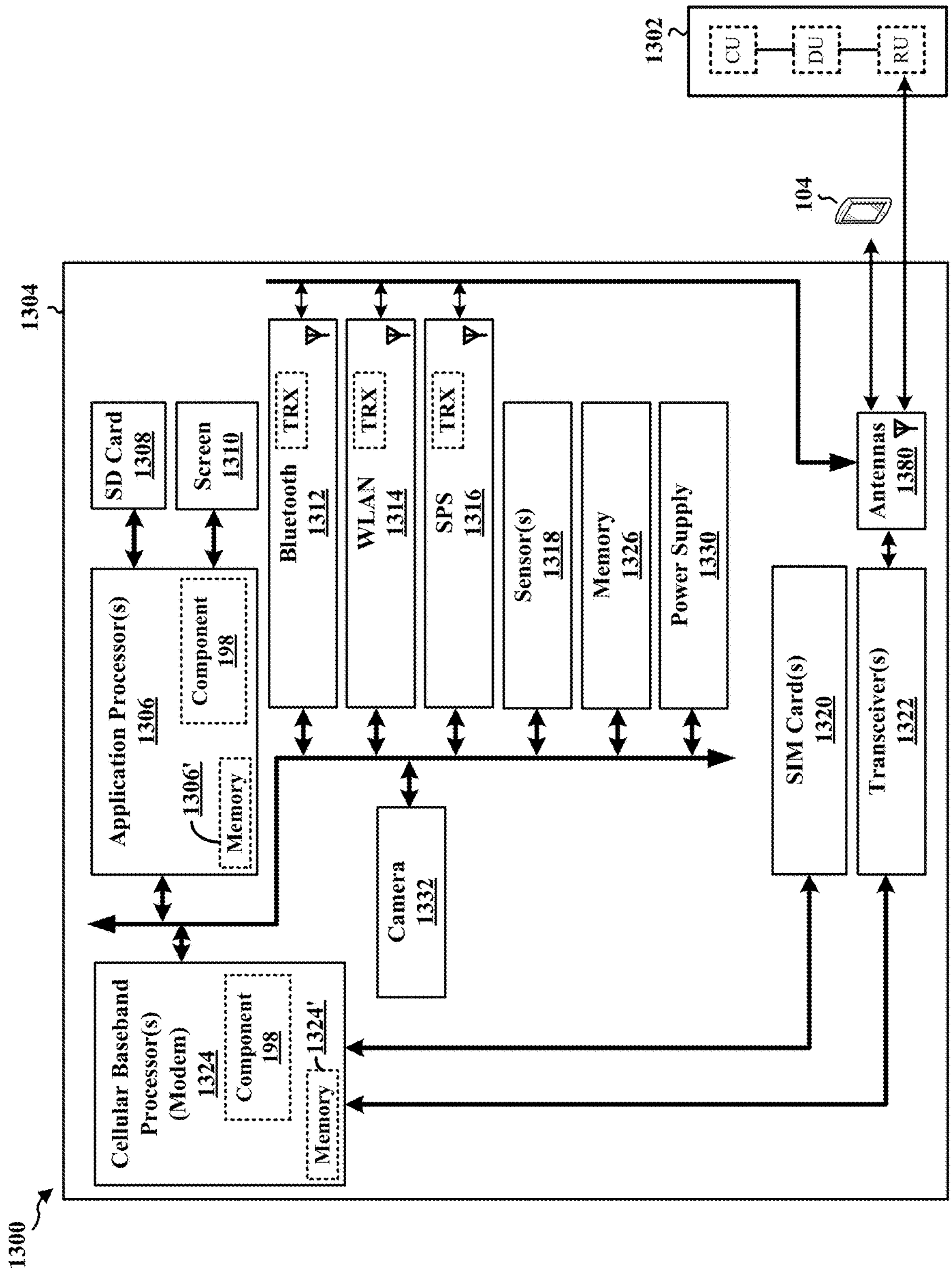

1300
1304
1302
CU
DU
RU
104
SD Card 1308
Screen 1310
Application Processor(s) 1306
Component 198
1306'
Memory
Bluetooth 1312
TRX
WLAN 1314
TRX
SPS 1316
TRX
Sensor(s) 1318
Memory 1326
Power Supply 1330
Camera 1332
Antennas 1380
SIM Card(s) 1320
Transceiver(s) 1322
Cellular Baseband Processor(s) (Modem) 1324
Component 198
1324'
Memory

FIG. 13

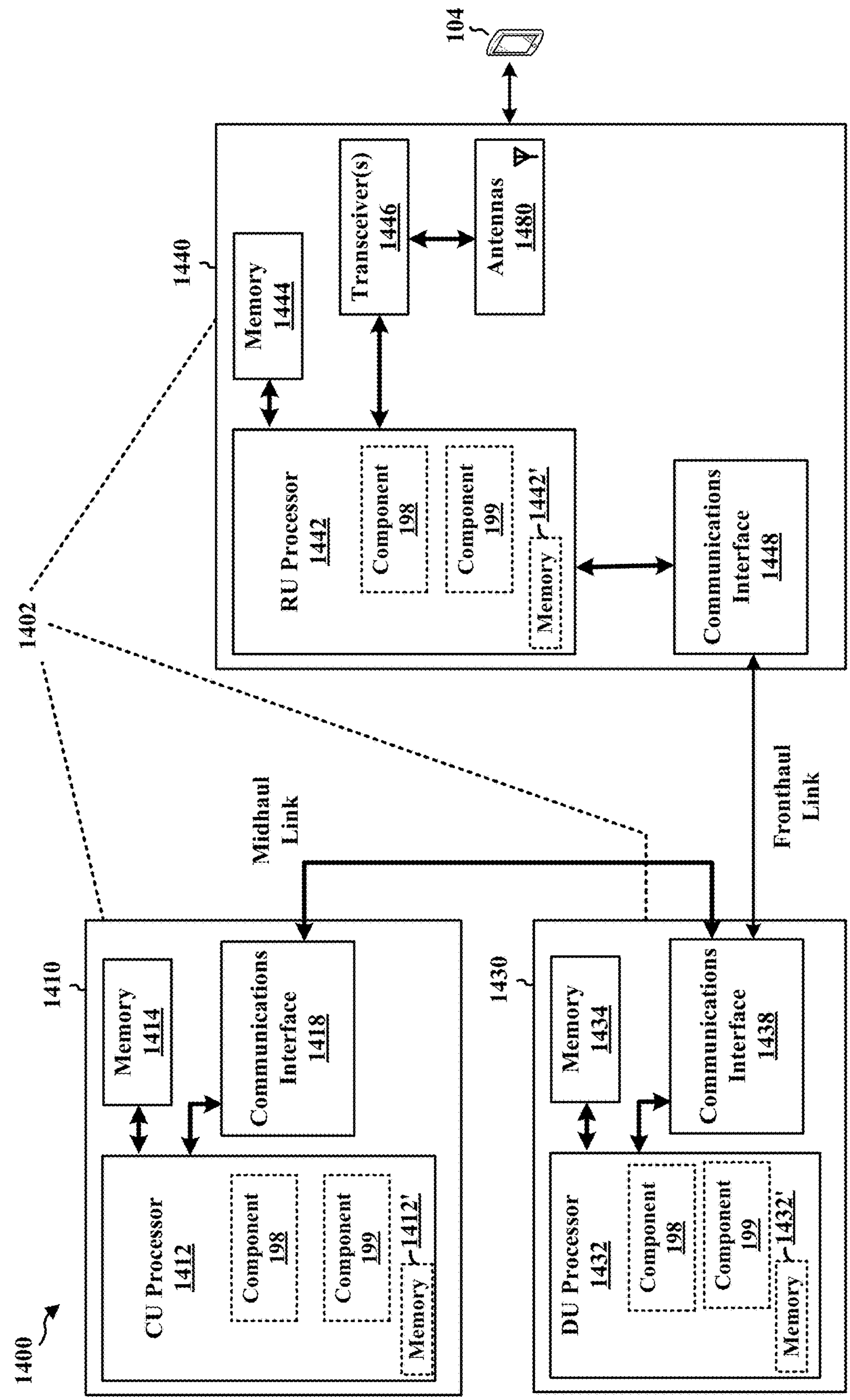

1400
1402
1410
Memory
1414
Communications
Interface
1418
CU Processor
1412
Component
198
Component
199
1412'
Memory
Midhaul
Link
1430
Memory
1434
Communications
Interface
1438
DU Processor
1432
Component
198
Component
199
1432'
Memory
Fronthaul
Link
1440
Memory
1444
Transceiver(s)
1446
Antennas
1480
RU Processor
1442
Component
198
Component
199
1442'
Memory
Communications
Interface
1448
104

FIG. 14

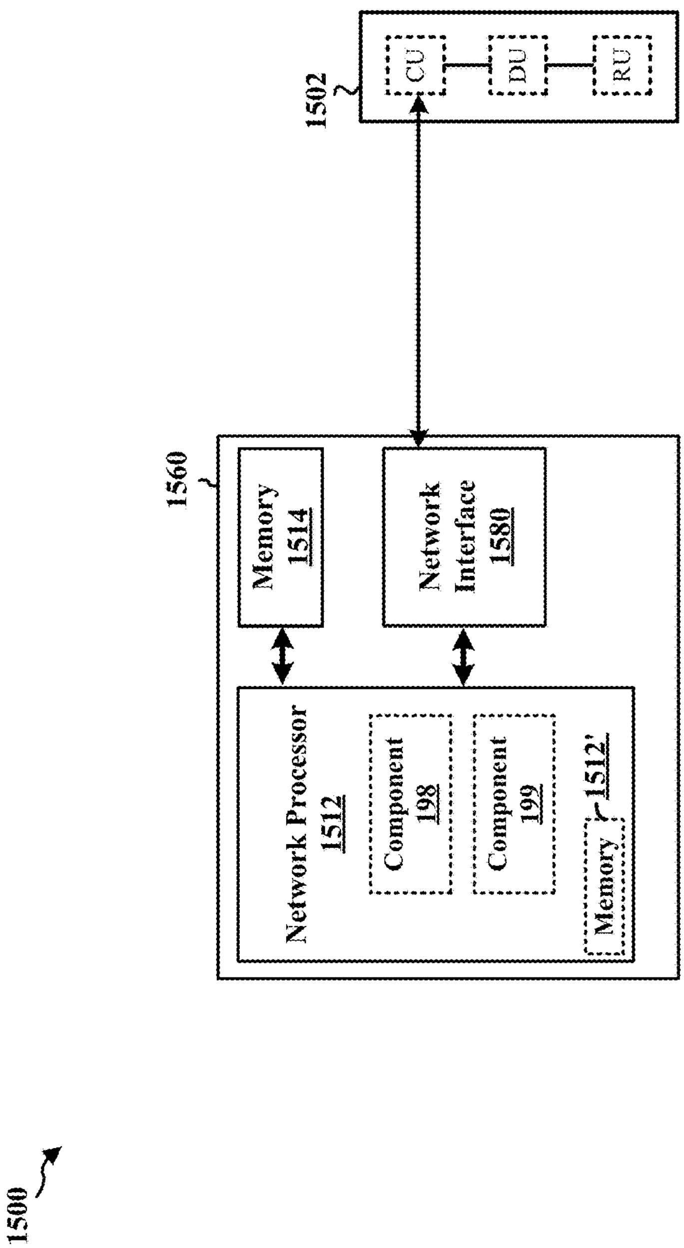

1500
1560
Memory
1514
Network Interface
1580
Network Processor
1512
Component
198
Component
199
Memory
1512'
1502
CU
DU
RU

FIG. 15

SUBSAMPLE CONFIGURATION FOR POSITIONING

TECHNICAL FIELD

[0001] The present disclosure relates generally to communication systems, and more particularly, to a wireless positioning system.

INTRODUCTION

[0002] Wireless communication systems are widely deployed to provide various telecommunication services such as telephony, video, data, messaging, and broadcasts. Typical wireless communication systems may employ multiple-access technologies capable of supporting communication with multiple users by sharing available system resources. Examples of such multiple-access technologies include code division multiple access (CDMA) systems, time division multiple access (TDMA) systems, frequency division multiple access (FDMA) systems, orthogonal frequency division multiple access (OFDMA) systems, single-carrier frequency division multiple access (SC-FDMA) systems, and time division synchronous code division multiple access (TD-SCDMA) systems.

[0003] These multiple access technologies have been adopted in various telecommunication standards to provide a common protocol that enables different wireless devices to communicate on a municipal, national, regional, and even global level. An example telecommunication standard is 5G New Radio (NR). 5G NR is part of a continuous mobile broadband evolution promulgated by Third Generation Partnership Project (3GPP) to meet new requirements associated with latency, reliability, security, scalability (e.g., with Internet of Things (IoT)), and other requirements. 5G NR includes services associated with enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable low latency communications (URLLC). Some aspects of 5G NR may be based on the 4G Long Term Evolution (LTE) standard. There exists a need for further improvements in 5G NR technology. These improvements may also be applicable to other multi-access technologies and the telecommunication standards that employ these technologies.

BRIEF SUMMARY

[0004] The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects. This summary neither identifies key or critical elements of all aspects nor delineates the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.

[0005] In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may include a wireless device, such as a user equipment (UE), a base station, or a transmission reception point (TRP). The apparatus may select a subsampling configuration from a plurality of subsampling configurations. The apparatus may receive a set of positioning signals. The apparatus may measure the received set of positioning signals. The apparatus may calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The apparatus may output the calculated subset of measurements to a positioning model. For example, the apparatus may train the positioning model based on the calculated subset of measurements, the apparatus may calculate a set of positioning outputs based on the calculated subset of measurements, or the apparatus may transmit the calculated subset of measurements for the positioning model (e.g., to a location management function (LMF), to an over-the-top (OTT) server).

[0006] In an aspect of the disclosure, a method, a computer-readable medium, and an apparatus are provided. The apparatus may include a network entity, such as an LMF. The apparatus may transmit an indicator of a plurality of subsampling configurations. The apparatus may receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

[0007] In some aspects, the techniques described herein relate to a method of wireless communication at a wireless device, including: selecting a subsampling configuration from a plurality of subsampling configurations; receiving a set of positioning signals; measuring the set of positioning signals; calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration; and outputting the calculated subset of measurements to a positioning model.

[0008] In some aspects, the techniques described herein relate to a method, where outputting the calculated subset of measurements to the positioning model includes at least one of: training the positioning model based on the calculated subset of measurements; calculating a set of positioning outputs based on the calculated subset of measurements; or transmitting the calculated subset of measurements for the positioning model.

[0009] In some aspects, the techniques described herein relate to a method, further including: transmitting the calculated set of positioning outputs after the calculation of the set of positioning outputs.

[0010] In some aspects, the techniques described herein relate to a method, further including: receiving the plurality of subsampling configurations before the selection of the subsampling configuration; and transmitting a positioning report including an indicator of the selected subsampling configuration.

[0011] In some aspects, the techniques described herein relate to a method, further including: transmitting a second indicator of a capability for the wireless device to calculate the subset of measurements before the reception of the plurality of subsampling configurations, where each of the plurality of subsampling configurations satisfy the capability.

[0012] In some aspects, the techniques described herein relate to a method, further including: receiving a request for the capability before the transmission of the second indicator of the capability.

[0013] In some aspects, the techniques described herein relate to a method, where transmitting the second indicator of the capability for the wireless device to calculate the subset of measurements includes: transmitting a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message including the second indicator of the capability for the wireless device to calculate the subset of measurements.

[0014] In some aspects, the techniques described herein relate to a method, further including: receiving a second indicator of the subsampling configuration before the selection of the subsampling configuration, where selecting the subsampling configuration from the plurality of subsampling configurations includes: selecting the subsampling configuration from the plurality of subsampling configurations based on the received second indicator of the subsampling configuration.

[0015] In some aspects, the techniques described herein relate to a method, where receiving the second indicator of the subsampling configuration includes: receiving a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) including the second indicator of the subsampling configuration.

[0016] In some aspects, the techniques described herein relate to a method, where receiving the plurality of subsampling configurations includes: receiving a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message including the plurality of subsampling configurations.

[0017] In some aspects, the techniques described herein relate to a method, further including: receiving an indicator of the subsampling configuration before the selection of the subsampling configuration, where selecting the subsampling configuration from the plurality of subsampling configurations includes: selecting the subsampling configuration from the plurality of subsampling configurations based on the received indicator.

[0018] In some aspects, the techniques described herein relate to a method, further including: selecting the subsampling configuration from the plurality of subsampling configurations based on a set of criteria.

[0019] In some aspects, the techniques described herein relate to a method, where the set of subsampling configurations include a set of path selection configurations.

[0020] In some aspects, the techniques described herein relate to a method, where calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals includes at least one of: truncating a channel frequency response (CFR) of the measured set of positioning signals; truncating a transform output of the measured set of positioning signals; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured local maximum values; selecting the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation; or selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured minimum delay values.

[0021] In some aspects, the techniques described herein relate to a method, where the wireless device includes at least one of a user equipment (UE), a base station, or a transmission reception point (TRP).

[0022] In some aspects, the techniques described herein relate to a method of wireless communication at a network entity, including: transmitting a plurality of subsampling configurations; and receiving a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

[0023] In some aspects, the techniques described herein relate to a method, further including: training a positioning model based on the set of measurements; or calculating a second set of positioning outputs using the positioning model based on the set of measurements.

[0024] In some aspects, the techniques described herein relate to a method, where the positioning report includes an indicator of the at least one of the plurality of subsampling configurations.

[0025] In some aspects, the techniques described herein relate to a method, further including: receiving an indicator of a capability for a wireless device to utilize a subsampling configuration before the transmission of the plurality of subsampling configurations, where each of the plurality of subsampling configurations satisfy the capability.

[0026] In some aspects, the techniques described herein relate to a method, further including: transmitting a request for the capability before the reception of the indicator of the capability.

[0027] In some aspects, the techniques described herein relate to a method, where receiving the indicator of the capability for the wireless device to utilize the subsampling configuration includes: receiving a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message including the indicator of the capability for the wireless device to utilize the subsampling configuration.

[0028] In some aspects, the techniques described herein relate to a method, further including: transmitting an indicator of the at least one of the plurality of subsampling configurations after the transmission of the plurality of subsampling configurations.

[0029] In some aspects, the techniques described herein relate to a method, where transmitting the indicator of the at least one of the plurality of subsampling configurations includes: transmitting a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) including the indicator of the at least one of the plurality of subsampling configurations.

[0030] In some aspects, the techniques described herein relate to a method, where transmitting the plurality of subsampling configurations includes: transmitting a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message including the plurality of subsampling configurations.

[0031] In some aspects, the techniques described herein relate to a method, where the plurality of subsampling configurations includes a set of path selection configurations.

[0032] In some aspects, the techniques described herein relate to a method, where the plurality of subsampling configurations includes at least one of: a first subsampling configuration to truncate a channel frequency response (CFR); a second subsampling configuration to truncate a transform output of a set of positioning signal measurements; a third subsampling configuration to select a first subset of samples from the set of positioning signal measurements based on a power threshold range; a fourth subsampling configuration to select a second subset of samples from the set of positioning signal measurements based on a magnitude threshold range; a fifth subsampling configuration to select a third subset of samples from the set of positioning signal measurements based on measured local maximum values; a sixth subsampling configuration to select a fourth subset of samples from the set of positioning signal measurements based on an output of a super resolution calculation; or a seventh subsampling configuration to select a fifth subset of samples from the set of positioning signal measurements based on measured minimum delay values.

[0033] In some aspects, the techniques described herein relate to a method, where the network entity includes a location management function (LMF).

[0034] To the accomplishment of the foregoing and related ends, the one or more aspects may include the features hereinafter fully described and particularly pointed out in the claims. The following description and the drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. **1** is a diagram illustrating an example of a wireless communications system and an access network.

[0036] FIG. **2**A is a diagram illustrating an example of a first frame, in accordance with various aspects of the present disclosure.

[0037] FIG. **2**B is a diagram illustrating an example of downlink (DL) channels within a subframe, in accordance with various aspects of the present disclosure.

[0038] FIG. **2**C is a diagram illustrating an example of a second frame, in accordance with various aspects of the present disclosure.

[0039] FIG. **2**D is a diagram illustrating an example of uplink (UL) channels within a subframe, in accordance with various aspects of the present disclosure.

[0040] FIG. **3** is a diagram illustrating an example of a base station and user equipment (UE) in an access network.

[0041] FIG. **4** is a diagram illustrating an example of positioning based on positioning signal measurements.

[0042] FIG. **5** is a diagram illustrating an example of positioning based on positioning signal measurements.

[0043] FIG. **6**A is a diagram illustrating an example of a positioning model trained using direct positioning labels.

[0044] FIG. **6**B is a diagram illustrating an example of a positioning model trained using intermediate positioning labels.

[0045] FIG. **7**A is a diagram illustrating an example of a wireless device with a positioning model, where the wireless device is configured to calculate a location of the wireless device using the positioning model.

[0046] FIG. **7**B is a diagram illustrating an example of a wireless device with a positioning model, where the wireless device is configured to calculate an intermediate measurement using the positioning model.

[0047] FIG. **8**A is a diagram illustrating an example of a network entity with a positioning model, where the network entity is configured to calculate a location of the wireless device using the positioning model.

[0048] FIG. **8**B is a diagram illustrating an example of a network entity with a positioning model, where the network entity is configured to calculate a location of the wireless device using the positioning model.

[0049] FIG. **8**C is a diagram illustrating an example of a wireless device with a positioning model, where the wireless device is configured to calculate an intermediate measurement using the positioning model.

[0050] FIG. **9** is a connection flow diagram illustrating an example of a positioning target wireless device configured to subsample measurements for a positioning model.

[0051] FIG. **10** is a connection flow diagram illustrating an example of a positioning neighbor wireless device configured to subsample measurements for a positioning model.

[0052] FIG. **11** is a flowchart of a method of wireless communication.

[0053] FIG. **12** is a flowchart of a method of wireless communication.

[0054] FIG. **13** is a diagram illustrating an example of a hardware implementation for an example apparatus and/or network entity.

[0055] FIG. **14** is a diagram illustrating an example of a hardware implementation for an example network entity.

[0056] FIG. **15** is a diagram illustrating an example of a hardware implementation for an example network entity.

DETAILED DESCRIPTION

[0057] The following description is directed to examples for the purposes of describing innovative aspects of this disclosure. However, a person having ordinary skill in the art may recognize that the teachings herein may be applied in a multitude of ways. Some or all of the described examples may be implemented in any device, system or network that is capable of transmitting and receiving radio frequency (RF) signals according to one or more of the Institute of Electrical and Electronics Engineers (IEEE) 1102.11 standards, the IEEE 1102.15 standards, the Bluetooth® standards as defined by the Bluetooth Special Interest Group (SIG), or the Long Term Evolution (LTE), 3G, 4G or 5G (New Radio (NR)) standards promulgated by the 3rd Generation Partnership Project (3GPP), among others. The described examples may be implemented in any device, system or network that is capable of transmitting and receiving RF signals according to one or more of the following technologies or techniques: code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single-carrier FDMA (SC-FDMA), spatial division multiple access (SDMA), rate-splitting multiple access (RSMA), multi-user shared access (MUSA), single-user (SU) multiple-input multiple-output (MIMO) and multi-user (MU)-MIMO. The described examples also may be implemented using other wireless communication protocols or RF signals suitable for use in one or more of a wireless personal area network (WPAN), a wireless local area network (WLAN), a wireless wide area network (WWAN), a wireless metropolitan area network (WMAN), or an internet of things (IoT) network.

[0058] Various aspects relate generally to wireless positioning systems. Some aspects more specifically relate to wireless positioning devices configured to subsample measurements based on one of a plurality of subsampling configurations.

[0059] In some examples, a wireless device, such as a user equipment (UE), a base station, or a transmission reception point (TRP) may select a subsampling configuration from a plurality of subsampling configurations. The wireless device may receive a set of positioning signals. The wireless device may measure the received set of positioning signals. The wireless device may calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The wireless device may output the calculated subset of measurements to a positioning model. For example, the wireless device may train the positioning model based on the calculated subset of measurements, the wireless device may calculate a set of positioning outputs based on the calculated subset of measurements, or the wireless device may transmit the calculated subset of measurements for the positioning model (e.g., to a location management function (LMF). The positioning model may be, for example, a positioning model trained using artificial intelligence machine learning (AI/ML).

[0060] In some examples, a network entity, such as an LMF may transmit an indicator of a plurality of subsampling configurations. The network entity may receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations. Subsampling may include selecting a subset of samples to use, for example by truncating a sample or by selecting samples associated with a subset of paths.

[0061] For positioning models at a network entity (e.g., LMF), a wireless device (e.g., UE, base station) may select and report a subset of samples and/or paths of measurements (e.g., channel impulse response (CIR), power delay profile (PDP), delay profile (DP)). If the subsampling method for training the positioning model is different from the subsampling method for using the positioning model to calculate positioning outputs, the positioning accuracy when using the positioning model to calculate positioning outputs may degrade. In some aspects, a wireless device may be configured by a network entity (e.g., an LMF) for a plurality of subsampling methods to determine subsampling measurements (i.e., path and/or sample measurements) for a positioning model. The wireless device may measure reference signals and determine subsampling measurements based on a selected subsampling method and may report an indicator of the selected subsampling method to the network entity along with the calculated subsampling measurements. The wireless device may be configured for the selected method by the network entity or the wireless device may be configured to select the subsampling method based on different criteria. For example, depending upon the multipath nature of a wireless device, some subsampling configurations may provide richer features than others. For example, in a rich multipath environment (e.g., large number of reflections), considering subsampling based on peaks may enrich the feature space and produce better positioning calculations than a subsampling method based on a strongest power/magnitude. In another example, if a channel has a limited number of peaks (e.g., low multipath order, smaller number of paths), subsampling with a stronger power/magnitude may produce more accurate results. The criteria may include, for example, a delay spread of a measured positioning signal (e.g., CIR, PDP, or DP measurement), a Rician factor (i.e., K-factor) of a measured positioning signal, a peak width, a number of paths, or a path order. The wireless device may select a subsampling configuration based on a measurement satisfying a range (e.g., subsample based on peaks if the number of paths is greater or equal to a threshold value, subsample based on power/magnitude if the number of paths is less than or equal to a threshold value). A power of a signal may be computed based on the magnitude of a measurement of samples. In other words, the power may be a different scale than the magnitude, allowing both power and magnitude to express the same measurement in different ways.

[0062] In one aspect, the wireless device and network entity may agree on supported subsampling methods and corresponding identifiers (IDs) offline (e.g., without signaling such configurations). During operation, the wireless device and network entity may refer to the subsampling configurations based on the agreed upon subsampling IDs. In one aspect, a supported subsampling method be assigned as part of meta information associated with a positioning model when doing positioning model registration via an ID used to refer to the subsampling method. In one aspect, the subsampling method may be applied based on a beam, a transmission reception point (TRP), and/or a positioning frequency layer (PFL) basis. In one aspect, a network entity may configure both the subsampling method at one or both of a TRP and/or a UE.

[0063] Particular aspects of the subject matter described in this disclosure can be implemented to realize one or more of the following potential advantages. In some examples, by configuring a wireless device to select from a plurality of subsampling configurations to measure positioning signals, the described techniques can be used to improve the accuracy and reliability of using positioning models to calculate a set of positioning outputs.

[0064] The detailed description set forth below in connection with the drawings describes various configurations and does not represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, these concepts may be practiced without these specific details. In some instances, well known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0065] Several aspects of telecommunication systems are presented with reference to various apparatus and methods. These apparatus and methods are described in the following detailed description and illustrated in the accompanying drawings by various blocks, components, circuits, processes, algorithms, etc. (collectively referred to as "elements"). These elements may be implemented using electronic hardware, computer software, or any combination thereof. Whether such elements are implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system.

[0066] By way of example, an element, or any portion of an element, or any combination of elements may be implemented as a "processing system" that includes one or more processors. When multiple processors are implemented, the multiple processors may perform the functions individually or in combination. Examples of processors include microprocessors, microcontrollers, graphics processing units (GPUs), central processing units (CPUs), application processors, digital signal processors (DSPs), reduced instruction set computing (RISC) processors, systems on a chip (SoC), baseband processors, field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise, shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software components, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, or any combination thereof.

[0067] Accordingly, in one or more example aspects, implementations, and/or use cases, the functions described may be implemented in hardware, software, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Storage media may be any available media that can be accessed by a computer. By way of example, such computer-readable media can include a random-access memory (RAM), a read-only memory (ROM), an electrically erasable programmable ROM (EEPROM), optical disk storage, magnetic disk storage, other magnetic storage devices, combinations of the types of computer-readable media, or any other medium that can be used to store computer executable code in the form of instructions or data structures that can be accessed by a computer.

[0068] While aspects, implementations, and/or use cases are described in this application by illustration to some examples, additional or different aspects, implementations and/or use cases may come about in many different arrangements and scenarios. Aspects, implementations, and/or use cases described herein may be implemented across many differing platform types, devices, systems, shapes, sizes, and packaging arrangements. For example, aspects, implementations, and/or use cases may come about via integrated chip implementations and other non-module-component based devices (e.g., end-user devices, vehicles, communication devices, computing devices, industrial equipment, retail/purchasing devices, medical devices, artificial intelligence (AI)-enabled devices, etc.). While some examples may or may not be specifically directed to use cases or applications, a wide assortment of applicability of described examples may occur. Aspects, implementations, and/or use cases may range a spectrum from chip-level or modular components to non-modular, non-chip-level implementations and further to aggregate, distributed, or original equipment manufacturer (OEM) devices or systems incorporating one or more techniques herein. In some practical settings, devices incorporating described aspects and features may also include additional components and features for implementation and practice of claimed and described aspect. For example, transmission and reception of wireless signals necessarily includes a number of components for analog and digital purposes (e.g., hardware components including antenna, RF-chains, power amplifiers, modulators, buffer, processor(s), interleaver, adders/summers, etc.). Techniques described herein may be practiced in a wide variety of devices, chip-level components, systems, distributed arrangements, aggregated or disaggregated components, end-user devices, etc. of varying sizes, shapes, and constitution.

[0069] Deployment of communication systems, such as 5G NR systems, may be arranged in multiple manners with various components or constituent parts. In a 5G NR system, or network, a network node, a network entity, a mobility element of a network, a radio access network (RAN) node, a core network node, a network element, or a network equipment, such as a base station (BS), or one or more units (or one or more components) performing base station functionality, may be implemented in an aggregated or disaggregated architecture. For example, a BS (such as a Node B (NB), evolved NB (CNB), NR BS, 5G NB, access point (AP), a transmission reception point (TRP), or a cell, etc.) may be implemented as an aggregated base station (also known as a standalone BS or a monolithic BS) or a disaggregated base station.

[0070] An aggregated base station may be configured to utilize a radio protocol stack that is physically or logically integrated within a single RAN node. A disaggregated base station may be configured to utilize a protocol stack that is physically or logically distributed among two or more units (such as one or more central or centralized units (CUs), one or more distributed units (DUs), or one or more radio units (RUS)). In some aspects, a CU may be implemented within a RAN node, and one or more DUs may be co-located with the CU, or alternatively, may be geographically or virtually distributed throughout one or multiple other RAN nodes. The DUs may be implemented to communicate with one or more RUs. Each of the CU, DU and RU can be implemented as virtual units, i.e., a virtual central unit (VCU), a virtual distributed unit (VDU), or a virtual radio unit (VRU).

[0071] Base station operation or network design may consider aggregation characteristics of base station functionality. For example, disaggregated base stations may be utilized in an integrated access backhaul (IAB) network, an open radio access network (O-RAN (such as the network configuration sponsored by the O-RAN Alliance)), or a virtualized radio access network (vRAN, also known as a cloud radio access network (C-RAN)). Disaggregation may include distributing functionality across two or more units at various physical locations, as well as distributing functionality for at least one unit virtually, which can enable flexibility in network design. The various units of the disaggregated base station, or disaggregated RAN architecture, can be configured for wired or wireless communication with at least one other unit.

[0072] FIG. **1** is a diagram **100** illustrating an example of a wireless communications system and an access network. The illustrated wireless communications system includes a disaggregated base station architecture. The disaggregated base station architecture may include one or more CUs **110** that can communicate directly with a core network **120** via a backhaul link, or indirectly with the core network **120** through one or more disaggregated base station units (such as a Near-Real Time (Near-RT) RAN Intelligent Controller (RIC) **125** via an E2 link, or a Non-Real Time (Non-RT) RIC **115** associated with a Service Management and Orchestration (SMO) Framework **105**, or both). A CU **110** may communicate with one or more DUs **130** via respective midhaul links, such as an F1 interface. The DUs **130** may communicate with one or more RUs **140** via respective fronthaul links. The RUs **140** may communicate with respective UEs **104** via one or more radio frequency (RF) access links. In some implementations, the UE **104** may be simultaneously served by multiple RUs **140**.

[0073] Each of the units, i.e., the CUS **110**, the DUs **130**, the RUs **140**, as well as the Near-RT RICs **125**, the Non-RT RICs **115**, and the SMO Framework **105**, may include one or more interfaces or be coupled to one or more interfaces configured to receive or to transmit signals, data, or information (collectively, signals) via a wired or wireless transmission medium. Each of the units, or an associated processor or controller providing instructions to the communication interfaces of the units, can be configured to communicate with one or more of the other units via the transmission medium. For example, the units can include a wired interface configured to receive or to transmit signals over a wired transmission medium to one or more of the other units. Additionally, the units can include a wireless interface, which may include a receiver, a transmitter, or a transceiver (such as an RF transceiver), configured to receive or to transmit signals, or both, over a wireless transmission medium to one or more of the other units.

[0074] In some aspects, the CU **110** may host one or more higher layer control functions. Such control functions can include radio resource control (RRC), packet data convergence protocol (PDCP), service data adaptation protocol (SDAP), or the like. Each control function can be implemented with an interface configured to communicate signals with other control functions hosted by the CU **110**. The CU **110** may be configured to handle user plane functionality (i.e., Central Unit-User Plane (CU-UP)), control plane functionality (i.e., Central Unit-Control Plane (CU-CP)), or a combination thereof. In some implementations, the CU **110** can be logically split into one or more CU-UP units and one or more CU-CP units. The CU-UP unit can communicate bidirectionally with the CU-CP unit via an interface, such as an E1 interface when implemented in an O-RAN configuration. The CU **110** can be implemented to communicate with the DU **130**, as necessary, for network control and signaling.

[0075] The DU **130** may correspond to a logical unit that includes one or more base station functions to control the operation of one or more RUs **140**. In some aspects, the DU **130** may host one or more of a radio link control (RLC) layer, a medium access control (MAC) layer, and one or more high physical (PHY) layers (such as modules for forward error correction (FEC) encoding and decoding, scrambling, modulation, demodulation, or the like) depending, at least in part, on a functional split, such as those defined by 3GPP. In some aspects, the DU **130** may further host one or more low PHY layers. Each layer (or module) can be implemented with an interface configured to communicate signals with other layers (and modules) hosted by the DU **130**, or with the control functions hosted by the CU **110**.

[0076] Lower-layer functionality can be implemented by one or more RUs **140**. In some deployments, an RU **140**, controlled by a DU **130**, may correspond to a logical node that hosts RF processing functions, or low-PHY layer functions (such as performing fast Fourier transform (FFT), inverse FFT (iFFT), digital beamforming, physical random access channel (PRACH) extraction and filtering, or the like), or both, based at least in part on the functional split, such as a lower layer functional split. In such an architecture, the RU(s) **140** can be implemented to handle over the air (OTA) communication with one or more UEs **104**. In some implementations, real-time and non-real-time aspects of control and user plane communication with the RU(s) **140** can be controlled by the corresponding DU **130**. In some scenarios, this configuration can enable the DU(s) **130** and the CU **110** to be implemented in a cloud-based RAN architecture, such as a vRAN architecture.

[0077] The SMO Framework **105** may be configured to support RAN deployment and provisioning of non-virtualized and virtualized network elements. For non-virtualized network elements, the SMO Framework **105** may be configured to support the deployment of dedicated physical resources for RAN coverage requirements that may be managed via an operations and maintenance interface (such as an O1 interface). For virtualized network elements, the SMO Framework **105** may be configured to interact with a cloud computing platform (such as an open cloud (O-Cloud) **190**) to perform network element life cycle management (such as to instantiate virtualized network elements) via a cloud computing platform interface (such as an O2 interface). Such virtualized network elements can include, but are not limited to, CUs **110**, DUs **130**, RUs **140** and Near-RT RICs **125**. In some implementations, the SMO Framework **105** can communicate with a hardware aspect of a 4G RAN, such as an open eNB (O-eNB) **111**, via an O1 interface. Additionally, in some implementations, the SMO Framework **105** can communicate directly with one or more RUs **140** via an O1 interface. The SMO Framework **105** also may include a Non-RT RIC **115** configured to support functionality of the SMO Framework **105**.

[0078] The Non-RT RIC **115** may be configured to include a logical function that enables non-real-time control and optimization of RAN elements and resources, artificial intelligence (AI)/machine learning (ML) (AI/ML) workflows including model training and updates, or policy-based guidance of applications/features in the Near-RT RIC **125**. The Non-RT RIC **115** may be coupled to or communicate with (such as via an A1 interface) the Near-RT RIC **125**. The Near-RT RIC **125** may be configured to include a logical function that enables near-real-time control and optimization of RAN elements and resources via data collection and actions over an interface (such as via an E2 interface) connecting one or more CUs **110**, one or more DUs **130**, or both, as well as an O-eNB, with the Near-RT RIC **125**.

[0079] In some implementations, to generate AI/ML models to be deployed in the Near-RT RIC **125**, the Non-RT RIC **115** may receive parameters or external enrichment information from external servers. Such information may be utilized by the Near-RT RIC **125** and may be received at the SMO Framework **105** or the Non-RT RIC **115** from non-network data sources or from network functions. In some examples, the Non-RT RIC **115** or the Near-RT RIC **125** may be configured to tune RAN behavior or performance. For example, the Non-RT RIC **115** may monitor long-term trends and patterns for performance and employ AI/ML models to perform corrective actions through the SMO Framework **105** (such as reconfiguration via **01**) or via creation of RAN management policies (such as A1 policies).

[0080] At least one of the CU **110**, the DU **130**, and the RU **140** may be referred to as a base station **102**. Accordingly, a base station **102** may include one or more of the CU **110**, the DU **130**, and the RU **140** (each component indicated with dotted lines to signify that each component may or may not be included in the base station **102**). The base station **102** provides an access point to the core network **120** for a UE **104**. The base station **102** may include macrocells (high power cellular base station) and/or small cells (low power cellular base station). The small cells include femtocells, picocells, and microcells. A network that includes both small cell and macrocells may be known as a heterogeneous network. A heterogeneous network may also include Home Evolved Node Bs (eNBs) (HeNBs), which may provide service to a restricted group known as a closed subscriber group (CSG). The communication links between the RUs **140** and the UEs **104** may include uplink (UL) (also referred to as reverse link) transmissions from a UE **104** to an RU **140** and/or downlink (DL) (also referred to as forward link) transmissions from an RU **140** to a UE **104**. The communication links may use multiple-input and multiple-output (MIMO) antenna technology, including spatial multiplexing, beamforming, and/or transmit diversity. The communication links may be through one or more carriers. The base station **102**/UEs **104** may use spectrum up to Y MHz (e.g., 5, 10, 15, 20, 100, 400, etc. MHz) bandwidth per carrier allocated in a carrier aggregation of up to a total of Yx MHz (x component carriers) used for transmission in each direction. The carriers may or may not be adjacent to each other. Allocation of carriers may be asymmetric with respect to DL and UL (e.g., more or fewer carriers may be allocated for DL than for UL). The component carriers may include a primary component carrier and one or more secondary component carriers. A primary component carrier may be referred to as a primary cell (PCell) and a secondary component carrier may be referred to as a secondary cell (SCell).

[0081] Certain UEs **104** may communicate with each other using device-to-device (D2D) communication link **158**. The D2D communication link **158** may use the DL/UL wireless wide area network (WWAN) spectrum. The D2D communication link **158** may use one or more sidelink channels, such as a physical sidelink broadcast channel (PSBCH), a physical sidelink discovery channel (PSDCH), a physical sidelink shared channel (PSSCH), and a physical sidelink control channel (PSCCH). D2D communication may be through a variety of wireless D2D communications systems, such as for example, Bluetooth™ (Bluetooth is a trademark of the Bluetooth Special Interest Group (SIG)), Wi-Fi™ (Wi-Fi is a trademark of the Wi-Fi Alliance) based on the Institute of Electrical and Electronics Engineers (IEEE) 1102.11 standard, LTE, or NR.

[0082] The wireless communications system may further include a Wi-Fi AP **150** in communication with UEs **104** (also referred to as Wi-Fi stations (STAs)) via communication link **154**, e.g., in a 5 GHz unlicensed frequency spectrum or the like. When communicating in an unlicensed frequency spectrum, the UEs **104**/AP **150** may perform a clear channel assessment (CCA) prior to communicating in order to determine whether the channel is available.

[0083] The electromagnetic spectrum is often subdivided, based on frequency/wavelength, into various classes, bands, channels, etc. In 5G NR, two initial operating bands have been identified as frequency range designations FRI (410 MHz-7.125 GHZ) and FR2 (24.25 GHz-52.6 GHz). Although a portion of FR1 is greater than 6 GHz, FR1 is often referred to (interchangeably) as a "sub-6 GHz" band in various documents and articles. A similar nomenclature issue sometimes occurs with regard to FR2, which is often referred to (interchangeably) as a "millimeter wave" band in documents and articles, despite being different from the extremely high frequency (EHF) band (30 GHz-300 GHz) which is identified by the International Telecommunications Union (ITU) as a "millimeter wave" band.

[0084] The frequencies between FR1 and FR2 are often referred to as mid-band frequencies. Recent 5G NR studies have identified an operating band for these mid-band frequencies as frequency range designation FR3 (7.125 GHZ-24.25 GHZ). Frequency bands falling within FR3 may inherit FR1 characteristics and/or FR2 characteristics, and thus may effectively extend features of FR1 and/or FR2 into mid-band frequencies. In addition, higher frequency bands are currently being explored to extend 5G NR operation beyond 52.6 GHz. For example, three higher operating bands have been identified as frequency range designations FR2-2 (52.6 GHz-71 GHZ), FR4 (71 GHz-114.25 GHz), and FR5 (114.25 GHz-300 GHz). Each of these higher frequency bands falls within the EHF band.

[0085] With the above aspects in mind, unless specifically stated otherwise, the term "sub-6 GHz" or the like if used herein may broadly represent frequencies that may be less than 6 GHz, may be within FR1, or may include mid-band frequencies. Further, unless specifically stated otherwise, the term "millimeter wave" or the like if used herein may broadly represent frequencies that may include mid-band frequencies, may be within FR2, FR4, FR2-2, and/or FR5, or may be within the EHF band.

[0086] The base station **102** and the UE **104** may each include a plurality of antennas, such as antenna elements, antenna panels, and/or antenna arrays to facilitate beamforming. The base station **102** may transmit a beamformed signal **182** to the UE **104** in one or more transmit directions. The UE **104** may receive the beamformed signal from the base station **102** in one or more receive directions. The UE **104** may also transmit a beamformed signal **184** to the base station **102** in one or more transmit directions. The base station **102** may receive the beamformed signal from the UE **104** in one or more receive directions. The base station **102**/UE **104** may perform beam training to determine the best receive and transmit directions for each of the base station **102**/UE **104**. The transmit and receive directions for the base station **102** may or may not be the same. The transmit and receive directions for the UE **104** may or may not be the same.

[0087] The base station **102** may include and/or be referred to as a gNB, Node B, eNB, an access point, a base transceiver station, a radio base station, a radio transceiver, a transceiver function, a basic service set (BSS), an extended service set (ESS), a TRP, network node, network entity, network equipment, or some other suitable terminology. The base station **102** can be implemented as an integrated access and backhaul (IAB) node, a relay node, a sidelink node, an aggregated (monolithic) base station with a baseband unit (BBU) (including a CU and a DU) and an RU, or as a disaggregated base station including one or more of a CU, a DU, and/or an RU. The set of base stations, which may include disaggregated base stations and/or aggregated base stations, may be referred to as next generation (NG) RAN (NG-RAN).

[0088] The core network **120** may include an Access and Mobility Management Function (AMF) **161**, a Session Management Function (SMF) **162**, a User Plane Function (UPF) **163**, a Unified Data Management (UDM) **164**, one or more location servers **168**, and other functional entities. The AMF **161** is the control node that processes the signaling between the UEs **104** and the core network **120**. The AMF **161** supports registration management, connection management, mobility management, and other functions. The SMF **162** supports session management and other functions. The UPF **163** supports packet routing, packet forwarding, and other functions. The UDM **164** supports the generation of authentication and key agreement (AKA) credentials, user identification handling, access authorization, and subscription management. The one or more location servers **168** are illustrated as including a Gateway Mobile Location Center (GMLC) **165** and a Location Management Function (LMF) **166**. However, generally, the one or more location servers **168** may include one or more location/positioning servers, which may include one or more of the GMLC **165**, the LMF **166**, a position determination entity (PDE), a serving mobile location center (SMLC), a mobile positioning center (MPC), or the like. The GMLC **165** and the LMF **166** support UE location services. The GMLC **165** provides an interface for clients/applications (e.g., emergency services) for accessing UE positioning information. The LMF **166** receives measurements and assistance information from the NG-RAN and the UE **104** via the AMF **161** to compute the position of the UE **104**. The NG-RAN may utilize one or more positioning methods in order to determine the position of the UE **104**. Positioning the UE **104** may involve signal measurements, a position estimate, and an optional velocity computation based on the measurements. The signal measurements may be made by the UE **104** and/or the base station **102** serving the UE **104**. The signals measured may be based on one or more of a satellite positioning system (SPS) **170** (e.g., one or more of a Global Navigation Satellite System (GNSS), global position system (GPS), non-terrestrial network (NTN), or other satellite position/location system), LTE signals, wireless local area network (WLAN) signals, Bluetooth signals, a terrestrial beacon system (TBS), sensor-based information (e.g., barometric pressure sensor, motion sensor), NR enhanced cell ID (NR E-CID) methods, NR signals (e.g., multi-round trip time (Multi-RTT), DL angle-of-departure (DL-AoD), DL time difference of arrival (DL-TDOA), UL time difference of arrival (UL-TDOA), and UL angle-of-arrival (UL-AoA) positioning), and/or other systems/signals/sensors.

[0089] Examples of UEs **104** include a cellular phone, a smart phone, a session initiation protocol (SIP) phone, a laptop, a personal digital assistant (PDA), a satellite radio, a global positioning system, a multimedia device, a video device, a digital audio player (e.g., MP3 player), a camera, a game console, a tablet, a smart device, a wearable device, a vehicle, an electric meter, a gas pump, a large or small kitchen appliance, a healthcare device, an implant, a sensor/actuator, a display, or any other similar functioning device. Some of the UEs **104** may be referred to as IoT devices (e.g., parking meter, gas pump, toaster, vehicles, heart monitor, etc.). The UE **104** may also be referred to as a station, a mobile station, a subscriber station, a mobile unit, a subscriber unit, a wireless unit, a remote unit, a mobile device, a wireless device, a wireless communications device, a remote device, a mobile subscriber station, an access terminal, a mobile terminal, a wireless terminal, a remote terminal, a handset, a user agent, a mobile client, a client, or some other suitable terminology. In some scenarios, the term UE may also apply to one or more companion devices such as in a device constellation arrangement. One or more of these devices may collectively access the network and/or individually access the network.

[0090] Referring again to FIG. **1**, in certain aspects, the UE **104** and/or a base station **102** may have a subsampling component **198** that may be configured to select a subsampling configuration from a plurality of subsampling configurations. The subsampling component **198** may be configured to receive a set of positioning signals. The subsampling component **198** may be configured to measure the received set of positioning signals. The subsampling component **198** may be configured to calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The subsampling component **198** may be configured to output the calculated subset of measurements to a positioning model, for example by training the positioning model based on the calculated subset of measurements, by calculating a set of positioning outputs based on the calculated subset of measurements, or by transmitting the calculated subset of measurements for the positioning model (e.g., to the LMF **166**). In certain aspects, the base station **102**, the core network **120**, the one or more location servers **168**, or the LMF **166** may have a subsampling configuration component **199** that may be configured to transmit an indicator of a plurality of subsampling configurations. The subsampling configuration component **199** may be configured to receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

[0091] FIG. **2**A is a diagram **200** illustrating an example of a first subframe within a 5G NR frame structure. FIG. **2**B is a diagram **230** illustrating an example of DL channels within a 5G NR subframe. FIG. **2**C is a diagram **250** illustrating an example of a second subframe within a 5G NR frame structure. FIG. **2**D is a diagram **280** illustrating an example of UL channels within a 5G NR subframe. The 5G NR frame structure may be frequency division duplexed (FDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for either DL or UL, or may be time division duplexed (TDD) in which for a particular set of subcarriers (carrier system bandwidth), subframes within the set of subcarriers are dedicated for both DL and UL. In the examples provided by FIGS. **2**A, **2**C, the 5G NR frame structure is assumed to be TDD, with subframe 4 being configured with slot format 28 (with mostly DL), where D is DL, U is UL, and F is flexible for use between DL/UL, and subframe 3 being configured with slot format 1 (with all UL). While subframes 3, 4 are shown with slot formats 1, 28, respectively, any particular subframe may be configured with any of the various available slot formats 0-61. Slot formats 0, 1 are all DL, UL, respectively. Other slot formats 2-61 include a mix of DL, UL, and flexible symbols. UEs are configured with the slot format (dynamically through DL control information (DCI), or semi-statically/statically through radio resource control (RRC) signaling) through a received slot format indicator (SFI). Note that the description infra applies also to a 5G NR frame structure that is TDD.

[0092] FIGS. **2**A-**2**D illustrate a frame structure, and the aspects of the present disclosure may be applicable to other wireless communication technologies, which may have a different frame structure and/or different channels. A frame (10 ms) may be divided into 10 equally sized subframes (1 ms). Each subframe may include one or more time slots. Subframes may also include mini-slots, which may include 7, 4, or 2 symbols. Each slot may include 14 or 12 symbols, depending on whether the cyclic prefix (CP) is normal or extended. For normal CP, each slot may include 14 symbols, and for extended CP, each slot may include 12 symbols. The symbols on DL may be CP orthogonal frequency division multiplexing (OFDM) (CP-OFDM) symbols. The symbols on UL may be CP-OFDM symbols (for high throughput scenarios) or discrete Fourier transform (DFT) spread OFDM (DFT-s-OFDM) symbols (for power limited scenarios; limited to a single stream transmission). The number of slots within a subframe is based on the CP and the numerology. The numerology defines the subcarrier spacing (SCS) (see Table 1). The symbol length/duration may scale with 1/SCS.

TABLE 1

Numerology, SCS, and CP

μ	SCS $\Delta f = 2^{\mu} \cdot 15$[kHz]	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal
5	480	Normal
6	960	Normal

[0093] For normal CP (14 symbols/slot), different numerologies μ 0 to 4 allow for 1, 2, 4, 8, and 16 slots, respectively, per subframe. For extended CP, the numerology 2 allows for 4 slots per subframe. Accordingly, for normal CP and numerology μ, there are 14 symbols/slot and 24 slots/subframe. The subcarrier spacing may be equal to $2^{\mu}*15$ kHz, where μ is the numerology 0 to 4. As such, the numerology μ=0 has a subcarrier spacing of 15 kHz and the numerology μ=4 has a subcarrier spacing of 240 kHz. The symbol length/duration is inversely related to the subcarrier spacing. FIGS. **2**A-**2**D provide an example of normal CP with 14 symbols per slot and numerology μ=2 with 4 slots per subframe. The slot duration is 0.25 ms, the subcarrier spacing is 60 kHz, and the symbol duration is approximately 16.67 μs. Within a set of frames, there may be one or more different bandwidth parts (BWPs) (see FIG. **2**B) that are frequency division multiplexed. Each BWP may have a particular numerology and CP (normal or extended).

[0094] A resource grid may be used to represent the frame structure. Each time slot includes a resource block (RB) (also referred to as physical RBs (PRBs)) that extends 12 consecutive subcarriers. The resource grid is divided into multiple resource elements (REs). The number of bits carried by each RE depends on the modulation scheme.

[0095] As illustrated in FIG. **2**A, some of the REs carry reference (pilot) signals (RS) for the UE. The RS may include demodulation RS (DM-RS) (indicated as R for one particular configuration, but other DM-RS configurations are possible) and channel state information reference signals (CSI-RS) for channel estimation at the UE. The RS may also include beam measurement RS (BRS), beam refinement RS (BRRS), and phase tracking RS (PT-RS).

[0096] FIG. **2**B illustrates an example of various DL channels within a subframe of a frame. The physical downlink control channel (PDCCH) carries DCI within one or more control channel elements (CCEs) (e.g., 1, 2, 4, 8, or 16 CCEs), each CCE including six RE groups (REGs), each REG including 12 consecutive REs in an OFDM symbol of an RB. A PDCCH within one BWP may be referred to as a control resource set (CORESET). A UE is configured to monitor PDCCH candidates in a PDCCH search space (e.g., common search space, UE-specific search space) during PDCCH monitoring occasions on the CORESET, where the PDCCH candidates have different DCI formats and different aggregation levels. Additional BWPs may be located at greater and/or lower frequencies across the channel bandwidth. A primary synchronization signal (PSS) may be within symbol 2 of particular subframes of a frame. The PSS is used by a UE **104** to determine subframe/symbol timing and a physical layer identity. A secondary synchronization signal (SSS) may be within symbol 4 of particular subframes of a frame. The SSS is used by a UE to determine a physical layer cell identity group number and radio frame timing. Based on the physical layer identity and the physical layer cell identity group number, the UE can determine a physical cell identifier (PCI). Based on the PCI, the UE can determine the locations of the DM-RS. The physical broadcast channel (PBCH), which carries a master information block (MIB), may be logically grouped with the PSS and SSS to form a synchronization signal (SS)/PBCH block (also referred to as SS block (SSB)). The MIB provides a number of RBs in the system bandwidth and a system frame number (SFN). The physical downlink shared channel (PDSCH) carries user data, broadcast system information not transmitted through the PBCH such as system information blocks (SIBs), and paging messages.

[0097] As illustrated in FIG. **2**C, some of the REs carry DM-RS (indicated as R for one particular configuration, but other DM-RS configurations are possible) for channel estimation at the base station. The UE may transmit DM-RS for the physical uplink control channel (PUCCH) and DM-RS for the physical uplink shared channel (PUSCH). The PUSCH DM-RS may be transmitted in the first one or two symbols of the PUSCH. The PUCCH DM-RS may be transmitted in different configurations depending on whether short or long PUCCHs are transmitted and depending on the particular PUCCH format used. The UE may transmit sounding reference signals (SRS). The SRS may be transmitted in the last symbol of a subframe. The SRS may have a comb structure, and a UE may transmit SRS on one of the combs. The SRS may be used by a base station for channel quality estimation to enable frequency-dependent scheduling on the UL.

[0098] FIG. **2**D illustrates an example of various UL channels within a subframe of a frame. The PUCCH may be located as indicated in one configuration. The PUCCH carries uplink control information (UCI), such as scheduling requests, a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), and hybrid automatic repeat request (HARQ) acknowledgment (ACK) (HARQ-ACK) feedback (i.e., one or more HARQ ACK bits indicating one or more ACK and/or negative ACK (NACK)). The PUSCH carries data, and may additionally be used to carry a buffer status report (BSR), a power headroom report (PHR), and/or UCI.

[0099] FIG. **3** is a block diagram of a base station **310** in communication with a UE **350** in an access network. In the DL, Internet protocol (IP) packets may be provided to a controller/processor **375**. The controller/processor **375** implements layer 3 and layer 2 functionality. Layer 3 includes a radio resource control (RRC) layer, and layer 2 includes a service data adaptation protocol (SDAP) layer, a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, and a medium access control (MAC) layer. The controller/processor **375** provides RRC layer functionality associated with broadcasting of system information (e.g., MIB, SIBs), RRC connection control (e.g., RRC connection paging, RRC connection establishment, RRC connection modification, and RRC connection release), inter radio access technology (RAT) mobility, and measurement configuration for UE measurement reporting; PDCP layer functionality associated with header compression/decompression, security (ciphering, deciphering, integrity protection, integrity verification), and handover support functions; RLC layer functionality associated with the transfer of upper layer packet data units (PDUs), error correction through ARQ, concatenation, segmentation, and reassembly of RLC service data units (SDUs), re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto transport blocks (TBs), demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0100] The transmit (TX) processor **316** and the receive (RX) processor **370** implement layer 1 functionality associated with various signal processing functions. Layer 1, which includes a physical (PHY) layer, may include error detection on the transport channels, forward error correction (FEC) coding/decoding of the transport channels, interleaving, rate matching, mapping onto physical channels, modulation/demodulation of physical channels, and MIMO antenna processing. The TX processor **316** handles mapping to signal constellations based on various modulation schemes (e.g., binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), M-phase-shift keying (M-PSK), M-quadrature amplitude modulation (M-QAM)). The coded and modulated symbols may then be split into parallel streams. Each stream may then be mapped to an OFDM subcarrier, multiplexed with a reference signal (e.g., pilot) in the time and/or frequency domain, and then combined together using an Inverse Fast Fourier Transform (IFFT) to produce a physical channel carrying a time domain OFDM symbol stream. The OFDM stream is spatially precoded to produce multiple spatial streams. Channel estimates from a channel estimator **374** may be used to determine the coding and modulation scheme, as well as for spatial processing. The channel estimate may be derived from a reference signal and/or channel condition feedback transmitted by the UE **350**. Each spatial stream may then be provided to a different antenna **320** via a separate transmitter **318**Tx. Each transmitter **318**Tx may modulate a radio frequency (RF) carrier with a respective spatial stream for transmission.

[0101] At the UE **350**, each receiver **354**Rx receives a signal through its respective antenna **352**. Each receiver **354**Rx recovers information modulated onto an RF carrier and provides the information to the receive (RX) processor **356**. The TX processor **368** and the RX processor **356** implement layer 1 functionality associated with various signal processing functions. The RX processor **356** may perform spatial processing on the information to recover any spatial streams destined for the UE **350**. If multiple spatial streams are destined for the UE **350**, they may be combined by the RX processor **356** into a single OFDM symbol stream. The RX processor **356** then converts the OFDM symbol stream from the time-domain to the frequency domain using a Fast Fourier Transform (FFT). The frequency domain signal includes a separate OFDM symbol stream for each subcarrier of the OFDM signal. The symbols on each subcarrier, and the reference signal, are recovered and demodulated by determining the most likely signal constellation points transmitted by the base station **310**. These soft decisions may be based on channel estimates computed by the channel estimator **358**. The soft decisions are then decoded and deinterleaved to recover the data and control signals that were originally transmitted by the base station **310** on the physical channel. The data and control signals are then provided to the controller/processor **359**, which implements layer 3 and layer 2 functionality.

[0102] The controller/processor **359** can be associated with at least one memory **360** that stores program codes and data. The at least one memory **360** may be referred to as a computer-readable medium. In the UL, the controller/processor **359** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, and control signal processing to recover IP packets. The controller/processor **359** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0103] Similar to the functionality described in connection with the DL transmission by the base station **310**, the controller/processor **359** provides RRC layer functionality associated with system information (e.g., MIB, SIBs) acquisition, RRC connections, and measurement reporting; PDCP layer functionality associated with header compression/decompression, and security (ciphering, deciphering, integrity protection, integrity verification); RLC layer functionality associated with the transfer of upper layer PDUs, error correction through ARQ, concatenation, segmentation, and reassembly of RLC SDUs, re-segmentation of RLC data PDUs, and reordering of RLC data PDUs; and MAC layer functionality associated with mapping between logical channels and transport channels, multiplexing of MAC SDUs onto TBs, demultiplexing of MAC SDUs from TBs, scheduling information reporting, error correction through HARQ, priority handling, and logical channel prioritization.

[0104] Channel estimates derived by a channel estimator **358** from a reference signal or feedback transmitted by the base station **310** may be used by the TX processor **368** to select the appropriate coding and modulation schemes, and to facilitate spatial processing. The spatial streams generated by the TX processor **368** may be provided to different antenna **352** via separate transmitters **354**Tx. Each transmitter **354**Tx may modulate an RF carrier with a respective spatial stream for transmission.

[0105] The UL transmission is processed at the base station **310** in a manner similar to that described in connection with the receiver function at the UE **350**. Each receiver **318**Rx receives a signal through its respective antenna **320**. Each receiver **318**Rx recovers information modulated onto an RF carrier and provides the information to a RX processor **370**.

[0106] The controller/processor **375** can be associated with at least one memory **376** that stores program codes and data. The at least one memory **376** may be referred to as a computer-readable medium. In the UL, the controller/processor **375** provides demultiplexing between transport and logical channels, packet reassembly, deciphering, header decompression, control signal processing to recover IP packets. The controller/processor **375** is also responsible for error detection using an ACK and/or NACK protocol to support HARQ operations.

[0107] At least one of the TX processor **368**, the RX processor **356**, and the controller/processor **359** may be configured to perform aspects in connection with the sub-sampling component **198** of FIG. **1**.

[0108] At least one of the TX processor **316**, the RX processor **370**, and the controller/processor **375** may be configured to perform aspects in connection with the sub-sampling component **198** of FIG. **1**.

[0109] At least one of the TX processor **316**, the RX processor **370**, and the controller/processor **375** may be configured to perform aspects in connection with the sub-sampling configuration component **199** of FIG. **1**.

[0110] FIG. **4** is a diagram **400** illustrating an example of a positioning based on positioning signal measurements. A positioning signal may be any reference signal which may be measured to calculate a position attribute or a location attribute of a wireless device, for example a positioning reference signal (PRS), a sounding reference signal (SRS), a channel state information (CSI) reference signal (CSI-RS), or a synchronization and signal block (SSB). The wireless device **402** may be a base station, such as a TRP, or a UE with a known position/location, such as a positioning reference unit (PRU) or a UE with a high-accuracy sensor that may identify the location of the UE, for example a GNSS sensor or a GPS sensor. The wireless device **406** may be a base station or a UE with a known position/location. The wireless device **404** may be a UE or a TRP configured to perform positioning to gather data, for example to gather data to train an artificial intelligence machine learning (AI/ML or AIML) model, test positioning signal strength or test positioning noise attributes in an area. The wireless device **404** may transmit UL-SRS **412** at time T_{SRS_TX} and receive DL positioning reference signals (PRS) (DL-PRS) **410** at time T_{PRS_RX}. The wireless device **406** may receive the UL-SRS **412** at time T_{SRS_RX} and transmit the DL-PRS **410** at time T_{PRS_TX}. The wireless device **404** may receive the DL-PRS **410** before transmitting the UL-SRS **412**, or may transmit the UL-SRS **412** before receiving the DL-PRS **410**. In both cases, a positioning server (e.g., location server(s) **168**, LMF **166**) or the wireless device **404** may determine the RTT **414** based on $||T_{SRS\_RX}-T_{PRS\_TX}|-|T_{SRS\_TX}-T_{PRS\_RX}||$. Accordingly, multi-RTT positioning may make use of the UE Rx-Tx time difference measurements (i.e., $|T_{SRS\_TX}-T_{PRS\_RX}|$) and DL-PRS reference signal received power (RSRP) (DL-PRS-RSRP) of downlink signals received from multiple wireless devices **402**, **406** and measured by the wireless device **404**, and the measured TRP Rx-Tx time difference measurements (i.e., $|T_{SRS\_RX}-T_{PRS\_TX}|$) and UL-SRS-RSRP at multiple wireless devices **402**, **406** of uplink signals transmitted from wireless device **404**. The wireless device **404** may measure the UE Rx-Tx time difference measurements (and optionally DL-PRS-RSRP of the received signals) using assistance data received from the positioning server, and the wireless devices **402**, **406** may measure the gNB Rx-Tx time difference measurements (and optionally UL-SRS-RSRP of the received signals) using assistance data received from the positioning server. The measurements may be used at the positioning server or the wireless device **404** to determine the RTT. The RTT may be used to estimate the location of the wireless device **404**. Other methods are possible for determining the RTT, such as for example using DL-TDOA and/or UL-TDOA measurements.

[0111] DL-AoD positioning may make use of the measured DL-PRS-RSRP of downlink signals received from multiple wireless devices **402**, **406** at the wireless device **404**. The wireless device **404** may measure the DL-PRS-RSRP of the received signals using assistance data received from the positioning server, and the resulting measurements may be used along with the azimuth angle of departure (A-AoD), the zenith angle of departure (Z-AoD), and/or other configuration information to locate the wireless device **404** in relation to the neighboring wireless devices **402**, **406**.

[0112] DL-TDOA positioning may make use of the DL reference signal time difference (RSTD) (and optionally DL-PRS-RSRP) of downlink signals received from multiple wireless devices **402**, **406** at the wireless device **404**. The wireless device **404** may measure the DL RSTD (and optionally DL-PRS-RSRP) of the received signals using assistance data received from the positioning server, and the resulting measurements may be used along with other configuration information to locate a position/location the wireless device **404** in relation to the neighboring wireless devices **402**, **406**.

[0113] UL-TDOA positioning may make use of the UL relative time of arrival (RTOA) (and optionally UL-SRS-RSRP) at multiple wireless devices **402**, **406** of uplink signals transmitted from wireless device **404**. The wireless devices **402**, **406** may measure the UL-RTOA (and optionally UL-SRS-RSRP) of the received signals using assistance data received from the positioning server, and the resulting measurements may be used along with other configuration information to estimate the location of the wireless device **404**.

[0114] UL-AoA positioning may make use of the measured azimuth angle of arrival (A-AoA) and zenith angle of arrival (Z-AoA) at multiple wireless devices **402**, **406** of uplink signals transmitted from the wireless device **404**. The wireless devices **402**, **406** may measure the A-AoA and the Z-AoA of the received signals using assistance data received from the positioning server, and the resulting measurements may be used along with other configuration information to estimate the location of the wireless device **404**.

[0115] Additional positioning methods may be used for estimating the location of the wireless device **404**, such as for example, UE-side UL-AoD and/or DL-AoA. Note that data/measurements from various technologies may be combined in various ways to increase accuracy, to determine and/or to enhance certainty, to supplement/complement measurements, and/or to substitute/provide for missing information.

[0116] FIG. **5** is a diagram **500** illustrating a network entity **508** that may be configured to coordinate a wireless device **502** and a wireless device **506** to perform positioning with a wireless device **504**. The location of the wireless device **502** and the wireless device **506** may be known to at least one of the devices, such as the wireless device **502**, the wireless device **504**, the wireless device **506**, the network entity **508**, and/or the server **520**. The wireless device **502** may be a base station, a gNB, or a TRP. The wireless device **506** may be a base station, a gNB, or a TRP. The wireless device **504** may be a UE. In some aspects, the UE may be a PRU. A PRU may be a UE with a known location. For example, the PRU may be affixed in a known location or may be placed in a known location for a period of time, or the PRU may have a set of sensors (e.g., high-accuracy GNSS sensor) that may be used to accurately calculate the location of the PRU. In some aspects, the wireless device **504** may be a PRU configured to train a positioning model based on a set of inputs and a set of labels. In some aspects, the wireless device **504** may be a UE configured to use a positioning model to calculate a set of outputs based on a set of inputs, for example measurements of positioning signals. The network entity **508** may be connected to the wireless device **502** and the wireless device **506** via a physical link, for example a backhaul link or a midhaul link, or via a wireless link, such as an air interface (a UE-UTRAN (Uu)) link. The network entity **508** may be part of a core network, such as an LMF or a set of location servers. The network entity **508** may configure positioning occasions between the wireless device **502**, the wireless device **504**, and the wireless device **506**. The server **520** may be an over-the-top (OTT) server or some other server functionally connected to a network that communicates with the network entity **508**, the wireless device **502** and/or the wireless device **506**, and/or with the wireless device **504** via a wireless device, such as the wireless device **502** and/or the wireless device **506**. The server **520** may have storage for storing positioning models, for example AI/ML positioning models, trained using sets of positioning signals received by a wireless device, such as the wireless device **502**, the wireless device **504**, and/or the wireless device **506**.

[0117] To perform positioning, the network entity **508** may configure one or more of the wireless devices to transmit positioning signals at one another. For example, the wireless device **504** may transmit the set of positioning signals **512** at the wireless device **502**. The set of positioning signals **512** may be a set of SRSs, SSBs, or CSI-RSs. The wireless device **502** may measure the set of positioning signals **512**. The wireless device **502** may transmit the set of positioning signals **516** at the wireless device **504**. The set of positioning signals **516** may be a set of PRSs, SSBs, or CSI-RSs. The wireless device **504** may measure the set of positioning signals **516**. The wireless device **504** may transmit a set of positioning signals **514** at the wireless device **506**. The set of positioning signals **514** may be a set of SRSs, SSBs, or CSI-RSs. The wireless device **506** may measure the set of positioning signals **514**. The wireless device **506** may transmit a set of positioning signals **518** at the wireless device **504**. The set of positioning signals **518** may be a set of PRSs, SSBs, or CSI-RSs. The wireless device **504** may measure the set of positioning signals **518**. One or more of the wireless devices may measure the received positioning signals to calculate a positioning measurement that may be used to calculate a position/location of the wireless device **504**, or may be used to calculate a position/location of the wireless device **504**. For example, if the location of the wireless device **502** and the location of the wireless device **506** are known, the location of the wireless device **504** may be calculated based on a RTT between the wireless device **502** and the wireless device **504**, and a RTT between the wireless device **504** and the wireless device **506**. In another example, the wireless device **504** may calculate an angle of arrival (AoA) or an angle of departure (AoD) of the set of positioning signals **516**, and may calculate an AoA or an AoD of the set of positioning signals **518**. The calculated AoAs and/or AoDs may be used to calculate a position of the wireless device **504** if the location of the wireless device **502** and the location of the wireless device **506** are also known. Other measurements, such as RTOA, line-of-sight (LOS) identification (identifying whether there is a direct line-of-sight path between wireless devices), or multi-cell round trip time (multi-RTT) calculations may be performed to calculate the position of the wireless device **504**, or to calculate a measurement that may be used to calculate the position of the wireless device **504**.

[0118] In some aspects, a positioning model may be used to calculate one or more positioning metrics based on the measurements. For example, based on the measurements of the set of positioning signals **512** and/or the set of positioning signals **514** transmitted by the wireless device **504**, a position/location of the wireless device **504** may be calculated or estimated, or an intermediate measurement that may be used to calculate the position/location of the wireless device **504** may be calculated or estimated. Such a positioning metric may also be referred to as a positioning output. A positioning model may be trained using artificial intelligence (AI)/machine learning (ML) (AI/ML or AIML), based on a set of inputs (e.g., measurements of positioning signals, assistance information associated with the positioning signals) and a set of labels. A positioning signal may include any reference signal transmitted from a wireless device, such as a PRS, a SRS, an SSB, or a CSI-RS. An RS transmitted from a UE, such as a PRU, may be referred to as an uplink positioning signal, or an UL positioning signal. An RS transmitted from a base station, or TRP, may be referred to as a downlink positioning signal, or a DL positioning signal. A measurement may be a delay profile (DP), a power delay profile (PDP), a channel impulse response (CIR), a channel frequency response (CFR), or other measurement used for performing positioning on a target wireless device. A label may be a calculated, derived, or given (i.e., known) expected result associated with a set of inputs, such as a position/location of a wireless device **504** or an intermediate measurement (e.g., a timing measurement, an angle measurement, a LOS identification) that may be used to calculate the position/location of the wireless device **504**. A set of inputs and a set of labels may be used for generating and/or training a positioning model using AI/ML.

[0119] When training a positioning model, measurements of positioning signals as inputs, clean or noisy labels (clean labels may have a quality metric greater or equal to a threshold, noisy labels may have a quality metric less than or equal to the threshold) as expected outputs, and training data assistance information as inputs or expected outputs. The positioning model may operate on any wireless device based on a set of inputs. For example, the wireless device **502** may have a positioning model configured to accept a set of positioning measurements and generate an estimate of a position/location of the wireless device **504**. In another example, the wireless device **502** may have a positioning model configured to accept a set of positioning measurements and generate an intermediate measurement (e.g., a timing measurement, an angle measurement, a LOS identification) that may be used (by the wireless device **502**, or another entity, such as the network entity **508**, the wireless device **504**, or the wireless device **506**) to calculate the position/location of the wireless device **504**. In another example, the network entity **508** may have a positioning model configured to accept a set of positioning measurements and generate an estimate of a position/location of the wireless device **504**, or generate an intermediate measurement that may be used to calculate the position/location of the wireless device **504**. In another example, the wireless device **504** may have a positioning model configured to accept a set of positioning measurements and generate an estimate of a position/location of the wireless device **504**, or generate an intermediate measurement that may be used to calculate the position/location of the wireless device **504**. In some aspects, the positioning measurements may be aggregated by the entity with the positioning model, for example the network entity **508** may aggregate measurements of the set of positioning signals **512** from the wireless device **502**, measurements of the set of positioning signals **514** the wireless device **506** to use as inputs to a positioning model, measurements of the set of positioning signals **516** from the wireless device **504**, and/or measurements of the set of positioning signals **518** from the wireless device **504**.

[0120] A positioning model may be trained on a wireless device that performs positioning, such as the wireless device **502**, the wireless device **504**, the wireless device **506**, the network entity **508**, and/or the server **520**. The inputs to the positioning model may include measurements of positioning signals, such as measurements of SRS, PRS, SSB, and/or CSI-RS. The inputs to the measurements may include assistance information associated with the measured positioning signals, such as BWP of a positioning signal resource, number of TRPs, beam information, positioning signal configuration). The labels/outputs for the positioning model may include a location, or an intermediate measurement. In one aspect, the server **520** may be an OTT server configured to train and store positioning models. In another aspect, the network entity **508** may be configured to train and store positioning models. In other words, the server **520** or the network entity **508** may be a training entity configured to train positioning models based on input measurements taken by a wireless device, such as the wireless device **502**, the wireless device **504**, and/or the wireless device **506**, and based on labels either known (e.g., stored on memory) or calculated by at least one of the wireless device **502**, the wireless device **504**, the wireless device **506**, and/or the network entity **508**. A positioning model may be configured to calculate a set of outputs. The set of outputs may include, for example, position of a wireless device, a reference signal time difference (RSTD), a line of sight (LOS) indicator (e.g., whether there exists a direct line-of-sight path between wireless devices, the likelihood of whether there exists a direct line-of-sight path between wireless devices), a multipath timing indicator (e.g., a time of flight per path, a time of arrival per path with respect to a timing mark), a multipath power indicator (e.g., strength of a signal per path), a multipath phase indicator (e.g., phase of a signal per path), a reference signal received power (RSRP), and/or an angle of departure (AoD).

[0121] In some aspects, a positioning model may be configured to use measurements of positioning signals transmitted from a wireless device to calculate a position of the wireless device **504**, or to calculate an intermediate measurement that may be used to calculate the position of the wireless device **504**. The positioning model may be trained via a training entity, and may be used at the wireless device **502**, at the wireless device **504**, at the wireless device **506**, or at the network entity **508**. For example, a positioning model at the wireless device **504** may be configured to calculate the location of the wireless device **504** based on measurements of the set of positioning signals **516** and/or the set of positioning signals **518**. In another example, the wireless device **502** may transmit a set of intermediate measurements to the network entity **508** so that the network entity **508** may calculate the location of the wireless device **504** based on the set of intermediate measurements. In another example, the wireless device **504** may transmit measurements of the set of positioning signals **516** and/or the set of positioning signals **518** to the network entity **508**. The positioning model may be at the network entity **508**. The positioning model at the network entity **508** may calculate the location of the wireless device **504** based on the transmitted measurements of the set of positioning signals **516** and/or the set of positioning signals **518** from the wireless device **504**, the transmitted measurements of the set of positioning signals **512** from the wireless device **502**, and/or the transmitted measurements of the set of positioning signals **514** from the wireless device **506**. In other words, any of the wireless device **502**, the wireless device **504**, and/or the wireless device **506** may assist the network entity **508** in performing positioning using a trained positioning model.

[0122] In some aspects, a positioning model may be site-specific. For example, a first positioning model may be trained in a location, or a set of locations, associated with a first site having a first set of borders, and a second positioning model may be trained in a location, or a set of locations, associated with a second site having a second set of borders. A wireless device may be configured to use one of a plurality of site-specific positioning models. For example, the wireless device may select a site-specific positioning model based on its location, or may select a site-specific positioning model based on an indicator, for example a signal transmitted from the network entity **508** that indicates that a particular site-specific positioning model from a plurality of site-specific positioning models be selected.

[0123] Measurements of positioning signals may be performed by measuring channels between a target device (e.g., the wireless device **504**) and a set of network nodes (e.g., the wireless device **502** and the wireless device **506**). The wireless device **504** may transmit a positioning signal, such as an SRS, an SSB, or a CSI-RS. The wireless device **502** and/or the wireless device **506** may measure the positioning signal for data collection purposes to train a positioning model. The wireless device **504** and/or the wireless device **506** may transmit a positioning signal, such as a PRS, an SSB, or a CSI-RS. The wireless device **504** may measure the positioning signal for data collection purposes to train the positioning model. The wireless device **502**, the wireless device **504**, and/or the wireless device **506** may measure a positioning signal resource in a plurality of ways, for example the measurement may be a channel impulse response (CIR), a channel frequency response (CFR), a power delay profile (PDP), a delay profile (DP), a set of reflection paths, a reception-transmission (Rx-Tx) time difference, a received signal strength indicator (RSSI), a reference signal received power (RSRP), a reference signal received power per path (RSRPP), a reference signal received quality (RSRQ), a time of arrival (ToA), a time of departure (ToD), a reference signal time difference (RSTD), an angle of arrival (AoA), and/or an angle of departure (AoD).

[0124] While the diagram **500** illustrates two positioning neighbor wireless devices, wireless device **502** and wireless device **506**, configured to perform positioning with one positioning target wireless device, wireless device **504**, to calculate a position/location of the wireless device **504**, any number of positioning neighbor wireless devices may be configured to perform positioning with any number of positioning target wireless devices. For example, four positioning neighbor wireless devices may be configured to calculate the position/location of two positioning target wireless devices, three positioning neighbor wireless devices may be configured to calculate the position/location of one positioning target wireless device, or two positioning neighbor wireless devices may be configured to calculate the position/location of one positioning target wireless device.

[0125] A measurement of a positioning signal (PRS, SRS, SSB) may include a channel frequency response (CFR) measurement, a channel impulse response (CIR) measurement, a power delay profile (PDP) measurement, or a delay profile (DP) measurement. A wireless device may measure a CFR by applying channel estimation in a frequency domain based on a positioning signal sequence (e.g., a PRS sequence, an SRS sequence) mapped to a set of OFDM signals. The wireless device may measure a CIR based on a CFR, for example by applying an inverse fast Fourier transform (IFFT) to the CFR (i.e., CIR=IFFT (CFR)). The wireless device may calculate a CIR as the largest measurement size, where the CIR includes a list of measurements where each measurement contains the information of a delay, power, and phase of a positioning signal. The wireless device may subsample a CIR by applying truncation to such a CIR. The CIR may also correspond with a set of time, power/magnitude, and/or phase information that are derived from the output of an IFFT of the CFR. The wireless device may measure a PDP be calculating the absolute value of a CIR (i.e., abs (CIR)) at a particular measurement point. The wireless device may calculate a PDP by correlating a plurality of time and power information derived from the CIR. The wireless device may calculate a PDP as a smaller measurement size than the CIR, where the PDP includes a list of measurements where each measurement contains the information of a delay and power of a positioning signal. The wireless device may subsample a PDP by applying truncation to the PDP. The wireless device may calculate a DP by correlating timing information of CIR or PDP measurements with the significant power information or peak information. The wireless device may calculate a DP by correlating a plurality of timing information derived from a CIR or PDP. In some aspects, the wireless device may calculate a DP by degenerating the PDP (e.g., the timing representation of the PDP). The wireless device may calculate a DP as a smallest measurement size, where the DP includes a list of measurements where each measurement contains the information of a delay. The wireless device may subsample a DP by applying truncation to the DP.

[0126] In some aspects, a positioning model may be trained using subsampled measurements, for example truncated measurements, specific values of samples (e.g., local maximum values, local minimum values), or samples associated with specified paths (e.g., first received path, direct LOS path). A wireless device that measures positioning signals (e.g., a CIR, PDP, or DP measurement of a PRS, SRS, or SSB) may use a predefined methodology to subsample measurements to use for a positioning model. The subsampled measurements may be used to train a positioning model along with a set of labels, or may be used to calculate positioning outputs using a trained positioning model. In some aspects, where the positioning model is not on a wireless device that receives and measures positioning signals (e.g., at the network entity **508**, at the server **520**), wireless resources may be conserved by transmitting subsampled measurements to the entity with the positioning model. The wireless device receiving positioning signals may subsample a measurement (e.g., CIR/PDP/DP) of a positioning signal (e.g., PRS, SRS, SSB) using a subsampling configuration to select a subset of the measurements to report. A wireless device, for example the wireless device **502**, the wireless device **504**, or the wireless device **506**, may report subsampled measurements of a positioning signal using a predefined methodology, for example by selecting a subset of specific measurements, measurements associated with a subset of samples, or measurements associated with a subset of paths, for reporting to the device with the positioning model (e.g., the network entity **508**, the server **520**). The network entity **508** may exchange control signals with such a wireless device to ensure that subsampling is aligned between the wireless device and the device with the positioning model.

[0127] In some aspects, the wireless device may keep a plurality of subsampling configurations in device memory at a time if the subsampling configurations are frequently activated (e.g., at least once every ten minutes), allowing the wireless device to dynamically switch between subsampling configurations kept in device memory. The wireless device may be configured to activate a plurality of positioning models activated (e.g., loaded in memory and ready to use to calculate a positioning output based on input measurements), where each of the plurality of positioning models corresponds with a different subsampling configuration. In some aspects, the plurality of positioning models may consider different periodicity (e.g., alternating) of their measurement occasions to provide different positioning accuracy. In such aspects, the positioning models may appear to be running simultaneously, even if they may be utilized in an alternating fashion. For example, a positioning model with high complexity (e.g., larger processing time) may be configured to accept a first subsampling configuration running on a longer repetition of measurement occasion (e.g., every 4 measurement occasions) when compared to a positioning model with a lower complexity (e.g., lower processing time) running on a shorter repetition of measurement occasion (e.g., 3 measurement occasions in a row, then skipping one measurement occasion). The positioning model with higher complexity be more accurate than the positioning model with lower complexity, and may bolster the calculations of the positioning model with lower complexity.

[0128] In some aspects, the network entity **508** may be configured to activate a subsampling method at a wireless device (e.g., the wireless device **502**, the wireless device **504**, or the wireless device **506**) via a command issued from the network entity **508** to the wireless device. The wireless device may calculate a subsample of a set of measurements based on the activated method and report the subsampled measurements to the network entity **508**. In some aspects, a wireless device may be configured to autonomously select a configured method. The network entity **508** may provide a variety of configured methods to the wireless device, or a set of positioning models associated with the configured methods (e.g., a set of positioning model IDs that have been trained using the configured methods). The wireless device may calculate a subsample of a set of measurements based on the activated method and report the subsampled measurements to the network entity **508** along with an indicator of the autonomously selected configured method.

[0129] As used herein, a subsample may include a selected path of a set of paths received by the wireless device or a selected sample of a set of samples received by the wireless device. A sample may refer to a signal processing entity that is correlated with a set of timing information, power/magnitude information, and phase information. A path may refer to a geometrical description of a signal trajectory from a transmitting device to a receiving device. A path may also be correlated with a set of timing information, power/magnitude information, and phase information. A subsample may correspond with a path. A subsample may be used to describe a path. A wireless device may process a set of samples to obtain timing, power/magnitude, and phase information associated with a path. For example, a wireless device may apply interpolation between samples to obtain timing, power/magnitude, and phase information associated with a path. In another example, a wireless device may apply a super resolution method (e.g., multiple signal classification (MUSIC) or matrix pencil) to obtain timing, power/magnitude, and phase information associated with a path.

[0130] FIG. **6**A is a diagram **600** illustrating an example of a positioning model **602**. The positioning model **602** may be trained using direct positioning labels. For example, the positioning model **602** may be trained using a set of measurement inputs **604** and a set of label inputs **603**. The set of measurement inputs **604** may include, for example, a set of measurements of SRS positioning signals, a set of measurements of PRS positioning signals, and/or a set of measurements of SSB positioning signals. The measurements may include a CFR, a CIR, a PDP, and/or a DP. The set of label inputs **603** may include, for example, a location of a wireless device, for example a PRU/UE with a known location, or a sensor that can accurately calculate the location of the wireless device (e.g., a GPS sensor, a camera). The positioning model **602** may be trained using AI/ML techniques to calculate the set of label inputs **603** based on the set of measurement inputs **604**.

[0131] Once the positioning model **602** is trained, the positioning model **602** may be used to calculate a set of outputs **606** based on the set of measurement inputs **604**. The set of outputs **606** may include an estimate of the location of a wireless device that received and measured a set of positioning signals, or that transmitted a set of positioning signals for measuring at another wireless device. The positioning model **602** may be referred to as a direct positioning model that directly calculates a location of a wireless device. In some aspects, the positioning model **602** may be trained using AI/ML techniques, in which case the positioning model **602** may be referred to as a direct AI/ML positioning model.

[0132] FIG. **6**B is a diagram **650** illustrating an example of a positioning model **652**. The positioning model **652** may be trained using intermediate measurement labels. Intermediate measurements may be measurements that may be used to calculate a location of a wireless device. For example, the positioning model **652** may be trained using a set of inputs **654** and a set of labels **653**. The set of inputs **654** may include, for example, a set of measurements of SRS positioning signals, a set of measurements of PRS positioning signals, and/or a set of measurements of SSB positioning signals. The measurements may include a CFR, a CIR, a PDP, and/or a DP. The set of labels **653** may include, for example, a set of timing measurements (e.g., ToA, ToD), a set of angle measurements (e.g., AoA, AoD), or a line-of-sight (LOS) identification (e.g., a probability that there exists a direct line of sight between a wireless device that transmits a positioning signal and a wireless device that receives a positioning signal). The set of labels **653** may be obtained by known environmental conditions, for example a training entity may know that there exists a barrier that blocks a direct LOS between two wireless devices, or a training entity may know the AoD of a positioning signal that is transmitted from a wireless device. The wireless device may be a PRU/UE in a known environment where intermediate measurements are known. The positioning model **652** may be trained using AI/ML techniques to calculate the set of labels **653** based on the set of inputs **654**.

[0133] Once the positioning model **652** is trained, the positioning model **652** may be used to calculate a set of outputs **656** based on the set of inputs **654**. The set of outputs **656** may include an intermediate measurement that may be used to calculate a location of a wireless device associated with the intermediate measurement (e.g., the wireless device may transmit or receive a positioning signal associated with the intermediate measurement). A device may then use the set of outputs **656** to calculate a location of a wireless device, for example by feeding the set of outputs **656** into a positioning calculation **658** to calculate a set of outputs **660**. The positioning calculation **658** may include, for example, a non-AI algorithm (e.g., a Chan algorithm, a Kalman Filter (KF)), or an AI positioning model that is trained using a set of intermediate measurements and a known location of a wireless device. The wireless device used to train the positioning model **652** may be a different wireless device used to train the positioning calculation **658**. The positioning model **652** may be referred to as an indirect positioning model that indirectly calculates a location of a wireless device by providing intermediate measurements that may be used by another technique, or another device, to calculate the location of a wireless device. In some aspects, the positioning model **652** may be trained using AI/ML techniques, in which case the positioning model **652** may be referred to as an indirect AI/ML positioning model.

[0134] FIG. **7**A is a diagram **700** illustrating an example of a wireless device **706** with a positioning model **708**. The wireless device **706** may store the positioning model **708** on a local memory of the wireless device **706**, or may access the positioning model **708** on an accessible device, for example a cloud server or an over the top (OTT) server. The positioning model **708** may include a direct positioning model used to calculate the location of the wireless device **706**, or may include an indirect positioning model used to calculate an intermediate measurement associated with the wireless device **706**, which the wireless device **706** may use to calculate its location (e.g., using a KF or a direct positioning model). The wireless device **706** may include a UE or a PRU used to train the positioning model **708** or to use the positioning model **708** to calculate the location of the wireless device **706**.

[0135] The wireless device **704** may be a device that transmits positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The network entity **702** may include a core network device, an LMF, or a set of location servers. The wireless device **704** may transmit a set of positioning signals **710**. The wireless device **706** may receive the set of positioning signals **710** transmitted by the wireless device **704**. The positioning signals **710** may include a set of PRSs or a set of SSBs. The wireless device **706** may measure the set of positioning signals **710** and may input the measurements of the positioning signals **710** into the positioning model **708**, for example to train the positioning model **708**, to calculate the location of the wireless device **706**, or to calculate an intermediate measurement that may be used by the wireless device **706** to calculate the location of the wireless device **706**. The wireless device **706** may transmit an indication of a location **712** to a network entity **702**. The network entity **702** may receive the indication of the location **712** from the wireless device **706**. The network entity **702** may determine the location of the wireless device **706** based on the indication of the location **712**.

[0136] FIG. **7**B is a diagram **750** illustrating an example of a wireless device **756** with a positioning model **758**. The wireless device **756** may store the positioning model **758** on a local memory of the wireless device **756**, or may access the positioning model **758** on an accessible device, for example a cloud server or an OTT server. The positioning model **758** may include an indirect positioning model used to calculate an intermediate measurement associated with the wireless device **756**, which the network entity **752** may use to calculate the location of the wireless device **756** (e.g., using a KF or a direct positioning model). The wireless device **756** may include a UE or a PRU used to train the positioning model **758** or to use the positioning model **758** to calculate an intermediate measurement associated with the wireless device **756**.

[0137] The wireless device **754** may be a device that transmits positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The network entity **752** may include a core network device, an LMF, or a set of location servers. The wireless device **754** may transmit a set of positioning signals **760**. The wireless device **756** may receive the set of positioning signals **760** transmitted by the wireless device **754**. The positioning signals **760** may include a set of PRSs or a set of SSBs. The wireless device **756** may measure the set of positioning signals **760** and may input the measurements of the positioning signals **760** into the positioning model **758**, for example to train the positioning model **758** or to calculate an intermediate measurement that may be used by the network entity **752** to calculate the location of the wireless device **756**. The wireless device **756** may transmit an indication of the set of outputs **762** calculated by the positioning model **758** to a network entity **752**. The network entity **752** may receive the indication of the set of outputs **762** from the wireless device **756**. The network entity **752** may calculate the location of the wireless device **756** based on the indication of the set of outputs **762**, for example by feeding the set of outputs **762** into an algorithm (e.g., a Chan algorithm, a KF) or a direct positioning model. In some aspects, the network entity **752** may calculate the location of the wireless device **756** based on a plurality of measurements received by a plurality of wireless devices. For example, the wireless device **754** may receive a set of positioning signals from the wireless device **756**, may measure the set of positioning signals, and may transmit the measurements to the network entity **752** for the calculation of the location of the wireless device **756**. The measurements may include, for example, intermediate measurements calculated using another indirect positioning model, or may include direct measurements of the positioning signals. In another example, the wireless device **756** may transmit the measurements of the set of positioning signals **760** to the network entity **752** in addition to the set of outputs from the positioning model **758**.

[0138] FIG. **8**A is a diagram **800** illustrating an example of a network entity **802** with a positioning model **808**. The network entity **802** may store the positioning model **808** on a local memory of the network entity **802**, or may access the positioning model **808** on an accessible device, for example a cloud server or an OTT server. The positioning model **808** may include a direct positioning model used to calculate the location of the wireless device **806**, or may include an indirect positioning model used to calculate an intermediate measurement associated with the wireless device **806**, which the network entity **802** may use to calculate the location of the wireless device **806** (e.g., using a KF or a direct positioning model). The network entity **802** may include a core network device, such as an LMF or a set of location servers, or may include a server, for example an OTT server, used to train the positioning model **808** or to use the positioning model **808** to calculate the location of the wireless device **806**.

[0139] The wireless device **804** may be a device that transmits positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The wireless device **806** may be a device that receives and measures positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The wireless device **804** may transmit a set of positioning signals **810**. The wireless device **806** may receive the set of positioning signals **810** transmitted by the wireless device **804**. The positioning signals **810** may include a set of PRSs or a set of SSBs. The wireless device **806** may measure the set of positioning signals **810** and may transmit an indication of the set of measurements **812** (e.g., an indication of a CFR, CIR, PDP, or DP) to the network entity **802**. The network entity **802** may input a representation of the indication of the set of measurements **812** into the positioning model **808**, for example to train the positioning model **808**, to calculate the location of the wireless device **806**, or to calculate an intermediate measurement that may be used by the wireless device **806** to calculate the location of the wireless device **806**. The network entity **802** may determine the location of the wireless device **806** based on the calculation by the positioning model **808**. In some aspects, the network entity **802** may collect a set of measurements from a plurality of devices to input into the positioning model **808**. For example, the wireless device **804** may receive a set of positioning signals (e.g., a set of SSBs, a set of SRSs) from the wireless device **806**, may measure the set of positioning signals, and may transmit the measurements to the network entity **802**, which the network entity **802** may use to calculate the location of the wireless device **806**, or may use as an input into the positioning model **808**.

[0140] FIG. **8**B is a diagram **830** illustrating an example of a network entity **832** with a positioning model **838**. The network entity **832** may store the positioning model **838** on a local memory of the network entity **832**, or may access the positioning model **838** on an accessible device, for example a cloud server or an OTT server. The positioning model **838** may include a direct positioning model used to calculate the location of the wireless device **836**, or may include an indirect positioning model used to calculate an intermediate measurement associated with the wireless device **836**, which the network entity **832** may use to calculate the location of the wireless device **836** (e.g., using a KF or a direct positioning model). The network entity **832** may include a core network device, such as an LMF or a set of location servers, or may include a server, for example an OTT server, used to train the positioning model **838** or to use the positioning model **838** to calculate the location of the wireless device **836**.

[0141] The wireless device **836** may be a device that transmits positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The wireless device **834** may be a device that receives and measures positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The wireless device **836** may transmit a set of positioning signals **840**. The wireless device **834** may receive the set of positioning signals **840** transmitted by the wireless device **836**. The positioning signals **840** may include a set of SRSs or a set of SSBs. The wireless device **834** may measure the set of positioning signals **840** and may transmit an indication of the set of measurements **842** (e.g., an indication of a CFR, CIR, PDP, or DP) to the network entity **832**. The network entity **832** may input a representation of the indication of the set of measurements **842** into the positioning model **838**, for example to train the positioning model **838**, to calculate the location of the wireless device **836**, or to calculate an intermediate measurement that may be used by the wireless device **836** to calculate the location of the wireless device **836**. The network entity **832** may determine the location of the wireless device **836** based on the calculation by the positioning model **838**. In some aspects, the network entity **832** may collect a set of measurements from a plurality of devices to input into the positioning model **838**. For example, the wireless device **836** may receive a set of positioning signals (e.g., a set of SSBs, a set of PRSs) from the wireless device **834**, may measure the set of positioning signals, and may transmit the measurements to the network entity **832**, which the network entity **832** may use to calculate the location of the wireless device **836**, or may use as an input into the positioning model **838**.

[0142] FIG. **8C** is a diagram **860** illustrating an example of a wireless device **864** with a positioning model **868**. The wireless device **864** may store the positioning model **868** on a local memory of the wireless device **864**, or may access the positioning model **868** on an accessible device, for example a cloud server or an OTT server. The positioning model **868** may include an indirect positioning model used to calculate an intermediate measurement associated with the wireless device **866**, which the network entity **862** may use to calculate the location of the wireless device **866** (e.g., using a KF or a direct positioning model). The wireless device **864** may include a base station, a network node, or a TRP used to train the positioning model **868** or to use the positioning model **868** to calculate an intermediate measurement associated with the wireless device **866**.

[0143] The wireless device **866** may be a device that transmits positioning signals, for example a network node, a UE, a PRU, a base station, or a TRP. The network entity **862** may include a core network device, an LMF, or a set of location servers. The wireless device **866** may transmit a set of positioning signals **870**. The wireless device **864** may receive the set of positioning signals **870** transmitted by the wireless device **866**. The positioning signals **870** may include a set of SRSs or a set of SSBs. The wireless device **864** may measure the set of positioning signals **870** and may input the measurements of the positioning signals **870** into the positioning model **868**, for example to train the positioning model **868** or to calculate an intermediate measurement that may be used by the network entity **862** to calculate the location of the wireless device **866**. The wireless device **864** may transmit an indication of the set of outputs **872** calculated by the positioning model **868** to a network entity **862**. The network entity **862** may receive the indication of the set of outputs **872** from the wireless device **864**. The network entity **862** may calculate the location of the wireless device **866** based on the indication of the set of outputs **872**, for example by feeding the set of outputs **872** into an algorithm (e.g., a Chan algorithm, a KF) or a direct positioning model. In some aspects, the network entity **862** may calculate the location of the wireless device **866** based on a plurality of measurements received by a plurality of wireless devices. For example, the wireless device **866** may receive a set of positioning signals (e.g., PRSs, SSBs) from the wireless device **864**, may measure the set of positioning signals, and may transmit the measurements to the network entity **862** for the calculation of the location of the wireless device **866**. The measurements may include, for example, intermediate measurements calculated using another indirect positioning model, or may include direct measurements of the positioning signals. In another example, the wireless device **864** may transmit the measurements of the set of positioning signals **870** to the network entity **862** in addition to the set of outputs from the positioning model **868**.

[0144] FIG. **9** is a connection flow diagram **900** illustrating an example of a network entity **906** configured to configure subsampling of measurements of a set of positioning signals (e.g., SRS, PRS, SSB) for a positioning target wireless device **902**. The positioning target wireless device **902** may be a UE or a PRU. The set of positioning neighbor wireless devices **904** may include a set of base stations and/or a set of TRPs. The network entity **906** may include an LMF or a set of location servers.

[0145] The network entity **906** may transmit a capability request **908** to the positioning target wireless device **902**. The positioning target wireless device **902** may receive the capability request **908** from the network entity **906**. The positioning target wireless device **902** may transmit a subsampling capability **910** to the network entity **906**. The network entity **906** may receive the subsampling capability **910** from the positioning target wireless device **902**. The subsampling capability **910** may indicate to the network entity **906** which subsampling configurations/methods the positioning target wireless device **902** supports to sub-select measurements of positioning signals. The positioning target wireless device **902** may transmit the subsampling capability **910** as a long-term evolution (LTE) positioning protocol (LPP) message, for example as part of an assistance data exchange procedure, as part of an assistance information exchange procedure, as part of a provide location request procedure, or as part of a broadcast information (positioning system information block (posSIB) procedure.

[0146] At **912**, the network entity **906** may configure subsampling of the measurements of the set of positioning signals **922** by the positioning target wireless device **902**. The network entity **906** may transmit a plurality of subsampling configurations **914** to the positioning target wireless device **902**. The positioning target wireless device **902** may receive the plurality of subsampling configurations **914** from the network entity **906**. The plurality of subsampling configurations **914** may include an indicator of a plurality of subsampling configurations/methods to determine path/sample measurements for use with a positioning model, for example for training a set of AI/ML positioning models, or for using a set of AI/ML positioning models to calculate a location of the positioning target wireless device **902** or an intermediate measurement that may be used to calculate the location of the positioning target wireless device **902**.

[0147] At **916**, the network entity **906** may configure positioning for the positioning target wireless device **902** and the set of positioning neighbor wireless devices **904**. The configuration may include a configuration for the set of positioning neighbor wireless devices **904** to transmit a set of positioning signals **922** at the positioning target wireless device **902**, and for the positioning target wireless device **902** to measure the set of positioning signals **922** received from the set of positioning neighbor wireless devices **904** for a set of positioning models.

[0148] The network entity **906** may transmit a set of positioning configurations **918** at the positioning target wireless device **902**. The positioning target wireless device **902** may receive the set of positioning configurations **918** from the network entity **906**. The network entity may transmit a set of positioning configurations **920** at the set of positioning neighbor wireless devices **904**. The set of positioning neighbor wireless devices **904** may receive the set of positioning configurations **920** from the network entity **906**. The set of positioning neighbor wireless devices **904** may transmit the signals **922** at the positioning target wireless device **902** based on the set of positioning configurations **920** received from the network entity **906**. The set of positioning signals **922** may include a set of positioning RSs, for example PRSs, and/or SSBs.

[0149] At **924**, the positioning target wireless device **902** may measure the set of positioning signals **922**. At **926**, the positioning target wireless device **902** may apply one of the plurality of subsampling configurations **914** to one or more of the set of measured positioning signals. In other words, the positioning target wireless device **902** may measure the set of positioning signals **922** based on the plurality of subsampling configurations **914**. For example, the positioning target wireless device **902** may determine path/sample measurements using one of the plurality of methods indicated by the plurality of subsampling configurations **914**. The positioning target wireless device **902** may select the subsampling configuration selected from the plurality of subsampling configurations **914** based on a signal received from the network entity **906** (e.g., an RRC, a MAC-CE, DCI, or posSIB with an indicator indicating one of the plurality of subsampling configurations **914**). The positioning target wireless device **902** may autonomously select the subsampling configuration selected from the plurality of subsampling configurations **914**, for example in response to an environmental trigger (e.g., select a first subsampling configuration of the plurality of subsampling configurations **914** in response to an RSRP of a measured positioning signal is greater than or equal to a threshold value, and a second subsampling configuration of the plurality of subsampling configurations **914** in response to the RSRP of the measured positioning signal being less than or equal to the threshold value).

[0150] In some aspects, the selected subsampling configuration may include applying a transform to a subsampling response (e.g., IFFT). In some aspects, the selected subsampling configuration may include truncating a CFR (e.g., truncating frequency-domain consecutive samples/paths/measurements). In some aspects, the selected subsampling configuration may include truncating a transform output (e.g., an output of an IFFT). In some aspects, the truncation may include truncating time-domain consecutive samples/paths/measurements whose magnitude is greater than or equal to a threshold value. In some aspects, the threshold value may be defined as a dB value below an offset value of a maximum measured magnitude of a set of measurements. In some aspects, the selected subsampling configuration may include sub-selecting a number of strongest measured power/magnitude values. In some aspects, the selected subsampling configuration may include sub-selecting a number of highest measured peaks. In some aspects, the selected subsampling configuration may include sub-selecting a set of outputs of a super resolution approach (e.g., multiple signal classification (MUSIC) or matrix pencil). In some aspects, the selected subsampling configuration may include sub-selecting a set of measurements based on a minimum delay. For example, the positioning target wireless device **902** may determine a sample/path with a measured magnitude that is greater than or equal to a threshold value as a first path, and may sub-select samples/paths adjacent that have a timing within a second threshold value of the first path. In some aspects, the selected subsampling configuration may include a combination of the above (e.g., applying a transform, a truncation of the transform output, and sub-selecting from the truncated values by a criteria, such as strongest power or minimum delay).

[0151] At **928**, the positioning target wireless device **902** may calculate a set of outputs using a positioning model based on the subsampled measurements of the positioning signals. The positioning target wireless device **902** may transmit a set of positioning reports **930** to the network entity **906** based on the calculation at **928**. The network entity **906** may receive the set of positioning reports **930** from the positioning target wireless device **902**. The set of positioning reports **930** may include at least some of the outputs from the positioning model calculation at **928**. The set of positioning reports **930** may include an indicator of the applied determination from the plurality of subsampling configurations **914** used by the positioning target wireless device **902** along with the calculated set of outputs.

[0152] In some aspects, the set of positioning reports **930** may include an indicator of the subsampled measurements calculated at **926**, and the network entity **906** may use the subsampled measurements on a set of positioning models. The network entity **906** may collect a set of subsampled measurements from a plurality of wireless devices, for example the set of positioning neighbor wireless devices **904** in addition to the positioning target wireless device **902**.

[0153] FIG. **10** is a connection flow diagram **1000** illustrating an example of a network entity **1006** configured to configure subsampling of measurements of a set of positioning signals (e.g., SRS, PRS, SSB) for one of a set of positioning neighbor wireless devices **1004**. The positioning target wireless device **1002** may be a UE or a PRU. The set of positioning neighbor wireless devices **1004** may include a set of base stations and/or a set of TRPs. The network entity **1006** may include an LMF or a set of location servers.

[0154] The network entity **1006** may transmit a capability request **1008** to one of the set of positioning neighbor wireless devices **1004**. The one of the set of positioning neighbor wireless devices **1004** may receive the capability request **1008** from the network entity **1006**. The one of the set of positioning neighbor wireless devices **1004** may transmit a subsampling capability **1010** to the network entity **1006**. The network entity **1006** may receive the subsampling capability **1010** from the one of the set of positioning neighbor wireless devices **1004**. The subsampling capability **1010** may indicate to the network entity **906** which subsampling configurations/methods the one of the set of positioning neighbor wireless devices **1004** supports to sub-select measurements of positioning signals. The one of the set of positioning neighbor wireless devices **1004** may transmit the subsampling capability **1010** as a new radio positioning protocol (NRPP) message, for example as part of an assistance data exchange procedure, as part of a TRP information exchange procedure, or as part of a capability exchange procedure.

[0155] At **1012**, the network entity **1006** may configure subsampling of the measurements of the set of positioning signals **1022** by the one of the set of positioning neighbor wireless devices **1004**. The network entity **1006** may transmit a plurality of subsampling configurations **1014** to the one of the set of positioning neighbor wireless devices **1004**. The one of the set of positioning neighbor wireless devices **1004** may receive the plurality of subsampling configurations **1014** from the network entity **1006**. The plurality of subsampling configurations **1014** may include an indicator of a plurality of subsampling configurations/methods to determine path/sample measurements for use with a positioning model, for example for training a set of AI/ML positioning models, or for using a set of AI/ML positioning models to calculate a location of the positioning target wireless device **1002** or an intermediate measurement that may be used to calculate the location of the positioning target wireless device **1002**.

[0156] At **1016**, the network entity **1006** may configure positioning for the positioning target wireless device **1002** and the set of positioning neighbor wireless devices **1004**. The configuration may include a configuration for the set of positioning neighbor wireless devices **1004** to transmit a set of positioning signals **1022** at the positioning target wireless device **1002**, and for the positioning target wireless device **1002** to measure the set of positioning signals **1022** received from the set of positioning neighbor wireless devices **1004** for a set of positioning models.

[0157] The network entity **1006** may transmit a set of positioning configurations **1018** at the positioning target wireless device **1002**. The positioning target wireless device **1002** may receive the set of positioning configurations **1018** from the network entity **1006**. The network entity may transmit a set of positioning configurations **1020** at the set of positioning neighbor wireless devices **1004**. The set of positioning neighbor wireless devices **1004** may receive the set of positioning configurations **1020** from the network entity **1006**. The positioning target wireless device **1002** may transmit the signals **1022** at the set of positioning neighbor wireless devices **1004** based on the set of positioning configurations **1020** received from the network entity **1006**. The set of positioning signals **1022** may include a set of positioning RSs, for example SRSs and/or SSBs.

[0158] At **1024**, the set of positioning neighbor wireless devices **1004** may measure the set of positioning signals **1022**. At **1026**, at least one of the set of positioning neighbor wireless devices **1004** may apply one of the plurality of subsampling configurations **1014** to one or more of the set of measured positioning signals. In other words, the one of the set of positioning neighbor wireless devices **1004** may measure the set of positioning signals **1022** based on the plurality of subsampling configurations **1014**. For example, the one of the set of positioning neighbor wireless devices **1004** may determine path/sample measurements using one of the plurality of methods indicated by the plurality of subsampling configurations **1014**. The one of the set of positioning neighbor wireless devices **1004** may select the subsampling configuration selected from the plurality of subsampling configurations **1014** based on a signal received from the network entity **1006** (e.g., an RRC, a MAC-CE, or posSIB with an indicator indicating one of the plurality of subsampling configurations **1014**). The one of the set of positioning neighbor wireless devices **1004** may autonomously select the subsampling configuration selected from the plurality of subsampling configurations **1014**, for example in response to an environmental trigger (e.g., select a first subsampling configuration of the plurality of subsampling configurations **1014** in response to an RSRP of a measured positioning signal is greater than or equal to a threshold value, and a second subsampling configuration of the plurality of subsampling configurations **1014** in response to the RSRP of the measured positioning signal being less than or equal to the threshold value).

[0159] In some aspects, the selected subsampling configuration may include applying a transform to a subsampling response (e.g., IFFT). In some aspects, the selected subsampling configuration may include truncating a CFR (e.g., truncating frequency-domain consecutive samples/paths/measurements). In some aspects, the selected subsampling configuration may include truncating a transform output (e.g., an output of an IFFT). In some aspects, the truncation may include truncating time-domain consecutive samples/paths/measurements whose magnitude is greater than or equal to a threshold value. In some aspects, the threshold value may be defined as a dB value below an offset value of a maximum measured magnitude of a set of measurements. In some aspects, the selected subsampling configuration may include sub-selecting a number of strongest measured power/magnitude values. In some aspects, the selected subsampling configuration may include sub-selecting a number of highest measured peaks. In some aspects, the selected subsampling configuration may include sub-selecting a set of outputs of a super resolution approach (e.g., MUSIC or matrix pencil). In some aspects, the selected subsampling configuration may include sub-selecting a set of measurements based on a minimum delay. For example, the one of the set of positioning neighbor wireless devices **1004** may determine a sample/path with a measured magnitude that is greater than or equal to a threshold value as a first path, and may sub-select samples/paths adjacent that have a timing within a second threshold value of the first path. In some aspects, the selected subsampling configuration may include a combination of the above (e.g., applying a transform, a truncation of the transform output, and sub-selecting from the truncated values by a criteria, such as strongest power or minimum delay).

[0160] At **1028**, the one of the set of positioning neighbor wireless devices **1004** may calculate a set of outputs using a positioning model based on the subsampled measurements of the positioning signals. The one of the set of positioning neighbor wireless devices **1004** may transmit a set of positioning reports **1030** to the network entity **1006** based on the calculation at **1028**. The network entity **1006** may receive the set of positioning reports **1030** from the one of the set of positioning neighbor wireless devices **1004**. The set of positioning reports **1030** may include at least some of the outputs from the positioning model calculation at **1028**. The set of positioning reports **1030** may include an indicator of the applied determination from the plurality of subsampling configurations **1014** used by the one of the set of positioning neighbor wireless devices **1004** along with the calculated set of outputs.

[0161] In some aspects, the set of positioning reports **1030** may include an indicator of the subsampled measurements calculated at **1026**, and the network entity **1006** may use the subsampled measurements on a set of positioning models. The network entity **1006** may collect a set of subsampled measurements from a plurality of wireless devices, for example the positioning target wireless device **1002** in addition to the set of positioning neighbor wireless devices **1004**.

[0162] FIG. **11** is a flowchart **1100** of a method of wireless communication. The method may be performed by a wireless device (e.g., the UE **104**, the UE **350**; the base station **102**, the base station **310**; the wireless device **402**, the wireless device **404**, the wireless device **406**, the wireless device **502**, the wireless device **504**, the wireless device **506**; the positioning target wireless device **902**, the positioning target wireless device **1002**; at least one of the set of positioning neighbor wireless devices **904**, at least one of the set of positioning neighbor wireless devices **1004**; the apparatus **1304**; the network entity **1302**, the network entity **1402**, the network entity **1560**). At **1102**, the wireless device may select a subsampling configuration from a plurality of subsampling configurations. For example, **1102** may be performed by the positioning target wireless device **902** in FIG. **9**, which may select a subsampling configuration from the plurality of subsampling configurations **914** indicated by the network entity **906**. In another example, **1102** may be performed by one of the set of positioning neighbor wireless devices **1004** in FIG. **10**, which may select a subsampling configuration from the plurality of subsampling configurations **1014** indicated by the network entity **1006**. Moreover, **1102** may be performed by the component **198** in FIG. **1**, **3**, **13**, **14**, or **15**.

[0163] At **1104**, the wireless device may receive a set of positioning signals. For example, **1104** may be performed by the positioning target wireless device **902** in FIG. **9**, which may receive the set of positioning signals **922** from the set of positioning neighbor wireless devices **904**. In another example, **1104** may be performed by one of the set of positioning neighbor wireless devices **1004** in FIG. **10**, which may receive the set of positioning signals **1022** from the positioning target wireless device **902**. Moreover, **1104** may be performed by the component **198** in FIG. **1**, **3**, **13**, **14**, or **15**.

[0164] At **1106**, the wireless device may measure the received set of positioning signals. For example, **1106** may be performed by the positioning target wireless device **902** in FIG. **9**, which may, at **924**, measure the received set of positioning signals. In another example, **1106** may be performed by one of the set of positioning neighbor wireless devices **1004** in FIG. **10**, which may, at **1024**, measure the received set of positioning signals. Moreover, **1106** may be performed by the component **198** in FIG. **1**, **3**, **13**, **14**, or **15**.

[0165] At **1108**, the wireless device may calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. For example, **1108** may be performed by the positioning target wireless device **902** in FIG. **9**, which may, at **926**, calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. In another example, **1108** may be performed by one of the set of positioning neighbor wireless devices **1004** in FIG. **10**, which may, at **1026**, calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. Moreover, **1108** may be performed by the component **198** in FIG. **1**, **3**, **13**, **14**, or **15**.

[0166] At **1110**, the wireless device may output the calculated subset of measurements to a positioning model. For example, **1110** may be performed by the positioning target wireless device **902** in FIG. **9**, which may, at **928**, output the calculated subset of measurements to a set of positioning models. In some aspects, the positioning target wireless device **902** may transmit the set of positioning reports **930** that include the calculated subset of measurements to the network entity **906**, which may then use the calculated subset of measurements with a set of positioning models. In another example, **1110** may be performed by at least one of the set of positioning neighbor wireless devices **1004** in FIG. **10**, which may, at **1028**, output the calculated subset of measurements to a set of positioning models. In some aspects, at least one of the one of the set of positioning neighbor wireless devices **1004** may transmit the set of positioning reports **1030** to the network entity **1006**, which may then use the calculated subset of measurements with a set of positioning models. Moreover, **1110** may be performed by the component **198** in FIG. **1**, **3**, **13**, **14**, or **15**.

[0167] FIG. **12** is a flowchart **1200** of a method of wireless communication. The method may be performed by a network entity (e.g., the base station **102**, the base station **310**; the core network **120**; one or more location servers **168**; the LMF **166**; the network entity **1302**, the network entity **1402**, the network entity **1560**). At **1202**, the network entity may transmit an indicator of a plurality of subsampling configurations. For example, **1202** may be performed by the network entity **906** in FIG. **9**, which may transmit an indicator of the plurality of subsampling configurations **914** to the positioning target wireless device **902**. Moreover, **1202** may be performed by the component **199** in FIG. **1**, **3**, **14**, or **15**.

[0168] At **1204**, the network entity may receive a positioning report. The positioning report may include at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations. For example, **1204** may be performed by the network entity **906** in FIG. **9**, which may receive set of positioning reports **930** from the positioning target wireless device **902**. The set of positioning reports **930** may include at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations. Moreover, **1204** may be performed by the component **199** in FIG. **1**, **3**, **14**, or **15**.

[0169] FIG. **13** is a diagram **1300** illustrating an example of a hardware implementation for an apparatus **1304**. The apparatus **1304** may be a UE, a component of a UE, or may implement UE functionality. In some aspects, the apparatus **1304** may include at least one cellular baseband processor **1324** (also referred to as a modem) coupled to one or more transceivers **1322** (e.g., cellular RF transceiver). The cellular baseband processor(s) **1324** may include at least one on-chip memory **1324'**. In some aspects, the apparatus **1304** may further include one or more subscriber identity modules (SIM) cards **1320** and at least one application processor **1306** coupled to a secure digital (SD) card **1308** and a screen **1310**. The application processor(s) **1306** may include on-chip memory **1306'**. In some aspects, the apparatus **1304** may further include a Bluetooth module **1312**, a WLAN module **1314**, an SPS module **1316** (e.g., GNSS module), one or more sensor modules **1318** (e.g., barometric pressure sensor/altimeter; motion sensor such as inertial measurement unit (IMU), gyroscope, and/or accelerometer(s); light detection and ranging (LIDAR), radio assisted detection and ranging (RADAR), sound navigation and ranging (SONAR), magnetometer, audio and/or other technologies used for positioning), additional memory modules **1326**, a power supply **1330**, and/or a camera **1332**. The Bluetooth module **1312**, the WLAN module **1314**, and the SPS module **1316** may include an on-chip transceiver (TRX) (or in some cases, just a receiver (RX)). The Bluetooth module **1312**, the WLAN module **1314**, and the SPS module **1316** may include their own dedicated antennas and/or utilize the antennas **1380** for communication. The cellular baseband processor(s) **1324** communicates through the transceiver(s) **1322** via one or more antennas **1380** with the UE **104** and/or with an RU associated with a network entity **1302**. The cellular baseband processor(s) **1324** and the application processor(s) **1306** may each include a computer-readable medium/memory **1324'**, **1306'**, respectively. The additional memory modules **1326** may also be considered a computer-readable medium/memory. Each computer-readable medium/memory **1324'**, **1306'**, **1326** may be non-transitory. The cellular baseband processor(s) **1324** and the application processor(s) **1306** are each responsible for general processing, including the execution of software stored on the computer-readable medium/memory. The software, when executed by the cellular baseband processor(s) **1324**/application processor(s) **1306**, causes the cellular baseband processor(s) **1324**/application processor(s) **1306** to perform the various functions described supra. The cellular baseband processor(s) **1324** and the application processor(s) **1306** are configured to perform the various functions described supra based at least in part of the information stored in the memory. That is, the cellular baseband processor(s) **1324** and the application processor(s) **1306** may be configured to perform a first subset of the various functions described supra without information stored in the memory and may be configured to perform a second subset of the various functions described supra based on the information stored in the memory. The computer-readable medium/memory may also be used for storing data that is manipulated by the cellular baseband processor(s) **1324**/application processor(s) **1306** when executing software. The cellular baseband processor (s) **1324**/application processor(s) **1306** may be a component of the UE **350** and may include the at least one memory **360** and/or at least one of the TX processor **368**, the RX processor **356**, and the controller/processor **359**. In one configuration, the apparatus **1304** may be at least one processor chip (modem and/or application) and include just the cellular baseband processor(s) **1324** and/or the application processor(s) **1306**, and in another configuration, the apparatus **1304** may be the entire UE (e.g., see UE **350** of FIG. **3**) and include the additional modules of the apparatus **1304**.

[0170] As discussed supra, the component **198** may be configured to select a subsampling configuration from a plurality of subsampling configurations. The component **198** may be configured to receive a set of positioning signals. The component **198** may be configured to measure the received set of positioning signals. The component **198** may be configured to calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The component **198** may be configured to output the calculated subset of measurements to a positioning model, for example by training the positioning model based on the calculated subset of measurements, by calculating a set of positioning outputs based on the calculated subset of measurements, or by transmitting the calculated subset of measurements for the positioning model. The component **198** may be within the cellular baseband processor(s) **1324**, the application processor(s) **1306**, or both the cellular baseband processor(s) **1324** and the application processor(s) **1306**. The component **198** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. When multiple processors are implemented, the multiple processors may perform the stated processes/algorithm individually or in combination. As shown, the apparatus **1304** may include a variety of components configured for various functions. In one configuration, the apparatus **1304**, and in particular the cellular baseband processor(s) **1324** and/or the application processor (s) **1306**, may include means for selecting a subsampling configuration from a plurality of subsampling configurations. The apparatus **1304** may include means for receiving a set of positioning signals. The apparatus **1304** may include means for measuring the set of positioning signals. The apparatus **1304** may include means for calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The apparatus **1304** may include means for outputting the calculated subset of measurements to a positioning model. The apparatus **1304** may include means for outputting the calculated subset of measurements to the positioning model by at least one of (a) training the positioning model based on the calculated subset of measurements, (b) calculating a set of positioning outputs based on the calculated subset of measurements, or (c) transmitting the calculated subset of measurements for the positioning model. The apparatus **1304** may include means for transmitting the calculated set of positioning outputs after the calculation of the set of positioning outputs. The apparatus **1304** may include means for receiving the plurality of subsampling configurations before the selection of the subsampling configuration. The apparatus **1304** may include means for transmitting a positioning report. The positioning report may include an indicator of the selected subsampling configuration. The apparatus **1304** may include means for transmitting a second indicator of a capability for the apparatus **1304** to calculate the subset of measurements before the reception of the plurality of subsampling configurations. Each of the plurality of subsampling configurations may satisfy the capability. The apparatus **1304** may include means for receiving a request for the capability before the transmission of the second indicator of the capability. The apparatus **1304** may include means for transmitting the second indicator of the capability for the apparatus **1304** to calculate the subset of measurements by transmitting an NRPP message. The NRPP message may include the second indicator of the capability for the apparatus **1304** to calculate the subset of measurements. The apparatus **1304** may include means for receiving a second indicator of the subsampling configuration before the selection of the subsampling configuration. The apparatus **1304** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received second indicator of the subsampling configuration. The apparatus **1304** may include means for receiving the second indicator of the subsampling configuration by receiving a posSIB, a MAC-CE, or DCI. The posSIB may include the second indicator of the subsampling configuration. The MAC-CE may include the second indicator of the subsampling configuration. The DCI may include the second indicator of the subsampling configuration. The apparatus **1304** may include means for receiving the plurality of subsampling configurations by receiving an LPP message or an NRPP message. The LPP message may include the plurality of subsampling configurations. The NRPP message may include the plurality of subsampling configurations. The apparatus **1304** may include means for receiving an indicator of the subsampling configuration before the selection of the subsampling configuration. The apparatus **1304** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received indicator. The apparatus **1304** may include means for selecting the subsampling configuration from the plurality of subsampling configurations based on a set of criteria. The selected subsampling configuration may include a path selection configuration. The apparatus **1304** may include means for calculating the subset of measurements of the measured set of positioning signals based on the selected subsampling configuration by (a) selecting a path of a plurality of paths of the set of positioning signals, and (b) calculating the subset of measurements corresponding with the selected path. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a CFR of the measured set of positioning signals. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a transform output of the measured set of positioning signals. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured local maximum values. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation. The apparatus **1304** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured minimum delay values. The apparatus **1304** may include at least one of a UE, a base station, or a TRP. The means may be the component **198** of the apparatus **1304** configured to perform the functions recited by the means. As described supra, the apparatus **1304** may include the TX processor **368**, the RX processor **356**, and the controller/processor **359**. As such, in one configuration, the means may be the TX processor **368**, the RX processor **356**, and/or the controller/processor **359** configured to perform the functions recited by the means.

[0171] FIG. **14** is a diagram **1400** illustrating an example of a hardware implementation for a network entity **1402**. The network entity **1402** may be a BS, a component of a BS, or may implement BS functionality. The network entity **1402** may include at least one of a CU **1410**, a DU **1430**, or an RU **1440**. For example, depending on the layer functionality handled by the component **199**, the network entity **1402** may include the CU **1410**; both the CU **1410** and the DU **1430**; each of the CU **1410**, the DU **1430**, and the RU **1440**; the DU **1430**; both the DU **1430** and the RU **1440**; or the RU **1440**. The CU **1410** may include at least one CU processor **1412**. The CU processor(s) **1412** may include on-chip memory **1412'**. In some aspects, the CU **1410** may further include additional memory modules **1414** and a communications interface **1418**. The CU **1410** communicates with the DU **1430** through a midhaul link, such as an F1 interface. The DU **1430** may include at least one DU processor **1432**. The DU processor(s) **1432** may include on-chip memory **1432'**. In some aspects, the DU **1430** may further include additional memory modules **1434** and a communications interface **1438**. The DU **1430** communicates with the RU **1440** through a fronthaul link. The RU **1440** may include at least one RU processor **1442**. The RU processor(s) **1442** may include on-chip memory **1442'**. In some aspects, the RU **1440** may further include additional memory modules **1444**, one or more transceivers **1446**, antennas **1480**, and a communications interface **1448**. The RU **1440** communicates with the UE **104**. The on-chip memory **1412'**, **1432'**, **1442'** and the additional memory modules **1414**, **1434**, **1444** may each be considered a computer-readable medium/memory. Each computer-readable medium/memory may be non-transitory. Each of the processors **1412**, **1432**, **1442** is responsible for general processing, including the execution of software stored on the computer-readable medium/memory. The software, when executed by the corresponding processor(s) causes the processor(s) to perform the various functions described supra. The computer-readable medium/memory may also be used for storing data that is manipulated by the processor(s) when executing software.

[0172] As discussed supra, the component **198** may be configured to select a subsampling configuration from a plurality of subsampling configurations. The component **198** may be configured to receive a set of positioning signals. The component **198** may be configured to measure the received set of positioning signals. The component **198** may be configured to calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The component **198** may be configured to output the calculated subset of measurements to a positioning model, for example by training the positioning model based on the calculated subset of measurements, by calculating a set of positioning outputs based on the calculated subset of measurements, or by transmitting the calculated subset of measurements for the positioning model. The component **198** may be within one or more processors of one or more of the CU **1410**, DU **1430**, and the RU **1440**. The component **198** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. When multiple processors are implemented, the multiple processors may perform the stated processes/algorithm individually or in combination. The network entity **1402** may include a variety of components configured for various functions. In one configuration, the network entity **1402** may include means for selecting a subsampling configuration from a plurality of subsampling configurations. The network entity **1402** may include means for receiving a set of positioning signals. The network entity **1402** may include means for measuring the set of positioning signals. The network entity **1402** may include means for calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The network entity **1402** may include means for outputting the calculated subset of measurements to a positioning model. The network entity **1402** may include means for outputting the calculated subset of measurements to the positioning model by at least one of (a) training the positioning model based on the calculated subset of measurements, (b) calculating a set of positioning outputs based on the calculated subset of measurements, or (c) transmitting the calculated subset of measurements for the positioning model. The network entity **1402** may include means for transmitting the calculated set of positioning outputs after the calculation of the set of positioning outputs. The network entity **1402** may include means for receiving the plurality of subsampling configurations before the selection of the subsampling configuration. The network entity **1402** may include means for transmitting a positioning report. The positioning report may include an indicator of the selected subsampling configuration. The network entity **1402** may include means for transmitting a second indicator of a capability for the network entity **1402** to calculate the subset of measurements before the reception of the plurality of subsampling configurations. Each of the plurality of subsampling configurations may satisfy the capability. The network entity **1402** may include means for receiving a request for the capability before the transmission of the second indicator of the capability. The network entity **1402** may include means for transmitting the second indicator of the capability for the network entity **1402** to calculate the subset of measurements by transmitting an NRPP message. The NRPP message may include the second indicator of the capability for the network entity **1402** to calculate the subset of measurements. The network entity **1402** may include means for receiving a second indicator of the subsampling configuration before the selection of the subsampling configuration. The network entity **1402** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received second indicator of the subsampling configuration. The network entity **1402** may include means for receiving the second indicator of the subsampling configuration by receiving a posSIB, a MAC-CE, or DCI. The posSIB may include the second indicator of the subsampling configuration. The MAC-CE may include the second indicator of the subsampling configuration. The DCI may include the second indicator of the subsampling configuration. The network entity **1402** may include means for receiving the plurality of subsampling configurations by receiving an LPP message or an NRPP message. The LPP message may include the plurality of subsampling configurations. The NRPP message may include the plurality of subsampling configurations. The network entity **1402** may include means for receiving an indicator of the subsampling configuration before the selection of the subsampling configuration. The network entity **1402** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received indicator. The network entity **1402** may include means for selecting the subsampling configuration from the plurality of subsampling configurations based on a set of criteria. The selected subsampling configuration may include a path selection configuration. The network entity **1402** may include means for calculating the subset of measurements of the measured set of positioning signals based on the selected subsampling configuration by (a) selecting a path of a plurality of paths of the set of positioning signals, and (b) calculating the subset of measurements corresponding with the selected path. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a CFR of the measured set of positioning signals. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a transform output of the measured set of positioning signals. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured local maximum values. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation. The network entity **1402** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured minimum delay values. The network entity **1402** may include at least one of a UE, a base station, or a TRP. The means may be the component **198** of the network entity **1402** configured to perform the functions recited by the means. As described supra, the network entity **1402** may include the TX processor **316**, the RX processor **370**, and the controller/processor **375**. As such, in one configuration, the means may be the TX processor **316**, the RX processor **370**, and/or the controller/processor **375** configured to perform the functions recited by the means.

[0173] As discussed supra, the component **199** may be configured to transmit an indicator of a plurality of subsampling configurations. The subsampling configuration component **199** may be configured to receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations. The component **199** may be within one or more processors of one or more of the CU **1410**, DU **1430**, and the RU **1440**. The component **199** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. When multiple processors are implemented, the multiple processors may perform the stated processes/algorithm individually or in combination. The network entity **1402** may include a variety of components configured for various functions. In one configuration, the network entity **1402** may include means for transmitting an indicator of a plurality of subsampling configurations. The network entity **1402** may include means for receiving a positioning report. The positioning report may include a set of measurements based on at least one of the plurality of subsampling configurations. The positioning report may include a set of positioning outputs based on at least one of the plurality of subsampling configurations. The network entity **1402** may include means for training a positioning model based on the set of measurements. The network entity **1402** may include means for calculating a second set of positioning outputs using the positioning model based on the set of measurements. The positioning report may include an indicator of the at least one of the plurality of subsampling configurations. The network entity **1402** may include means for receiving an indicator of a capability for a wireless device to utilize a subsampling configuration before the transmission of the plurality of subsampling configurations. Each of the plurality of subsampling configurations may satisfy the capability. The network entity **1402** may include means for transmitting a request for the capability before the reception of the indicator of the capability. The network entity **1402** may include means for receiving the indicator of the capability for the wireless device to utilize the subsampling configuration by receiving an LPP message. The LPP message may include the indicator of the capability for the wireless device to utilize the subsampling configuration. The network entity **1402** may include means for receiving the indicator of the capability for the wireless device to utilize the subsampling configuration by receiving an NRPP message. The NRPP message may include the indicator of the capability for the wireless device to utilize the subsampling configuration. The network entity **1402** may include means for transmitting an indicator of the at least one of the plurality of subsampling configurations after the transmission of the plurality of subsampling configurations. The network entity **1402** may include means for transmitting the indicator of the at least one of the plurality of subsampling configurations by transmitting a posSIB, a MAC-CE, or DCI. The posSIB may include the indicator of the at least one of the plurality of subsampling configurations. The MAC-CE may include the indicator of the at least one of the plurality of subsampling configurations. The DCI may include the indicator of the at least one of the plurality of subsampling configurations. The network entity **1402** may include means for transmitting the plurality of subsampling configurations by transmitting an LPP message. The LPP message may include in indicator of the plurality of subsampling configurations. The network entity **1402** may include means for transmitting the plurality of subsampling configurations by transmitting an NRPP message. The NRPP message may include the plurality of subsampling configurations. The plurality of subsampling configurations may include a set of path selection configurations. The plurality of subsampling configurations may include a first subsampling configuration to truncate a CFR. The plurality of subsampling configurations may include a second subsampling configuration to truncate a transform output of a set of positioning signal measurements. The plurality of subsampling configurations may include a third subsampling configuration to select a first subset of samples from the set of positioning signal measurements based on a power threshold range. The plurality of subsampling configurations may include a fourth subsampling configuration to select a second subset of samples from the set of positioning signal measurements based on a magnitude threshold range. The plurality of subsampling configurations may include a fifth subsampling configuration to select a third subset of samples from the set of positioning signal measurements based on measured local maximum values. The plurality of subsampling configurations may include a sixth subsampling configuration to select a fourth subset of samples from the set of positioning signal measurements based on an output of a super resolution calculation. The plurality of subsampling configurations may include a seventh subsampling configuration to select a fifth subset of samples from the set of positioning signal measurements based on measured minimum delay values. The network entity **1402** may include an LMF. The means may be the component **199** of the network entity **1402** configured to perform the functions recited by the means. As described supra, the network entity **1402** may include the TX processor **316**, the RX processor **370**, and the controller/processor **375**. As such, in one configuration, the means may be the TX processor **316**, the RX processor **370**, and/or the controller/processor **375** configured to perform the functions recited by the means.

[0174] FIG. **15** is a diagram **1500** illustrating an example of a hardware implementation for a network entity **1560**. In one example, the network entity **1560** may be within the core network **120**. The network entity **1560** may include at least one network processor **1512**. The network processor(s) **1512** may include on-chip memory **1512'**. In some aspects, the network entity **1560** may further include additional memory modules **1514**. The network entity **1560** communicates via the network interface **1580** directly (e.g., backhaul link) or indirectly (e.g., through a RIC) with the CU **1502**. The on-chip memory **1512'** and the additional memory modules **1514** may each be considered a computer-readable medium/memory. Each computer-readable medium/memory may be non-transitory. The network processor(s) **1512** is responsible for general processing, including the execution of software stored on the computer-readable medium/memory. The software, when executed by the corresponding processor(s) causes the processor(s) to perform the various functions described supra. The computer-readable medium/memory may also be used for storing data that is manipulated by the processor(s) when executing software.

[0175] As discussed supra, the component **198** may be configured to select a subsampling configuration from a plurality of subsampling configurations. The component **198** may be configured to receive a set of positioning signals. The component **198** may be configured to measure the received set of positioning signals. The component **198** may be configured to calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The component **198** may be configured to output the calculated subset of measurements to a positioning model, for example by training the positioning model based on the calculated subset of measurements, by calculating a set of positioning outputs based on the calculated subset of measurements, or by transmitting the calculated subset of measurements for the positioning model. The component **198** may be within the network processor(s) **1512**. The component **198** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. When multiple processors are implemented, the multiple processors may perform the stated processes/algorithm individually or in combination. The network entity **1560** may include a variety of components configured for various functions. In one configuration, the network entity **1560** may include means for selecting a subsampling configuration from a plurality of subsampling configurations. The network entity **1560** may include means for receiving a set of positioning signals. The network entity **1560** may include means for measuring the set of positioning signals. The network entity **1560** may include means for calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration. The network entity **1560** may include means for outputting the calculated subset of measurements to a positioning model. The network entity **1560** may include means for outputting the calculated subset of measurements to the positioning model by at least one of (a) training the positioning model based on the calculated subset of measurements, (b) calculating a set of positioning outputs based on the calculated subset of measurements, or (c) transmitting the calculated subset of measurements for the positioning model. The network entity **1560** may include means for transmitting the calculated set of positioning outputs after the calculation of the set of positioning outputs. The network entity **1560** may include means for receiving the plurality of subsampling configurations before the selection of the subsampling configuration. The network entity **1560** may include means for transmitting a positioning report. The positioning report may include an indicator of the selected subsampling configuration. The network entity **1560** may include means for transmitting a second indicator of a capability for the network entity **1560** to calculate the subset of measurements before the reception of the plurality of subsampling configurations. Each of the plurality of subsampling configurations may satisfy the capability. The network entity **1560** may include means for receiving a request for the capability before the transmission of the second indicator of the capability. The network entity **1560** may include means for transmitting the second indicator of the capability for the network entity **1560** to calculate the subset of measurements by transmitting an NRPP message. The NRPP message may include the second indicator of the capability for the network entity **1560** to calculate the subset of measurements. The network entity **1560** may include means for receiving a second indicator of the subsampling configuration before the selection of the subsampling configuration. The network entity **1560** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received second indicator of the subsampling configuration. The network entity **1560** may include means for receiving the second indicator of the subsampling configuration by receiving a posSIB, a MAC-CE, or DCI. The posSIB may include the second indicator of the subsampling configuration. The MAC-CE may include the second indicator of the subsampling configuration. The DCI may include the second indicator of the subsampling configuration. The network entity **1560** may include means for receiving the plurality of subsampling configurations by receiving an LPP message or an NRPP message. The LPP message may include the plurality of subsampling configurations. The NRPP message may include the plurality of subsampling configurations. The network entity **1560** may include means for receiving an indicator of the subsampling configuration before the selection of the subsampling configuration. The network entity **1560** may include means for selecting the subsampling configuration from the plurality of subsampling configurations by selecting the subsampling configuration from the plurality of subsampling configurations based on the received indicator. The network entity **1560** may include means for selecting the subsampling configuration from the plurality of subsampling configurations based on a set of criteria. The selected subsampling configuration may include a path selection configuration.

The network entity **1560** may include means for calculating the subset of measurements of the measured set of positioning signals based on the selected subsampling configuration by (a) selecting a path of a plurality of paths of the set of positioning signals, and (b) calculating the subset of measurements corresponding with the selected path. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a CFR of the measured set of positioning signals. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by truncating a transform output of the measured set of positioning signals. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured local maximum values. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation. The network entity **1560** may include means for calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals by selecting the subset of samples from the measured set of positioning signals in response to the subset of samples including measured minimum delay values. The network entity **1560** may include at least one of a UE, a base station, or a TRP. The means may be the component **198** of the network entity **1560** configured to perform the functions recited by the means.

[0176] As discussed supra, the component **199** may be configured to transmit an indicator of a plurality of subsampling configurations. The subsampling configuration component **199** may be configured to receive a positioning report including at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations. The component **199** may be within the network processor(s) **1512**. The component **199** may be one or more hardware components specifically configured to carry out the stated processes/algorithm, implemented by one or more processors configured to perform the stated processes/algorithm, stored within a computer-readable medium for implementation by one or more processors, or some combination thereof. When multiple processors are implemented, the multiple processors may perform the stated processes/algorithm individually or in combination. The network entity **1560** may include a variety of components configured for various functions. In one configuration, the network entity **1560** may include means for transmitting an indicator of a plurality of subsampling configurations. The network entity **1560** may include means for receiving a positioning report. The positioning report may include a set of measurements based on at least one of the plurality of subsampling configurations. The positioning report may include a set of positioning outputs based on at least one of the plurality of subsampling configurations. The network entity **1560** may include means for training a positioning model based on the set of measurements. The network entity **1560** may include means for calculating a second set of positioning outputs using the positioning model based on the set of measurements. The positioning report may include an indicator of the at least one of the plurality of subsampling configurations. The network entity **1560** may include means for receiving an indicator of a capability for a wireless device to utilize a subsampling configuration before the transmission of the plurality of subsampling configurations. Each of the plurality of subsampling configurations may satisfy the capability. The network entity **1560** may include means for transmitting a request for the capability before the reception of the indicator of the capability. The network entity **1560** may include means for receiving the indicator of the capability for the wireless device to utilize the subsampling configuration by receiving an LPP message. The LPP message may include the indicator of the capability for the wireless device to utilize the subsampling configuration. The network entity **1560** may include means for receiving the indicator of the capability for the wireless device to utilize the subsampling configuration by receiving an NRPP message. The NRPP message may include the indicator of the capability for the wireless device to utilize the subsampling configuration. The network entity **1560** may include means for transmitting an indicator of the at least one of the plurality of subsampling configurations after the transmission of the plurality of subsampling configurations. The network entity **1560** may include means for transmitting the indicator of the at least one of the plurality of subsampling configurations by transmitting a posSIB, a MAC-CE, or DCI. The posSIB may include the indicator of the at least one of the plurality of subsampling configurations. The MAC-CE may include the indicator of the at least one of the plurality of subsampling configurations. The DCI may include the indicator of the at least one of the plurality of subsampling configurations. The network entity **1560** may include means for transmitting the plurality of subsampling configurations by transmitting an LPP message. The LPP message may include in indicator of the plurality of subsampling configurations. The network entity **1560** may include means for transmitting the plurality of subsampling configurations by transmitting an NRPP message. The NRPP message may include the plurality of subsampling configurations. The plurality of subsampling configurations may include a set of path selection configurations. The plurality of subsampling configurations may include a first subsampling configuration to truncate a CFR. The plurality of subsampling configurations may include a second subsampling configuration to truncate a transform output of a set of positioning signal measurements. The plurality of subsampling configurations may include a third subsampling configuration to select a first subset of samples from the set of positioning signal measurements based on a power threshold range. The plurality of subsampling configurations may include a fourth subsampling configuration to select a second subset of samples from the set of positioning signal measurements based on a magnitude threshold range. The plurality of subsampling configurations may include a fifth subsampling configuration to select a third subset of samples from the set of positioning signal measurements based on measured local maximum values. The plurality of subsampling configurations may include a sixth subsampling configuration to select a fourth subset of samples from the set of positioning signal measurements based on an output of a super resolution calculation. The plurality of subsampling configurations may include a seventh subsampling configuration to select a fifth subset of samples from the set of positioning signal measurements based on measured minimum delay values. The network entity **1560** may include an LMF. The means may be the component **199** of the network entity **1560** configured to perform the functions recited by the means.

[0177] It is understood that the specific order or hierarchy of blocks in the processes/flowcharts disclosed is an illustration of example approaches. Based upon design preferences, it is understood that the specific order or hierarchy of blocks in the processes/flowcharts may be rearranged. Further, some blocks may be combined or omitted. The accompanying method claims present elements of the various blocks in a sample order, and are not limited to the specific order or hierarchy presented.

[0178] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not limited to the aspects described herein, but are to be accorded the full scope consistent with the language claims. Reference to an element in the singular does not mean "one and only one" unless specifically so stated, but rather "one or more." Terms such as "if," "when," and "while" do not imply an immediate temporal relationship or reaction. That is, these phrases, e.g., "when," do not imply an immediate action in response to or during the occurrence of an action, but simply imply that if a condition is met then an action will occur, but without requiring a specific or immediate time constraint for the action to occur. The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects. Unless specifically stated otherwise, the term "some" refers to one or more. Combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" include any combination of A, B, and/or C, and may include multiples of A, multiples of B, or multiples of C. Specifically, combinations such as "at least one of A, B, or C," "one or more of A, B, or C," "at least one of A, B, and C," "one or more of A, B, and C," and "A, B, C, or any combination thereof" may be A only, B only, C only, A and B, A and C, B and C, or A and B and C, where any such combinations may contain one or more member or members of A, B, or C. Sets should be interpreted as a set of elements where the elements number one or more. Accordingly, for a set of X, X would include one or more elements. When at least one processor is configured to perform a set of functions, the at least one processor, individually or in any combination, is configured to perform the set of functions. Accordingly, each processor of the at least one processor may be configured to perform a particular subset of the set of functions, where the subset is the full set, a proper subset of the set, or an empty subset of the set. A processor may be referred to as processor circuitry. A memory/memory module may be referred to as memory circuitry. If a first apparatus receives data from or transmits data to a second apparatus, the data may be received/transmitted directly between the first and second apparatuses, or indirectly between the first and second apparatuses through a set of apparatuses. A device configured to "output" data or "provide" data, such as a transmission, signal, or message, may transmit the data, for example with a transceiver, may send the data to a component of the device that transmits the data, or may send the data to a component of the device. A device configured to "obtain" data, such as a transmission, signal, or message, may receive, for example with a transceiver, may obtain the data from a component of the device that receives the data, or may obtain the data from a component of the device. Information stored in a memory includes instructions and/or data. All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are encompassed by the claims. Moreover, nothing disclosed herein is dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. The words "module," "mechanism," "element," "device," and the like may not be a substitute for the word "means." As such, no claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

[0179] As used herein, the phrase "based on" shall not be construed as a reference to a closed set of information, one or more conditions, one or more factors, or the like. In other words, the phrase "based on A" (where "A" may be information, a condition, a factor, or the like) shall be construed as "based at least on A" unless specifically recited differently.

[0180] The following aspects are illustrative only and may be combined with other aspects or teachings described herein, without limitation.

[0181] Aspect 1 is a method of wireless communication at a wireless device, comprising: selecting a subsampling configuration from a plurality of subsampling configurations; receiving a set of positioning signals; measuring the set of positioning signals; calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration; and outputting the calculated subset of measurements to a positioning model.

[0182] Aspect 2 is the method of aspect 1, wherein outputting the calculated subset of measurements to the positioning model comprises at least one of: training the positioning model based on the calculated subset of measurements; calculating a set of positioning outputs based on the calculated subset of measurements; or transmitting the calculated subset of measurements for the positioning model.

[0183] Aspect 3 is the method of aspect 2, further comprising transmitting the calculated set of positioning outputs after the calculation of the set of positioning outputs.

[0184] Aspect 4 is the method of any of aspects 1 to 3, further comprising: receiving the plurality of subsampling configurations before the selection of the subsampling configuration; and transmitting a positioning report comprising an indicator of the selected subsampling configuration.

[0185] Aspect 5 is the method of aspect 4, further comprising: transmitting a second indicator of a capability for the wireless device to calculate the subset of measurements before the reception of the plurality of subsampling configurations, wherein each of the plurality of subsampling configurations satisfy the capability.

[0186] Aspect 6 is the method of aspect 5, further comprising: receiving a request for the capability before the transmission of the second indicator of the capability.

[0187] Aspect 7 is the method of either of aspects 5 or 6, wherein transmitting the second indicator of the capability for the wireless device to calculate the subset of measurements comprises transmitting a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the second indicator of the capability for the wireless device to calculate the subset of measurements.

[0188] Aspect 8 is the method of any of aspects 4 to 7, further comprising: receiving a second indicator of the subsampling configuration before the selection of the subsampling configuration, wherein selecting the subsampling configuration from the plurality of subsampling configurations comprises selecting the subsampling configuration from the plurality of subsampling configurations based on the received second indicator of the subsampling configuration.

[0189] Aspect 9 is the method of aspect 8, wherein receiving the second indicator of the subsampling configuration comprises: receiving a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) comprising the second indicator of the subsampling configuration.

[0190] Aspect 10 is the method of any of aspects 4 to 9, wherein receiving the plurality of subsampling configurations comprises: receiving a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the plurality of subsampling configurations.

[0191] Aspect 11 is the method of any of aspects 1 to 10, further comprising: receiving an indicator of the subsampling configuration before the selection of the subsampling configuration, wherein selecting the subsampling configuration from the plurality of subsampling configurations comprises selecting the subsampling configuration from the plurality of subsampling configurations based on the received indicator.

[0192] Aspect 12 is the method of any of aspects 1 to 11, further comprising: selecting the subsampling configuration from the plurality of subsampling configurations based on a set of criteria.

[0193] Aspect 13 is the method of any of aspects 1 to 12, wherein the selected subsampling configuration comprises a path selection configuration, wherein calculating the subset of measurements of the measured set of positioning signals based on the selected subsampling configuration comprises: selecting a path of a plurality of paths of the set of positioning signals; and calculating the subset of measurements corresponding with the selected path.

[0194] Aspect 14 is the method of any of aspects 1 to 13, wherein calculating the subset of measurements associated with a subset of samples of the measured set of positioning signals comprises at least one of: truncating a channel frequency response (CFR) of the measured set of positioning signals; truncating a transform output of the measured set of positioning signals; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range; selecting the subset of samples from the measured set of positioning signals in response to the subset of samples comprising measured local maximum values; selecting the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation; or selecting the subset of samples from the measured set of positioning signals in response to the subset of samples comprising measured minimum delay values.

[0195] Aspect 15 is the method of any of aspects 1 to 14, wherein the wireless device comprises at least one of a user equipment (UE), a base station, or a transmission reception point (TRP).

[0196] Aspect 16 is a method of wireless communication at a network entity, comprising: transmitting a plurality of subsampling configurations; and receiving a positioning report comprising at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

[0197] Aspect 17 is the method of aspect 16, further comprising: training a positioning model based on the set of measurements; or calculating a second set of positioning outputs using the positioning model based on the set of measurements.

[0198] Aspect 18 is the method of either of aspects 16 or 17, wherein the positioning report comprises an indicator of the at least one of the plurality of subsampling configurations.

[0199] Aspect 19 is the method of any of aspects 16 to 18, further comprising: receiving an indicator of a capability for a wireless device to utilize a subsampling configuration before the transmission of the plurality of subsampling configurations, wherein each of the plurality of subsampling configurations satisfy the capability.

[0200] Aspect 20 is the method of aspect 19, further comprising transmitting a request for the capability before the reception of the indicator of the capability.

[0201] Aspect 21 is the method of either of aspects 19 or 20, wherein receiving the indicator of the capability for the wireless device to utilize the subsampling configuration comprises: receiving a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the indicator of the capability for the wireless device to utilize the subsampling configuration.

[0202] Aspect 22 is the method of any of aspects 16 to 21, further comprising transmitting an indicator of the at least one of the plurality of subsampling configurations after the transmission of the plurality of subsampling configurations.

[0203] Aspect 23 is the method of aspect 22, wherein transmitting the indicator of the at least one of the plurality of subsampling configurations comprises: transmitting a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) comprising the indicator of the at least one of the plurality of subsampling configurations.

[0204] Aspect 24 is the method of any of aspects 16 to 23, wherein transmitting the plurality of subsampling configurations comprises: transmitting a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the plurality of subsampling configurations.

[0205] Aspect 25 is the method of any of aspects 16 to 24, wherein the plurality of subsampling configurations comprises a set of path selection configurations.

[0206] Aspect 26 is the method of any of aspects 16 to 25, wherein the plurality of subsampling configurations comprises at least one of: a first subsampling configuration to truncate a channel frequency response (CFR); a second subsampling configuration to truncate a transform output of a set of positioning signal measurements; a third subsampling configuration to select a first subset of samples from the set of positioning signal measurements based on a power threshold range; a fourth subsampling configuration to select a second subset of samples from the set of positioning signal measurements based on a magnitude threshold range; a fifth subsampling configuration to select a third subset of samples from the set of positioning signal measurements based on measured local maximum values; a sixth subsampling configuration to select a fourth subset of samples from the set of positioning signal measurements based on an output of a super resolution calculation; or a seventh subsampling configuration to select a fifth subset of samples from the set of positioning signal measurements based on measured minimum delay values.

[0207] Aspect 27 is the method of any of aspects 16 to 26, wherein the network entity comprises a location management function (LMF).

[0208] Aspect 28 is an apparatus for wireless communication, comprising: at least one memory; and at least one processor coupled to the at least one memory and, based at least in part on information stored in the at least one memory, the at least one processor, individually or in any combination, is configured to perform the method of any of aspects 1 to 27.

[0209] Aspect 29 is an apparatus for wireless communication, comprising means for performing each step in the method of any of aspects 1 to 27.

[0210] Aspect 30 is the apparatus of any of aspects 1 to 27, further comprising a transceiver (e.g., functionally connected to the at least one processor of Aspect 28) configured to receive or to transmit in association with the method of any of aspects 1 to 27.

[0211] Aspect 31 is a computer-readable medium (e.g., a non-transitory computer-readable medium) storing computer executable code, the code when executed by at least one processor causes the at least one processor, individually or in any combination, to perform the method of any of aspects 1 to 27.

What is claimed is:

1. An apparatus for wireless communication at a wireless device, comprising:

at least one memory; and

at least one processor coupled to the at least one memory and, based at least in part on information stored in the at least one memory, the at least one processor, individually or in any combination, is configured to:

select a subsampling configuration from a plurality of subsampling configurations;

receive a set of positioning signals;

measure the received set of positioning signals;

calculate a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration; and

output the calculated subset of measurements to a positioning model.

2. The apparatus of claim **1**, wherein, to output the calculated subset of measurements to the positioning model, the at least one processor, individually or in any combination, is configured to:

train the positioning model based on the calculated subset of measurements;

calculate a set of positioning outputs based on the calculated subset of measurements; or

transmit the calculated subset of measurements for the positioning model.

3. The apparatus of claim **2**, wherein the at least one processor, individually or in any combination, is further configured to:

transmit the calculated set of positioning outputs after the calculation of the set of positioning outputs.

4. The apparatus of claim **1**, wherein the at least one processor, individually or in any combination, is further configured to:

receive a first indicator of the plurality of subsampling configurations before the selection of the subsampling configuration; and

transmit a positioning report comprising a second indicator of the selected subsampling configuration.

5. The apparatus of claim **4**, wherein the at least one processor, individually or in any combination, is further configured to:

transmit a third indicator of a capability for the wireless device to calculate the subset of measurements before the reception of the plurality of subsampling configurations, wherein each of the plurality of subsampling configurations satisfy the capability.

6. The apparatus of claim **5**, wherein the at least one processor, individually or in any combination, is further configured to:

receive a request for the capability before the transmission of the third indicator of the capability.

7. The apparatus of claim **5**, wherein transmitting the third indicator of the capability for the wireless device to calculate the subset of measurements comprises:

transmit a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the third indicator of the capability for the wireless device to calculate the subset of measurements.

8. The apparatus of claim **4**, wherein the at least one processor, individually or in any combination, is further configured to:

receive a third indicator of the subsampling configuration before the selection of the subsampling configuration, wherein to select the subsampling configuration from the plurality of subsampling configurations, the at least one processor, individually or in any combination, is configured to:

select the subsampling configuration from the plurality of subsampling configurations based on the received third indicator of the subsampling configuration.

9. The apparatus of claim **8**, wherein, to receive the third indicator of the subsampling configuration, the at least one processor, individually or in any combination, is configured to:

receive a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) comprising the third indicator of the subsampling configuration.

10. The apparatus of claim **4**, wherein, to receive the plurality of subsampling configurations, the at least one processor, individually or in any combination, is configured to:

receive a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the plurality of subsampling configurations.

11. The apparatus of claim **1**, wherein the at least one processor, individually or in any combination, is further configured to:

receive an indicator of the subsampling configuration before the selection of the subsampling configuration, wherein to select the subsampling configuration from the plurality of subsampling configurations, the at least one processor, individually or in any combination, is configured to:

select the subsampling configuration from the plurality of subsampling configurations based on the received indicator.

12. The apparatus of claim **1**, wherein the at least one processor, individually or in any combination, is further configured to:

select the subsampling configuration from the plurality of subsampling configurations based on a set of criteria.

13. The apparatus of claim **1**, wherein the selected subsampling configuration comprises a path selection configuration, wherein, to calculate the subset of measurements of the measured set of positioning signals based on the selected subsampling configuration, the at least one processor, individually or in any combination, is configured to:

select a path of a plurality of paths of the received set of positioning signals; and

calculate the subset of measurements corresponding with the selected path.

14. The apparatus of claim **1**, wherein, to calculate the subset of measurements associated with a subset of samples of the measured set of positioning signals, the at least one processor, individually or in any combination, is configured to, at least one of:

truncate a channel frequency response (CFR) of the measured set of positioning signals;

truncate a transform output of the measured set of positioning signals;

select the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a power threshold range;

select the subset of samples from the measured set of positioning signals in response to the subset of samples satisfying a magnitude threshold range;

select the subset of samples from the measured set of positioning signals in response to the subset of samples comprising measured local maximum values;

select the subset of samples from the measured set of positioning signals based on an output of a super resolution calculation; or

select the subset of samples from the measured set of positioning signals in response to the subset of samples comprising measured minimum delay values.

15. The apparatus of claim **1**, wherein the wireless device comprises at least one of a user equipment (UE), a base station, or a transmission reception point (TRP).

16. The apparatus of claim **1**, further comprising a transceiver coupled to the at least one processor, wherein the at least one processor, individually or in any combination, is further configured to:

receive, via the transceiver, the set of positioning signals.

17. An apparatus for wireless communication at a network entity, comprising:

at least one memory; and

at least one processor coupled to the at least one memory and, based at least in part on information stored in the at least one memory, the at least one processor, individually or in any combination, is configured to:

transmit an indicator of a plurality of subsampling configurations; and

receive a positioning report comprising at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

18. The apparatus of claim **17**, wherein the at least one processor, individually or in any combination, is further configured to:

train a positioning model based on the set of measurements; or

calculate a second set of positioning outputs using the positioning model based on the set of measurements.

19. The apparatus of claim **17**, wherein the positioning report comprises a second indicator of the at least one of the plurality of subsampling configurations.

20. The apparatus of claim **17**, wherein the at least one processor, individually or in any combination, is further configured to:

receive a second indicator of a capability for a wireless device to utilize a subsampling configuration before the transmission of the plurality of subsampling configurations, wherein each of the plurality of subsampling configurations satisfy the capability.

21. The apparatus of claim **20**, wherein the at least one processor, individually or in any combination, is further configured to:

transmit a request for the capability before the reception of the second indicator of the capability.

22. The apparatus of claim **20**, wherein, to receive the second indicator of the capability for the wireless device to utilize the subsampling configuration, the at least one processor, individually or in any combination, is configured to:

receive a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the second indicator of the capability for the wireless device to utilize the subsampling configuration.

23. The apparatus of claim **17**, wherein the at least one processor, individually or in any combination, is further configured to:

transmit a second indicator of the at least one of the plurality of subsampling configurations after the transmission of the plurality of subsampling configurations.

24. The apparatus of claim **23**, wherein, to transmit the second indicator of the at least one of the plurality of subsampling configurations, the at least one processor, individually or in any combination, is configured to:

transmit a positioning broadcast signaling (posSIB), a medium access control (MAC) control element (MAC-CE), or downlink control information (DCI) comprising the second indicator of the at least one of the plurality of subsampling configurations.

25. The apparatus of claim **17**, further comprising a transceiver coupled to the at least one processor, wherein, to transmit the plurality of subsampling configurations, the at least one processor, individually or in any combination, is configured to:

transmit, via the transceiver, a long-term evolution (LTE) positioning protocol (LPP) message or a new radio positioning protocol (NRPP) message comprising the plurality of subsampling configurations.

26. The apparatus of claim **17**, wherein the plurality of subsampling configurations comprises a set of path selection configurations.

27. The apparatus of claim **17**, wherein the plurality of subsampling configurations comprises at least one of:

a first subsampling configuration to truncate a channel frequency response (CFR);

a second subsampling configuration to truncate a transform output of a set of positioning signal measurements;

a third subsampling configuration to select a first subset of samples from the set of positioning signal measurements based on a power threshold range;

a fourth subsampling configuration to select a second subset of samples from the set of positioning signal measurements based on a magnitude threshold range;

a fifth subsampling configuration to select a third subset of samples from the set of positioning signal measurements based on measured local maximum values;

a sixth subsampling configuration to select a fourth subset of samples from the set of positioning signal measurements based on an output of a super resolution calculation; or

a seventh subsampling configuration to select a fifth subset of samples from the set of positioning signal measurements based on measured minimum delay values.

28. The apparatus of claim **17**, wherein the network entity comprises a location management function (LMF).

29. A method of wireless communication at a wireless device, comprising:

selecting a subsampling configuration from a plurality of subsampling configurations;

receiving a set of positioning signals;

measuring the set of positioning signals;

calculating a subset of measurements of the measured set of positioning signals based on the selected subsampling configuration; and

outputting the calculated subset of measurements to a positioning model.

30. A method of wireless communication at a network entity, comprising:

transmitting a plurality of subsampling configurations; and

receiving a positioning report comprising at least one of a set of measurements based on at least one of the plurality of subsampling configurations or a set of positioning outputs based on the at least one of the plurality of subsampling configurations.

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