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(54) **SIGNAL STRENGTH BASED POSITIONING WITH CARRIER FREQUENCY INFORMATION**

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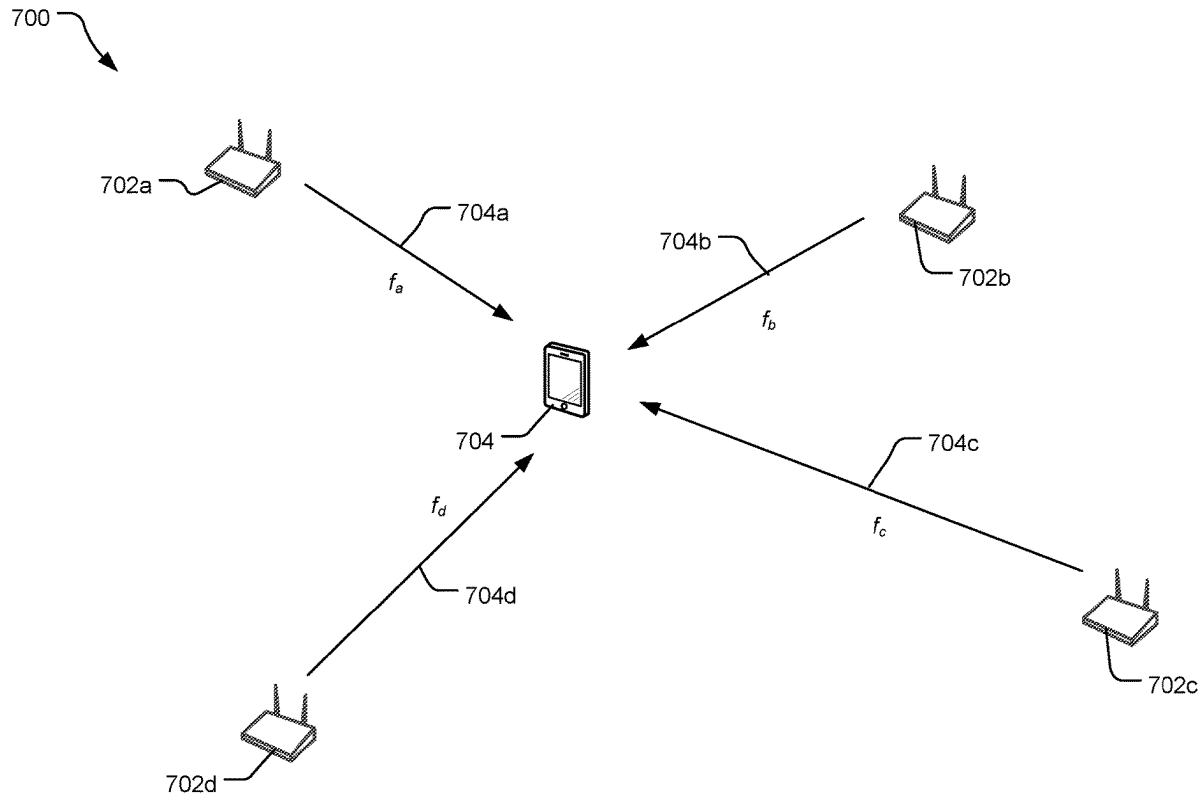
(57) **ABSTRACT**

Techniques are provided for positioning wireless devices such as user equipment (UEs), access points (APs), asset tags, and other wireless devices. An example method for estimating a position based on measured signal strength values includes obtaining signal strength values for a plurality of positioning signals, determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals, and estimating the position based on the signal strength values and the one or more offset values.



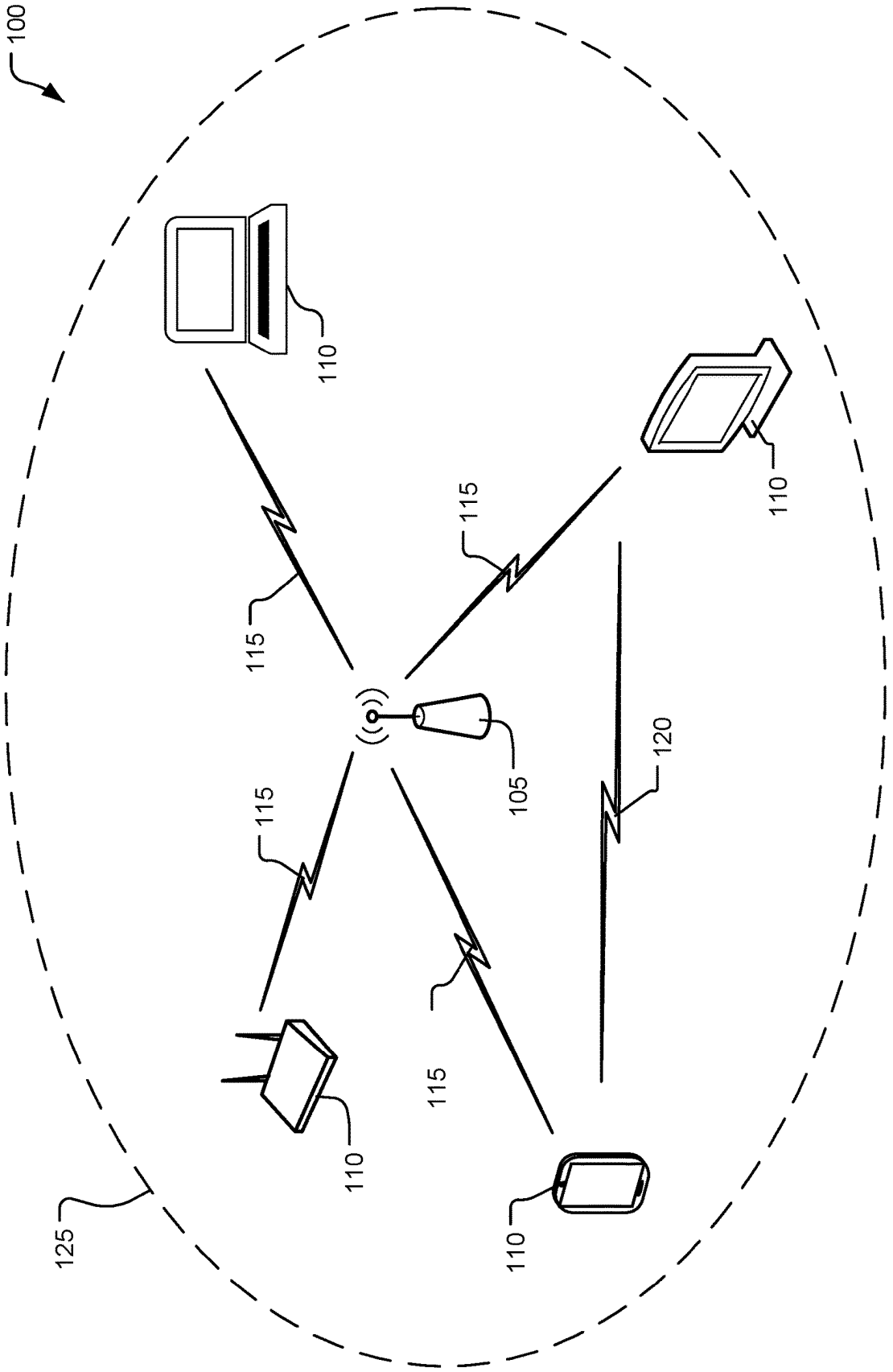


FIG. 1

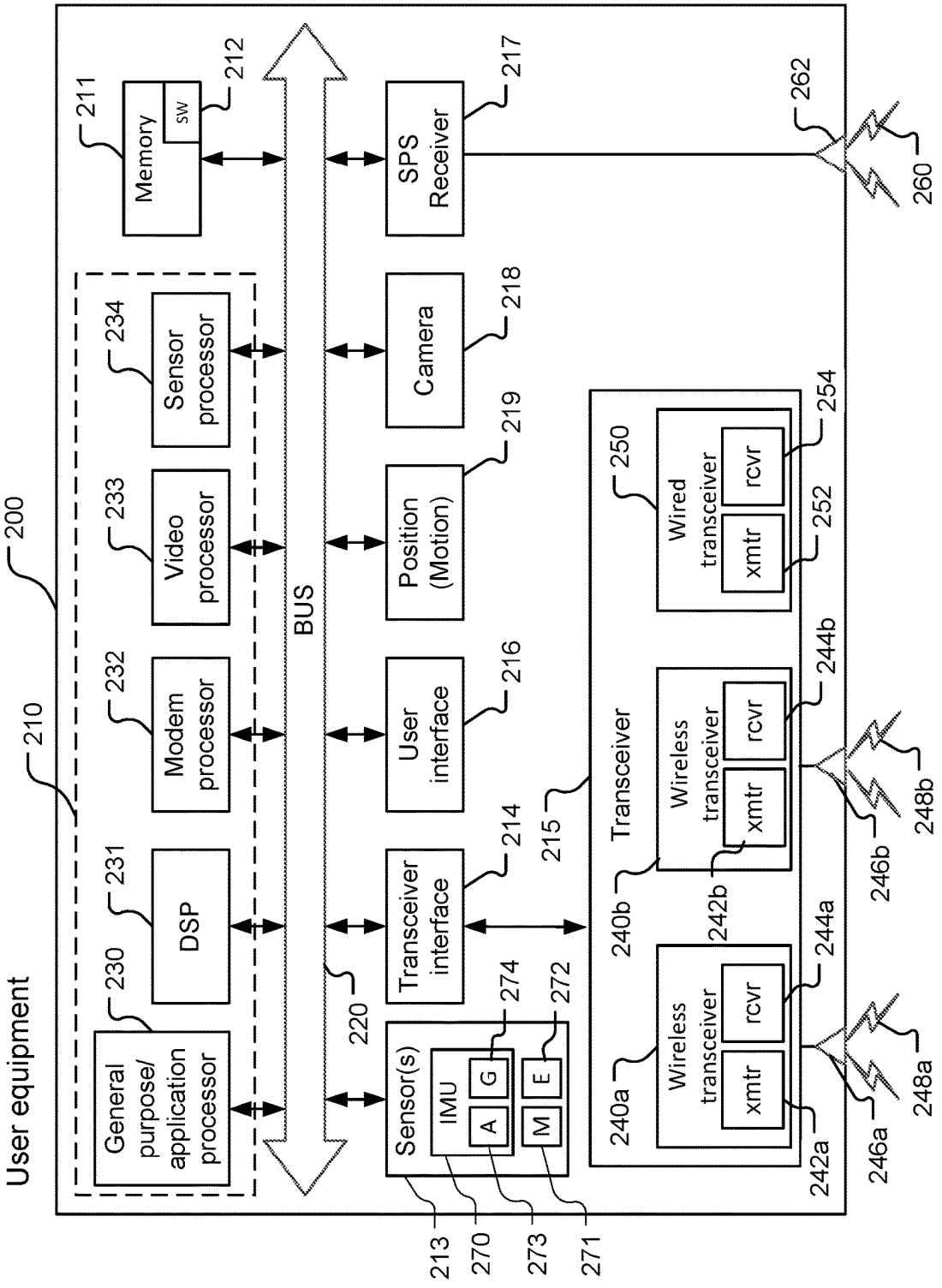

User equipment
200
210
General purpose/ application processor
230
DSP
231
Modem processor
232
Video processor
233
Sensor processor
234
BUS
Memory
SW
211
212
SPS Receiver
217
262
260
Camera
218
Position (Motion)
219
User interface
216
Transceiver interface
214
220
Sensor(s)
IMU
A
G
M
E
274
272
213
270
273
271
215
Transceiver
240a
240b
Wireless transceiver
xmtr
rcvr
242a
242b
244a
244b
Wired transceiver
250
252
254
246a
246b
248a
248b

FIG. 2

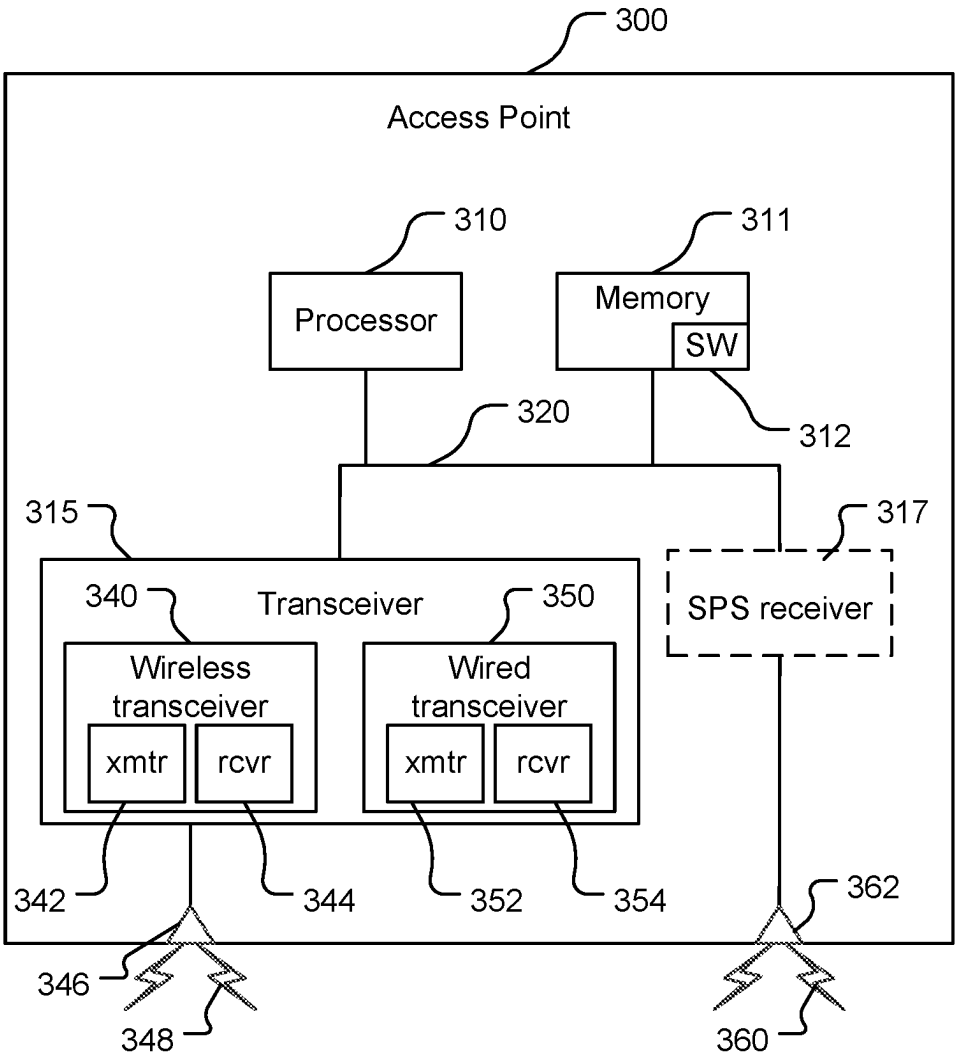

300
Access Point
310
Processor
311
Memory
SW
312
320
315
317
340
Transceiver
350
SPS receiver
Wireless transceiver
xmtr
rcvr
Wired transceiver
xmtr
rcvr
342
344
352
354
362
346
348
360

FIG. 3

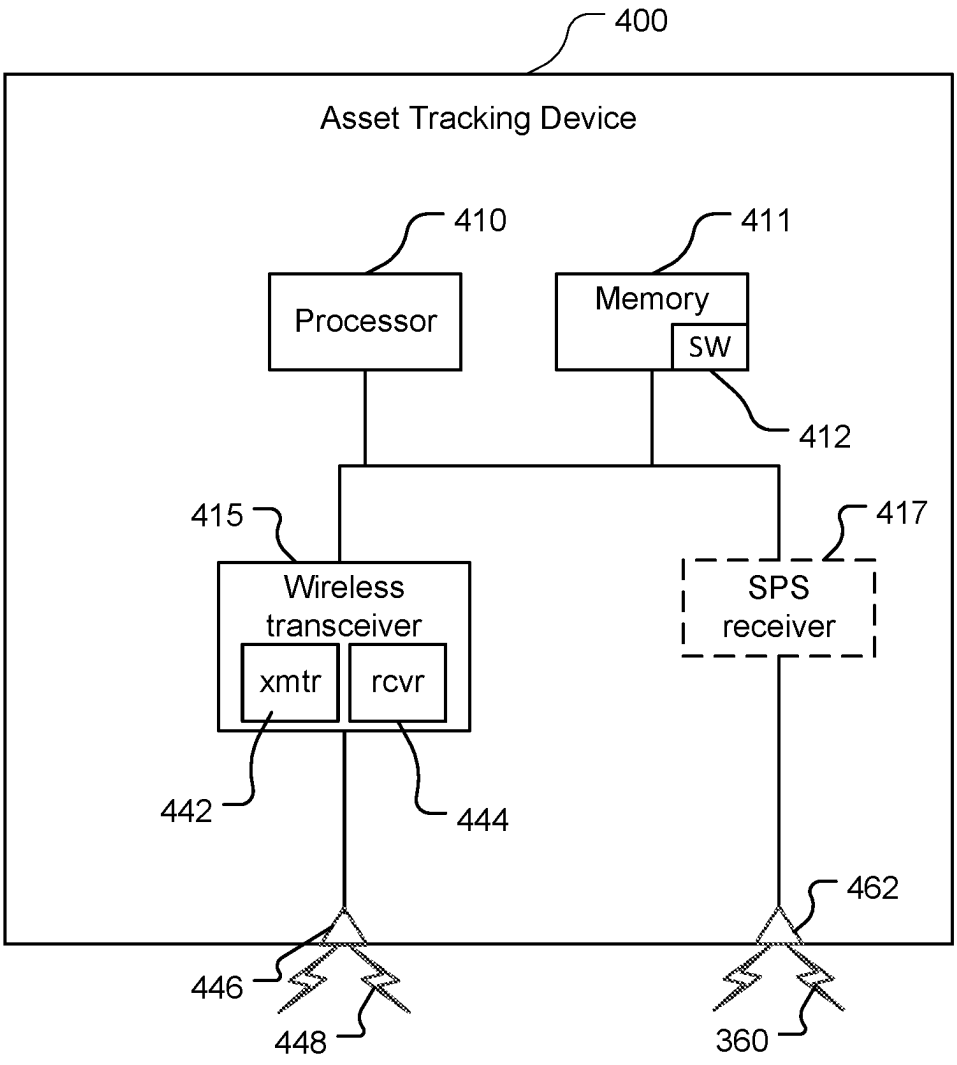

400
Asset Tracking Device
410
Processor
411
Memory
SW
412
415
Wireless transceiver
xmtr
rcvr
417
SPS receiver
442
444
462
446
448
360

FIG. 4

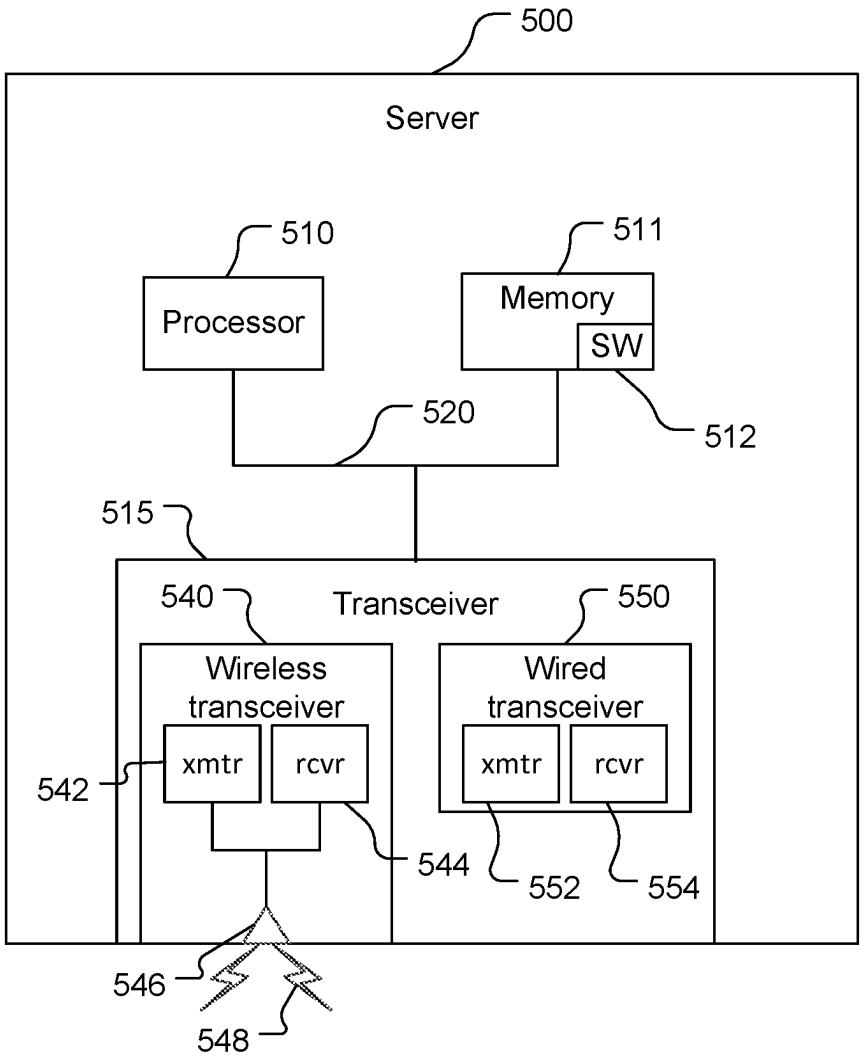

500
Server
510
Processor
511
Memory
SW
512
520
515
Transceiver
540
Wireless transceiver
xmtr
rcvr
542
544
550
Wired transceiver
xmtr
rcvr
552
554
546
548

FIG. 5

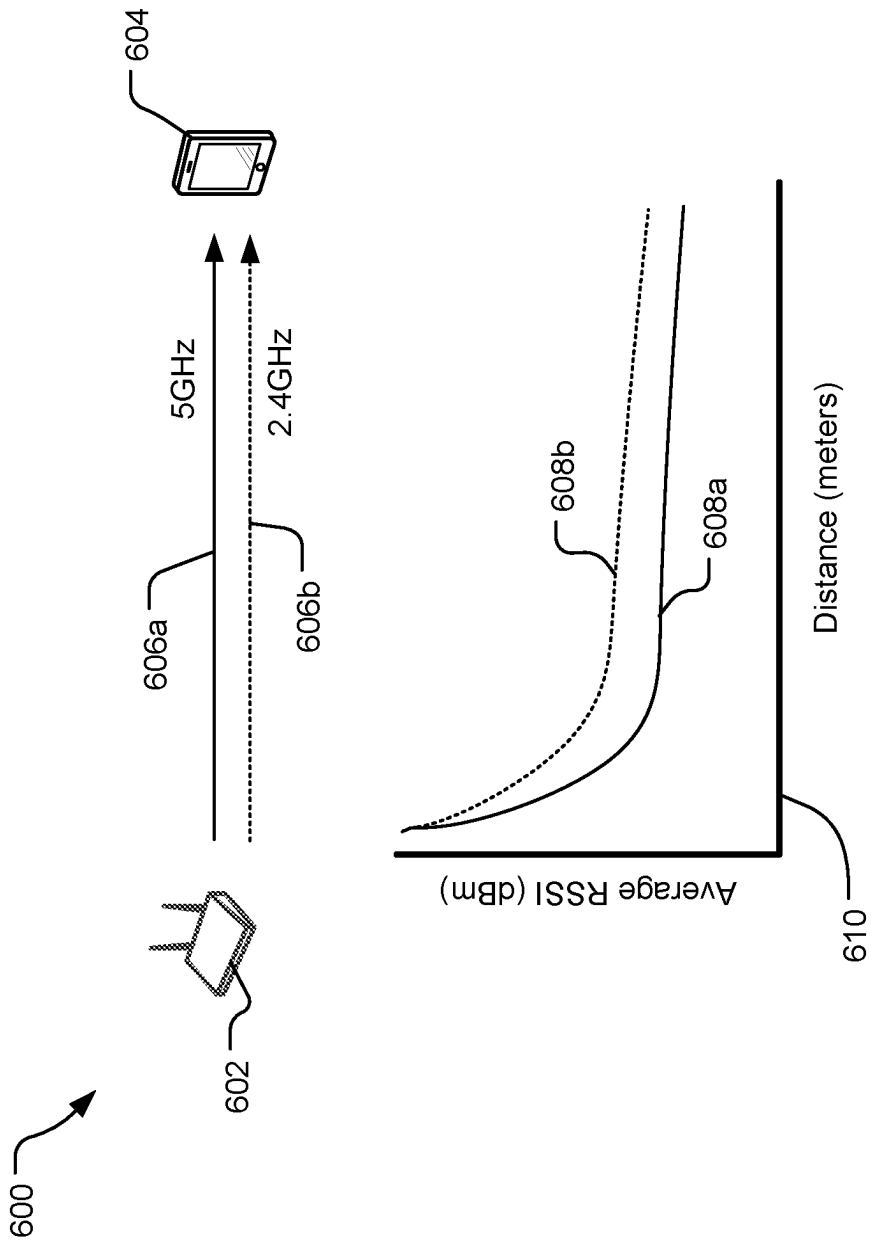

600
602
604
5GHz
2.4GHz
606a
606b
608a
608b
Average RSSI (dBm)
Distance (meters)
610

FIG. 6

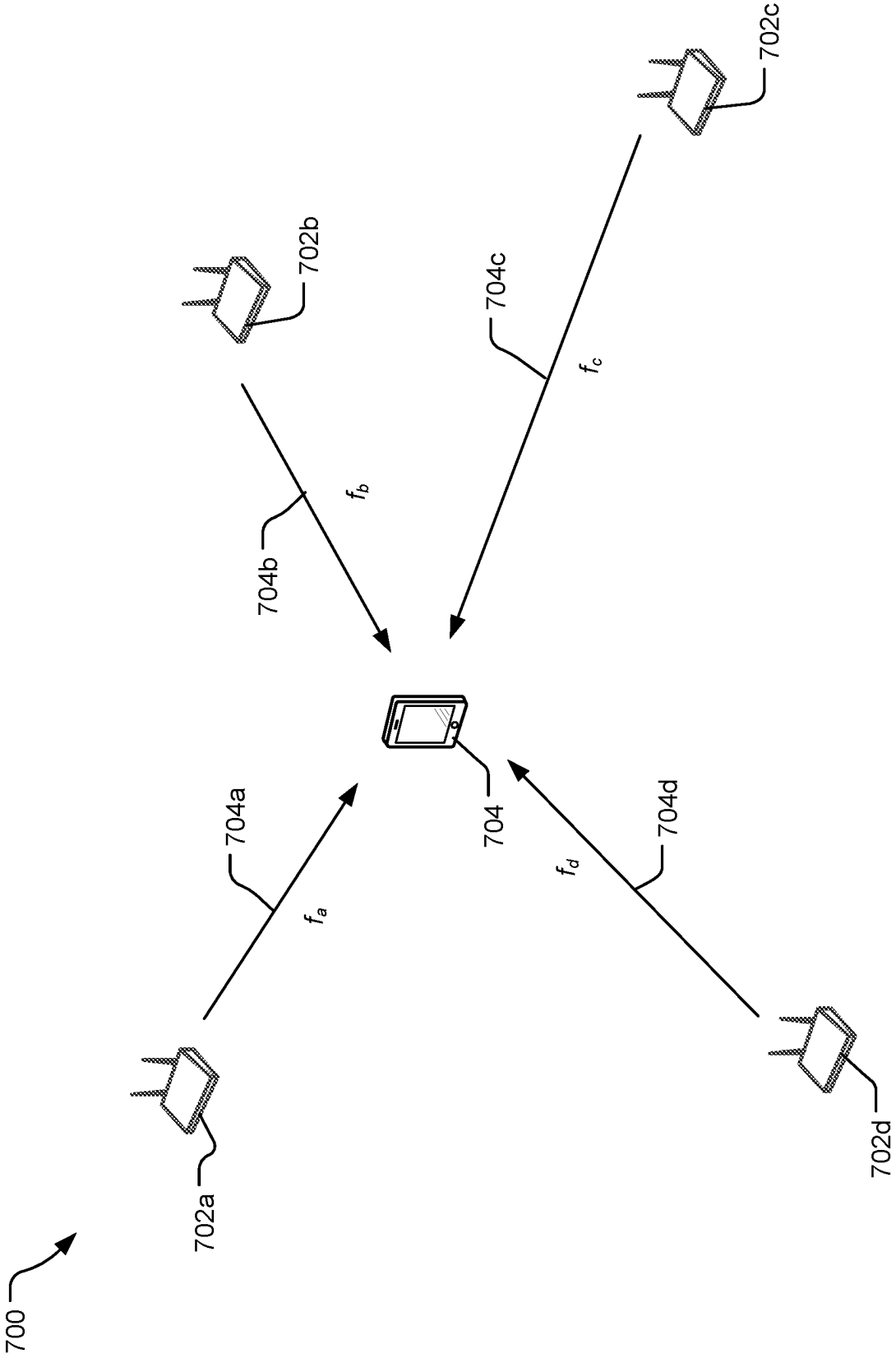


FIG. 7A

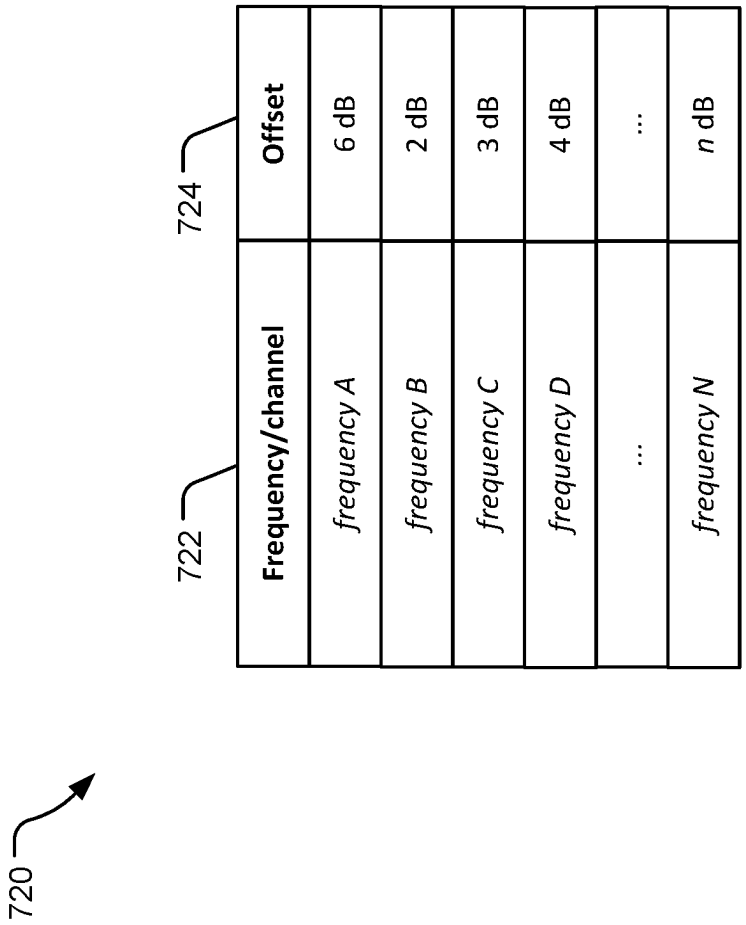

720
722
724
Frequency/channel
Offset
frequency A
6 dB
frequency B
2 dB
frequency C
3 dB
frequency D
4 dB
...
...
frequency N
n dB

FIG. 7B

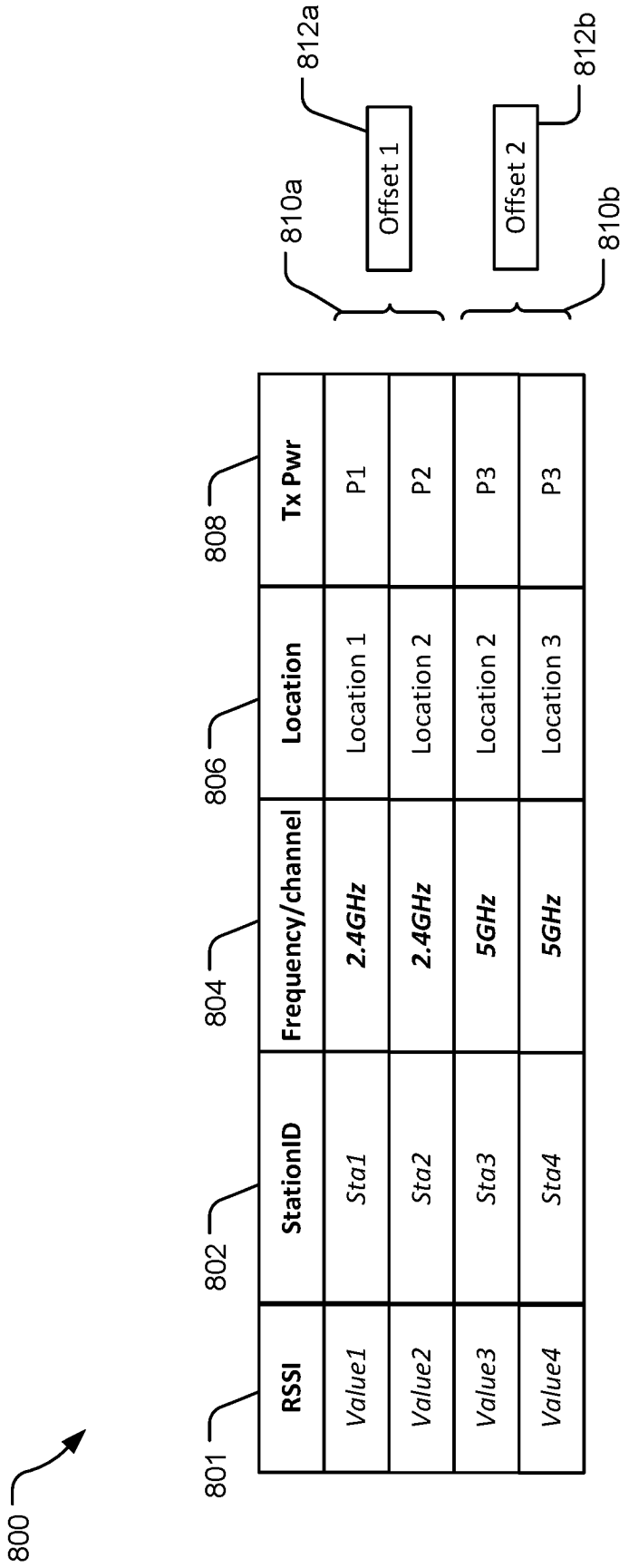

800
801
802
804
806
808
RSSI
StationID
Frequency/channel
Location
Tx Pwr
Value1
Sta1
2.4GHz
Location 1
P1
Value2
Sta2
2.4GHz
Location 2
P2
Value3
Sta3
5GHz
Location 2
P3
Value4
Sta4
5GHz
Location 3
P3
810a
812a
Offset 1
Offset 2
812b
810b

FIG. 8A

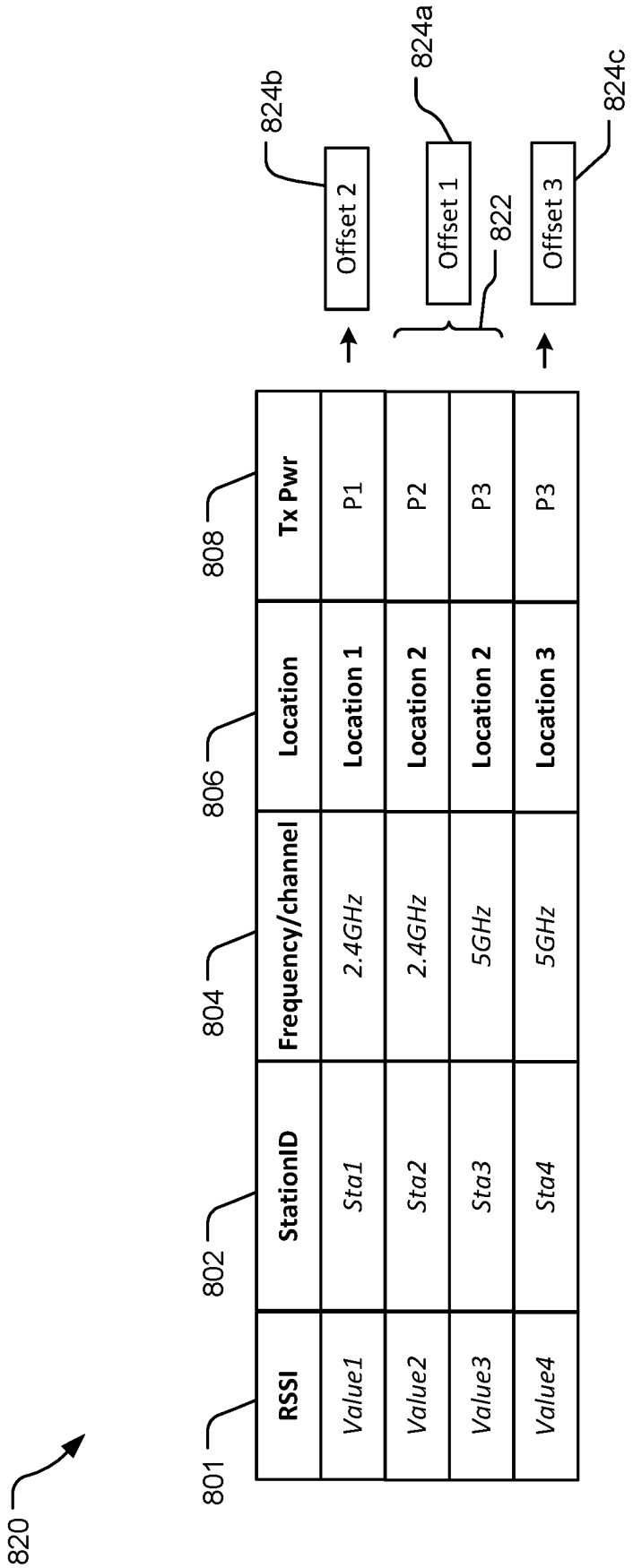

820
801
802
804
806
808
RSSI
StationID
Frequency/channel
Location
Tx Pwr
Value1
Sta1
2.4GHz
Location 1
P1
Value2
Sta2
2.4GHz
Location 2
P2
Value3
Sta3
5GHz
Location 2
P3
Value4
Sta4
5GHz
Location 3
P3
824b
Offset 2
824a
Offset 1
822
824c
Offset 3

FIG. 8B

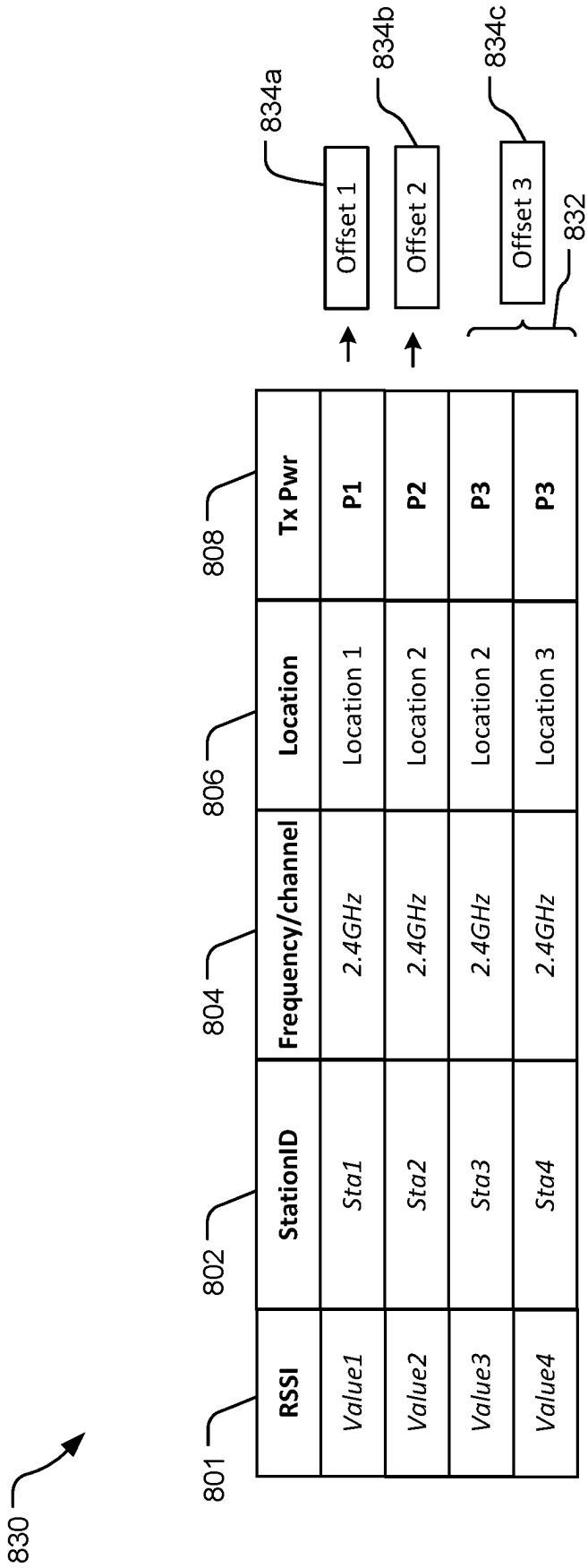

830
801
802
804
806
808
RSSI
StationID
Frequency/channel
Location
Tx Pwr
Value1
Sta1
2.4GHz
Location 1
P1
Value2
Sta2
2.4GHz
Location 2
P2
Value3
Sta3
2.4GHz
Location 2
P3
Value4
Sta4
2.4GHz
Location 3
P3
834a
834b
834c
Offset 1
Offset 2
Offset 3
832

FIG. 8C

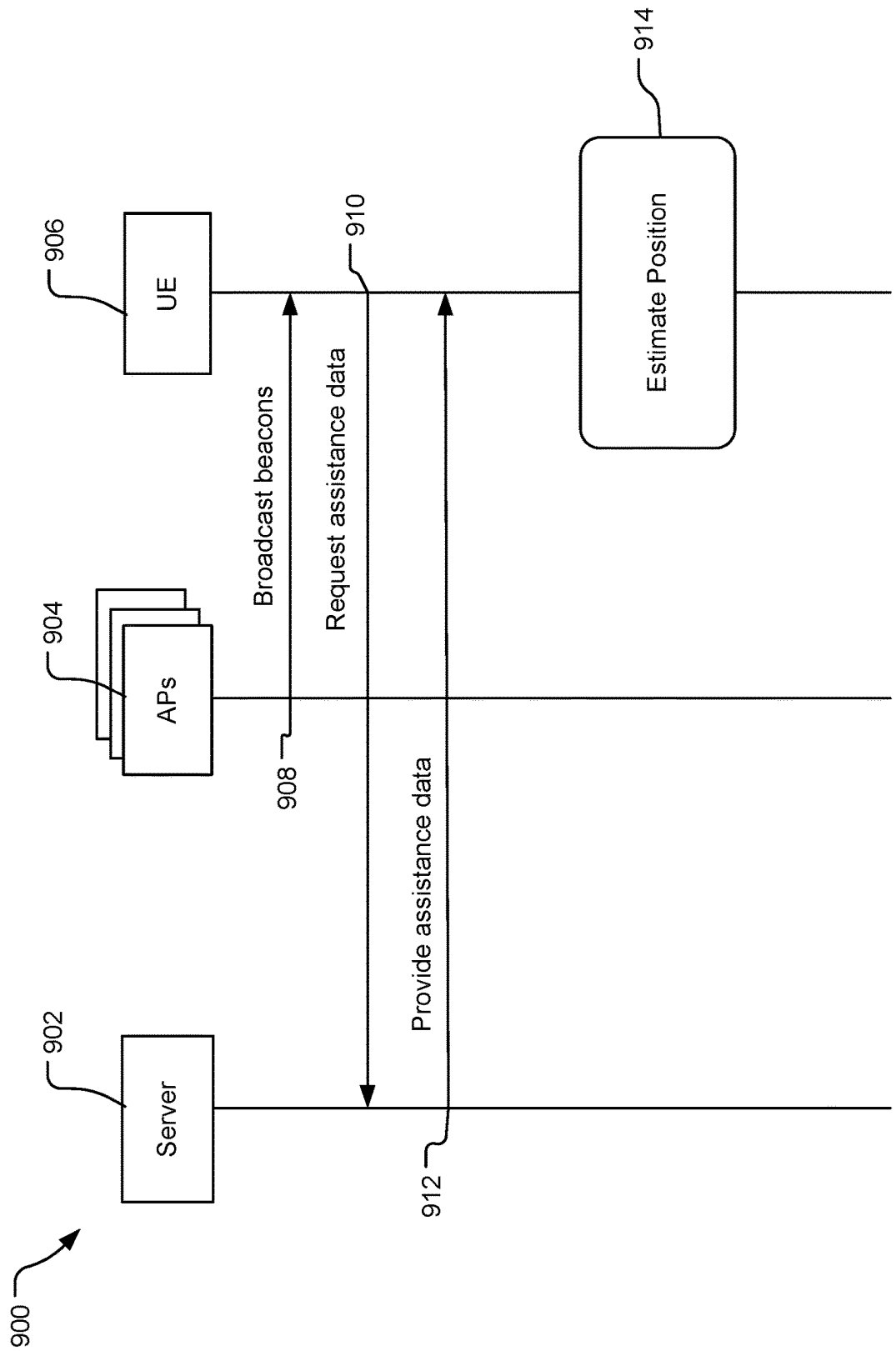

900
902
Server
904
APs
906
UE
908
Broadcast beacons
910
Request assistance data
912
Provide assistance data
914
Estimate Position

FIG. 9A

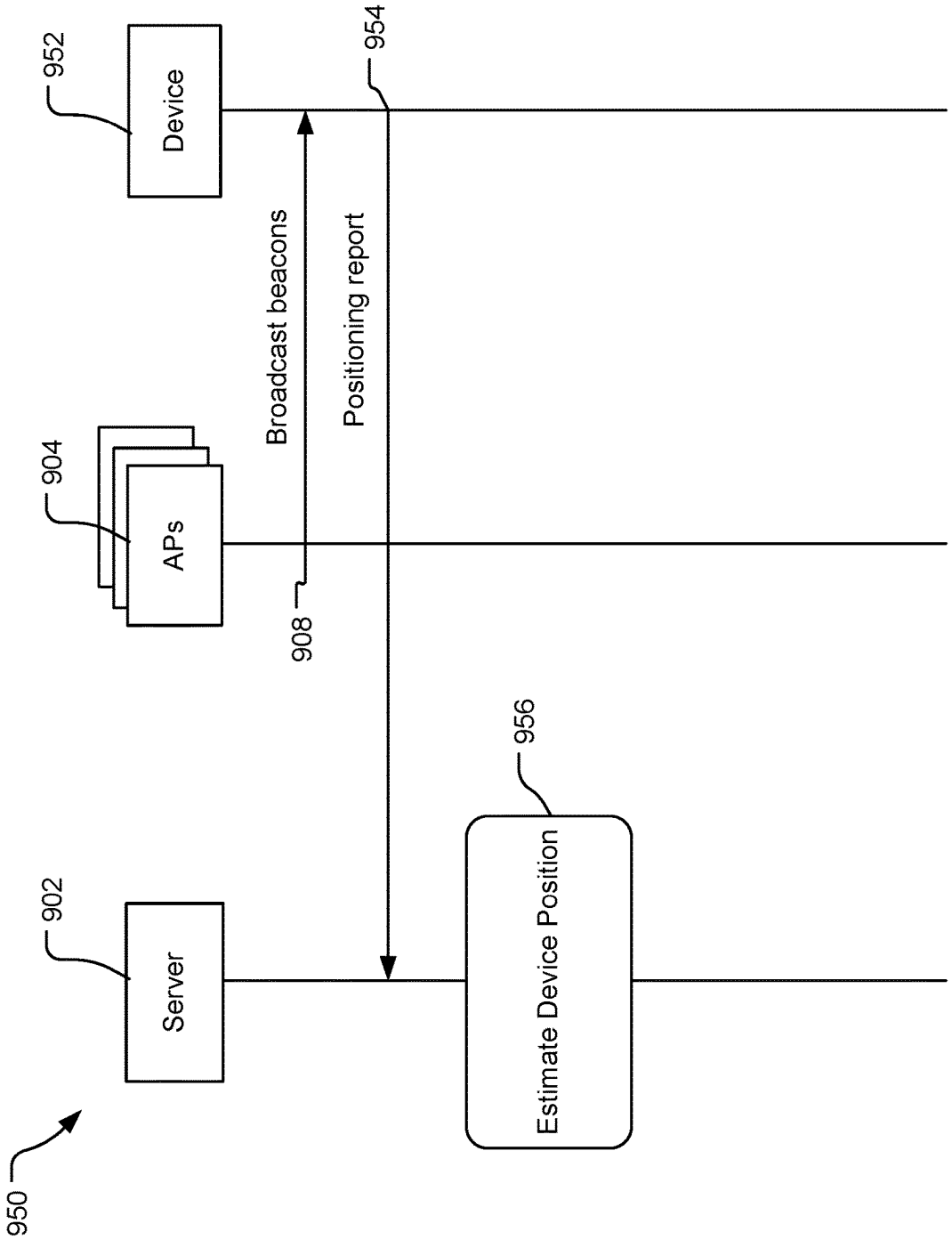

950
902
Server
904
APs
952
Device
908
Broadcast beacons
954
Positioning report
956
Estimate Device Position

FIG. 9B

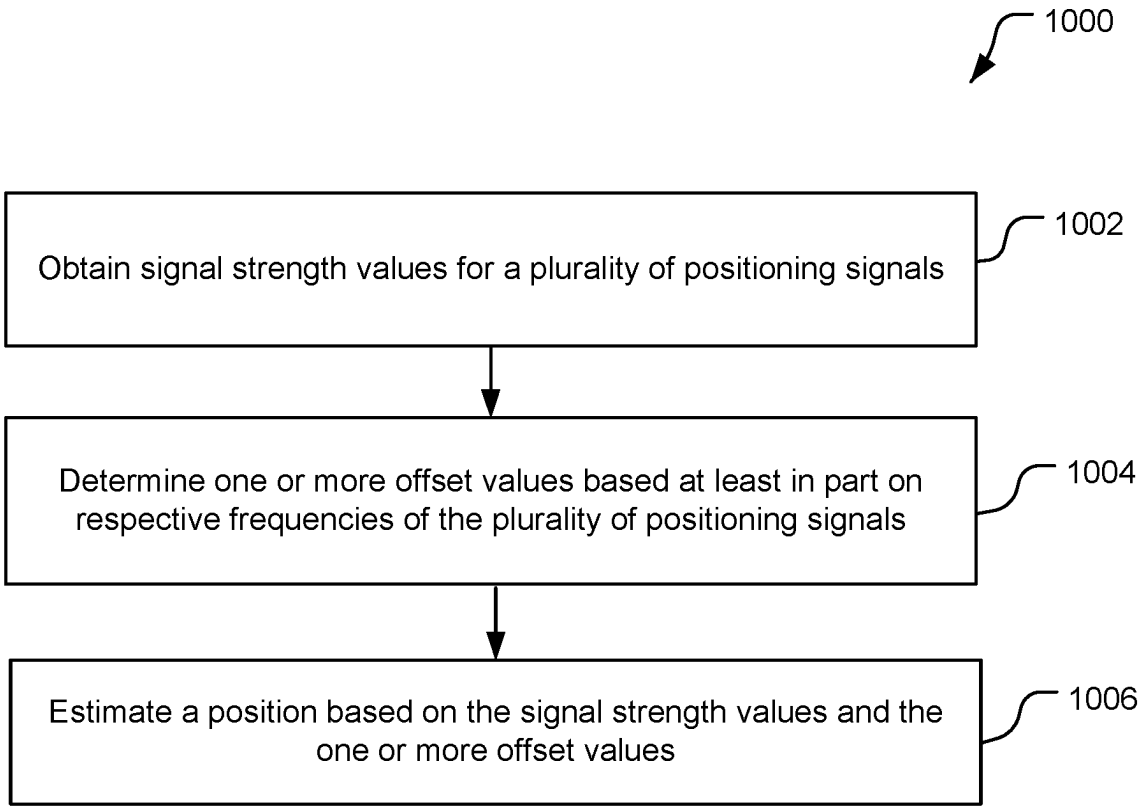

1000
Obtain signal strength values for a plurality of positioning signals
1002
Determine one or more offset values based at least in part on respective frequencies of the plurality of positioning signals
1004
Estimate a position based on the signal strength values and the one or more offset values
1006

FIG. 10

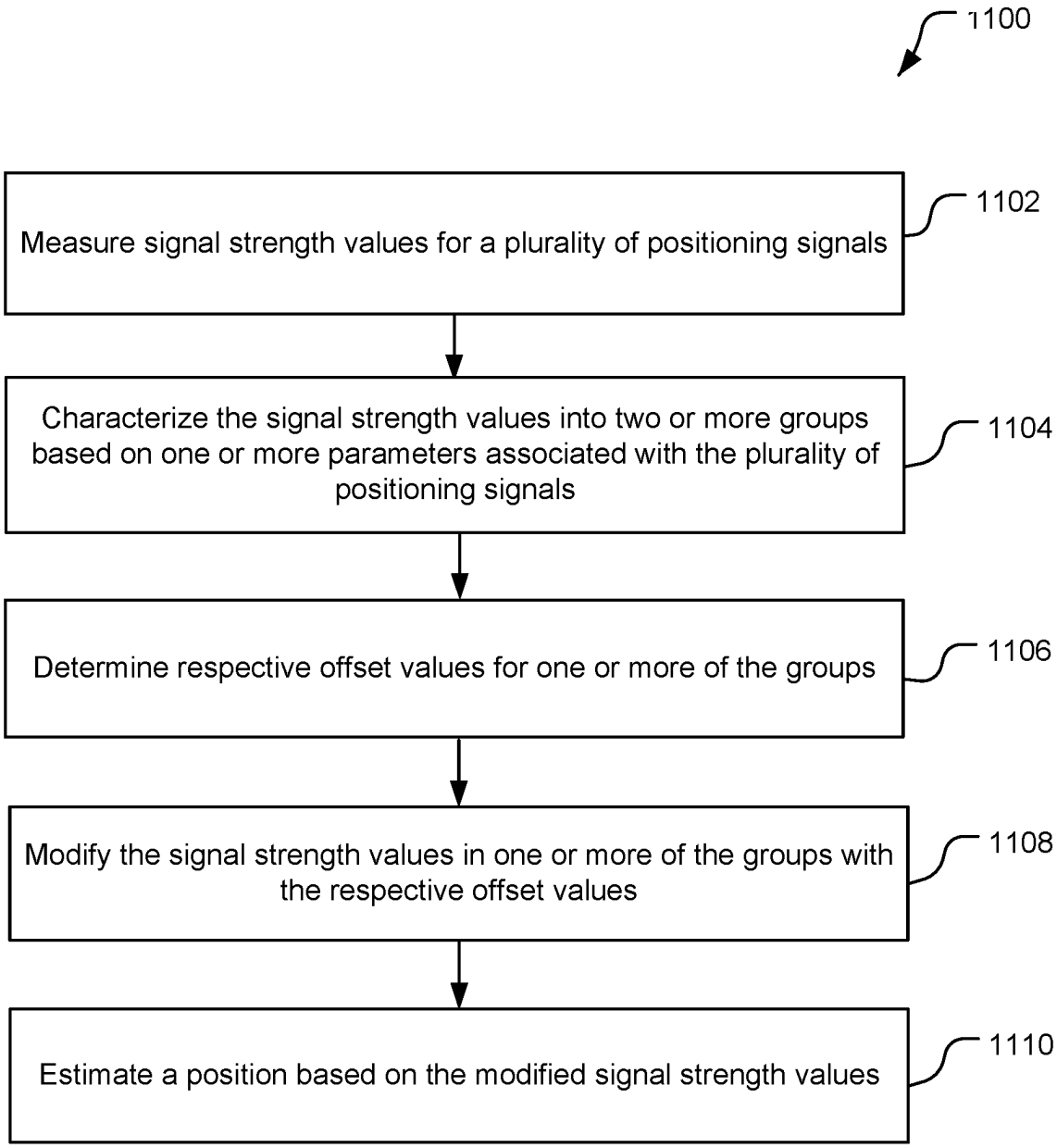

1100
Measure signal strength values for a plurality of positioning signals
1102
Characterize the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals
1104
Determine respective offset values for one or more of the groups
1106
Modify the signal strength values in one or more of the groups with the respective offset values
1108
Estimate a position based on the modified signal strength values
1110

FIG. 11

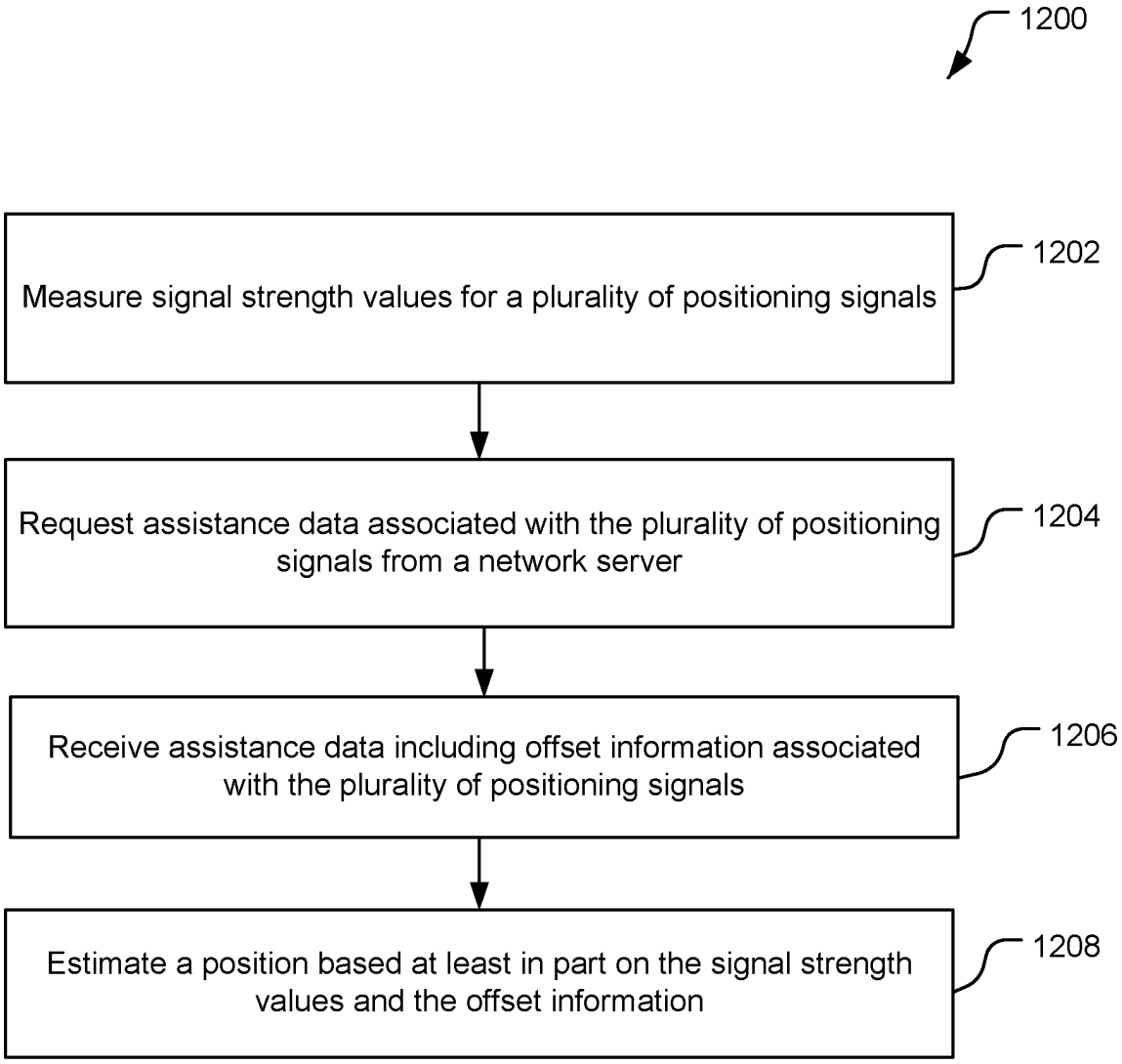

1200
Measure signal strength values for a plurality of positioning signals
1202
Request assistance data associated with the plurality of positioning signals from a network server
1204
Receive assistance data including offset information associated with the plurality of positioning signals
1206
Estimate a position based at least in part on the signal strength values and the offset information
1208

FIG. 12

SIGNAL STRENGTH BASED POSITIONING WITH CARRIER FREQUENCY INFORMATION

BACKGROUND

[0001] The use of wireless devices for many everyday activities is becoming common. Modern wireless devices may make use of one or more wireless communication technologies. For example, a wireless device may communicate using a short range communication technology such as WiFi technology, Bluetooth® technology, ultrawideband (UWB) technology, millimeter wave (mmWave) technology, etc. The use of short range communication technologies, such as WiFi and Bluetooth®, in wireless devices has become much more common in the last several years and is regularly used in retail businesses, offices, homes, cars, manufacturing operations, and public gathering places. Access points may be installed to enable data communication between wireless devices and a network. Some access points may enable access to the Internet. Short range communication technologies may be used in ranging and radio frequency sensing operations. The use of access points in ranging and positioning applications, however, is often limited because the accuracy of some positioning measurements may be limited.

SUMMARY

[0002] An example method for estimating a position based on measured signal strength values according to the disclosure includes obtaining signal strength values for a plurality of positioning signals, determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals, and estimating the position based on the signal strength values and the one or more offset values.

[0003] An example method for characterizing signal strength measurements and determining a position estimate according to the disclosure includes measuring signal strength values for a plurality of positioning signals, characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals, determining respective offset values for one or more of the groups, modifying the signal strength values in one or more of the groups with the respective offset values, and estimating a position based on the modified signal strength values.

[0004] An example apparatus according to the disclosure includes at least one memory, at least one transceiver, at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to: obtain signal strength values for a plurality of positioning signals, determine one or more offset values associated with the plurality of positioning signals, and estimate a position based on the signal strength values and the one or more offset values.

[0005] An example apparatus according to the disclosure includes at least one memory, at least one transceiver, at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to: measure signal strength values for a plurality of positioning signals, characterize the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals, determine respective offset values for one or more of the groups, modify the signal strength values in one or more of the groups with the respective offset values, and estimate a position based on the modified signal strength values.

[0006] Items and/or techniques described herein may provide one or more of the following capabilities, as well as other capabilities not mentioned. Stations in a wireless network may transmit positioning signals. Mobile devices and other wireless nodes may be configured to obtain signal strength measurements for the positioning signals and determine position estimates based on the signal strength measurements. Offset values may be applied to the signal strength measurements to improve the accuracy of the position estimates. The offset values may be based on a carrier frequency, free-path loss computations, statistical channel models and/or derived models. The offset values may be based on the topology of the stations. The mobile devices may receive assistance data including offset values or other information to enable the computation of offset values. The accuracy of position estimates based on signal strength measurements may be improved. Other capabilities may be provided and not every implementation according to the disclosure must provide any, let alone all, of the capabilities discussed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a diagram of an example wireless local area network (WLAN).

[0008] FIG. **2** is a block diagram of components of an example wireless device or user equipment.

[0009] FIG. **3** is a block diagram of components of an example access point.

[0010] FIG. **4** is a block diagram of components of an example asset tracking device.

[0011] FIG. **5** is a block diagram of components of an example server.

[0012] FIG. **6** is a diagram of determining a distance based on example signal strength measurements.

[0013] FIG. **7**A is a diagram of an example procedure for determining an estimated position based on multiple signal strength measurements.

[0014] FIG. **7**B is a table of example signal strength offsets based on frequency or channel information.

[0015] FIGS. **8**A-**8**C include example grouping schemes for determining a signal strength offset.

[0016] FIGS. **9**A-**9**B are example message flows for determining a position estimate based at least in part on signal strength offset information.

[0017] FIG. **10** is a process flow diagram of an example method for estimating a position based on measured signal strength values.

[0018] FIG. **11** is a process flow diagram of an example method for characterizing signal strength measurements and determining a position estimate.

[0019] FIG. **12** is a process flow diagram of an example method for utilizing assistance data and measured signal strength values to determine a position estimate.

DETAILED DESCRIPTION

[0020] Techniques are discussed herein for positioning wireless devices such as user equipment (UEs), access points (APs), asset tags, and other wireless devices. Wireless devices may be configured to determine a range between the

devices based on measuring the signal strength of received radio frequency (RF) signals. Cellular, WiFi, Bluetooth®, Bluetooth® Low Energy (BLE), sidelink, ultrawideband (UWB), and other wireless technologies may utilize received signal strength indicator (RSSI) values to determine the relative distance between stations. Other ranging techniques may also be used, however, RSSI may be a preferred method in many use cases. For example, a wireless device may be a low-cost device (e.g., asset tag, RedCap UE, etc.) and may lack the capabilities to obtain more complex measurements such as time of arrival (ToA) and angle of arrival (AoA) which may require additional hardware and/or advanced processing capabilities. In some networks, the network stations (e.g., legacy WiFi APs) may not support two-way ranging using ToA measurements and thus may utilize RSSI measurements for positioning operations.

[0021] In general, RSSI-based positioning may yield low accuracies as compared to more complex techniques such as ToA. The position accuracy may be further reduced when the distance between the stations is increased. For example, in large indoor areas such as warehouses and large retail areas, the APs may be over 25 m apart from one another. Base stations in wide area networks may have even larger distances between the stations which may further exacerbate the decreased position accuracy.

[0022] Although being a low-complexity approach, RSSI-based positioning typically yields lower accuracies, that are proportional to the density of anchor nodes. Hence, in large stores and warehouses, where APs tend to be far apart (25-30 m), accuracy tends to be low. This effect is exacerbated in macro-scenarios where gNBs are several hundreds of meters apart. Further, the reference signals may be transmitted over different channels and may undergo different levels of attenuation. As a result, a mobile device may obtain non-uniform RSSI measurements which may further reduce the accuracy.

[0023] The techniques provided herein may be implemented to improve the position accuracy of RSSI measurements with the use of offset values which are applied to the RSSI measurements. In an example, a RSSI offset may be applied to the measured RSSI based on the carrier frequency of the positioning reference signal (or beacon). The offset may be based on a free-path loss, a statistical channel model and/or a derived model. A RSSI offset may be based on prior knowledge of the AP topology and associated capability information, such as the carrier frequency that is supported. RSSI offset values may be applied based on other parameters associated with the reference signals and the AP topology. In an example, a mobile device may receive assistance data from a network server that indicates offset information, such as how to calculate offset values and/or offset threshold values.

[0024] Particular aspects of the subject matter described in this disclosure may be implemented to realize one or more of the following potential advantages. The accuracy of position estimates based on signal strength measurements may be increased. Location estimates for low complexity devices (e.g., reduced capability, asset tags, etc.) and legacy APs may be improved. Signaling overhead (e.g., over-the-air messages) for device positioning may be reduced. Other advantages may also be realized.

[0025] The following description provides examples, and is not limiting of the scope, applicability, or examples set forth in the claims. Changes may be made in the function and arrangement of elements discussed without departing from the scope of the disclosure. Various examples may omit, substitute, or add various procedures or components as appropriate. For instance, the methods described may be performed in an order different from that described, and various steps may be added, omitted, or combined. Also, features described with respect to some examples may be combined in other examples.

[0026] Referring to FIG. **1**, a block diagram illustrates an example of a WLAN network **100** such as, e.g., a network implementing IEEE 802.11 and IEEE 802.15 families of standards. The WLAN network **100** may include an access point (AP) **105** and one or more wireless devices **110** or stations (STAs) **110**, such as mobile stations, head mounted devices (HMDs), personal digital assistants (PDAs), asset tracking devices, other handheld devices, netbooks, notebook computers, tablet computers, laptops, display devices (e.g., TVs, computer monitors, etc.), printers, IoT devices, asset tags, key fobs, vehicles, etc. The AP **105** and the wireless devices **110** may be WiFi, Bluetooth®, and/or UWB capable devices. While one AP **105** is illustrated, the WLAN network **100** may have multiple APs **105**. Each of the wireless devices **110**, which may also be referred to as mobile stations (MSs), mobile devices, access terminals (ATs), user equipment(s) (UE), wireless nodes, wireless devices, subscriber stations (SSs), or subscriber units, may associate and communicate with an AP **105** via a communication link **115**. Each AP **105** has a geographic coverage area **125** such that wireless devices **110** within that area can typically communicate with the AP **105**. The wireless devices **110** may be dispersed throughout the geographic coverage area **125**. Each wireless device **110** may be stationary or mobile.

[0027] A wireless device **110** can be covered by more than one AP **105** and can therefore associate with one or more APs **105** at different times. A single AP **105** and an associated set of stations may be referred to as a basic service set (BSS). An extended service set (ESS) is a set of connected BSSs. A distribution system (DS) is used to connect APs **105** in an extended service set. A geographic coverage area **125** for an access point **105** may be divided into sectors making up a portion of the coverage area. The WLAN network **100** may include access points **105** of different types (e.g., metropolitan area, home network, etc.), with varying sizes of coverage areas and overlapping coverage areas for different technologies. In other examples, other wireless devices can communicate with the AP **105**.

[0028] While the wireless devices **110** may communicate with each other through the AP **105** using communication links **115**, each wireless device **110** may also communicate directly with one or more other wireless devices **110** via a direct wireless link **120**. Two or more wireless devices **110** may communicate via a direct wireless link **120** when both wireless devices **110** are in the AP geographic coverage area **125** or when one or neither wireless device **110** is within the AP geographic coverage area **125**. Examples of direct wireless links **120** may include WiFi Direct connections, connections established by using a WiFi Tunneled Direct Link Setup (TDLS) link, 5G-NR sidelink, PC5, UWB, Bluetooth®, and other P2P group connections. The wireless devices **110** in these examples may communicate according to the WLAN radio and baseband protocol including physical and MAC layers from IEEE 802.11 and IEEE 802.15, and their various versions. For example, the one or more of

the wireless devices **110** and the AP **105** may be configured to utilize WiFi, Bluetooth®, and/or UWB signals for communications and/or positioning applications.

[0029] Referring also to FIG. **2**, a UE **200** is an example of the wireless devices **110** and comprises a computing platform including a processor **210**, memory **211** including software (SW) **212**, one or more sensors **213**, a transceiver interface **214** for a transceiver **215** (including one or more wireless transceivers such as a first wireless transceiver **240***a*, a second wireless transceiver **240***b*, and optionally a wired transceiver **250**), a user interface **216**, a Satellite Positioning System (SPS) receiver **217**, a camera **218**, and a position (motion) device **219**. The processor **210**, the memory **211**, the sensor(s) **213**, the transceiver interface **214**, the user interface **216**, the SPS receiver **217**, the camera **218**, and the position (motion) device **219** may be communicatively coupled to each other by a bus **220** (which may be configured, e.g., for optical and/or electrical communication). One or more of the shown apparatuses (e.g., the camera **218**, the position (motion) device **219**, and/or one or more of the sensor(s) **213**, etc.) may be omitted from the UE **200**. The processor **210** may include one or more hardware devices, e.g., a central processing unit (CPU), a microcontroller, an application specific integrated circuit (ASIC), etc. The processor **210** may comprise multiple processors including a general-purpose/application processor **230**, a Digital Signal Processor (DSP) **231**, a modem processor **232**, a video processor **233**, and/or a sensor processor **234**. One or more of the processors **230-234** may comprise multiple devices (e.g., multiple processors). For example, the sensor processor **234** may comprise, e.g., processors for radio frequency (RF) sensing and ultrasound. The modem processor **232** may support dual SIM/dual connectivity (or even more SIMs). For example, a SIM (Subscriber Identity Module or Subscriber Identification Module) may be used by an Original Equipment Manufacturer (OEM), and another SIM may be used by an end user of the UE **200** for connectivity. The memory **211** is a non-transitory storage medium that may include random access memory (RAM), flash memory, disc memory, and/or read-only memory (ROM), etc. The memory **211** stores the software (which may also include firmware) **212** which may be processor-readable, processor-executable software code containing instructions that are configured to, when executed, cause the processor **210** to perform various functions described herein. Alternatively, the software **212** may not be directly executable by the processor **210** but may be configured to cause the processor **210**, e.g., when compiled and executed, to perform the functions. The description may refer to the processor **210** performing a function, but this includes other implementations such as where the processor **210** executes software and/or firmware. The description may refer to the processor **210** performing a function as shorthand for one or more of the processors **230-234** performing the function. The description may refer to the UE **200** performing a function as shorthand for one or more appropriate components of the UE **200** performing the function. The processor **210** may include a memory with stored instructions in addition to and/or instead of the memory **211**. Functionality of the processor **210** is discussed more fully below.

[0030] The configuration of the UE **200** shown in FIG. **2** is an example and not limiting of the disclosure, including the claims, and other configurations may be used. For example, an example configuration of the UE includes one or more of the processors **230-234** of the processor **210**, the memory **211**, and the wireless transceivers **240***a-b*. Other example configurations include one or more of the processors **230-234** of the processor **210**, the memory **211**, the wireless transceivers **240***a-b*, and one or more of the sensor (s) **213**, the user interface **216**, the SPS receiver **217**, the camera **218**, the PMD **219**, and/or the wired transceiver **250**. Other configurations may not include all of the components of the UE **200**. For example, an IoT device may include more wireless transceivers **240***a-b*, the memory **211** and a general-purpose processor **230**. A multi-link device may simultaneously utilize the first wireless transceiver **240***a* on a first link using a first frequency band, and the second wireless transceiver **240***b* on a second link using a second frequency band. Additional transceivers may also be used for additional links and frequency bands and radio access technologies.

[0031] The UE **200** may comprise the modem processor **232** that may be capable of performing baseband processing of signals received and down-converted by the transceiver **215** and/or the SPS receiver **217**. The modem processor **232** may perform baseband processing of signals to be upconverted for transmission by the transceiver **215**. Also or alternatively, baseband processing may be performed by the general-purpose processor **230** and/or the DSP **231**. Other configurations, however, may be used to perform baseband processing.

[0032] The UE **200** may include the sensor(s) **213** that may include, for example, an Inertial Measurement Unit (IMU) **270**, one or more magnetometers **271**, and/or one or more environment sensors **272**. The IMU **270** may comprise one or more inertial sensors, for example, one or more accelerometers **273** (e.g., collectively responding to acceleration of the UE **200** in three dimensions) and/or one or more gyroscopes **274**. The magnetometer(s) may provide measurements to determine orientation (e.g., relative to magnetic north and/or true north) that may be used for any of a variety of purposes, e.g., to support one or more compass applications. The environment sensor(s) **272** may comprise, for example, one or more temperature sensors, one or more barometric pressure sensors, one or more ambient light sensors, one or more camera imagers, and/or one or more microphones, etc. The sensor(s) **213** may generate analog and/or digital signals indications of which may be stored in the memory **211** and processed by the DSP **231** and/or the general-purpose processor **230** in support of one or more applications such as, for example, applications directed to positioning and/or navigation operations.

[0033] The sensor(s) **213** may be used in relative location measurements, relative location determination, motion determination, etc. Information detected by the sensor(s) **213** may be used for motion detection, relative displacement, dead reckoning, sensor-based location determination, and/or sensor-assisted location determination. The sensor(s) **213** may be useful to determine whether the UE **200** is fixed (stationary) or mobile. In another example, for relative positioning information, the sensors/IMU can be used to determine the angle and/or orientation of the other device with respect to the UE **200**, etc.

[0034] The IMU **270** may be configured to provide measurements about a direction of motion and/or a speed of motion of the UE **200**, which may be used in relative location determination. For example, the one or more accelerometers **273** and/or the one or more gyroscopes **274** of the

IMU **270** may detect, respectively, a linear acceleration and a speed of rotation of the UE **200**. The linear acceleration and speed of rotation measurements of the UE **200** may be integrated over time to determine an instantaneous direction of motion as well as a displacement of the UE **200**. The instantaneous direction of motion and the displacement may be integrated to track a location of the UE **200**. For example, a reference location of the UE **200** may be determined, e.g., using the SPS receiver **217** (and/or by some other means) for a moment in time and measurements from the accelerometer (s) **273** and gyroscope(s) **274** taken after this moment in time may be used in dead reckoning to determine present location of the UE **200** based on movement (direction and distance) of the UE **200** relative to the reference location.

[0035] The magnetometer(s) **271** may determine magnetic field strengths in different directions which may be used to determine orientation of the UE **200**. For example, the orientation may be used to provide a digital compass for the UE **200**. The magnetometer(s) **271** may include a two-dimensional magnetometer configured to detect and provide indications of magnetic field strength in two orthogonal dimensions. Also or alternatively, the magnetometer(s) **271** may include a three-dimensional magnetometer configured to detect and provide indications of magnetic field strength in three orthogonal dimensions. The magnetometer(s) **271** may provide means for sensing a magnetic field and providing indications of the magnetic field, e.g., to the processor **210**.

[0036] The transceiver **215** may include wireless transceivers **240***a-b* and a wired transceiver **250** configured to communicate with other devices through wireless connections and wired connections, respectively. In an example, each of the wireless transceivers **240***a-b* may include respective transmitters **242***a-b* and receivers **244***a-b* coupled to one or more respective antennas **246***a-b* for transmitting and/or receiving wireless signals **248***a-b* and transducing signals from the wireless signals **248***a-b* to wired (e.g., electrical and/or optical) signals and from wired (e.g., electrical and/or optical) signals to the wireless signals **248***a-b*. Thus, the transmitters **242***a-b* may be the same transmitter, or may include multiple transmitters that may be discrete components or combined/integrated components, and/or the receivers **244***a-b* may be the same receiver, or may include multiple receivers that may be discrete components or combined/integrated components. The wireless transceivers **240***a-b* may be configured to communicate signals (e.g., with access points and/or one or more other devices) according to a variety of radio access technologies (RATs) such as 5G New Radio (NR), GSM (Global System for Mobiles), UMTS (Universal Mobile Telecommunications System), AMPS (Advanced Mobile Phone System), CDMA (Code Division Multiple Access), WCDMA (Wideband CDMA), LTE (Long-Term Evolution), LTE Direct (LTE-D), 3GPP LTE-V2X (PC5), IEEE 802.11 (including IEEE 802.11ax and 802.11be), WiFi, WiFi Direct (WiFi-D), Bluetooth®, IEEE 802.15 (UWB), Zigbee etc. The wireless transceivers **240***a-b* may be configured to obtain signal strength measurements for RF signals associated with one or more RATS. The wired transceiver **250** may include a transmitter **252** and a receiver **254** configured for wired communication. The transmitter **252** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the receiver **254** may include multiple receivers that may be discrete components or combined/integrated components. The wired transceiver **250** may be configured, e.g., for optical communication and/or electrical communication. The transceiver **215** may be communicatively coupled to the transceiver interface **214**, e.g., by optical and/or electrical connection. The transceiver interface **214** may be at least partially integrated with the transceiver **215**.

[0037] The user interface **216** may comprise one or more of several devices such as, for example, a speaker, microphone, display device, vibration device, keyboard, touch screen, etc. The user interface **216** may include more than one of any of these devices. The user interface **216** may be configured to enable a user to interact with one or more applications hosted by the UE **200**. For example, the user interface **216** may store indications of analog and/or digital signals in the memory **211** to be processed by DSP **231** and/or the general-purpose processor **230** in response to action from a user. Similarly, applications hosted on the UE **200** may store indications of analog and/or digital signals in the memory **211** to present an output signal to a user. The user interface **216** may include an audio input/output (I/O) device comprising, for example, a speaker, a microphone, digital-to-analog circuitry, analog-to-digital circuitry, an amplifier and/or gain control circuitry (including more than one of any of these devices). Other configurations of an audio I/O device may be used. Also or alternatively, the user interface **216** may comprise one or more touch sensors responsive to touching and/or pressure, e.g., on a keyboard and/or touch screen of the user interface **216**. In an example, the user interface **216** may include one or more biometric sensors configured to obtain biometric information from a user. For example, the biometric sensors may include a fingerprint capture device, a microphone (for voice input), the camera **218** (e.g., for facial recognition, iris detection), a display (e.g., for finger swipe recognition) or other such sensors. The IMU **270** may be configured to obtain motion data to determine biometric information such as the user's gait or step length. Other sensors in the UE **200** may also be used to obtain biometric information from a user.

[0038] The SPS receiver **217** (e.g., a Global Positioning System (GPS) receiver) may be capable of receiving and acquiring SPS signals **260** via an SPS antenna **262**. The antenna **262** is configured to transduce the SPS signals **260** to wired signals, e.g., electrical or optical signals, and may be integrated with one or more of the antennas **246***a-b*. The SPS receiver **217** may be configured to process, in whole or in part, the acquired SPS signals **260** for estimating a location of the UE **200**. For example, the SPS receiver **217** may be configured to determine location of the UE **200** by trilateration using the SPS signals **260**. The general-purpose processor **230**, the memory **211**, the DSP **231** and/or one or more specialized processors (not shown) may be utilized to process acquired SPS signals, in whole or in part, and/or to calculate an estimated location of the UE **200**, in conjunction with the SPS receiver **217**. The memory **211** may store indications (e.g., measurements) of the SPS signals **260** and/or other signals (e.g., signals acquired from the wireless transceivers **240***a-b*) for use in performing positioning operations. For example, the positioning operations may be based on RSSI measurements. The general-purpose processor **230**, the DSP **231**, and/or one or more specialized processors, and/or the memory **211** may provide or support a location engine for use in processing measurements to estimate a location of the UE **200**.

[0039] The UE **200** may include the camera **218** for capturing still or moving imagery. The camera **218** may comprise, for example, an imaging sensor (e.g., a charge coupled device or a CMOS imager), a lens, analog-to-digital circuitry, frame buffers, etc. Additional processing, conditioning, encoding, and/or compression of signals representing captured images may be performed by the general-purpose processor **230** and/or the DSP **231**. Also or alternatively, the video processor **233** may perform conditioning, encoding, compression, and/or manipulation of signals representing captured images. The video processor **233** may decode/decompress stored image data for presentation on a display device (not shown), e.g., of the user interface **216**.

[0040] The position (motion) device (PMD) **219** may be configured to determine a position and possibly motion of the UE **200**. For example, the PMD **219** may communicate with, and/or include some or all of, the SPS receiver **217**. The PMD **219** may also or alternatively be configured to determine location of the UE **200** using terrestrial-based signals (e.g., at least some of the wireless signals **248***a-b*) for trilateration or mulilateration, for assistance with obtaining and using the SPS signals **260**, or both. The PMD **219** may be configured to use one or more other techniques (e.g., relying on the UE's self-reported location (e.g., part of the UE's position beacon)) for determining the location of the UE **200**, and may use a combination of techniques (e.g., SPS and terrestrial positioning signals) to determine the location of the UE **200**. The PMD **219** may include one or more of the sensors **213** (e.g., gyroscope(s), accelerometer(s), magnetometer(s), etc.) that may sense orientation and/or motion of the UE **200** and provide indications thereof that the processor **210** (e.g., the general-purpose processor **230** and/or the DSP **231**) may be configured to use to determine motion (e.g., a velocity vector and/or an acceleration vector) of the UE **200**. The PMD **219** may be configured to provide indications of uncertainty and/or error in the determined position and/or motion. In an example the PMD **219** may be referred to as a Positioning Engine (PE), and may be performed by the general-purpose processor **230**. For example, the PMD **219** may be a logical entity and may be integrated with the general-purpose processor **230** and the memory **211**.

[0041] Referring also to FIG. **3**, an example of an access point (AP) **300** such as the AP **105** comprises a computing platform including a processor **310**, memory **311** including software (SW) **312**, a transceiver **315**, and (optionally) an SPS receiver **317**. The processor **310**, the memory **311**, the transceiver **315**, and the SPS receiver **317** may be communicatively coupled to each other by a bus **320** (which may be configured, e.g., for optical and/or electrical communication). One or more of the shown apparatuses (e.g., a wireless interface and/or the SPS receiver **317**) may be omitted from the AP **300**. The SPS receiver **317** may be configured similarly to the SPS receiver **217** to be capable of receiving and acquiring SPS signals **360** via an SPS antenna **362**. The processor **310** may include one or more intelligent hardware devices, e.g., a central processing unit (CPU), a microcontroller, an application specific integrated circuit (ASIC), etc. The processor **310** may comprise multiple processors (e.g., including a general-purpose/application processor, a DSP, a modem processor, a video processor, and/or a sensor processor as shown in FIG. **2**). The memory **311** is a non-transitory storage medium that may include random access memory (RAM)), flash memory, disc memory, and/or read-only memory (ROM), etc. The memory **311** stores the software **312** which may be processor-readable, processor-executable software code containing instructions that are configured to, when executed, cause the processor **310** to perform various functions described herein. Alternatively, the software **312** may not be directly executable by the processor **310** but may be configured to cause the processor **310**, e.g., when compiled and executed, to perform the functions. The description may refer to the processor **310** performing a function, but this includes other implementations such as where the processor **310** executes software and/or firmware. The description may refer to the processor **310** performing a function as shorthand for one or more of the processors contained in the processor **310** performing the function. The processor **310** may include a memory with stored instructions in addition to and/or instead of the memory **311**. Functionality of the processor **310** is discussed more fully below.

[0042] The transceiver **315** may include a wireless transceiver **340** and a wired transceiver **350** configured to communicate with other devices through wireless connections and wired connections, respectively. For example, the wireless transceiver **340** may include a transmitter **342** and receiver **344** coupled to one or more antennas **346** for transmitting (e.g., on one or more uplink channels) and/or receiving (e.g., on one or more downlink channels) wireless signals **348** and transducing signals from the wireless signals **348** to wired (e.g., electrical and/or optical) signals and from wired (e.g., electrical and/or optical) signals to the wireless signals **348**. Thus, the transmitter **342** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the receiver **344** may include multiple receivers that may be discrete components or combined/integrated components. The wireless transceiver **340** may be configured to communicate signals (e.g., with the UE **200**, one or more other UEs, and/or one or more other devices) according to a variety of radio access technologies (RATs) such as IEEE 802.11 (including IEEE 802.11ax and 802.11bc), WiFi, WiFi Direct (WiFi-D), Bluetooth®, IEEE 802.15 (UWB), Zigbee etc. The wired transceiver **350** may include a transmitter **352** and a receiver **354** configured for wired communication. The transmitter **352** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the receiver **354** may include multiple receivers that may be discrete components or combined/integrated components. The wired transceiver **350** may be configured, e.g., for optical communication and/or electrical communication.

[0043] Referring also to FIG. **4**, an example of an asset tracking device **400** such as an asset tag, key fob, TV remote, security system (e.g., vehicle, commercial, etc.), or other device configured to send and receive RF transmissions. The asset tracking device comprises a computing platform including a processor **410**, memory **411** including software (SW) **412**, a wireless transceiver **415**, and (optionally) an SPS receiver **417**. The SPS receiver **417** may be configured similarly to the SPS receiver **217** to be capable of receiving and acquiring SPS signals **360** via an SPS antenna **462**. The processor **410** may include one or more intelligent hardware devices, e.g., a central processing unit (CPU), a microcontroller, an application specific integrated circuit (ASIC), etc. The processor **410** may comprise multiple processors (e.g., including a general-purpose/application processor, a DSP, a

modem processor, a video processor, and/or a sensor processor as shown in FIG. **2**). The memory **411** is a non-transitory storage medium that may include random access memory (RAM)), flash memory, and/or read-only memory (ROM), etc. The memory **411** stores the software **412** which may be processor-readable, processor-executable software code containing instructions that are configured to, when executed, cause the processor **410** to perform various functions described herein. Alternatively, the software **412** may not be directly executable by the processor **410** but may be configured to cause the processor **410**, e.g., when compiled and executed, to perform the functions. The description may refer to the processor **410** performing a function, but this includes other implementations such as where the processor **410** executes software and/or firmware. The description may refer to the processor **410** performing a function as shorthand for one or more of the processors contained in the processor **410** performing the function. The processor **410** may include a memory with stored instructions in addition to and/or instead of the memory **411**. Functionality of the processor **410** is discussed more fully below.

[0044] The wireless transceiver **415** may be configured to communicate with other devices through wireless connections using RF protocols (e.g., WiFi, BTW, UWB, etc.) protocols. For example, the wireless transceiver **415** may include a transmitter **442** and receiver **444** coupled to one or more antennas **446** for transmitting (e.g., on one or more uplink channels) and/or receiving (e.g., on one or more downlink channels) RF wireless signals **448** and transducing signals from the RF wireless signals **448** to wired (e.g., electrical and/or optical) signals and from wired (e.g., electrical and/or optical) signals to the RF wireless signals **448**. In an example, the wireless transceiver **415** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the receiver **444** may include multiple receivers that may be discrete components or combined/integrated components. In an example, the wireless transceiver **415** may be configured to communicate signals according to a variety of radio access technologies (RATs). For example, the wireless transceiver **415** may be also configured to utilize RATs such as IEEE 802.11 (including IEEE 802.11ax/az and 802.11bc), WiFi, WiFi Direct (WiFi-D), Bluetooth®, IEEE 802.15 (UWB), Zigbee etc.

[0045] Referring also to FIG. **5**, a server **500** may comprise a computing platform including a processor **510**, memory **511** including software (SW) **512**, and a transceiver **515**. The processor **510**, the memory **511**, and the transceiver **515** may be communicatively coupled to each other by a bus **520** (which may be configured, e.g., for optical and/or electrical communication). One or more of the shown apparatus (e.g., a wireless transceiver) may be omitted from the server **500**. The processor **510** may include one or more intelligent hardware devices, e.g., a central processing unit (CPU), a microcontroller, an application specific integrated circuit (ASIC), etc. The processor **510** may comprise multiple processors (e.g., including a general-purpose/application processor, a DSP, a modem processor, a video processor, and/or a sensor processor). The memory **511** may be a non-transitory storage medium that may include random access memory (RAM)), flash memory, disc memory, and/or read-only memory (ROM), etc. The memory **511** may store the software **512** which may be processor-readable, processor-executable software code containing instructions that are configured to, when executed, cause the processor **510** to perform various functions described herein. Alternatively, the software **512** may not be directly executable by the processor **510** but may be configured to cause the processor **510**, e.g., when compiled and executed, to perform the functions. The description herein may refer to the processor **510** performing a function, but this includes other implementations such as where the processor **510** executes software and/or firmware. The description herein may refer to the processor **510** performing a function as shorthand for one or more of the processors contained in the processor **510** performing the function. The description herein may refer to the server **500** performing a function as shorthand for one or more appropriate components of the server **500** performing the function. The processor **510** may include a memory with stored instructions in addition to and/or instead of the memory **511**. Functionality of the processor **510** is discussed more fully below.

[0046] The transceiver **515** may include a wireless transceiver **540** and/or a wired transceiver **550** configured to communicate with other devices through wireless connections and wired connections, respectively. For example, the wireless transceiver **540** may include a wireless transmitter **542** and a wireless receiver **544** coupled to one or more antennas **546** for transmitting (e.g., on one or more downlink channels) and/or receiving (e.g., on one or more uplink channels) wireless signals **548** and transducing signals from the wireless signals **548** to wired (e.g., electrical and/or optical) signals and from wired (e.g., electrical and/or optical) signals to the wireless signals **548**. Thus, the wireless transmitter **542** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the wireless receiver **544** may include multiple receivers that may be discrete components or combined/integrated components. The wireless transceiver **540** may be configured to communicate signals (e.g., with the APs, UEs, and/or one or more other devices) according to a variety of radio access technologies (RATs) such as 5G New Radio (NR), GSM (Global System for Mobiles), UMTS (Universal Mobile Telecommunications System), AMPS (Advanced Mobile Phone System), CDMA (Code Division Multiple Access), WCDMA (Wideband CDMA), LTE (Long Term Evolution), LTE Direct (LTE-D), 3GPP LTE-V2X (PC5), IEEE 802.11 (including IEEE 802.11p), WiFi, WiFi Direct (WiFi-D), Bluetooth®, Zigbee etc. The wired transceiver **550** may include a wired transmitter **552** and a wired receiver **554** configured for wired communication with other network entities. The wired transmitter **552** may include multiple transmitters that may be discrete components or combined/integrated components, and/or the wired receiver **554** may include multiple receivers that may be discrete components or combined/integrated components. The wired transceiver **550** may be configured, e.g., for optical communication and/or electrical communication.

[0047] The description herein may refer to the processor **510** performing a function, but this includes other implementations such as where the processor **510** executes software (stored in the memory **511**) and/or firmware. The description herein may refer to the server **500** performing a function as shorthand for one or more appropriate components (e.g., the processor **510** and the memory **511**) of the server **500** performing the function. The configuration of the

server **500** shown in FIG. **5** is an example and not limiting of the disclosure, including the claims, and other configurations may be used.

[0048] Referring to FIG. **6**, a diagram **600** of determining a distance based on example signal strength measurements is shown. The diagram **600** includes an AP **602** and a UE **604** as example wireless nodes. The AP **602** may be configured to transmit signals, such as beacon signals, on one or more channels. For example, a first signal **606***a* may be transmitted in a 5 GHz band and a second signal **606***b* may be transmitted in a 2.4 GHz band. The 5 GHz and 2.4 GHz bands are examples, and not limitations as other channels and frequencies may be used. Signal strength measurements, such as RSSI, may be associated with signal attenuation such that smaller the RSSI value, the less the attenuation. RSSI based ranging may utilize different models to correlate a RSSI measurement value with a distance value. Some models may be based on theoretical and/or actual path loss measurements. For example, one or more models may be used to generate distance curves such as depicted in a graph **610**. The distance curves may be used to determine a distance between stations based on an RSSI measurement. In operation, however, different signals which are transmitted over different channels may undergo different levels of attenuation and the associated RSSI perceived by a measuring device may be non-uniform. For example, a first distance curve **608***a* may be associated with the first signal **606***a* (e.g., 5 GHZ), and a second distance curve **608***b* may be associated with the second signal **606***b*. Multiple measurements may be obtained and reported by either the AP **602** and the UE **604** and an average value (or median) of the measurements may be used. Trilateration (or multilateration) techniques may be used with RSSI measurements to obtain a position estimate of a wireless node, such as the UE **604**. Specifically, the position estimate may be based on the known positions of multiple stations, and the measured distances to those stations.

[0049] Referring to FIG. **7**A, a diagram of an example procedure for determining an estimated position based on multiple signal strength measurements is shown. The diagram **700** includes a plurality of wireless nodes such as a first AP **702***a*, a second AP **702***b*, a third AP **702***c*, a fourth AP **704***d*, and a UE **704**. The APs **702***a-d* and the UE **704** may be configured to transmit beacons and/or to obtain RSSI measurements based on the transmitted beacons. In an example, the first AP **702***a* may broadcast a first beacon signal **704***a*, the second AP **702***b* may broadcast a second beacon signal **704***b*, the third AP **702***c* may broadcast a third beacon signal **704***c*, and the fourth AP **702***d* may broadcast a fourth beacon signal **704***d*. The beacon signals **704***a-d* may be different reference signals and may utilize different bands, channels or frequencies. The beacon signals **704***a-d* which are transmitted over different channels may undergo different levels of attenuation, and the RSSI values perceived by the UE **704** may be non-uniform. This non-uniformity may decrease the accuracy of position estimates for the UE **704**. The impact of the non-uniformity may be mitigated by applying offset values to the RSSI values. In an example, the offset values may be based on the respective frequencies or channels of the beacon signals **704***a-d*.

[0050] In operation, in an example, the UE **704** may be configure to measure a set of RSSI values corresponding to a set of positioning reference signals, such as the beacon signals **704***a-d*, over a corresponding set of channels (carrier frequencies) and to select a RSSI offset value to be applied to the measured RSSI (i.e., New RSSI=Measured RSSI+Offset). In an example, the RSSI offset values may be based on the corresponding carrier frequencies of the beacon signals **704***a-c*. The offset values may be based on other parameters, such as coarse position information for the UE **704** and/or the APs **702***a-d*. The UE **704** (or a network entity) may be configured to estimate a position of the UE **704** based on the new RSSI values (i.e., with the offset applied to the measured RSSI value).

[0051] In an example, the RSSI offset values may be based on the frequency (channel) of the transmitted reference signal. Referring to FIG. **7**B, a table **720** of example signal strength offset values based on frequency or channel information is shown. The structure of the table **720** is an example, and not a limitation. The table **720** may include a first field **722** associated with different frequencies or channels, and a second field **724** including the corresponding offset values. In an example, the first field **722** may indicate respective frequency bands of the reference signals (e.g., 2.4 GHz band, 5 GHz band, etc.). Different techniques may be implemented to compute the offset values in the second field **724**. In an example, an offset value may be based on a free-space path loss formula:

$$\text{Offset}_n = 20 * \log\left(\frac{f_n(\text{GHz})}{\text{Median}\,(f_k)\,\text{across all } k \text{ measurements}}\right) \quad (1)$$

[0052] The UE **704** may be configured to select a median carrier frequency across a given set of 'k' beacons and apply a RSSI offset value to each of the measured RSSIs. This technique emulates a scenario where each of the beacon signals **704***a-d* are transmitted over the same median carrier frequency.

[0053] In an example, the offset values may be based on statistical channel models. For example, standard models such as those established by industry standards (e.g., 3GPP, IEEE, etc.) may be used to calculate an offset value as a function of the carrier frequency of the current beacon and the median carrier frequency of all the beacons under consideration. In an example, the offset values may be based on a path loss as per a derived model. For example, the offset values may be specified based on prior field measurements and provided to the UE **704** as assistance data. In an example, the table **720** may be represented in a data structure included in the assistance data. The offset values may be based on other parameters.

[0054] Referring to FIGS. **8**A-**8**C, example group schemes for determining a signal strength offset are shown. In an example, the topology of APs inside a building and their capability information may be utilized in determining offset values. The capability information may include location information (e.g., estimated locations in a location server, locations based on crowdsourced data, etc.), list of carrier frequencies over which the reference signals (or beacons) may be transmitted, and/or the transmit power of the reference signals (or beacons).

[0055] In an example, referring to FIG. **8**A, the offset values may be based on grouping reference signals based on a carrier frequency. A first example table **800** may include a RSSI measurement value field **801**, a station ID field **802**, a frequency/channel field **804**, a location field **806** and a transmit power field **808**. The structure and fields in the

tables in FIGS. **8**A-**8**C are examples, and not limitations, as other data structures and fields may be used. In operation, a set of RSSI values **801** corresponding to a set of received beacon frames may be measured and each measured RSSI value may be associated with a carrier frequency. The RSSI values maybe categorize into two or more groups, based on the corresponding carrier frequency. For example, as indicated in the table **800**, the offset values may be based on grouping the carrier frequency. A first group **810***a* may be based on the 2.4 GHz band and a second group **810***b* may be based on the 5 GHz band. A first offset value **812***a* may be applied to RSSI measurement values for signals in the first group **810***a*, and a second offset value **812***b* may be applied to RSSI values for signals in the second group **810***b*. A position estimate may be computed based on the new RSSI values (i.e., with respective offsets applied). In an example, if the ratio of the size of a first group (e.g., the first group **810***a*) to another second group (e.g., the second group **810***b*) exceeds a certain threshold, a RSSI offset value associated with the first group may be applied to the RSSI values from the first group, and the RSSI measurements for the other groups may have no offsets applied.

[0056] Referring to FIG. **8**B, a grouping scheme may be based on the locations of wireless nodes and/or the associated coverage areas. The UE **704** may be configured to measure a set of RSSI values corresponding to a set of received beacon frames, each of which may be associated with an AP with a known (may be a noisy estimate) location, and a carrier frequency. As indicated in a second example table **820**, the UE **704** may be configured to categorize a set of RSSI values **801** into two or more groups, based on the locations of the APs (e.g., a location field **806**). For example, a third group **822** may be generated based on the proximity of the locations of two or more APs. The RSSI values **801** measured from the stations in the third group **822** may be modified by a common offset value, such as the third offset value **824***a*. Other RSSI values may be modified by other offset values, such as a fourth offset value **824***b* and a fifth offset value **824***c*, respectively. In an example, some RSSI values may not be modified by offset values. An offset value may be assigned to an AP which is identified as a high-visibility AP (e.g., an AP whose measurements may be received across wide coverage areas as a result of being in a favorable location for providing coverage, such as in the center of the store). A high visibility AP may be a group of onc.

[0057] Referring to FIG. **8**C, a grouping scheme may be based on a transmitted power field **808** associated with a RSSI value **801**. The UE **704** may be configured to receive power indication information for each of the APs and may group stations based on the transmit power for the reference signals. As indicated in a third example table **830**, the UE **704** may be configured to categorize a set of RSSI values **801** into two or more groups, based on the transmit power field **808**. For example, a fourth group **832** may be generated based on the transmit power associated with the RSSI values, and a sixth offset value **834***c* may be applied to the RSSI values. Other transmit power values may have other offsets, such as a seventh offset value **834***a* and an eighth offset value **834***b* as indicated in FIG. **8**C. In an example, if the difference in transmit power of an AP from a first group and the median (or mean) transmit power of APs from a second group exceeds a certain threshold, then the UE **704** may be configured to select a RSSI offset value to be applied to the RSSI values from the first group.

[0058] The grouping schemes in FIGS. **8**A-**8**C are examples, and not limitations, as offset values may be assigned based on other parameters associated with wireless nodes in a network, and/or the respective reference signals transmitted by the wireless nodes. In an example, offset values may be associated with receiver capabilities. For example, the manufacturers make and model of the UE **704** may impact the RSSI measurements (e.g., due to different antenna configurations, different receiver sensitivities, etc.), and RSSI offset values may be associated with different UE configurations, along with other parameters such as described in FIGS. **8**A-**8**C.

[0059] Referring to FIGS. **9**A and **9**B, example message flows for determining a position estimate based at least in part on signal strength offset information are shown. A first example message flow **900** includes a server **902**, multiple wireless nodes such as multiple APs **904** configured to transmit positioning signals, and a UE **906**. The number and configurations of the wireless nodes in the message flow **900** are examples and not limitations as other network configurations with different wireless nodes may utilize the message flow **900**. The message flow **900** may be utilized for device based positioning, such as indoor navigation use cases where the UE **906** may be configured to determine a position estimate based on received beacons transmitted by the APs **904**. In an example, one or more of the APs **904** may be configured to broadcast beacons **908** which are received by the UE **906**. The UE **906** may provide one or more request assistance data messages **910** to the server **902**. The request assistance data messages **910** may include RSSI measurement information based on the received broadcast beacons **908**. The RSSI measurement information may include a set of RSSI measurements, the corresponding set of carrier frequencies, the corresponding set of AP identifiers (such as MAC address, SSID), the corresponding set of transmit power being used by AP (if available in the AP's beacon), and the corresponding set of AP locations (if available in the AP's beacon). Other information available from the measured beacons may also be included in the one or more request assistance data messages **910**.

[0060] The server **902** may be configured to provide assistance data **912** to the UE **906** based at least in part on receiving the request assistance messages. In an example, the assistance data **912** may include one or more RSSI offset values associated with the RSSI measurements. The assistance data **912** may include formulations to enable the UE **906** to compute one or more RSSI offset values. For example, the assistance data **912** may include a threshold value regarding size ratios between different AP groups (e.g., when the size ratio between groups is above the threshold value, a RSSI offset value is applied to each RSSI value in the larger group). The assistance data **912** may include a threshold value associated with differences in transmit power (e.g., when the difference in transmit power of a first group of APs exceeds the transmit power of a second group of APs by the threshold value, a RSSI offset value is applied to each RSSI value in the first group). The assistance data **912** may include indications of any high-visibility APs. The assistance data **912** may include other information to assist the UE **906** in performing positioning calculations. At stage **914**, the UE **906** may be configured to apply RSSI offset information to the measured RSSI values

to compute a position estimate. For example, the UE **906** may be configured to perform multilateration based on the RSSI ranges and locations of the APs **904** to estimate a current position.

[0061] Referring to FIG. **9**B, a second example message flow **950** includes the server **902**, the APs **904**, and a wireless device **952**, such as an asset tracking device **400** or other reduced capability device. The second message flow **950** may be implemented for server based positioning, such as for asset tracking use cases. The device **952** may be configured to receive the beacons **908** broadcast by the one or more APs **904**, and then send a positioning report **954** to the server **902**. The positioning report **954** may include RSSI measurement information based on the received broadcast beacons **908**. The RSSI measurement information may include a set of RSSI measurements, the corresponding set of carrier frequencies, the corresponding set of AP identifiers (such as MAC address, SSID), the corresponding set of transmit power being used by AP (if available in the AP's beacon), and the corresponding set of AP locations (if available in the AP's beacon). Other information available from the measured beacons may also be included in the positioning report **954**. At stage **956**, the server **902** may be configured to estimate a position for the device **952** based at least in part on the positioning report **954**.

[0062] Referring to FIG. **10**, with further reference to FIGS. **1**-**9**B, a method **1000** for estimating a position based on measured signal strength values includes the stages shown. The method **1000** is, however, an example and not limiting. The method **1000** may be altered, e.g., by having stages added, removed, rearranged, combined, performed concurrently, and/or having single stages split into multiple stages. The UE **200** or the server **500** may be configured to perform the method **1000**. For example, an asset tracking device **400** may be configured to provide signal strength measurements to the server **500**, and the server **500** may be configured to estimate a position of the asset tracking device **400**.

[0063] At stage **1002**, the method includes obtaining signal strength values for a plurality of positioning signals. The UE **200**, including the transceiver **215** and the processors **210**, is a means for obtaining signal strength values. In an example, a network node such as an AP may be configured to transmit reference signals, beacons, or other signals which may be received and measured by other wireless devices in a network. For example, referring to FIG. **9**A, the UE **906** may be configured to obtain signal strength values based on the broadcast beacons **908**. In an example, referring to FIG. **9**B, the server **902** may be configured to obtain the signal strength values in the positioning report **954** from the device **952**.

[0064] At stage **1004**, the method includes determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals. The UE **200**, including the transceiver **215** and the processors **210**, is a means for determining the one or more offset values. In an example, the offset values may be included in one or more data structures such as the table **720**. The offset values may be based on a free-space path loss formula, such as described in equation (1). The offset values may be based on statistical channel models. The offset values may be based at least in part on respective frequencies of the reference signals, such as described in FIGS. **7**A and **7**B. The offset values may be based on the respective frequency bands of each of the plurality of positioning signals (e.g., 2.4 GHz band, 5 GHz band, etc.). The offset values may also be based on parameter groupings, such as described in FIGS. **8**A-**8**C. In an example, referring to FIG. **9**A, the server **902** may be configured to provide assistance data **912** to the UE **906**. The assistance data **912** may include one or more offset values and/or formulations to enable the UE **906** to compute the one or more offset values (e.g., threshold values for AP grouping). In an example, an offset value may be based on the hardware configuration (e.g., antennas, receiver, etc.) of the UE **906** and may be stacked (e.g., combined) with other offset values.

[0065] At stage **1006**, the method includes estimating a position based on the signal strength values and the one or more offset values. The UE **200**, including the processors **210**, is a means for estimating the position. Referring to FIG. **9**A, the UE **906** may obtain a set of RSSI values corresponding to positioning signals measured at stage **1002**. The measured RSSI values may be combined with the one or more offset values determined at stage **1004** to produce a new RSSI value (i.e., New RSSI=Measured RSSI+Offset). The UE **906** may perform trilateration (or multilateration) based on the new RSSI values and the corresponding distances to determine a position estimate. For example, the UE **906** may obtain location information for the APs to compute a position estimate. In an example, the server **902** may be configured to receive a position report from the UE **906**, or an asset tracking device **400**, and to compute the position estimate.

[0066] Referring to FIG. **11**, with further reference to FIGS. **1**-**9**B, a method **1100** for characterizing signal strength measurements and determining a position estimate includes the stages shown. The method **1100** is, however, an example and not limiting. The method **1100** may be altered, e.g., by having stages added, removed, rearranged, combined, performed concurrently, and/or having single stages split into multiple stages.

[0067] At stage **1102**, the method includes measuring signal strength values for a plurality of positioning signals. The UE **200**, including the transceiver **215** and the processors **210**, is a means for measuring signal strength values. In an example, a network node such as an AP may be configured to transmit reference signals, beacons, or other signals which may be received and measured by other wireless devices in a network. For example, referring to FIG. **9**A, the UE **906** may be configured to obtain RSSI values based on the broadcast beacons **908**.

[0068] At stage **1104**, the method includes characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals. The UE **200**, including the transceiver **215** and the processors **210**, is a means for characterizing the signal strength values. In an example, referring to FIGS. **8**A-**8**C, the one or more parameters may be based on capability information associated with the wireless devices and the positioning signals. The capability information may include, for example, location information, carrier frequency information, and/or the transmit power information. Other parameters may also be used to divide the signal strength information into groups.

[0069] At stage **1106**, the method includes determining respective offset values for one or more of the groups. The UE **200**, including the processors **210**, is a means for determining the offset value. The offset value may be based

on a band, frequency and/or channel associated with a group and included in one or more data structures such as the table **720**. The offset values may be based on free-space path loss formulas and/or statistical channel models and applied based on the parameter groupings. In an example, assistance data **912** may include grouping information and associated offset values and/or formulations to enable the UE **906** to compute one or more offset values based on the groupings. In an example, configuration information associated with the receive chain(s) in UE **200** may be used to augment the offset values. For example, manufacturers make and model information may be associated with receiver offset values to be applied to the measured signals.

[0070] At stage **1108**, the method includes modifying the signal strength values in one or more of the groups with the respective offset values. The UE **200**, including the processors **210**, is a means for modifying the signal strength values. The measured signal strength values may be combined with the respective offset values determined at stage **1106** to produce a modified signal strength value (i.e., modified signal strength=Measured signal strength+offset value). An offset value may be applied to each measured value in a group.

[0071] At stage **1110**, the method includes estimating a position based on the modified signal strength values. The UE **200**, including the processors **210**, is a means for estimating a position. A UE (or other network resource) may perform trilateration (or multilateration) based in part on the modified signal strength values computed at stage **1108**. The UE may obtain location information for the APs to compute a position estimate.

[0072] Referring to FIG. **12**, with further reference to FIGS. **1**-**9**B, a method **1200** for utilizing assistance data and measured signal strength values to determine a position estimate includes the stages shown. The method **1200** is, however, an example and not limiting. The method **1200** may be altered, e.g., by having stages added, removed, rearranged, combined, performed concurrently, and/or having single stages split into multiple stages.

[0073] At stage **1202**, the method includes measuring signal strength values for a plurality of positioning signals. A UE **200**, including the transceiver **215** and the processors **210**, is a means for measuring signal strength values. In an example, a network node such as an AP may be configured to transmit reference signals, beacons, or other signals which may be received and measured by other wireless devices in a network. For example, referring to FIG. **9**A, the UE **906** may be configured to obtain RSSI values based on the broadcast beacons **908**.

[0074] At stage **1204**, the method includes requesting assistance data associated with the plurality of positioning signals from a network server. The UE **200**, including the transceiver **215** and the processors **210**, is a means for requesting assistance data. In an example, referring to FIG. **9**A, the UE **906** may provide one or more request assistance data messages **910** to the server **902**. The request assistance data messages **910** may include RSSI measurement information based on the received broadcast beacons **908**. The RSSI measurement information may include a set of RSSI measurements, the corresponding set of carrier frequencies, the corresponding set of AP identifiers (such as MAC address, SSID), the corresponding set of transmit power being used by an AP (if available in the AP's beacon), and the corresponding set of AP locations (if available in the AP's beacon). Other information available from the measured beacons may also be included in the one or more request assistance data messages **910**.

[0075] At stage **1206**, the method includes receiving assistance data including offset information associated with the plurality of positioning signals. The UE **200**, including the transceiver **215** and the processors **210**, is a means for receiving the assistance data. In an example, the offset information may include one or more offset values associated with the signal strength measurements. The offset information may include formulations to enable the UE to compute one or more offset values. For example, the offset information may include a threshold value regarding size ratios between different AP groups (e.g., when the size ratio between groups is above the threshold value, an offset value is applied to each signal strength value in the larger group). The offset information may include a threshold value associated with differences in transmit power (e.g., when the difference in transmit power of a first group of APs exceeds the transmit power of a second group of APs by the threshold value, an offset value may be applied to each signal strength value in the first group). The offset information may include indications of coverage areas for positioning signals (i.e., transmitted by high-visibility APs). The offset information may include other information to assist in obtaining offset values and in performing positioning calculations based on the signal strength measurements obtained at stage **1202**. In an example, a receiver offset value associated with the receive chain used to measure the signal strength values may be included in the assistance data. The receiver offset value may be based on calibration information and/or manufacturing information such as make and model identification information.

[0076] At stage **1208**, the method includes estimating a position based at least in part on the signal strength values and the offset information. The UE **200**, including the processors **210**, is a means for estimating the position. The UE may be configured to combined with the signal strength values with offset values derived from the offset information. The UE **906** may perform trilateration (or multilateration) based on the combined signal strength values and the corresponding distances to determine a position estimate.

[0077] Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software and computers, functions described above can be implemented using software executed by a processor, hardware, firmware, hardwiring, or a combination of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations. Components, functional or otherwise, shown in the figures and/or discussed herein as being connected or communicating with each other are communicatively coupled unless otherwise noted. That is, they may be directly or indirectly connected to enable communication between them.

[0078] As used herein, the singular forms "a," "an," and "the" include the plural forms as well, unless the context clearly indicates otherwise. For example, "a processor" may include one processor or multiple processors. The terms "comprises," "comprising," "includes," and/or "including," as used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but

do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0079] As used herein, unless otherwise stated, a statement that a function or operation is "based on" an item or condition means that the function or operation is based on the stated item or condition and may be based on one or more items and/or conditions in addition to the stated item or condition.

[0080] Also, as used herein, "or" as used in a list of items (possibly prefaced by "at least one of" or prefaced by "one or more of") indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C," or a list of "one or more of A, B, or C" or a list of A or B or C" means A, or B, or C, or AB (A and B), or AC (A and C), or BC (B and C), or ABC (i.e., A and B and C), or combinations with more than one feature (e.g., AA, AAB, ABBC, etc.). Thus, a recitation that an item, e.g., a processor, is configured to perform a function regarding at least one of A or B, or a recitation that an item is configured to perform a function A or a function B, means that the item may be configured to perform the function regarding A, or may be configured to perform the function regarding B, or may be configured to perform the function regarding A and B. For example, a phrase of "a processor configured to measure at least one of A or B" or "a processor configured to measure A or measure B" means that the processor may be configured to measure A (and may or may not be configured to measure B), or may be configured to measure B (and may or may not be configured to measure A), or may be configured to measure A and measure B (and may be configured to select which, or both, of A and B to measure). Similarly, a recitation of a means for measuring at least one of A or B includes means for measuring A (which may or may not be able to measure B), or means for measuring B (and may or may not be configured to measure A), or means for measuring A and B (which may be able to select which, or both, of A and B to measure). As another example, a recitation that an item, e.g., a processor, is configured to at least one of perform function X or perform function Y means that the item may be configured to perform the function X, or may be configured to perform the function Y, or may be configured to perform the function X and to perform the function Y. For example, a phrase of "a processor configured to at least one of measure X or measure Y" means that the processor may be configured to measure X (and may or may not be configured to measure Y), or may be configured to measure Y (and may or may not be configured to measure X), or may be configured to measure X and to measure Y (and may be configured to select which, or both, of X and Y to measure). Substantial variations may be made in accordance with specific requirements. For example, customized hardware might also be used, and/or particular elements might be implemented in hardware, software (including portable software, such as applets, etc.) executed by a processor, or both. Further, connection to other computing devices such as network input/output devices may be employed.

[0081] The systems and devices discussed above are examples. Various configurations may omit, substitute, or add various procedures or components as appropriate. For instance, features described with respect to certain configurations may be combined in various other configurations. Different aspects and elements of the configurations may be combined in a similar manner. Also, technology evolves and, thus, many of the elements are examples and do not limit the scope of the disclosure or claims.

[0082] A wireless communication system is one in which communications are conveyed wirelessly, i.e., by electromagnetic and/or acoustic waves propagating through atmospheric space rather than through a wire or other physical connection. A wireless communication network may not have all communications transmitted wirelessly, but is configured to have at least some communications transmitted wirelessly. Further, the term "wireless communication device," or similar term, does not require that the functionality of the device is exclusively, or even primarily, for communication, or that the device be a mobile device, but indicates that the device includes wireless communication capability (one-way or two-way), e.g., includes at least one radio (each radio being part of a transmitter, receiver, or transceiver) for wireless communication.

[0083] Specific details are given in the description to provide a thorough understanding of example configurations (including implementations). However, configurations may be practiced without these specific details. For example, well-known circuits, processes, algorithms, structures, and techniques have been shown without unnecessary detail in order to avoid obscuring the configurations. This description provides example configurations, and does not limit the scope, applicability, or configurations of the claims. Rather, the preceding description of the configurations provides a description for implementing described techniques. Various changes may be made in the function and arrangement of elements without departing from the scope of the disclosure.

[0084] The terms "processor-readable medium," "machine-readable medium," and "computer-readable medium," as used herein, refer to any medium that participates in providing data that causes a machine to operate in a specific fashion. Using a computing platform, various processor-readable media might be involved in providing instructions/code to processor(s) for execution and/or might be used to store and/or carry such instructions/code (e.g., as signals). In many implementations, a processor-readable medium is a physical and/or tangible storage medium. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media include, for example, optical and/or magnetic disks. Volatile media include, without limitation, dynamic memory.

[0085] A statement that a value exceeds (or is more than or above) a first threshold value is equivalent to a statement that the value meets or exceeds a second threshold value that is slightly greater than the first threshold value, e.g., the second threshold value being one value higher than the first threshold value in the resolution of a computing system. A statement that a value is less than (or is within or below) a first threshold value is equivalent to a statement that the value is less than or equal to a second threshold value that is slightly lower than the first threshold value, e.g., the second threshold value being one value lower than the first threshold value in the resolution of a computing system.

[0086] Implementation examples are described in the following numbered clauses:

[0087] Clause 1. A method for estimating a position based on measured signal strength values, comprising: obtaining signal strength values for a plurality of positioning signals; determining one or more offset values based at least in part on respective frequencies of the plurality of positioning

signals; and estimating the position based on the signal strength values and the one or more offset values.

[0088] Clause 2. The method of clause 1, further comprising: requesting assistance data from a server; and receiving the one or more offset values from the server.

[0089] Clause 3. The method of clause 2, wherein requesting the assistance data from the server includes providing the signal strength values to the server.

[0090] Clause 4. The method of clause 1, wherein the one or more offset values are based at least in part on respective frequency bands of the plurality of positioning signals.

[0091] Clause 5. The method of clause 1, wherein determining the one or more offset values includes calculating a free-space path loss based on a frequency of one or more of the plurality of positioning signals.

[0092] Clause 6. The method of clause 1, further comprising grouping the signal strength values based on one or more parameters associated with the plurality of positioning signals, wherein at least one offset value is associated with one group of the signal strength values.

[0093] Clause 7. The method of clause 6, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

[0094] Clause 8. The method of clause 1, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

[0095] Clause 9. The method of clause 1, wherein obtaining the signal strength values includes receiving a positioning report from a wireless device.

[0096] Clause 10. The method of clause 1, wherein the signal strength values are received signal strength indications.

[0097] Clause 11. The method of clause 1, further comprising: determining a receiver offset value associated with a receive chain utilized to receive one or more of the plurality of positioning signals; and estimating the position based at least in part on the receiver offset value.

[0098] Clause 12. A method for characterizing signal strength measurements and determining a position estimate, comprising: measuring signal strength values for a plurality of positioning signals; characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals; determining respective offset values for one or more of the groups; modifying the signal strength values in one or more of the groups with the respective offset values; and estimating a position based on the modified signal strength values.

[0099] Clause 13. The method of clause 12, further comprising: requesting assistance data from a server; and receiving the respective offset values from the server.

[0100] Clause 14. The method of clause 13, wherein requesting the assistance data from the server includes providing the signal strength values to the server.

[0101] Clause 15. The method of clause 12, wherein at least one of the respective offset values is based at least in part on a frequency of the plurality of positioning signals in one of the groups.

[0102] Clause 16. The method of clause 12, wherein the one or more parameters associated with the plurality of positioning signals includes a coverage area associated with a positioning signal.

[0103] Clause 17. The method of clause 12, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

[0104] Clause 18. The method of clause 12, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

[0105] Clause 19. The method of clause 12, wherein the signal strength values are received signal strength indications.

[0106] Clause 20. The method of clause 12, further comprising: determining a receiver offset value associated with a receive chain utilized to measure one or more of the plurality of positioning signals; and modifying the signal strength values based at least in part on the receiver offset value.

[0107] Clause 21. An apparatus, comprising: at least one memory; at least one transceiver; at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to: obtain signal strength values for a plurality of positioning signals; determine one or more offset values based at least in part on respective frequencies of the plurality of positioning signals; and estimate a position based on the signal strength values and the one or more offset values.

[0108] Clause 22. The apparatus of clause 21, wherein the at least one processor is further configured to: request assistance data from a server; and receive the one or more offset values from the server.

[0109] Clause 23. The apparatus of clause 22, wherein the at least one processor is further configured to provide the signal strength values to the server.

[0110] Clause 24. The apparatus of clause 21, wherein the one or more offset values are based at least in part on respective frequency bands of the plurality of positioning signals.

[0111] Clause 25. The apparatus of clause 21, wherein the at least one processor is further configured to calculate a free-space path loss based on a frequency of one or more of the plurality of positioning signals.

[0112] Clause 26. The apparatus of clause 21, wherein the at least one processor is further configured to group the signal strength values based on one or more parameters associated with the plurality of positioning signals, wherein at least one offset value is associated with one group of the signal strength values.

[0113] Clause 27. The apparatus of clause 26, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

[0114] Clause 28. The apparatus of clause 21, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

[0115] Clause 29. The apparatus of clause 21, wherein the at least one processor is further configured to receive a positioning report from a wireless device to obtain the signal strength values.

[0116] Clause 30. The apparatus of clause 21, wherein the signal strength values are received signal strength indications.

[0117] Clause 31. The apparatus of clause 21, wherein the at least on processor is further configured to: determine a

receiver offset value associated with a receive chain utilized to receive one or more of the plurality of positioning signals; and estimate the position based at least in part on the receiver offset value.

[0118] Clause 32. An apparatus, comprising: at least one memory; at least one transceiver; at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to: measure signal strength values for a plurality of positioning signals; characterize the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals; determine respective offset values for one or more of the groups; modify the signal strength values in one or more of the groups with the respective offset values; and estimate a position based on the modified signal strength values.

[0119] Clause 33. The apparatus of clause 32, wherein the at least one processor is further configured to: request assistance data from a server; and receive the respective offset values from the server.

[0120] Clause 34. The apparatus of clause 33, wherein the at least one processor is further configured to provide the signal strength values to the server.

[0121] Clause 35. The apparatus of clause 32, wherein at least one of the respective offset values is based at least in part on a frequency of the plurality of positioning signals in one of the groups.

[0122] Clause 36. The apparatus of clause 32, wherein the one or more parameters associated with the plurality of positioning signals includes a coverage area associated with a positioning signal.

[0123] Clause 37. The apparatus of clause 32, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

[0124] Clause 38. The apparatus of clause 32, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

[0125] Clause 39. The apparatus of clause 32, wherein the signal strength values are received signal strength indications.

[0126] Clause 40. The apparatus of clause 32, wherein the at least one processor is further configured to: determine a receiver offset value associated with a receive chain utilized to measure one or more of the plurality of positioning signals; and modify the signal strength values based at least in part on the receiver offset value.

[0127] Clause 41. An apparatus for estimating a position based on measured signal strength values, comprising: means for obtaining signal strength values for a plurality of positioning signals; means for determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals; and means for estimating the position based on the signal strength values and the one or more offset values.

[0128] Clause 42. An apparatus for characterizing signal strength measurements and determining a position estimate, comprising: means for measuring signal strength values for a plurality of positioning signals; means for characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals; means for determining respective offset values for one or more of the groups; means for modifying the signal strength values in one or more of the groups with the respective offset values; and means for estimating a position based on the modified signal strength values.

[0129] Clause 43. A non-transitory processor-readable storage medium comprising processor-readable instructions configured to cause one or more processors to estimate a position based on measured signal strength values, comprising code for: obtaining signal strength values for a plurality of positioning signals; determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals; and estimating the position based on the signal strength values and the one or more offset values.

[0130] Clause 44. A non-transitory processor-readable storage medium comprising processor-readable instructions configured to cause one or more processors to characterize signal strength measurements, and to determine a position estimate, comprising code for: measuring signal strength values for a plurality of positioning signals; characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals; determining respective offset values for one or more of the groups; modifying the signal strength values in one or more of the groups with the respective offset values; and estimating a position based on the modified signal strength values.

1. A method for estimating a position based on measured signal strength values, comprising:

obtaining signal strength values for a plurality of positioning signals;

determining one or more offset values based at least in part on respective frequencies of the plurality of positioning signals; and

estimating the position based on the signal strength values and the one or more offset values.

2. The method of claim **1**, further comprising:

requesting assistance data from a server; and

receiving the one or more offset values from the server.

3. The method of claim **2**, wherein requesting the assistance data from the server includes providing the signal strength values to the server.

4. The method of claim **1**, wherein the one or more offset values are based at least in part on respective frequency bands of the plurality of positioning signals.

5. The method of claim **1**, wherein determining the one or more offset values includes calculating a free-space path loss based on a frequency of one or more of the plurality of positioning signals.

6. The method of claim **1**, further comprising grouping the signal strength values based on one or more parameters associated with the plurality of positioning signals, wherein at least one offset value is associated with one group of the signal strength values.

7. The method of claim **6**, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

8. The method of claim **1**, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

9. The method of claim **1**, wherein obtaining the signal strength values includes receiving a positioning report from a wireless device.

10. The method of claim 1, wherein the signal strength values are received signal strength indications.

11. The method of claim 1, further comprising:

determining a receiver offset value associated with a receive chain utilized to receive one or more of the plurality of positioning signals; and

estimating the position based at least in part on the receiver offset value.

12. A method for characterizing signal strength measurements and determining a position estimate, comprising:

measuring signal strength values for a plurality of positioning signals;

characterizing the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals;

determining respective offset values for one or more of the groups;

modifying the signal strength values in one or more of the groups with the respective offset values; and

estimating a position based on the modified signal strength values.

13. The method of claim 12, further comprising:

requesting assistance data from a server; and

receiving the respective offset values from the server.

14. The method of claim 13, wherein requesting the assistance data from the server includes providing the signal strength values to the server.

15. The method of claim 12, wherein at least one of the respective offset values is based at least in part on a frequency of the plurality of positioning signals in one of the groups.

16. The method of claim 12, wherein the one or more parameters associated with the plurality of positioning signals includes a coverage area associated with a positioning signal.

17. The method of claim 12, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

18. The method of claim 12, wherein the plurality of positioning signals are beacon signals broadcast by one or more access points.

19. The method of claim 12, wherein the signal strength values are received signal strength indications.

20. The method of claim 12, further comprising:

determining a receiver offset value associated with a receive chain utilized to measure one or more of the plurality of positioning signals; and

modifying the signal strength values based at least in part on the receiver offset value.

21. An apparatus, comprising:

at least one memory;

at least one transceiver;

at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to:

obtain signal strength values for a plurality of positioning signals;

determine one or more offset values based at least in part on respective frequencies of the plurality of positioning signals; and

estimate a position based on the signal strength values and the one or more offset values.

22. The apparatus of claim 21, wherein the at least one processor is further configured to:

request assistance data from a server; and

receive the one or more offset values from the server.

23. The apparatus of claim 22, wherein the at least one processor is further configured to provide the signal strength values to the server.

24. The apparatus of claim 21, wherein the at least one processor is further configured to calculate a free-space path loss based on a frequency of one or more of the plurality of positioning signals.

25. The apparatus of claim 21, wherein the at least one processor is further configured to group the signal strength values based on one or more parameters associated with the plurality of positioning signals, wherein at least one offset value is associated with one group of the signal strength values.

26. The apparatus of claim 25, wherein the one or more parameters include a frequency of a positioning signal, a location of a station transmitting the positioning signal, a transmission power of the positioning signal, or combinations thereof.

27. The apparatus of claim 21, wherein the at least on processor is further configured to:

determine a receiver offset value associated with a receive chain utilized to receive one or more of the plurality of positioning signals; and

estimate the position based at least in part on the receiver offset value.

28. An apparatus, comprising:

at least one memory;

at least one transceiver;

at least one processor communicatively coupled to the at least one memory and the at least one transceiver, and configured to:

measure signal strength values for a plurality of positioning signals;

characterize the signal strength values into two or more groups based on one or more parameters associated with the plurality of positioning signals;

determine respective offset values for one or more of the groups;

modify the signal strength values in one or more of the groups with the respective offset values; and

estimate a position based on the modified signal strength values.

29. The apparatus of claim 28, wherein the at least one processor is further configured to:

request assistance data from a server; and

receive the respective offset values from the server.

30. The apparatus of claim 28, wherein the at least one processor is further configured to:

determine a receiver offset value associated with a receive chain utilized to measure one or more of the plurality of positioning signals; and

modify the signal strength values based at least in part on the receiver offset value.

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