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(54) METHOD AND SYSTEM FOR LOCATION BASED HANDS-FREE PAYMENT

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H04W 24/00 (2009.01)

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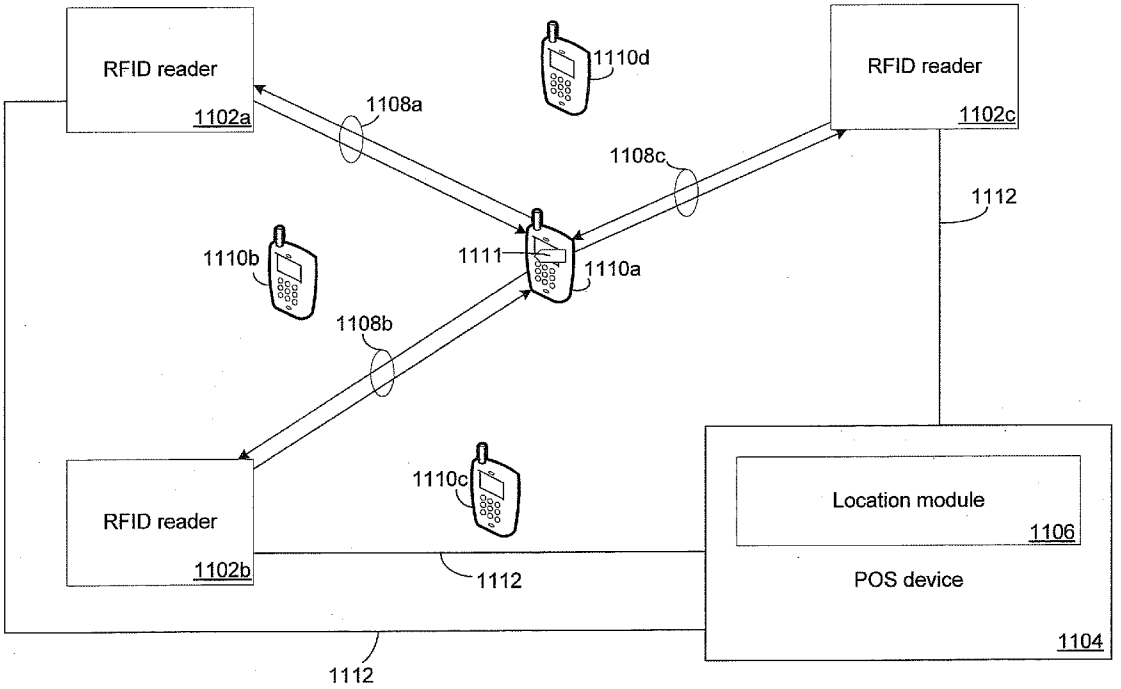
(57) **ABSTRACT**

Certain aspects of a method and system for location based hands-free payment may include a network that comprises a plurality of mobile devices and a plurality of point of sale devices. A first mobile device may determine its location coordinates and communicate them to a selected point of sale device. An authorization to execute a payment transaction may be triggered on the first mobile device when it is within a defined proximity of the selected point of sale device. In another embodiment of the invention, a first point of sale device may determine the location coordinates of a selected mobile device and trigger a notification based on a generated geo-fence when the selected mobile device is within a defined proximity of the first point of sale device.



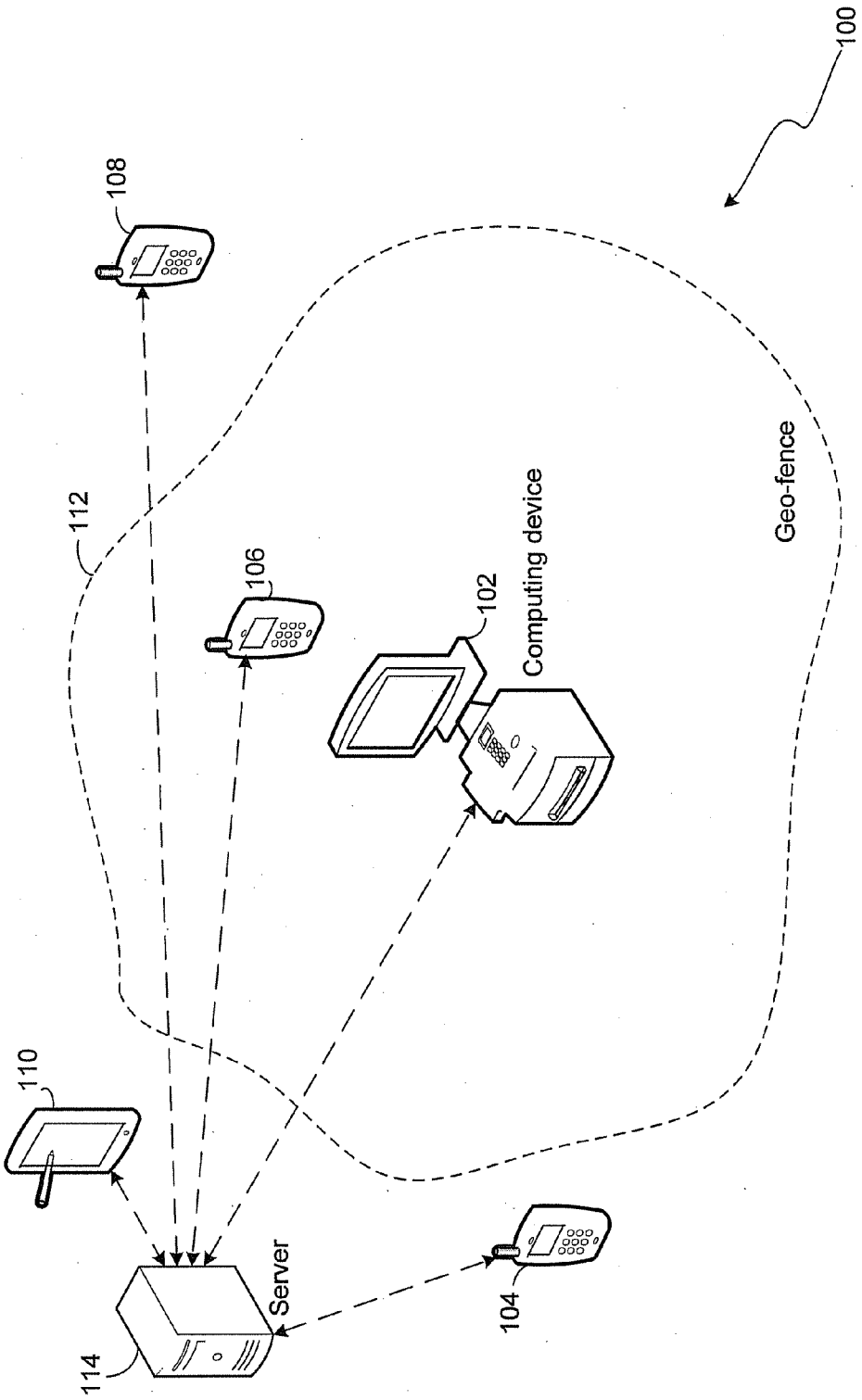

100
108
112
106
102
Computing device
Geo-fence
110
Server
114
104

FIG. 1A

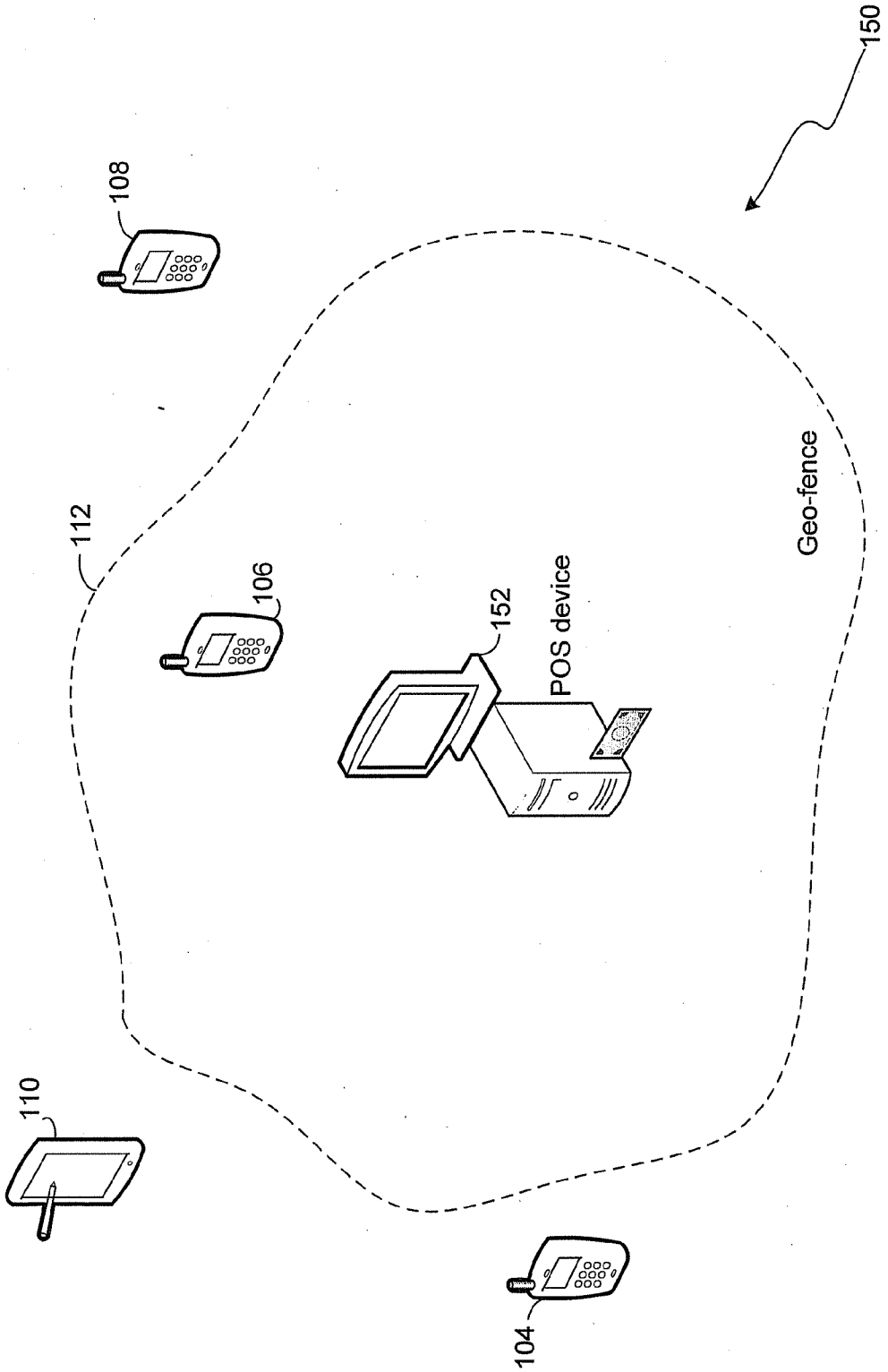


FIG. 1B

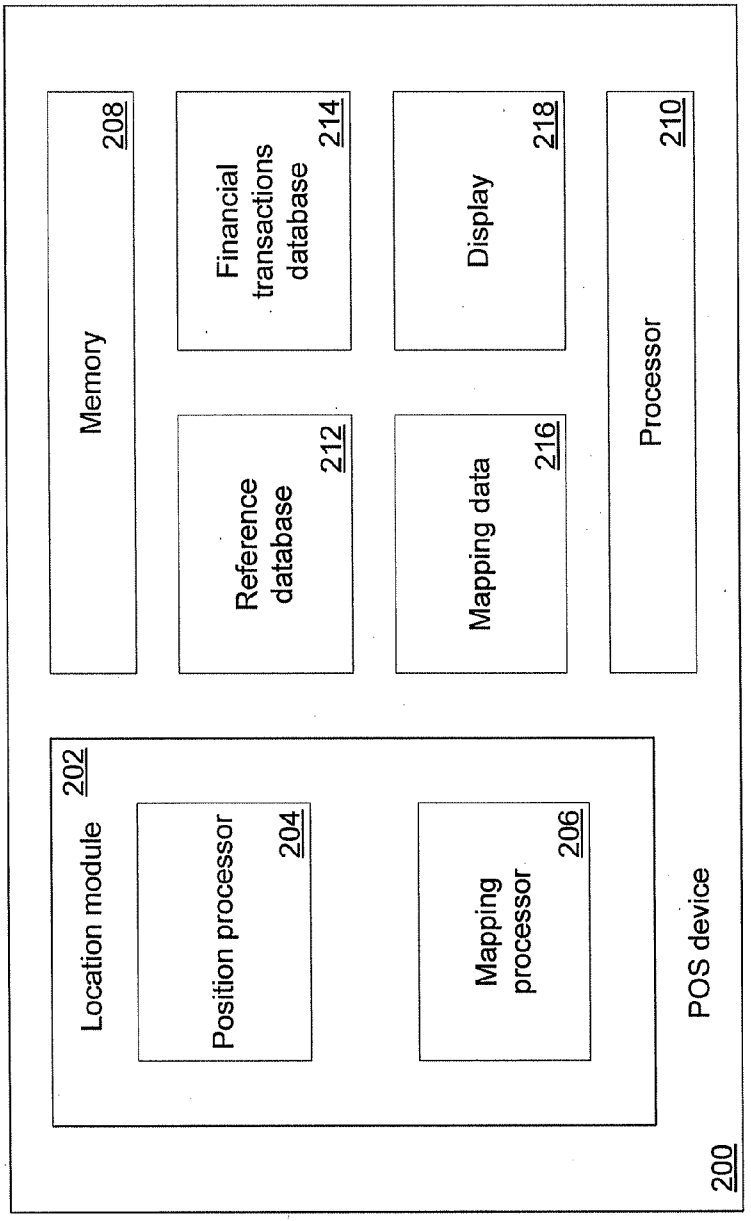

Location module
202
Position processor
204
Mapping processor
206
Memory
208
Reference database
212
Financial transactions database
214
Mapping data
216
Display
218
Processor
210
POS device
200

FIG. 2

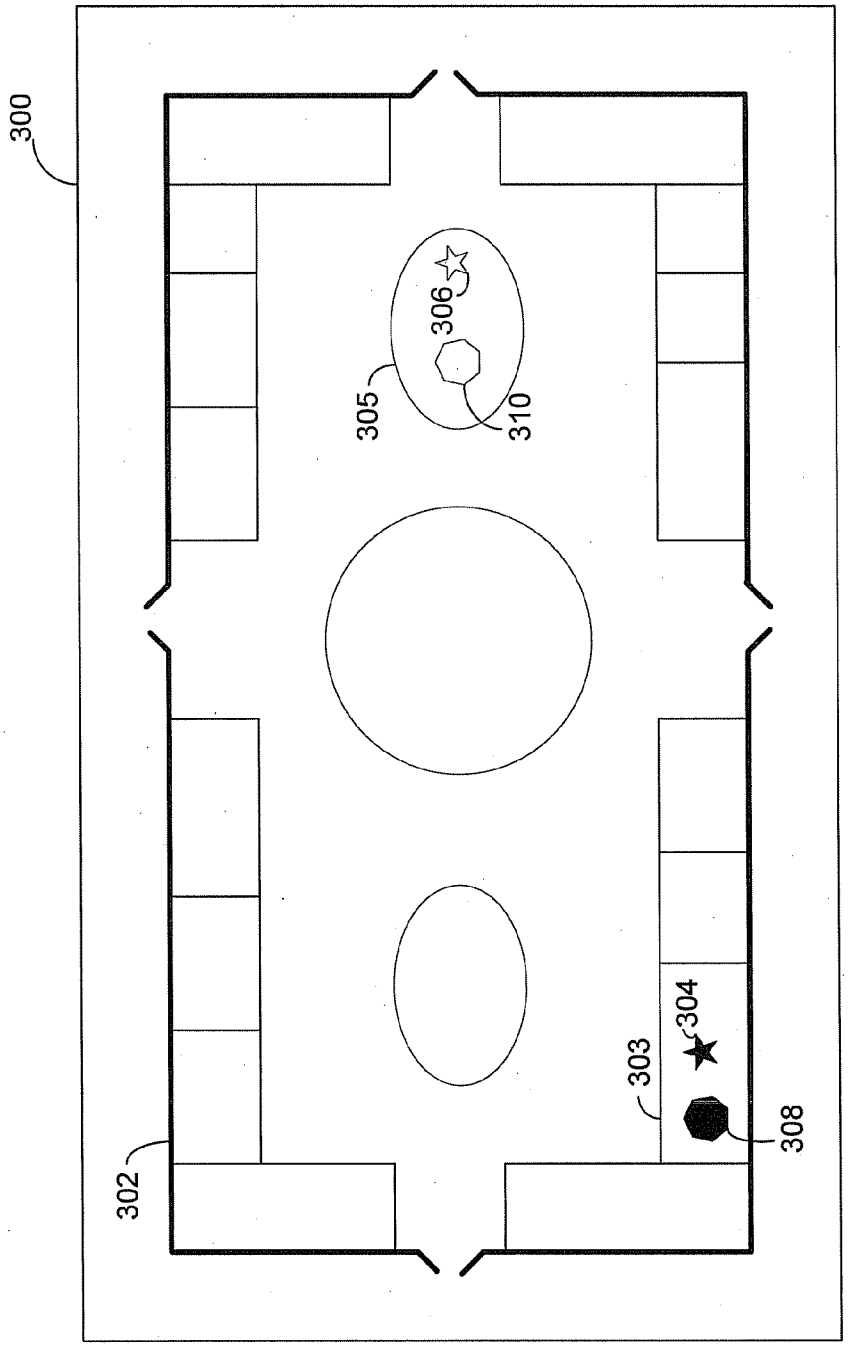


FIG. 3A

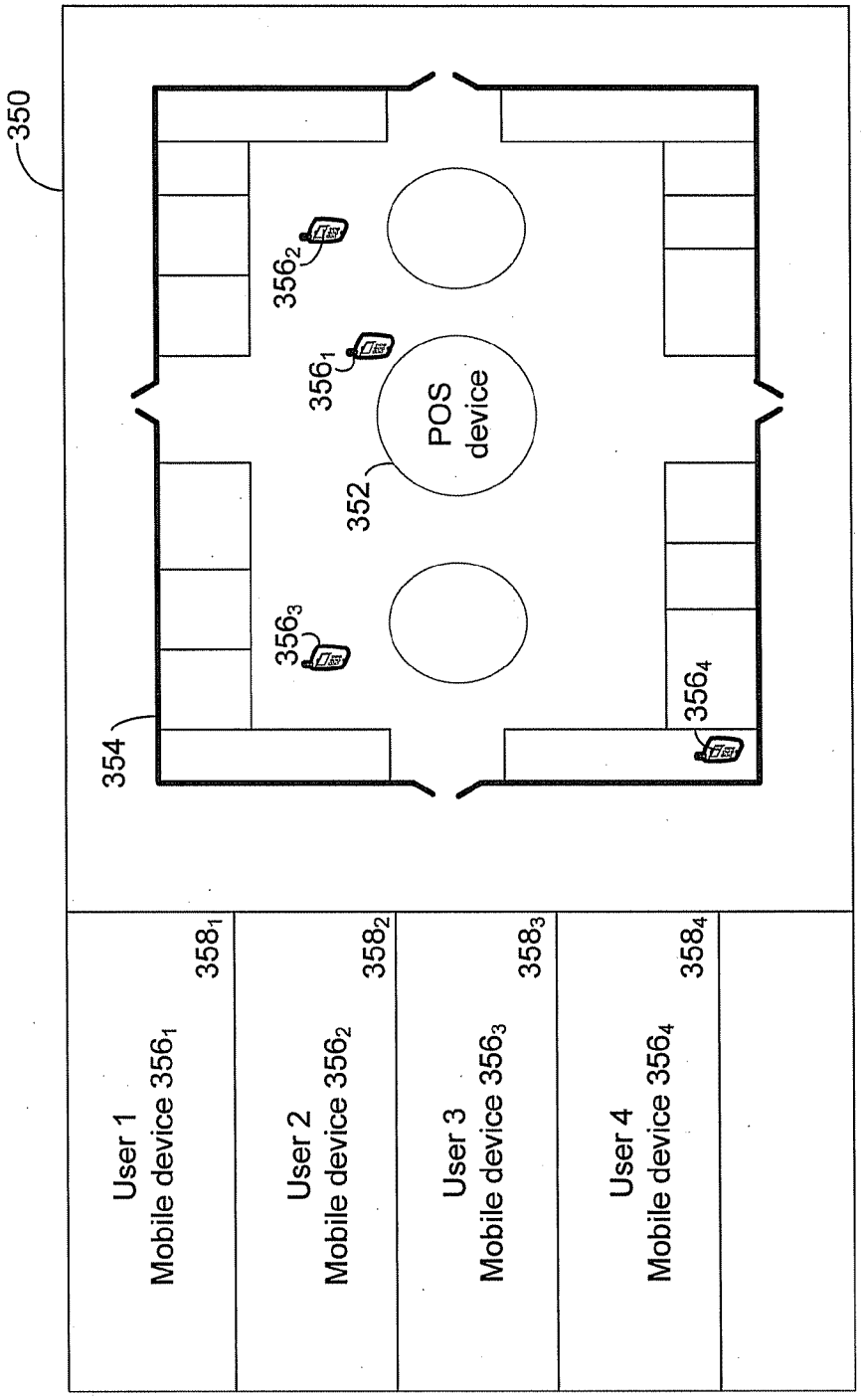

350
354
352
POS device
356_1
356_2
356_3
356_4
User 1
Mobile device 356_1
358_1
User 2
Mobile device 356_2
358_2
User 3
Mobile device 356_3
358_3
User 4
Mobile device 356_4
358_4

FIG. 3B

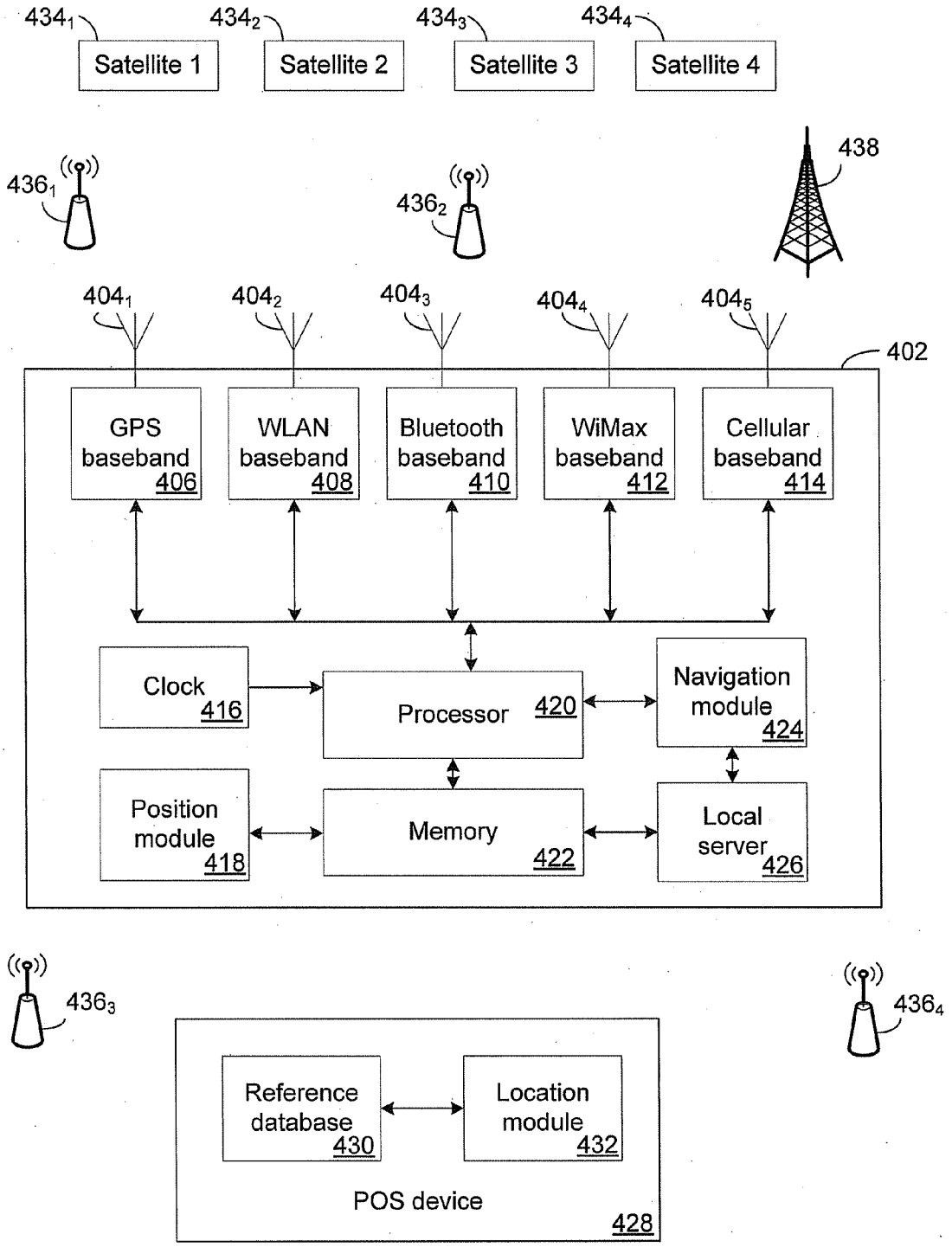

434₁
Satellite 1
434₂
Satellite 2
434₃
Satellite 3
434₄
Satellite 4
438
436₁
436₂
404₁
404₂
404₃
404₄
404₅
402
GPS baseband 406
WLAN baseband 408
Bluetooth baseband 410
WiMax baseband 412
Cellular baseband 414
Clock 416
Processor 420
Navigation module 424
Position module 418
Memory 422
Local server 426
436₃
436₄
Reference database 430
Location module 432
POS device 428

FIG. 4

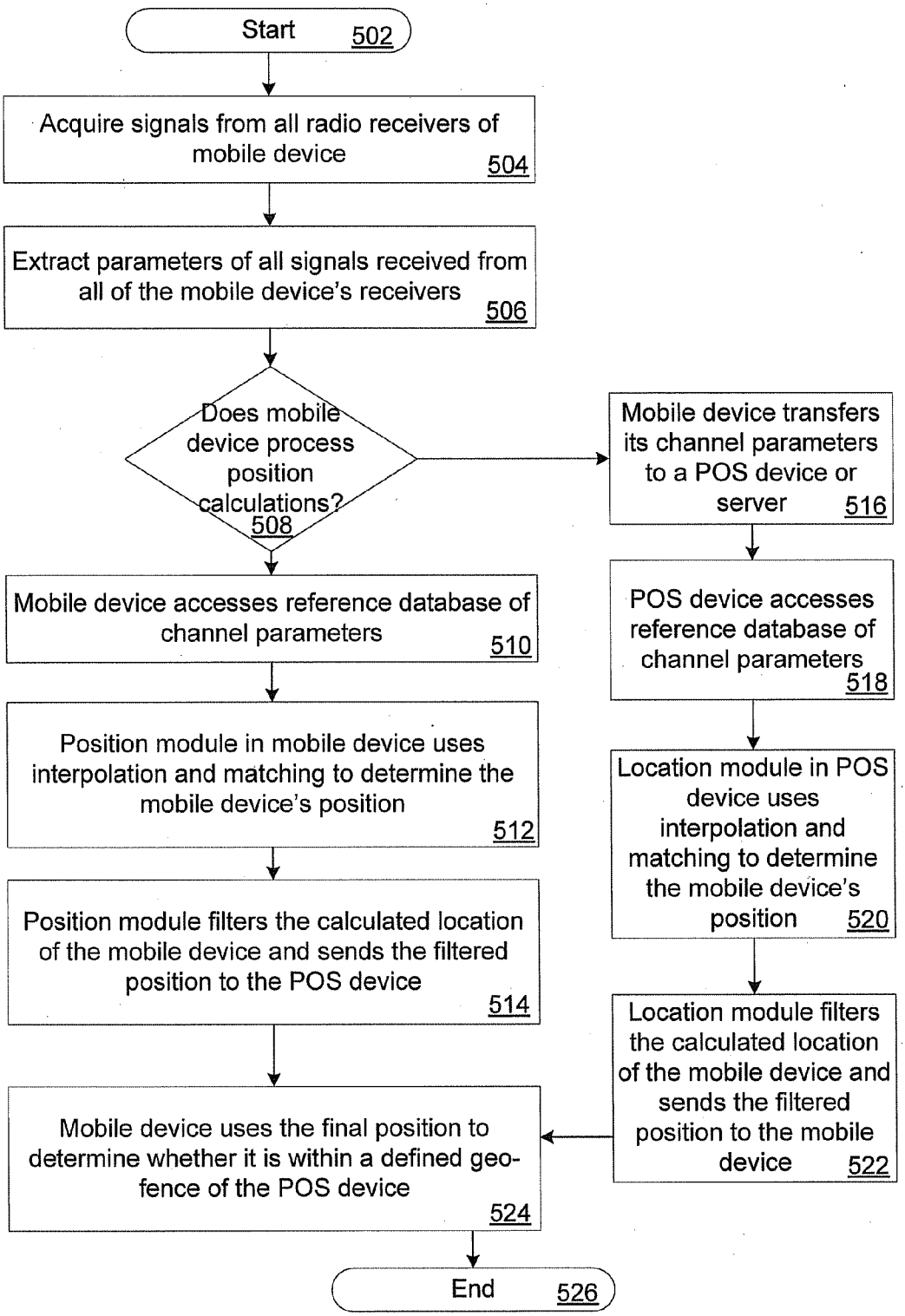

Start 502
Acquire signals from all radio receivers of mobile device 504
Extract parameters of all signals received from all of the mobile device's receivers 506
Does mobile device process position calculations? 508
Mobile device accesses reference database of channel parameters 510
Position module in mobile device uses interpolation and matching to determine the mobile device's position 512
Position module filters the calculated location of the mobile device and sends the filtered position to the POS device 514
Mobile device uses the final position to determine whether it is within a defined geo-fence of the POS device 524
Mobile device transfers its channel parameters to a POS device or server 516
POS device accesses reference database of channel parameters 518
Location module in POS device uses interpolation and matching to determine the mobile device's position 520
Location module filters the calculated location of the mobile device and sends the filtered position to the mobile device 522
End 526

FIG. 5

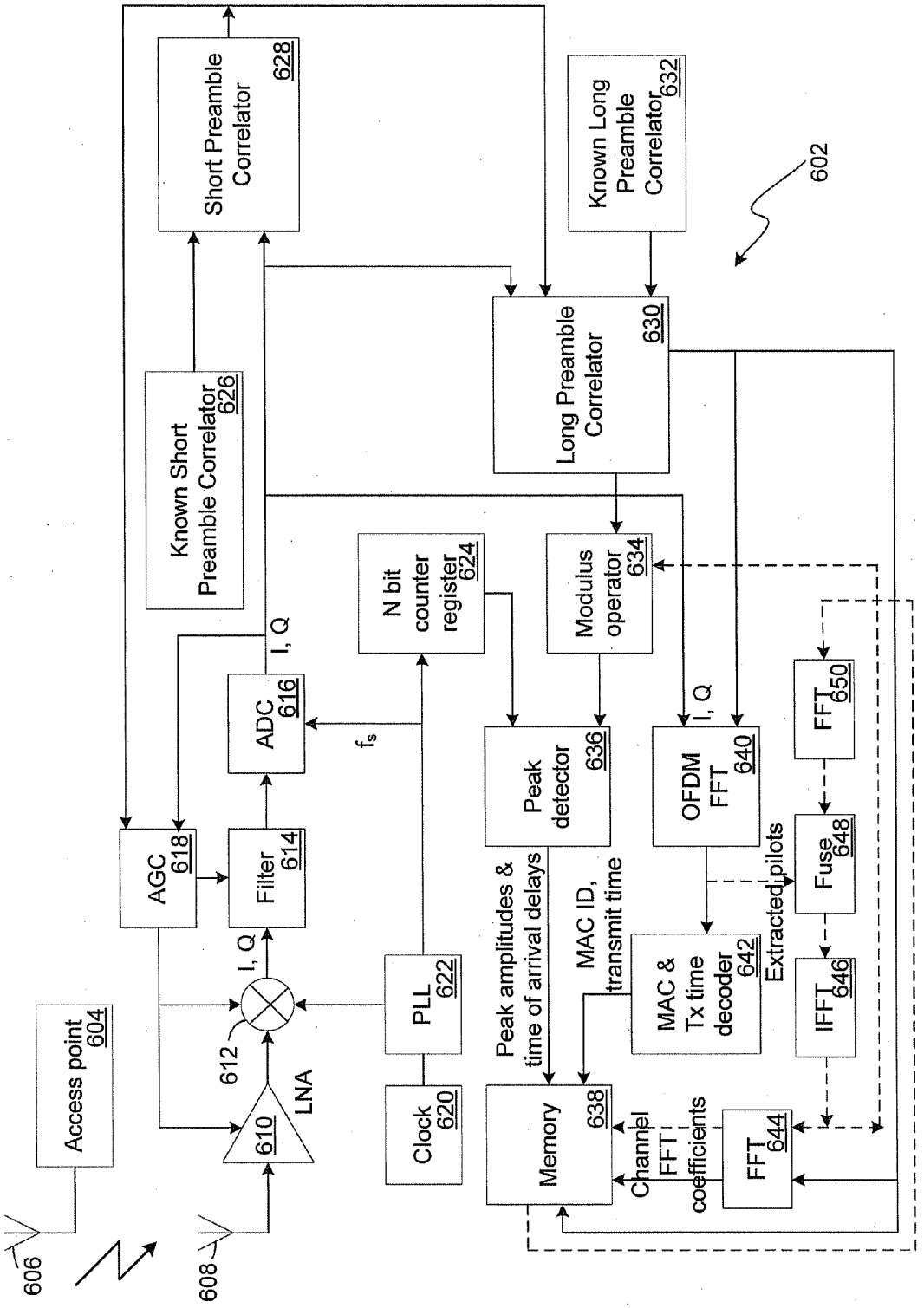

Short Preamble Correlator 628
Known Long Preamble Correlator 632
602
Long Preamble Correlator 630
Known Short Preamble Correlator 626
N bit counter register 624
Modulus operator 634
I, Q
ADC 616
f_s
Peak detector 636
OFDM FFT 640
FFT 650
AGC 618
Filter 614
Fuse 648
Extracted pilots
Peak amplitudes & time of arrival delays
MAC ID, transmit time
MAC & Tx time decoder 642
IFFT 646
Access point 604
612
PLL 622
610
LNA
Clock 620
Memory 638
Channel FFT coefficients
FFT 644
606
608

FIG. 6

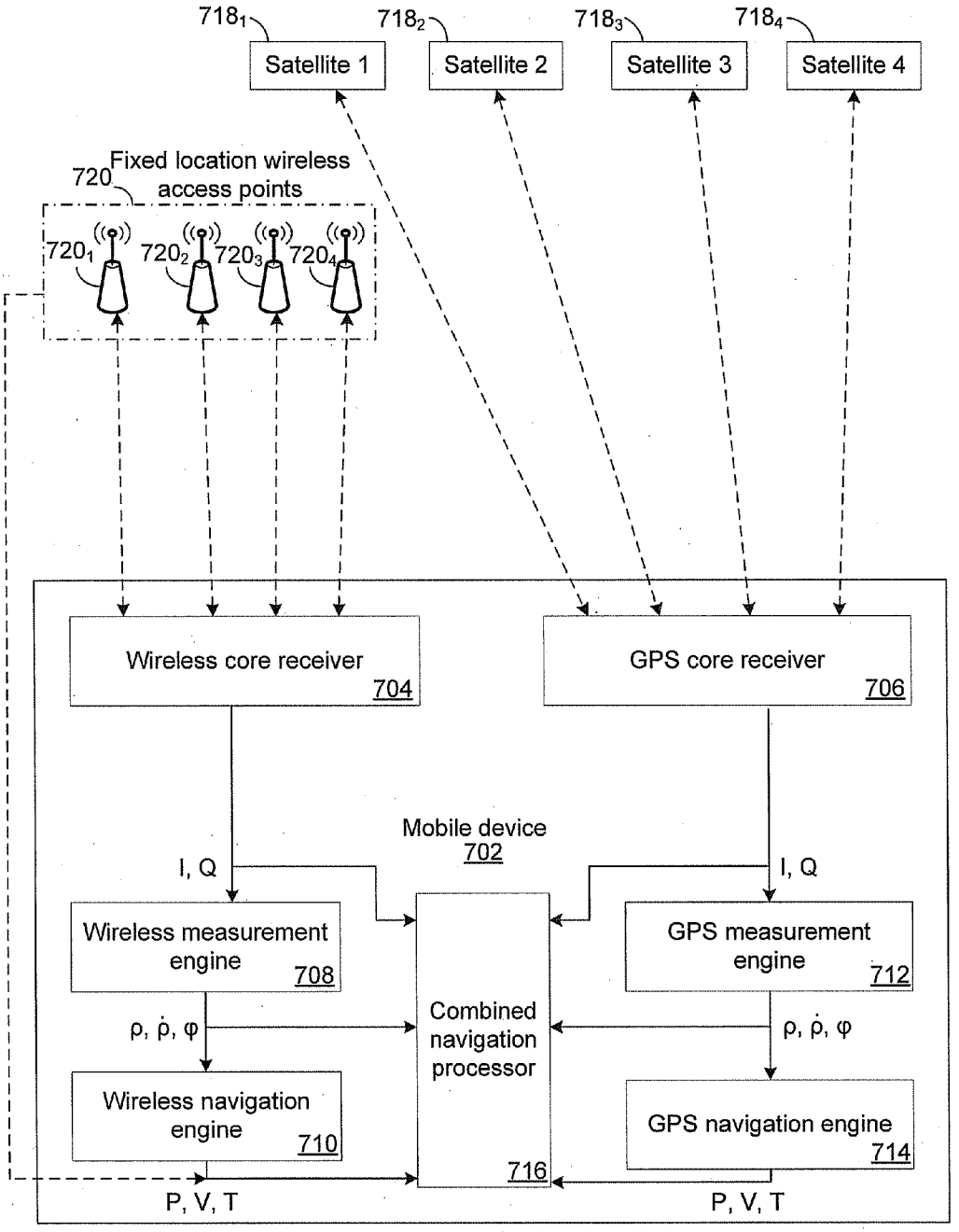

718₁
718₂
718₃
718₄
Satellite 1
Satellite 2
Satellite 3
Satellite 4
720
Fixed location wireless access points
720₁
720₂
720₃
720₄
Wireless core receiver
704
GPS core receiver
706
Mobile device
702
I, Q
I, Q
Wireless measurement engine
708
GPS measurement engine
712
ρ, ρ̇, φ
Combined navigation processor
ρ, ρ̇, φ
Wireless navigation engine
710
GPS navigation engine
714
716
P, V, T
P, V, T

FIG. 7

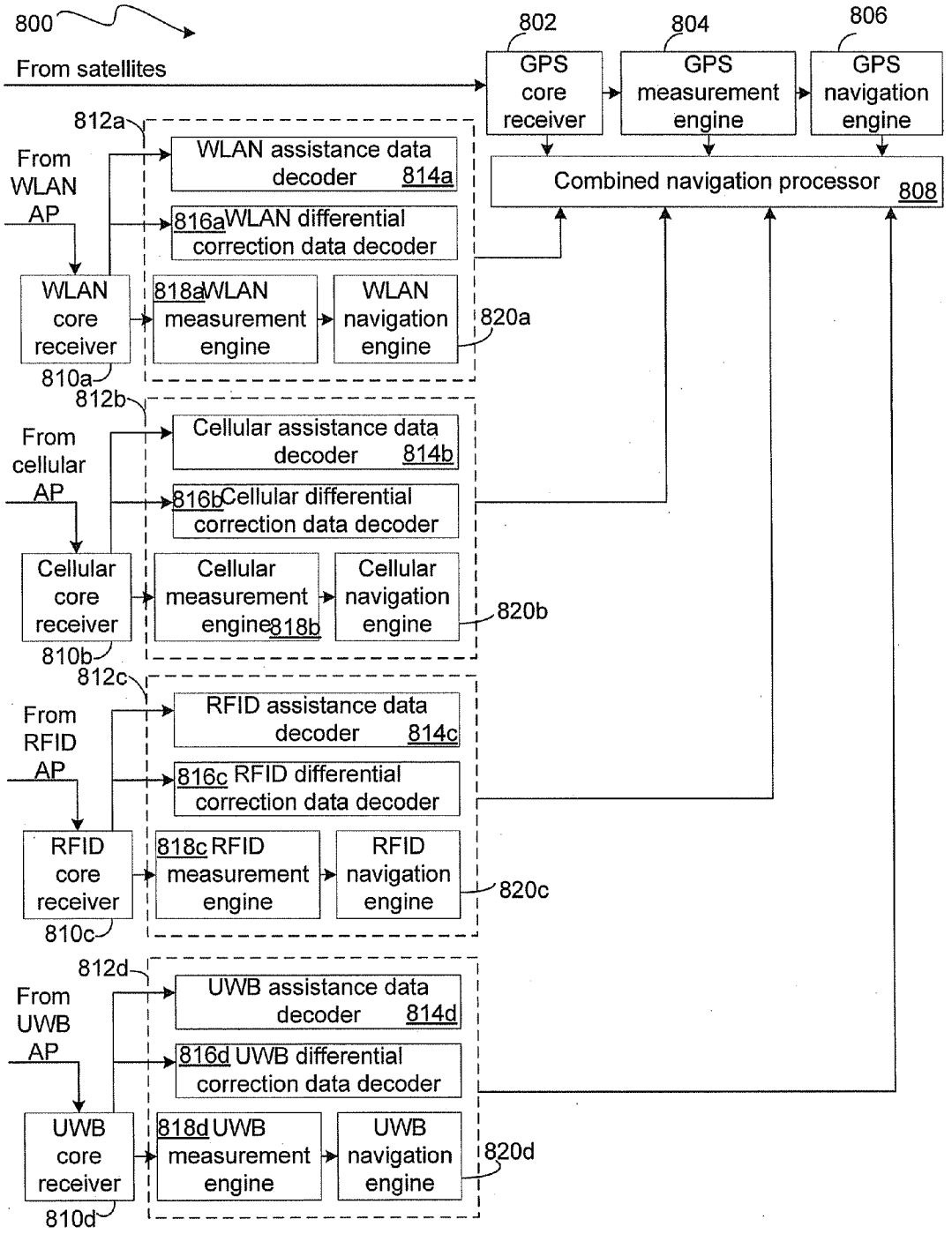

800
From satellites
802
GPS core receiver
804
GPS measurement engine
806
GPS navigation engine
Combined navigation processor 808
812a
From WLAN AP
WLAN assistance data decoder 814a
816a WLAN differential correction data decoder
WLAN core receiver
810a
818a WLAN measurement engine
WLAN navigation engine
820a
812b
From cellular AP
Cellular assistance data decoder 814b
816b Cellular differential correction data decoder
Cellular core receiver
810b
Cellular measurement engine 818b
Cellular navigation engine
820b
812c
From RFID AP
RFID assistance data decoder 814c
816c RFID differential correction data decoder
RFID core receiver
810c
818c RFID measurement engine
RFID navigation engine
820c
812d
From UWB AP
UWB assistance data decoder 814d
816d UWB differential correction data decoder
UWB core receiver
810d
818d UWB measurement engine
UWB navigation engine
820d

FIG. 8

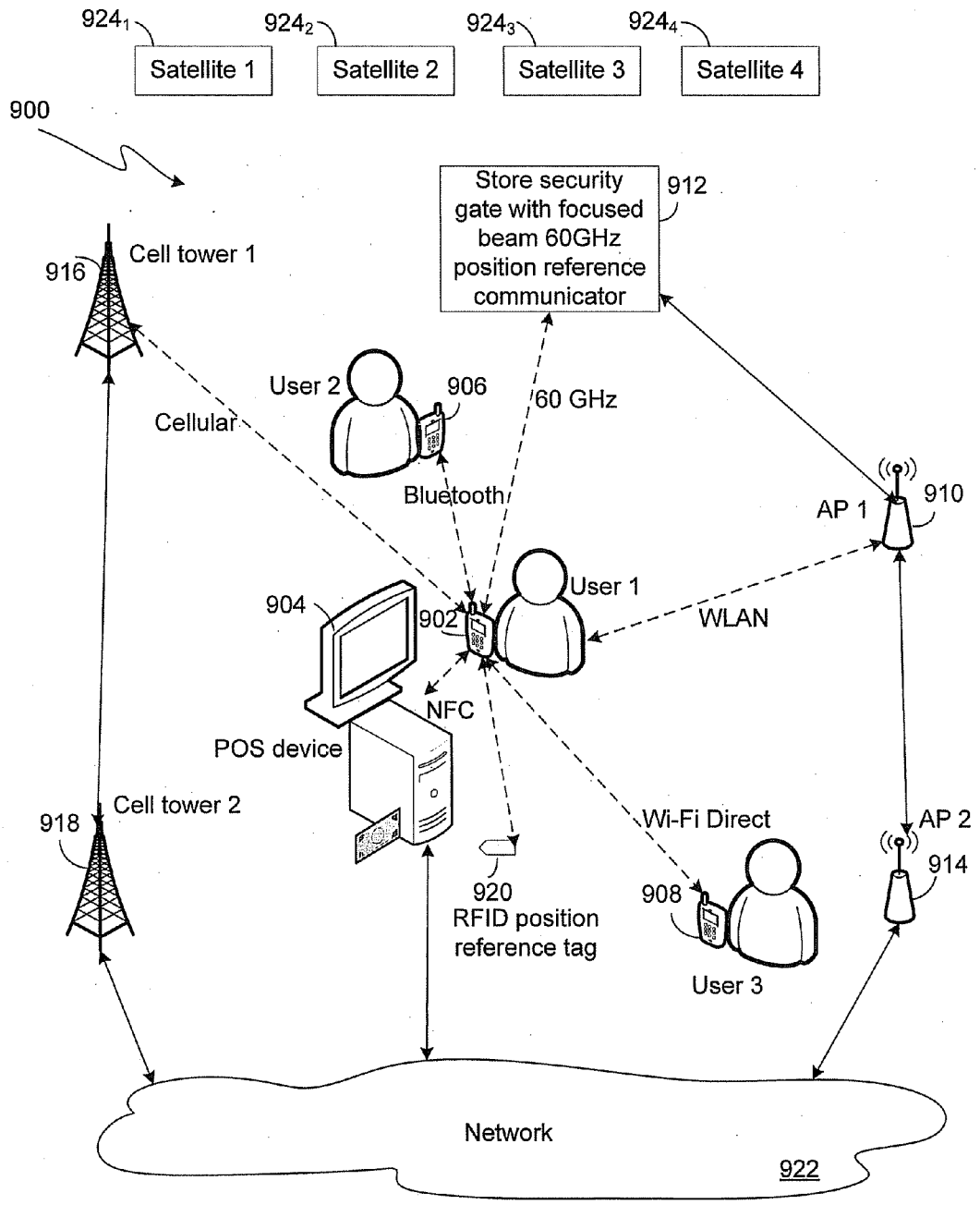

924₁
924₂
924₃
924₄
Satellite 1
Satellite 2
Satellite 3
Satellite 4
900
Store security gate with focused beam 60GHz position reference communicator
912
Cell tower 1
916
User 2
906
60 GHz
Cellular
Bluetooth
AP 1
910
User 1
904
902
WLAN
NFC
POS device
Cell tower 2
918
Wi-Fi Direct
AP 2
914
920
RFID position reference tag
908
User 3
Network
922

FIG. 9

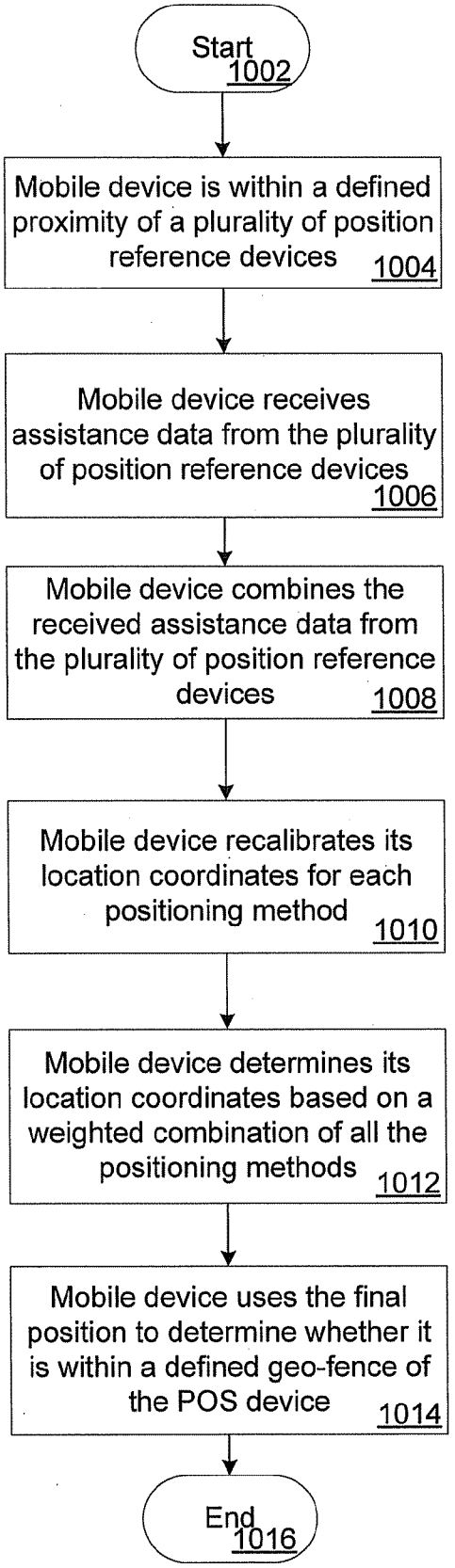

Start
1002
Mobile device is within a defined proximity of a plurality of position reference devices
1004
Mobile device receives assistance data from the plurality of position reference devices
1006
Mobile device combines the received assistance data from the plurality of position reference devices
1008
Mobile device recalibrates its location coordinates for each positioning method
1010
Mobile device determines its location coordinates based on a weighted combination of all the positioning methods
1012
Mobile device uses the final position to determine whether it is within a defined geo-fence of the POS device
1014
End
1016

FIG. 10

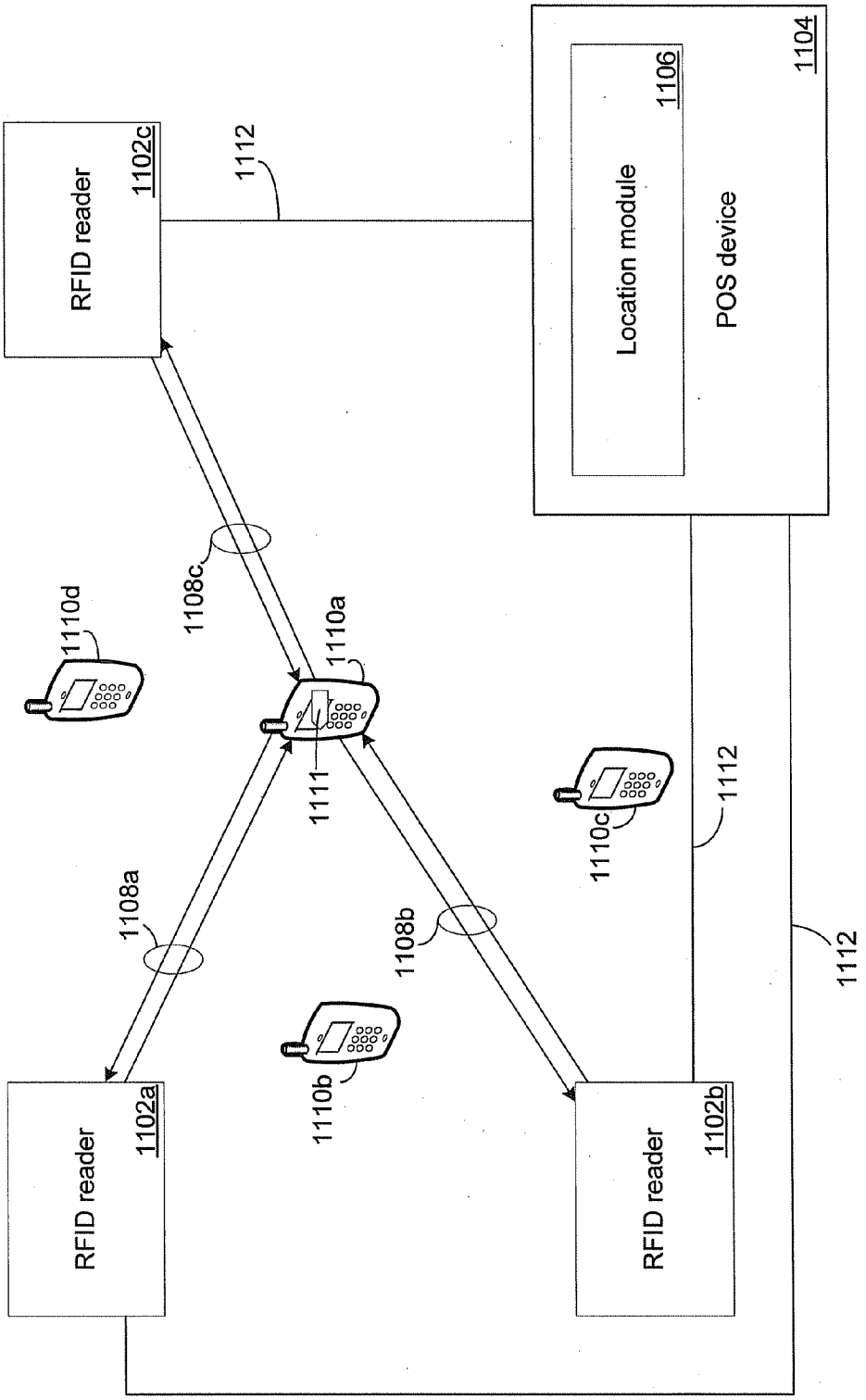

RFID reader
1102c
1112
Location module
1106
POS device
1104
1108c
1110d
1110a
1111
1110c
1112
1108a
1108b
1112
1110b
RFID reader
1102a
RFID reader
1102b

FIG. 11

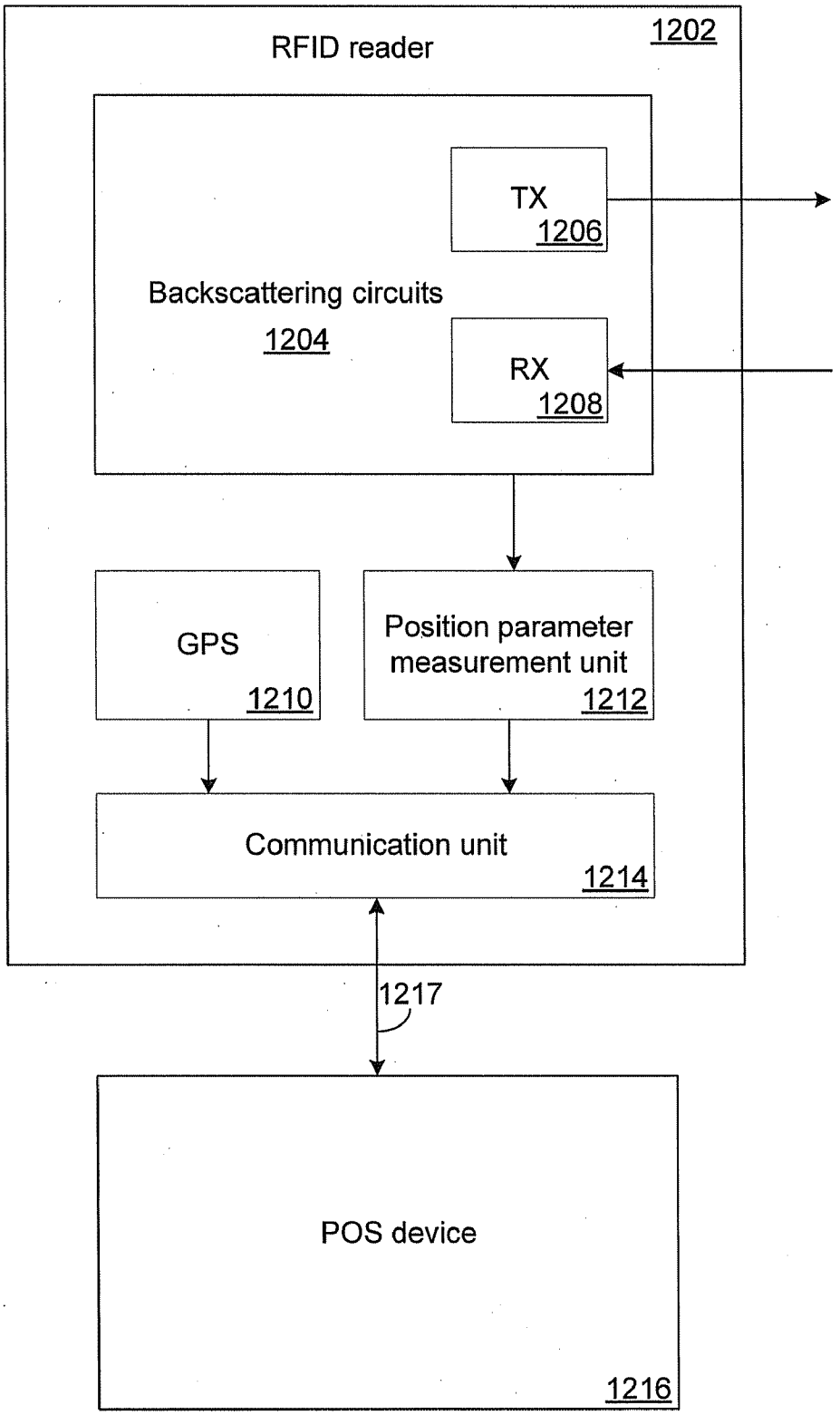

RFID reader
1202
TX
1206
Backscattering circuits
1204
RX
1208
GPS
1210
Position parameter measurement unit
1212
Communication unit
1214
1217
POS device
1216

FIG. 12

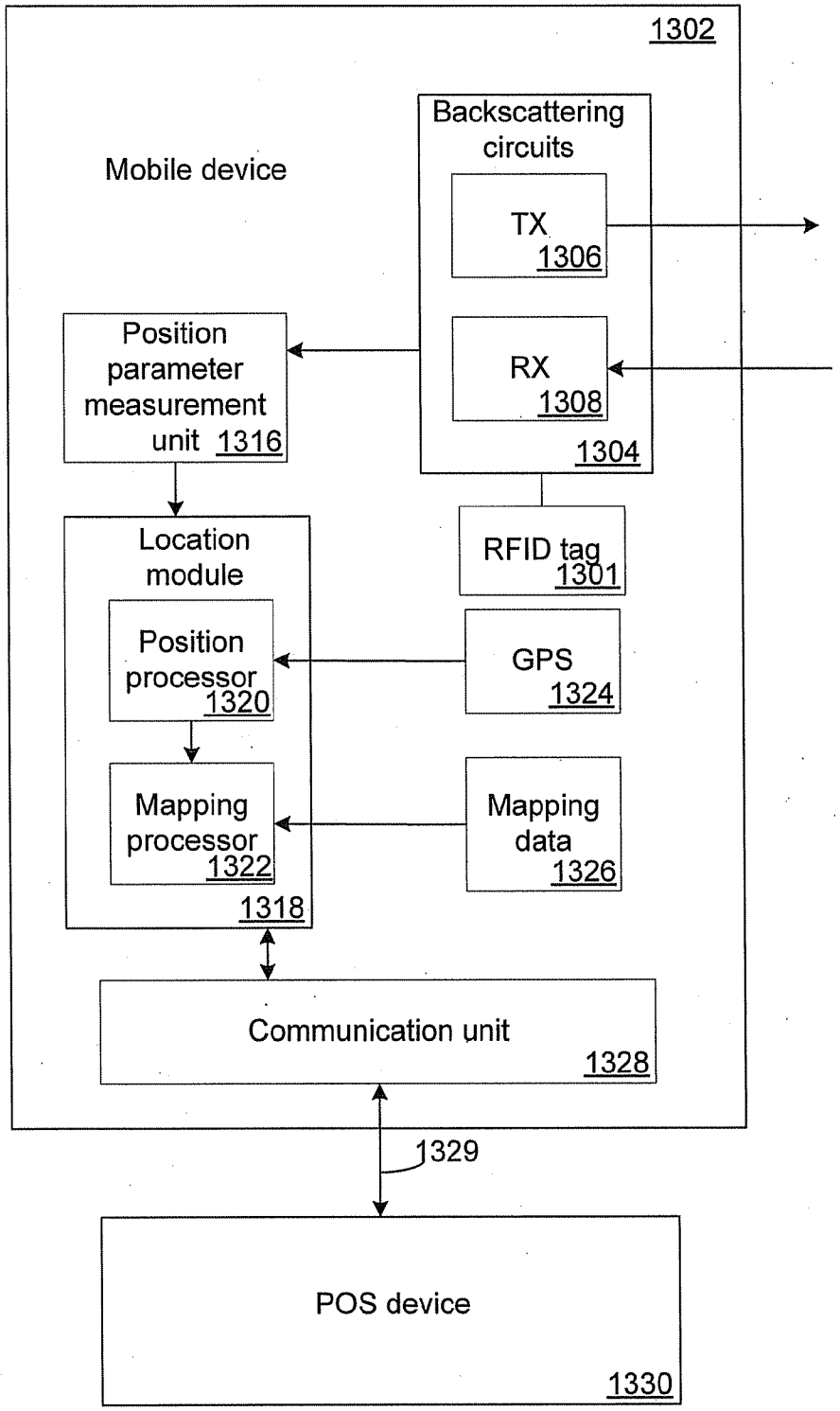

1302
Mobile device
Backscattering circuits
TX 1306
RX 1308
1304
Position parameter measurement unit 1316
Location module
Position processor 1320
Mapping processor 1322
1318
RFID tag 1301
GPS 1324
Mapping data 1326
Communication unit 1328
1329
POS device
1330

FIG. 13

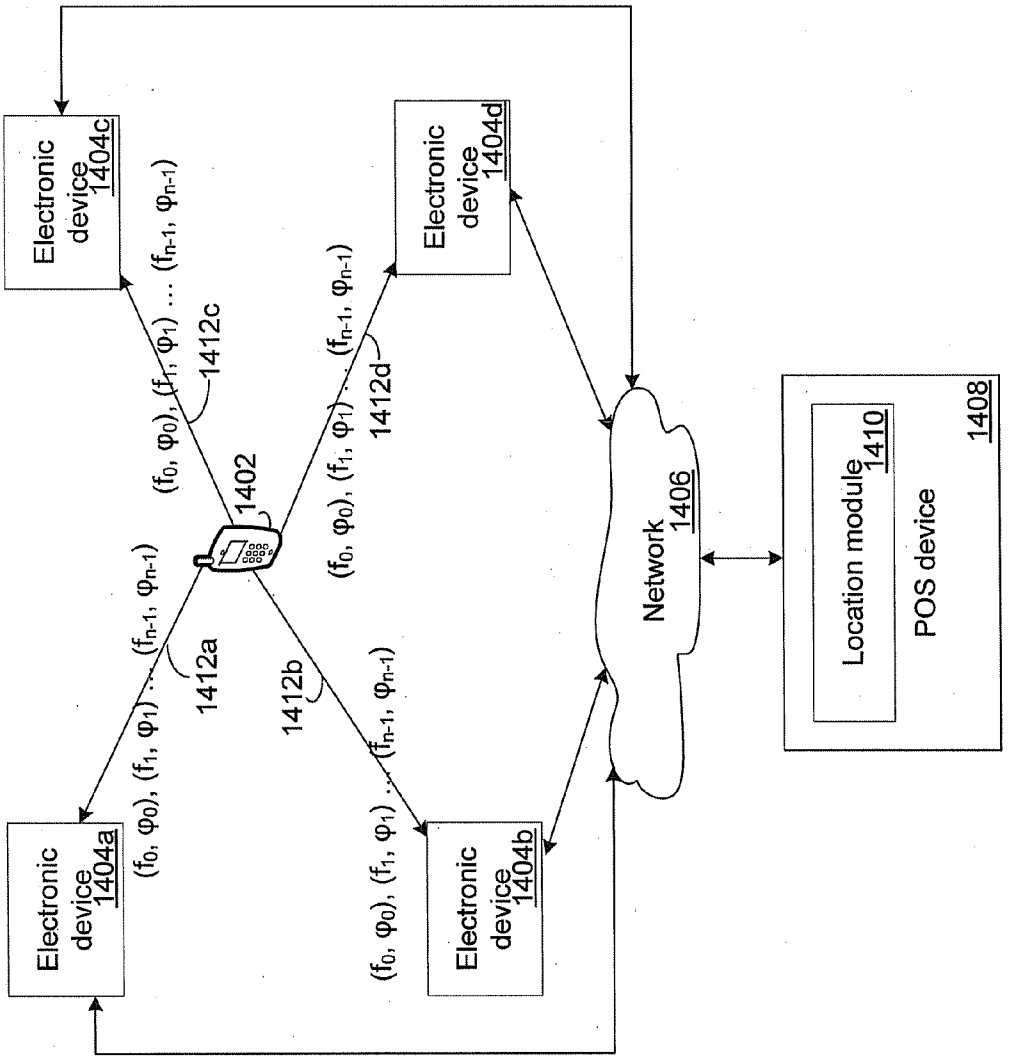

Electronic device 1404a
Electronic device 1404b
Electronic device 1404c
Electronic device 1404d
1402
1412a
1412b
1412c
1412d
$(f_0, \varphi_0), (f_1, \varphi_1) \ldots (f_{n-1}, \varphi_{n-1})$
Network 1406
Location module 1410
POS device
1408

FIG. 14

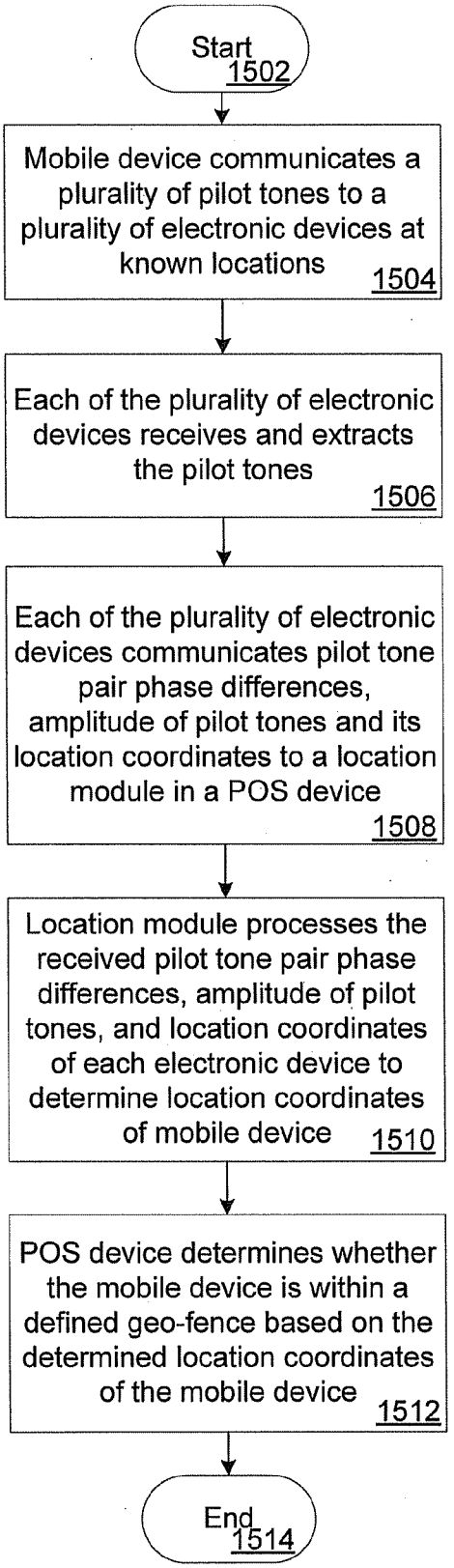

Start
1502
Mobile device communicates a plurality of pilot tones to a plurality of electronic devices at known locations
1504
Each of the plurality of electronic devices receives and extracts the pilot tones
1506
Each of the plurality of electronic devices communicates pilot tone pair phase differences, amplitude of pilot tones and its location coordinates to a location module in a POS device
1508
Location module processes the received pilot tone pair phase differences, amplitude of pilot tones, and location coordinates of each electronic device to determine location coordinates of mobile device
1510
POS device determines whether the mobile device is within a defined geo-fence based on the determined location coordinates of the mobile device
1512
End
1514

FIG. 15

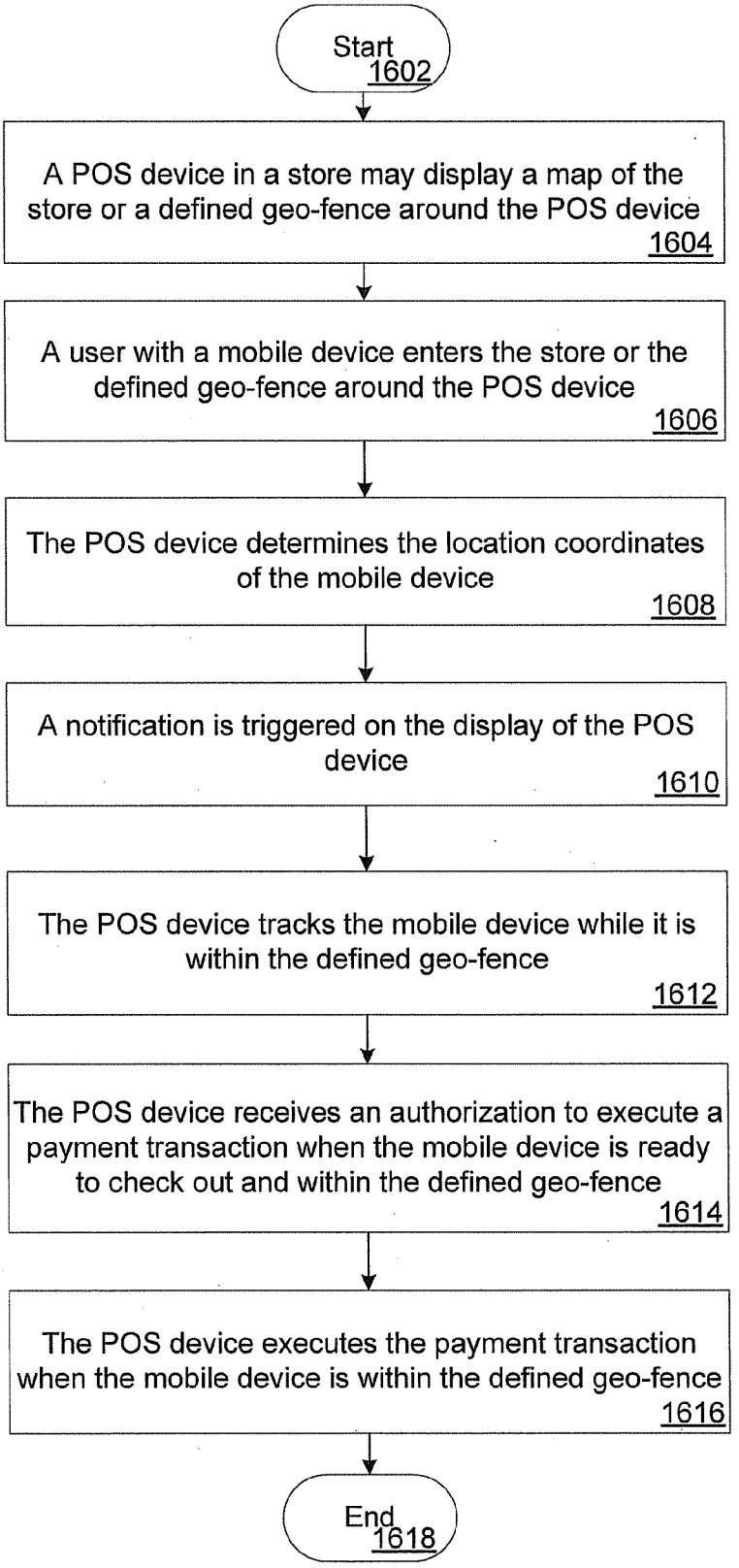

Start
1602
A POS device in a store may display a map of the store or a defined geo-fence around the POS device
1604
A user with a mobile device enters the store or the defined geo-fence around the POS device
1606
The POS device determines the location coordinates of the mobile device
1608
A notification is triggered on the display of the POS device
1610
The POS device tracks the mobile device while it is within the defined geo-fence
1612
The POS device receives an authorization to execute a payment transaction when the mobile device is ready to check out and within the defined geo-fence
1614
The POS device executes the payment transaction when the mobile device is within the defined geo-fence
1616
End
1618

FIG. 16A

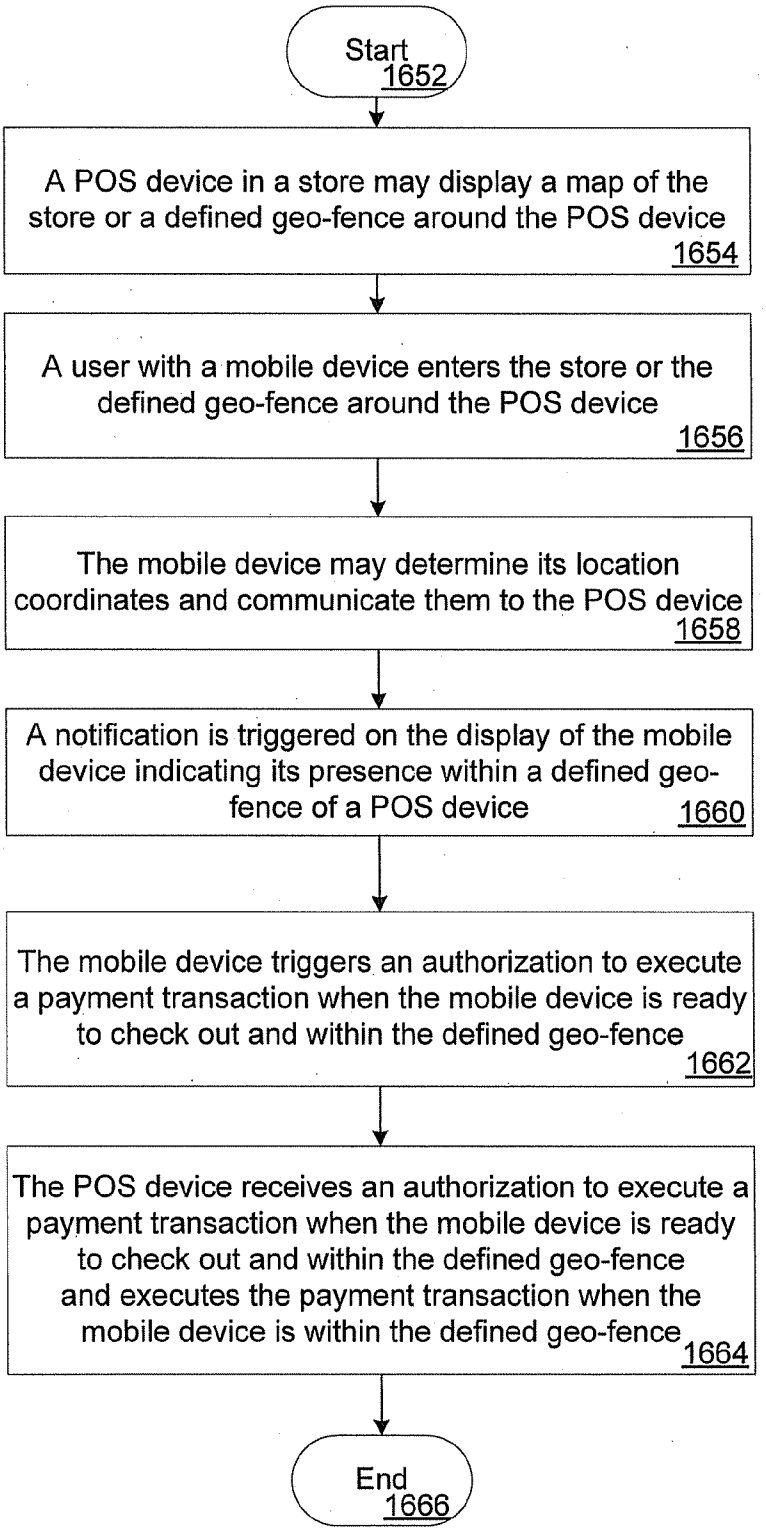

Start
1652
A POS device in a store may display a map of the store or a defined geo-fence around the POS device
1654
A user with a mobile device enters the store or the defined geo-fence around the POS device
1656
The mobile device may determine its location coordinates and communicate them to the POS device
1658
A notification is triggered on the display of the mobile device indicating its presence within a defined geo-fence of a POS device
1660
The mobile device triggers an authorization to execute a payment transaction when the mobile device is ready to check out and within the defined geo-fence
1662
The POS device receives an authorization to execute a payment transaction when the mobile device is ready to check out and within the defined geo-fence and executes the payment transaction when the mobile device is within the defined geo-fence
1664
End
1666

FIG. 16B

METHOD AND SYSTEM FOR LOCATION BASED HANDS-FREE PAYMENT

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This patent application makes reference to, claims priority to and claims benefit from U.S. Provisional Patent Application Ser. No. 61/511,963 filed on Jul. 26, 2011.

[0002] This application also makes reference to:

[0003] U.S. application Ser. No. _____ (Attorney Docket No. 25003US01), which is filed on even date herewith;

[0004] U.S. application Ser. No. 12/852,443 filed Aug. 6, 2010;

[0005] U.S. application Ser. No. 12/833,938 filed Jul. 9, 2010;

[0006] U.S. application Ser. No. 11/940,219 filed Nov. 14, 2007;

[0007] U.S. application Ser. No. 12/852,446 filed Aug. 6, 2010;

[0008] U.S. application Ser. No. 11/641,624 filed Dec. 18, 2006; and

[0009] U.S. application Ser. No. 12/843,868 filed Jul. 6, 2010.

[0010] Each of the above stated applications is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0011] Certain embodiments of the invention relate to electronic payment transaction systems. More specifically, certain embodiments of the invention relate to a method and system for location based hands-free payment.

BACKGROUND OF THE INVENTION

[0012] The proliferation of mobile devices such as smart phones, netbooks and tablet computers has led to a growing need to obtain accurate location information of such devices. Wireless positioning may involve obtaining wireless signals and processing the signals into a location estimate. The typical information used for positioning, such as Global Positioning System (GPS) signals, may be processed to find the position of a wireless device. For example, triangulation may be used where multiple range or angle measurements from known positions are used to calculate the position of a device.

[0013] One of the sources of errors in wireless positioning is multipath propagation. Multipath propagation occurs when a signal takes different paths when propagating from a source to a destination receiver. While the signal is traveling, objects get in the way and may cause the signal to bounce in different directions before getting to the receiver. As a result, some of the signals may be delayed and travel along longer paths to the receiver. In other instances, there may be no direct line of sight because an object is completely blocking the signal and any received signals occur only due to multipath propagation. These effects may cause errors in GPS data. The computed position of the device using common techniques such as triangulation may accordingly be incorrect.

[0014] The location-aware systems may differ in terms of accuracy, coverage, cost of installation, and maintenance of the systems. The GPS systems may use satellite signals and work in outdoor environments. However, they require direct line of sight and do not work well in an indoor environment. Cell tower triangulation is another method that uses signals from cellular towers to locate a wireless user. This method may also be limited in accuracy and reliability because of the coarse number of cell towers from a particular service provider that a mobile user can communicate with, as well as multipath issues.

[0015] Systems have been developed in the past that use the strength of wireless access point beacon signals in an outdoor environment to calculate the position of a mobile user. One technique is to create a database of wireless beacons and use that information together with the amplitude of beacons signals received by a mobile device to compute the location of the mobile device. Other techniques use radio frequency (RF) wireless signal strength information and triangulation to locate objects in an indoor environment. However, these methods provide poor indoor positioning accuracy because RF signal amplitude is greatly affected by metal objects, reflective surfaces, multipath, dead-spots, noise and interference.

[0016] Other methods use time of arrival information of cellular RF signals and cell tower triangulation to determine a coarse radio-based position and then use that information to assist a GPS system to determine the GPS-based position. Cell tower triangulation may be limited in accuracy and reliability because of the coarse number of cell towers and multipath issues. Also, these methods may require the presence of a GPS signal and a GPS time reference for measuring time of arrival of cellular RF signals. This approach may not work in indoor situations where GPS signals are weak or not present. These methods also require time synchronization and prior knowledge of the position of cellular base-stations. Other methods have also used cellular tower triangulation to determine a coarse pre-fix position and use that to assist a GPS system to determine the GPS-based position.

[0017] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0018] A system and/or method is provided for location based hands-free payment, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0019] These and other features and advantages of the present invention may be appreciated from a review of the following detailed description of the present invention, along with the accompanying figures in which like reference numerals refer to like parts throughout.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0020] FIG. **1**A is a block diagram of an exemplary network comprising one or more mobile devices and a computing device with a defined geo-fence, in accordance with an embodiment of the invention.

[0021] FIG. **1**B is a block diagram of an exemplary network comprising one or more mobile devices and a point of sale device, in accordance with an embodiment of the invention.

[0022] FIG. **2** is a block diagram of an exemplary POS device, in accordance with an embodiment of the invention.

[0023] FIG. **3**A is a diagram of an exemplary display showing a schematic map indicating defined geo-fences and a location of one or more mobile devices within the defined geo-fences, in accordance with an embodiment of the invention.

[0024] FIG. **3**B is a diagram of another exemplary display indicating a location of one or more registered mobile devices on a schematic map, in accordance with an embodiment of the invention.

[0025] FIG. **4** is an exemplary block diagram illustrating determination of a location of a mobile device based on receiving multipath signals, in accordance with an embodiment of the invention.

[0026] FIG. **5** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on receiving multipath signals, in accordance with an embodiment of the invention.

[0027] FIG. **6** is an exemplary block diagram illustrating determination of a location of a mobile device based on received signals with known radio transmission patterns, in accordance with an embodiment of the invention.

[0028] FIG. **7** is an exemplary block diagram of a combined GPS and wireless positioning system, in accordance with an embodiment of the invention.

[0029] FIG. **8** is another exemplary block diagram of a combined GPS and wireless positioning system, in accordance with an embodiment of the invention.

[0030] FIG. **9** is an exemplary diagram illustrating determination of a location of a mobile device based on receiving positioning assistance data using short range wireless communication protocols, in accordance with an embodiment of the invention.

[0031] FIG. **10** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on receiving positioning assistance data using short range wireless communication protocols, in accordance with an embodiment of the invention.

[0032] FIG. **11** is an exemplary block diagram of a RFID location system, in accordance with an embodiment of the invention.

[0033] FIG. **12** is an exemplary block diagram of a RFID reader, in accordance with an embodiment of the invention.

[0034] FIG. **13** is an exemplary block diagram of a mobile device with a RFID tag, in accordance with an embodiment of the invention.

[0035] FIG. **14** is an exemplary block diagram illustrating determination of a location of a mobile device based on measured phase differences and corresponding frequency differences, in accordance with an embodiment of the invention.

[0036] FIG. **15** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on measured phase differences and corresponding frequency differences, in accordance with an embodiment of the invention.

[0037] FIG. **16**A is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device by a POS device, in accordance with an embodiment of the invention.

[0038] FIG. **16**B is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0039] Certain embodiments of the invention may be found in a system and/or method for location based hands-free payment. Exemplary aspects of the invention may comprise a network that comprises a plurality of mobile devices and a plurality of point of sale devices. A first mobile device may determine its location coordinates and communicate them to a selected point of sale device. An authorization to execute a payment transaction may be triggered on the first mobile device when it is within a defined proximity of the selected point of sale device. In another embodiment of the invention, a first point of sale device may determine the location coordinates of a selected mobile device and trigger a notification based on a generated geo-fence when the selected mobile device is within a defined proximity of the first point of sale device.

[0040] FIG. **1**A is a block diagram of an exemplary network comprising one or more mobile devices and a computing device with a defined geo-fence, in accordance with an embodiment of the invention. Referring to FIG. **1**A, there is shown a network **100**. The network **100** may comprise a computing device **102**, a defined geo-fence **112** around the computing device **102**, a server **114**, and a plurality of mobile devices **104**, **106**, **108**, and **110**. The geo-fence **112** may be a virtually fenced-off geographic location. The geo-fence **112** around the computing device **102** may be defined as any regular or irregular polygonal shape and may be dynamically modified. In accordance with an embodiment, the computing device **102** may be enabled to define the geo-fence **112** to include a circle with a defined center and a defined radius on a map, or a rectangular area, or a polygon, for example. The computing device **102** may be operable to allow a user to drag and move the geo-fence **112**. Alternatively, the mobile device **106** with positioning capability may be moved around to different locations on the desired geo-fence boundary to define the geo-fence **112**, for example. In one embodiment of the invention, the defined geo-fence **112** may indicate a boundary of a store within a shopping mall or a food court, for example. In another embodiment of the invention, the defined geo-fence **112** may indicate a boundary of a particular department within a store or a restaurant, or a building, or a defined outdoor area, for example. In another embodiment, the geo-fence **112** may be a three-dimensional shape that may enclose a volume. For example, a geo-fence for a business that has multiple floor levels may include multiple floors, where there are a plurality of computing devices **102** on each floor and the calculated position of the mobile device **106** may also determine which floor it is on. Some examples of three dimensional geo-fence shapes may include a rectangular prism, triangular prism, pentagonal prism, octagonal prism, polyhedron, pyramids, sphere, cube, and/or a cylinder, for example.

[0041] The computing device **102** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to perform various operations. In one embodiment of the invention, the computing device **102** may comprise a computer, monitor, cash drawer, receipt printer, customer display, a barcode scanner, a debit and/or credit card reader, and one or more application-specific programs and input/output (I/O) devices for a particular environment in which it may serve. In another embodiment of the invention, the computing device **102** may also comprise a weight scale, a global positioning system (GPS), an integrated credit card processing system, a signature capture device and/or a customer pin pad device. The computing device **102** may use touch-screen technology

for ease of use and a computer may be built into its display to liberate counter space for a retailer. The computing device **102** may also use RFID readers for instances where the products use RFID tags instead of barcodes.

[0042] Each of the plurality of mobile devices **104**, **106**, **108**, and **110** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to communicate utilizing one or more communication standards. In this regard, the plurality of mobile devices **104**, **106**, **108**, and **110** may each be operable to transmit and/or receive data via Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), GPS, cellular, near field communication (NFC), and/or 60 GHz standards. Exemplary mobile devices may comprise laptop computers, tablet computers, mobile phones, personal digital assistants, personal media players, gaming devices, image and/or video cameras, for example. The plurality of mobile devices **104**, **106**, **108**, and **110** may be operable to receive, process, and present multimedia content and may additionally be enabled to run a network browser or other applications for providing Internet services to a user of the mobile device. In accordance with an embodiment of the invention, the plurality of mobile devices **104**, **106**, **108**, and **110** may comprise one or more application-specific programs for electronic payment transactions.

[0043] In operation, a user of a mobile device, for example, mobile device **106**, may enter a store or a defined geo-fence around the computing device **102**. The mobile device **106** may be operable to determine its location coordinates based on one or more positioning methods as detailed below with respect to, for example, FIGS. **4-15**. The mobile device **106** may be operable to communicate its determined location coordinates to a server **114**.

[0044] The server **114** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to receive the determined location coordinates of ne or more of the plurality of mobile devices **104**, **106**, **108**, and **110**. The server **114** may be operable to determine whether any of the plurality of mobile devices **104**, **106**, **108**, and **110** are within a defined geo-fence **112** of the computing device **102**. The server **114** may be operable to communicate the determined location coordinates of one or more of the plurality of mobile devices **104**, **106**, **108**, and **110** that are within the defined geo-fence **112** of the computing device **102**.

[0045] In instances where the mobile device **106** is within the defined geo-fence **112** of the computing device **102**, a notification may be triggered on the computing device **102** indicating the presence of the mobile device **106** within a defined proximity of the computing device **102**. The user with the mobile device **106** may choose to purchase one or more items within the store or the defined geo-fence **112**. The computing device **102** may trigger an authorization request to execute a payment transaction based on the one or more items chosen to be purchased when the mobile device **106** is within the defined geo-fence **112**. The mobile device **106** may trigger an authorization response to execute the payment transaction when the mobile device **106** is within the defined geo-fence **112**. In accordance with an embodiment of the invention, the user with the mobile device **106** may be able to execute the payment transaction without physically using or swiping a credit or debit card, or without physically tapping or holding the mobile device near the computing device **102**.

[0046] In accordance with another embodiment, when a user of a mobile device, for example, mobile device **106**, may enter or leave a geo-fence **112**, one or more software downloads and upgrades may be downloaded on to the mobile device **106**. For example, when mobile device **106** enters the geo-fence **112** of a mall an interactive map of the mall with deal advertisements may be downloaded on to the mobile device **106**. In another embodiment, when a user of a mobile device **106** may enter or leave a geo-fence **112**, the sound of the mobile device **106** may be turned on or switched off, or a volume of the mobile device **106** may be turned higher or lower. For example, when the mobile device **106** enters the geo-fence **112** of a library or a movie theater, the sound of the mobile device **106** may be turned off. In another embodiment, when a user of a mobile device **106** may enter or leave a geo-fence **112**, the mobile device **106** may be powered down or enter a sleep mode or powered up or activated, for example.

[0047] In another embodiment, calendar reminders may be linked to the location of a geo-fence **112**, location-based reminders may be created, a reminder may be sent with an email, SMS, vibration, voice, or facsimile (FAX) when a mobile device **106** enters or leaves the geo-fence **112**. For example, when the user enters a shopping mall, a shopping list reminder may be sent to the mobile device **106**. In another embodiment, the actions of a user with the mobile device **106** may be monitored and data-mined when they enter or leave a geo-fence **112**. For example, when a user enters a geo-fence **112** that marks the boundary of a store, a software or web service may monitor the actions of that user in terms of the amount of time they spend at certain store areas and which products they show the most interest in. This information may then be used to present them with personalized deal advertisements on their mobile device **106**, on electronic billboards and displays near them, or send them conventional mail marketing material.

[0048] In another embodiment, when a user of a mobile device **106** may enter or leave a geo-fence **112**, an email, SMS, vibration, voice, and/or FAX alert may be communicated to the mobile device **106** or to another device such as the mobile device **110**. In another embodiment, when a user of a mobile device **106** may enter or leave a geo-fence **112**, the user interface and functionality of a location-based application or a game may be changed so that it has a different look and feel with corresponding menus. For example, a location-based R-rated game on the mobile device **106** may switch to the functionality of a less violent home edition when the mobile device **106** enters the geo-fence **112** of the mobile device **106** user's home, and may switch back to the full version once the mobile device **106** leaves the geo-fence **112**. In another embodiment, a location-based application may be disabled or enabled when a user of the mobile device **106** enters or leaves the geo-fence **112**. For example, a kid may not be able to play games on the mobile device **106** when the mobile device **106** is within a defined geo-fence, such as, a school, a library, and/or a home. In another embodiment, the Internet connectivity of the mobile device **106** may be location-based and may be dynamically modified when inside a geo-fence **112**, for example, using Wi-Fi for Internet connectivity within a home or an office, and using a cellular data plan for Internet connectivity outside the geo-fence **112**. In another embodiment, the network security settings of a mobile device **106** may be dynamically modified based on the location of the mobile device **106** within or outside the geo-fence **112**. For example, for an office or home wireless network, only users inside a geo-fence **112** may be allowed to connect to the network and outside users may be denied access.

[0049] In another embodiment, a software application on the mobile device **106** may be location-based and may start running and perform certain functions when the mobile device **106** enters or leaves the geo-fence **112**. For example, when a user enters a geo-fence **112** around his/her home, his/her mobile device **106** may send an alert to software applications that run on the mobile device **106** or on a different networked computer. The software applications may then turn on the lights of the house, open the garage door or the front door, turn on the TV, turn on air cooling and/or heating, for example. Similarly, when a user leaves the geo-fence **112** around his/her home, the software applications may receive an alert and turn off the lights, close all the doors, turn off the TV and other appliances, and turn off air cooling and/or heating. In another embodiment, there may be several geo-fence boundaries such as **112** and when the mobile device **106** enters or leaves each boundary, different actions may be triggered. For example, a large geo-fence may extend outside the house for opening and/or closing the garage door and front door, while a smaller geo-fence inside the house's living room may be used for turning the living room lights on/off.

[0050] In another embodiment, a first list of phone numbers may be created, and one or more phone numbers listed in the first list may be blocked as incoming voice calls, if the mobile device **106** is within the geo-fence **112**. In another embodiment, a second list of phone numbers may be created, and one or more phone numbers listed in the second list may be blocked as incoming voice calls, if the mobile device **106** is outside the geo-fence **112**. In another embodiment, a third list of Internet web addresses may be created, and one or more web addresses listed in the third list may be blocked from being accessed, if the mobile device **106** is within the geo-fence **112**. In another embodiment, a fourth list of Internet web addresses may be created, and one or more web addresses listed in the fourth list may be blocked from being accessed, if the mobile device **106** is outside the geo-fence **112**.

[0051] In another embodiment, a user with the mobile device **106** may automatically check-in at a social networking web site, for example, Foursquare or Gowalla and receive award points when the user enters the geo-fence **112** of a particular location. This removes the need for the user to manually check-in to get award points. In another embodiment, a user with a mobile device **106** has to enter the geo-fence **112** associated with a business, for example, a restaurant, a hotel, a bar, or a night club in order to be able to write a review on a rating web site, for example, Yelp or Tripadvisor. The review may be written while the user is inside the geo-fence **112** or at a later time when the user is outside the geo-fence **112**.

[0052] In another embodiment, users of a ratings web site may filter the rating reviews of a business based on a function of the interaction of the reviewer with the geo-fence **112** associated with the business. The function may vary depending upon factors, such as, has the reviewer ever been inside the geo-fence **112**, how many times has the reviewer been inside the geo-fence **112**, what times and dates have the reviewer been inside the geo-fence **112**. The users of the ratings web site may, for example, filter out or assign a smaller weight to reviews from people who have not been inside the geo-fence **112** of a particular business, but have nonetheless written a review. This allows users of the rating web site to ignore or assign a smaller weight to the reviews from people who have written biased reviews of businesses such as hotels, brick and mortar stores, restaurants, and night clubs without visiting them. Similarly, users of the rating web site may filter out or assign a smaller weight to reviews from people who have spent excessive time inside the geo-fence **112** of a business. This may allow users of the rating web site to filter out or assign a smaller weight to the reviews from people who work for a business and write biased reviews on that business. In another embodiment, users of a ratings web site may filter the rating reviews of a business based on a function of the interaction of the reviewer with the geo-fence **112** associated with the business as well as the geo-fence **112** of related businesses. The geo-fence **112** may not only describe the geography it encloses, but may also have other properties, such as, a business category, for example, a restaurant, a hotel, a bar or a night club. For example, a person who has been inside the geo-fence **112** of many restaurants over a period of time as well as the geo-fence **112** of restaurant X can be considered an experienced reviewer of restaurants and his/her review of restaurant X may be given a higher weighting. In another embodiment, people posting reviews on a rating web site have stored their information with the web site. The information may include home address, age and/or marital status. Users of the ratings web site may then filter the reviews of others based on complex queries such as interaction of the reviewer with one or more geo-fences **112**, their home and/or work address, their demographics, and their current tracked location. For example, users of the rating web site can query the web site to "Show the top five highest rated hotels in Cancun from people who have been inside the geo-fences of the hotels in the past", or "Show the top five highest rated hotels in Cancun from people who have been inside the geo-fences of the hotels in the past and have been inside the geo-fences of at least 10 other hotels in Cancun in the past", or "Show the top five highest rated hotels in Cancun from people who live in California and who have been inside the geo-fences of the hotels in the past", or "Show the top five highest rated hotels in Cancun from people with kids who live in California and who have been inside the geo-fences of the hotels in the past", or "Show the top five highest rated hotels in Cancun from people with kids whose present tracked location is California and who have been inside the geo-fences of the hotels in the past". These query methods can be supplied to users with a simple user interface that has for example multiple checkboxes and fields that allow combining simple queries into more complex queries. It may be possible for a person posting a review on the ratings web site to login and post their review with a different computing device than their mobile position tracking device. People posting reviews of businesses on the ratings web site may disable position tracking or not provide it. However, as a result, their reviews may be assigned less weight by the ratings web site or by users of the ratings web site since there is no record of the reviewers being in the geographical proximity of the places they are reviewing.

[0053] In another embodiment, a user with the mobile device **106** who enters a geo-fence **112** may receive notifications to inform him/her which of his/her friends are inside the geo-fence **112** area. The notification may be via an email, SMS, vibration, voice, map on the display of the mobile device **106**, and/or a FAX alert. Similarly, when a user with the mobile device **106** leaves a geo-fence area **112** he/she may automatically check out and/or send notifications to his/her friends to notify them that he/she is no longer inside the geo-fence **112**. In another embodiment, a moving object may be carrying a first position tracking device within the mobile

device **106** and when the mobile device **106** enters or leaves a geo-fence **112**, a notification may be sent to a second mobile device **110**. The notification may be via an email, a SMS, vibration, voice, FAX alert, and/or map on the display of the mobile device **110** with the positions of the mobile device **106**, the geo-fence **112**, and the mobile device **110**. For example, the mobile device **106** may be attached to a child that is being tracked by a parent with the mobile device **110**, or the mobile device **106** may be attached to a company vehicle that is being tracked by a supervisor, or the mobile device **106** may be attached to a livestock that is being tracked by a farmer.

[0054] In accordance with an embodiment, the computing device **102** may be a point of sale (POS) device as illustrated in FIG. **1**B. Notwithstanding, the invention may not be so limited, and the computing device **102** may be any device with computer processing capability without limiting the scope of the invention.

[0055] FIG. **1**B is a block diagram of an exemplary network comprising one or more mobile devices and a point of sale device, in accordance with an embodiment of the invention. Referring to FIG. **1**B, there is shown a network **150**. The network **150** may comprise a POS device **152**, a defined geo-fence **112** around the POS device **152**, and a plurality of mobile devices **104**, **106**, **108**, and **110**. The geo-fence **112** may be a virtually fenced-off geographic location. The geo-fence **112** around the POS device **152** may be defined as any regular or irregular polygonal shape and may be dynamically modified. In accordance with an embodiment, the POS device **152** may be enabled to define the geo-fence **112** to include a circle with a defined center and a defined radius on a map, or a rectangular area, or a polygon, for example. The POS device **152** may be operable to allow a user to drag and move the geo-fence **112**. Alternatively, the mobile device **106** with positioning capability may be moved around to different locations on the desired geo-fence boundary to define the geo-fence **112**, for example. In one embodiment of the invention, the defined geo-fence **112** may indicate a boundary of a store within a shopping mall or a food court, for example. In another embodiment of the invention, the defined geo-fence **112** may indicate a boundary of a particular department within a store or a restaurant, or a building, or a defined outdoor area, for example. In another embodiment, the geo-fence **112** may be a three-dimensional shape that may enclose a volume. For example, a geo-fence for a business that has multiple floor levels may include multiple floors, where there are a plurality of POS devices **152** on each floor and the calculated position of the mobile device **106** may also determine which floor it is on. Some examples of three dimensional geo-fence shapes may include a rectangular prism, triangular prism, pentagonal prism, octagonal prism, polyhedron, pyramids, sphere, cube, and/or a cylinder, for example.

[0056] The POS device **152** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to record and track customer orders, process credit and debit cards, process electronic commerce payment transactions, connect to other systems in a network, purchasing, receiving and transferring of products to and from other locations, and/or manage inventory. In one embodiment of the invention, the POS device **152** may comprise a computer, monitor, cash drawer, receipt printer, customer display, a barcode scanner, a debit and/or credit card reader, and one or more application-specific programs and input/output (I/O) devices for a particular environment in which it may serve. In another embodiment of the invention, the POS device **152** may also comprise a weight scale, a global positioning system (GPS), an integrated credit card processing system, a signature capture device and/or a customer pin pad device. The POS device **152** may use touch-screen technology for ease of use and a computer may be built into its display to liberate counter space for a retailer. The POS device **152** may also use RFID readers for instances where the products use RFID tags instead of barcodes.

[0057] The POS device **152** may be operable to handle a myriad of customer based functions, such as, sales, returns, exchanges, layaways, gift cards, gift registries, customer loyalty programs, quantity discounts, pre-planned promotional sales, manufacturer coupon validation, foreign currency handling and multiple payment types. A POS device **152** for a restaurant, for example, may comprise all menu items stored in a database that may be queried for information in a plurality of ways. The POS device **152** may be utilized in various industries that may have a point of sale, such as, a service desk, including restaurants, lodging, entertainment, and museums. The POS device **152** may be web-enabled, and may be operable to remotely process transactions and track inventory across geographically-dispersed locations.

[0058] Each of the plurality of mobile devices **104**, **106**, **108**, and **110** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to communicate utilizing one or more communication standards. In this regard, the plurality of mobile devices **104**, **106**, **108**, and **110** may each be operable to transmit and/or receive data via Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), GPS, cellular, near field communication (NFC), and/or 60 GHz standards. Exemplary mobile devices may comprise laptop computers, tablet computers, mobile phones, personal digital assistants, personal media players, gaming devices, image and/or video cameras, for example. The plurality of mobile devices **104**, **106**, **108**, and **110** may be operable to receive, process, and present multimedia content and may additionally be enabled run a network browser or other applications for providing Internet services to a user of the mobile device. In accordance with an embodiment of the invention, the plurality of mobile devices **104**, **106**, **108**, and **110** may comprise one or more application-specific programs for electronic payment transactions.

[0059] In operation, a user of a mobile device, for example, mobile device **106**, may enter a store or a defined geo-fence around the POS device **152**. The POS device **152** may be operable to determine the location coordinates of the mobile device **106** based on one or more positioning methods as detailed below with respect to, for example, FIGS. **4**-**15**. In instances where the mobile device **106** is within the defined geo-fence **112** of the POS device **152**, a notification may be triggered on the POS device **152** indicating the presence of the mobile device **106** within a defined proximity of the POS device **152**. The user with the mobile device **106** may choose to purchase one or more items within the store or the defined geo-fence **112**. The POS device **152** may trigger an authorization request to execute a payment transaction based on the one or more items chosen to be purchased when the mobile device **106** is within the defined geo-fence **112**. The mobile device **106** may trigger an authorization response to execute the payment transaction when the mobile device **106** is within the defined geo-fence **112**. In accordance with an embodiment of the invention, the user with the mobile device **106** may be able to execute the payment transaction without

physically using or swiping a credit or debit card, or without physically tapping or holding the mobile device near the POS device **152**.

[0060] FIG. **2** is a block diagram of an exemplary POS device, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown a POS device **200**. The POS device **200** may be a networked server, for example. The POS device **200** may comprise a location module **202**, a processor **210**, a memory **208**, a reference database **212**, a financial transactions database **214**, mapping data **216**, and a display **218**.

[0061] The location module **202** may be operable to determine the location coordinates of the POS device **200** and/or one or more mobile devices, for example, mobile device **106**. The location coordinates may be determined in Cartesian coordinates, latitude and longitude coordinates and altitude for a 3D position, and polar coordinates. The location module **202** may comprise a position processor **204** and a mapping processor **206**.

[0062] The location module **202** may receive measured position parameters and positions of the systems where the position parameters were measured. The location module **202** may be operable to determine the position of the mobile device **106** based on one or more positioning methods as detailed below with respect to FIGS. **4-15**. The location module **202** may comprise a position processor **204** that may be operable to determine the raw location parameters that provide the position of a RFID tag in the mobile device **106**, for example. For example, the raw location parameters may represent the position of the RFID tag as longitude, latitude, altitude, in Cartesian coordinates, polar coordinates, such as, distances and angles, or as vectors, for example.

[0063] The location module **202** may comprise a mapping processor **206** that may be operable to receive the raw location parameters and mapping data, and transform the raw location parameters into mapping position information. The mapping data **216** may be used to transform the RFID tag's position from Cartesian coordinates or vector representations, for example, into mapped position information, such as, shelf locations, aisles, rooms, warehouses, hallways, or streets. The mapping software components may receive mapping data that maps raw position parameters into mapped position information. The mapping data **216** may further comprise images or maps that may be displayed to a user with the RFID tag superimposed on the image. The mapping data **216** may include information for translating raw location parameters into mapped position information, images, or information for translating between RFID tag IDs and the names of items to which the RFID tags are attached. In other embodiments of the invention, some or all of this information may be received from an external source system such as the POS device **200**, for example. In other embodiments of the invention, mapping data may be stored on the RFID tag itself. The mapping data **216** may further include navigation information for providing directions to the user based on the user's current location and the location of a RFID tag.

[0064] The processor **210** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to manage the operations of the POS device **200**. For example, the processor **210** may instruct one of a plurality of RFID readers to generate RF signals to a mobile device and receive backscattered signals from the mobile device to determine the location of the mobile device. The memory **208** may be operable to store the location coordinates of the plurality of RFID readers, for example.

[0065] The reference database **212** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to store the received channel parameters. The financial transactions database **214** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to store a user's past purchases with the store or restaurant, credit and/or debit card authorizations associated with the user, returns, exchanges, layaways, gift cards, gift registries, and/or customer loyalty programs associated with the user. The POS device **200** may trigger an authorization to execute a payment transaction for the one or more items to be purchased when the mobile device **106** is within the defined geo-fence **112**.

[0066] The display **218** may indicate a map of a store, a shopping mall, or a restaurant, for example. The map may indicate a plurality of POS devices, and one or more corresponding defined geo-fences around the POS devices respectively, which may represent individual stores in a shopping mall or restaurants in a food court, for example. The display **218** may indicate a location of one or more mobile devices within the defined geo-fences. The display **218** may also indicate a speed of movement and a direction of movement of the plurality of mobile devices at the selected plurality of point of sale devices.

[0067] Notwithstanding, the invention may not be so limited, and the signaling and position calculations of the mobile devices **104-110** may be controlled by a remote networked server **114**, for example. The plurality of the mobile devices **104-110** may be operable to communicate their determined location coordinates to a remote networked server **114**, for example, a server at the social networking site Foursquare. The remote networked server **114** may then provide the position and map results to the POS device **152** without limiting the scope of the invention.

[0068] FIG. **3**A is a diagram of an exemplary display showing a schematic map indicating defined geo-fences and a location of one or more mobile devices within the defined geo-fences, in accordance with an embodiment of the invention. Referring to FIG. **3**A, there is shown a display **300**. The display **300** may be a display of the POS device **152** or may be a display of the mobile device **106**, for example.

[0069] The display **300** may indicate a map **302** of a store, a shopping mall, or a restaurant, for example. The map **302** may indicate a plurality of POS devices **308** and **310**, and one or more corresponding defined geo-fences **303** and **305** around the POS devices **308** and **310** respectively, which may represent individual stores in a shopping mall or restaurants in a food court, for example. The display **300** may indicate a location of one or more mobile devices **304** and **306** within the defined geo-fences **303** and **305** respectively. The display **300** may also indicate a speed of movement and a direction of movement of the plurality of mobile devices **304** and **306** at the selected plurality of point of sale devices **308** and **310**. Accordingly, staff may be assigned to designated sections of a store or stores in a mall based on the indicated speed of movement and the direction of movement of the plurality of mobile devices **304** and **306** at the selected plurality of point of sale devices **308** and **310**. The staff at the POS devices **308** and **310** may also correlate the speed and/or direction and identifying information of users of mobile devices **304** and/or **306** on the map **302** with their own visual sight of the people in their vicinity and use that information when they interact

with the users of the mobile devices. The store advertising displays may also use the speed and direction information, where displays that are facing a user with a mobile device and are about to come into his/her range of view are activated and present customized information and advertisement to the user.

[0070] A user of the mobile device **304** may enter a store or the defined geo-fence **303** around the POS device **308**. The mobile device **304** may be operable to determine its location coordinates based on one or more positioning methods as detailed below with respect to FIGS. **4-15**, and communicate its location coordinates to the POS device **152**. In another embodiment of the invention, the POS device **308** may be operable to determine the location coordinates of the mobile device **304** based on one or more positioning methods as detailed below with respect to FIGS. **4-15**. In instances where the mobile device **304** is within the defined geo-fence **303** of the POS device **308**, a notification may be triggered on the mobile device **304** indicating its presence within a defined proximity of the POS device **308**. In another embodiment of the invention, in instances where the mobile device **304** is within the defined geo-fence **303** of the POS device **308**, a notification may be triggered on the POS device **308** indicating the presence of the mobile device **304** within a defined proximity of the POS device **308**.

[0071] The user with the mobile device **304** may choose to purchase one or more items within the defined geo-fence **303**. The POS device **308** may be operable to store the user's past purchases with the store or restaurant, credit and/or debit card authorizations associated with the user, returns, exchanges, layaways, gift cards, gift registries, and/or customer loyalty programs associated with the user. The POS device **308** may trigger an authorization to execute a payment transaction for the one or more items to be purchased when the mobile device **304** is within the defined geo-fence **303**. The mobile device **304** may preset its settings to trigger an authorization response to execute the payment transaction when the mobile device **304** is within the defined geo-fence **303**.

[0072] In accordance with another embodiment of the invention, the POS device **308** may be operable to determine the location coordinates of the mobile device **304** within a **10** meter radius, for example. Accordingly, the POS device **308** may enable triggering an authorization to execute a payment transaction only when the mobile device **304** is within a particular defined geo-fence **303**. In other words, the POS device **308** may not enable triggering an authorization to execute a payment transaction when the mobile device **304** is outside the defined geo-fence **303** or within a neighboring store or defined geo-fence **305**, for example. In another embodiment of the invention, the mobile device **304** may preset its settings to selectively trigger an authorization response to execute the payment transaction when the mobile device **304** is within a defined geo-fence **303**, and may choose not to trigger an authorization response to execute the payment transaction when the mobile device **304** is outside the defined geo-fence **303** or within a neighboring store or defined geo-fence **305**.

[0073] In another embodiment of the invention, the mobile device **304** may also choose to purchase one or more items from a neighboring store or defined geo-fence **305**. Accordingly, the POS device **310** in the neighboring geo-fence **305** may be operable to store the user's past purchases with the store, credit and/or debit card authorizations associated with the user, returns, exchanges, layaways, gift cards, gift registries, and/or customer loyalty programs associated with the user. The mobile device **304** may preset its settings to selectively trigger an authorization response to execute the payment transaction when the mobile device **304** is within the defined geo-fence **305**

[0074] In accordance with another embodiment of the invention, a POS device **308** may be operable to define multiple geo-fences and each geo-fence may cover different areas for different applications. For example, the geo-fence for a location-based hands-free payment may be inside the store or geo-fence **303** and a small distance or radius from the POS device **308**, while the geo-fence for sending deal advertisements may cover a larger distance and even include locations outside the store, for example, the stores and areas disclosed in map **302**. Notwithstanding, a store may have multiple POS devices. A deal advertisement may be sent from the store's server rather than a particular POS device within the store, for example.

[0075] In accordance with another embodiment of the invention, the users of mobile devices may use their mobile device to browse products of nearby merchants, make a reservation and/or place an order, and then when they are near a merchant's POS device **308**, may complete the transaction. The geo-fence for placing an order may be different, for example, the stores and areas disclosed in map **302** compared to the geo-fence **303** for proximity to the POS device **308** and completion of the transaction.

[0076] FIG. **3**B is a diagram of another exemplary display indicating a location of one or more registered mobile devices on a schematic map, in accordance with an embodiment of the invention. Referring to FIG. **3**B, there is shown a display **350**. The display **350** may be a display of the POS device **352**.

[0077] The display **350** may indicate a POS device **352** and its associated geo-fence **354** of a store, a shopping mall, or a restaurant, for example. The display **350** may indicate a location of one or more mobile devices $\mathbf{356}_1 \ldots \mathbf{356}_4$ within the defined geo-fence **354**. The display **350** may indicate a plurality of registered users with corresponding mobile devices within the geo-fence **354** in a column on one side of the display. For example, the display **350** may indicate the name, photograph, or other identification of users with mobile devices $\mathbf{356}_1 \ldots \mathbf{356}_4$ as tabs $\mathbf{358}_1 \ldots \mathbf{358}_4$ respectively. The tabs $\mathbf{358}_1 \ldots \mathbf{358}_4$ may be ordered according to a distance of the registered users to the POS device **352**. The ordering of the tabs $\mathbf{358}_1 \ldots \mathbf{358}_4$ may be updated as the registered users move closer or further away from the POS device **352**.

[0078] The users of the mobile devices $\mathbf{356}_1 \ldots \mathbf{356}_4$ may be registered either with a third party server or with the POS device **200** of a store. The registration of a user may include providing user identification credential information, and payment information, such as credit card information, or other forms of payment information, for example. Once a user is inside the geo-fence **354**, the information that is transmitted from the mobile device $\mathbf{356}_1$ to the POS device **352** to complete a transaction may not include their payment method details.

[0079] The operator of the POS device **352** may be able to zoom in and out of the geo-fence **354** and may select one or more users by clicking that user on the display **350** or clicking a mouse with its pointer on that user in the display **350**, for example. When the POS device **352** selects a user on the display **350**, the user's details in the column display may also be highlighted. In an alternative embodiment, when the POS device **352** selects a user by clicking on one of the tabs $\mathbf{358}_1 \ldots \mathbf{358}_4$, the selected user's location on the display **350** within the geo-fence **354** may be highlighted.

[0080] FIG. **4** is an exemplary block diagram illustrating determination of a location of a mobile device based on receiving multipath signals, in accordance with an embodiment of the invention. Referring to FIG. **4**, there is shown a mobile device **402**, a POS device **428**, a plurality of satellites $\mathbf{434}_1 \ldots \mathbf{434}_4$, a plurality of access points $\mathbf{436}_1 \ldots \mathbf{436}_4$, and a cell tower **438**. The POS device **428** comprises a reference database **430** and a location module **432**.

[0081] The mobile device **402** may comprise a plurality of baseband radios and corresponding antennas $\mathbf{404}_1 \ldots \mathbf{404}_5$ to receive and transmit signals associated with the respective baseband radios. For example, the mobile device **402** may comprise a GPS radio **406**, a WLAN radio **408**, a Bluetooth radio **410**, a WiMax radio **412**, and a cellular radio **414**. Notwithstanding, the invention need not necessarily be so limited, and other radios capable of transmitting and receiving signals using one or more standards, such as, NFC, Wi-Fi direct, 60 GHz, radio frequency identification (RFID), HD radio, and/or UWB standards may be utilized without limiting the scope of the invention. Furthermore, the mobile device **402** may comprise a subset of the listed radios in FIG. **4** without limiting the scope of the invention.

[0082] The mobile device **402** may further comprise a clock **416**, a position module **418**, a processor **420**, a memory **422**, a navigation module **424**, and a local server **426**. The mobile device **402** may be operable to be used about a geographical area of interest. For instance, the mobile device **402** may be within a vehicle, such as, a passenger car or a commercial truck equipped with radios to receive signals and can move to locations within a geographical area of interest. In indoor environments, a mobile device **402** may be carried by a user. In some embodiments of the invention, the mobile device **402** may be a portable wireless device, a consumer hand-held wireless device, a GPS-enabled media player, or a GPS-enabled laptop, for example.

[0083] The mobile device **402** may be operable to extract channel characteristics or parameters from a plurality of received signals and communicate the extracted channel parameters to the POS device **428**. The reference database **430** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to store the received channel parameters. In another embodiment, the POS device **428** may be operable to directly extract channel parameters from a plurality of received signals and store them in the reference database **430**.

[0084] The plurality of radios **406-414** in the mobile device **402**, the plurality of satellites $\mathbf{434}_1 \ldots \mathbf{434}_4$, access points $\mathbf{436}_1 \ldots \mathbf{436}_4$, and/or cell tower **438** in the geographical area of interest may be Multiple-Input Multiple-Output (MIMO) systems that have multiple antennas which transmit independently and accordingly improve the accuracy by providing more channel characteristics or parameters.

[0085] A GPS is a CDMA system that uses Pseudo Noise (PN) codes with embedded data that provide satellite locations and times. The GPS radio **406** may be of commercial quality in some embodiments of the invention and may be used to characterize the GPS communication channel. In some embodiments of the invention, the GPS radio **406** may also provide position values for all other radio communication channel readings.

[0086] The processor **420** may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to manage the operations of the plurality of radios **406-414**. For example, the processor **420** may instruct one of the plurality of radios **406-414** to scan for a particular signal and perform a channel measurement on a particular frequency with a particular fast Fourier transform (FFT) size and measurement time. The particular radio, for example, WLAN radio **408** may process the received signals to characterize the communication channel of that radio. The processor **420** may then transfer the channel parameters in an appropriate format into local memory **422**. The configuration of most of the wireless networks may not change with time since the signal sources, such as cell towers or permanent wireless access points do not move. However, some networks change with time because the signal sources move, such as, GPS satellites make complete orbits of the earth every **24** hours. For those channels that exhibit a time varying dimension, the channels are characterized at different time instances. The clock **416** may be used to time stamp the channel parameters that are stored in the local memory **422**. In some embodiments of the invention, the clock **416** may be obtained from a cell tower **438**, clocks of GPS satellites $\mathbf{434}_1 \ldots \mathbf{434}_4$, or other external sources.

[0087] In some embodiments of the invention, the channel parameters stored in memory **422** may be transferred to a reference database **430** at regular time intervals. In some embodiments of the invention, the transfer of data may be carried out by a local server **426** via a wired or wireless connection, such as, using cellular, WLAN, or other wireless method to a POS device **428**, which after authentication transfers the data to the reference database **430**. In some embodiments of the invention, the POS device **428** may be physically or logically part of an access point $\mathbf{436}_1 \ldots \mathbf{436}_4$.

[0088] In some embodiments of the invention, the mobile device **402** may be moved around and may scan geographical areas periodically and update the reference database **430** with a current set of channel parameters. In accordance with an embodiment of the invention, when the mobile device **402** takes a new measurement at a particular location and provides newest channel parameters at the current location coordinates, the POS device **428** may compare the newly measured channel parameters with the previously stored channel parameters stored in the reference database **430**. Based on the comparison, if there has been a change in the channel parameters associated with the current location coordinates of the mobile device **402**, the reference database **430** may be updated. The channel parameters at a particular location may be changed when some previously existing transmitters that were transmitting radio signals to the location were removed altogether or moved to a new location, new transmitters were added and transmit additional signals to the location, new buildings were built that obstruct signal paths, and/or previously existing buildings were demolished and no longer block or reflect signals, for example. For instance, when new measurement data indicates that no data is being received from a previously existing transmitter with a particular media access control (MAC) address and/or other identifying information, it may be concluded that the transmitter may have moved. In such cases, the channel parameters associated with that transmitter may be removed from the reference database **430** in some embodiments. Alternatively, when a transmitter's MAC address and/or other identifying information is detected that was not previously in the reference database **430**, the MAC address and/or other identifying information along with the channel parameters associated with that new transmitter may be added to the reference database **430**.

[0089] In accordance with an embodiment of the invention, a mobile device whose location coordinates are not known, for example, the mobile device **106** may retrieve a first set of parameters from the reference database **430** corresponding to a plurality of signals received at the current location coordinates of the mobile device **106**. The plurality of signals may

be received from a plurality of signal sources, such as, a plurality of satellites **434**$_1$ . . . **434**$_4$, a plurality of access points **436**$_1$ . . . **436**$_4$, and/or a cell tower **438**. The received plurality of signals may comprise at least one multipath signal. The reference database **430** may store channel parameters corresponding to the plurality of signals received at each of a plurality of location coordinates of the plurality of mobile devices in the network with known location coordinates.

[0090] The mobile device **106** may determine its location coordinates based on comparing the retrieved first set of parameters with the stored parameters in the reference database **430**. The retrieved first set of parameters and the stored parameters in the reference database **430** may comprise one or more of a time of arrival (TOA) delay extracted using received signal strength indicator (RSSI) transition, a time of arrival delay extracted using signal preamble correlation, a time difference of arrival (TDOA), a transmitted signal strength, an angle of arrival (AOA), equalizer filter coefficients, channel multipath profile, channel fast Fourier transform (FFT) coefficients, beacon signal strength, phase of each pilot tone, amplitude of each pilot tone and/or Doppler shift associated with movement of the plurality of mobile devices, for example, mobile device **402**.

[0091] In other embodiments of the invention, fixed radios or a plurality of access points **436**$_1$ . . . **436**$_4$ that are installed at different locations within the areas of interest may be used. For instance, fixed GPS receivers or other types of wireless RF radios that are networked may be installed at known coordinates on posts and buildings in some embodiments. These fixed radios may characterize radio channels and generate channel parameters, for example GPS channel parameters, such as, delay, phase, range to satellite, and/or satellite IDs and transmit the channel parameters at different time instances to a network server or the POS device **428** that may process the channel parameters further before storing the time, channel parameters and location coordinates in the reference database **430**.

[0092] In some embodiments of the invention, the position module **418** may be operable to match the received and extracted channel parameters with the channel parameters stored in the reference database **430** to determine the location coordinates of the mobile device **106**. The position module **418** may be operable to use interpolation or extrapolation and matching techniques to determine the location coordinates of the mobile device **106**.

[0093] In other embodiments of the invention, the location coordinates of the mobile device **106** may be performed by the location module **432** in the POS device. In such instances, the mobile device **106** may communicate the received channel parameters to the location module **432**. The location module **432** may be operable to compare the received channel parameters with the stored channel parameters in the reference database **430** and use interpolation and matching to determine the location coordinates of the mobile device **106**.

[0094] The navigation module **424** may be operable to utilize the determined location coordinates of the mobile device **106** for navigation purposes. For example, the navigation module **424** may indicate the location of the mobile device **106** on a map **302** and track the speed and direction of movement of the mobile device **106**.

[0095] Notwithstanding, the invention may not be so limited, and the reference database **430** and/or the location module **432** may be part of a remote server **114** or servers or the position calculations may be performed by a web-based service, rather than the POS device **428**, without limiting the scope of the invention.

[0096] FIG. **5** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on receiving multipath signals, in accordance with an embodiment of the invention. Referring to FIG. **5**, exemplary steps may begin at step **502**.

[0097] A user of a mobile device **402** equipped with a plurality of radios **406-414** may direct the mobile device **402** to determine the location coordinates of the user or the mobile device **402**. The user may direct or control the mobile device **402** by entering inputs, such as, clicking a mouse button, voice input, tapping a touch screen to select a user interface item, and/or pressing keys on a keyboard, for example. In other embodiments of the invention, the mobile device **402** may initiate the position finding automatically without being directed by the user. The mobile device **402** may also be controlled via gestures and/or voice.

[0098] In step **504**, the mobile device **402** may receive a plurality of signals at its plurality of radios **406-414**. The mobile device **402** in some embodiments may be equipped with radio receivers to receive different types of radio signals from different sources transmitting the signals in different standards. For example, the mobile device **402** may receive signals in GPS, cellular, WLAN, Bluetooth®, NFC, WiMaX, HD Radio™, UWB and/or 60 GHz standards. One or more radios **406-414** may regularly transmit beacon signals, while other radios may enter into a power save mode and require the mobile device **402** to initially transmit a probe request.

[0099] In step **506**, the mobile device **402** may extract channel parameters of all the signals received by all of the mobile device's radio receivers **406-414**. The mobile device **402** may characterize each received signal using one or more channel parameters, such as, a time of arrival delay extracted using RSSI transition, a time of arrival delay extracted using signal preamble correlation, a time difference of arrival, a transmitted signal strength, an angle of arrival, equalizer filter coefficients, channel multipath profile, channel FFT coefficients, beacon signal strength, phase of each pilot tone, amplitude of each pilot tone and/or Doppler shift associated with movement of the plurality of mobile devices. Each of the received plurality of signals may have a unique identifier that may identify the source of the signal. Exemplary identifiers may comprise a MAC ID for WLAN access points **436**$_1$ . . . **436**$_4$, a cell tower ID for cellular towers **438**, or satellite ID for GPS satellites **434**$_1$ . . . **434**$_4$. The mobile device **402** may then store the extracted channel parameters of the received signals and their corresponding identifications of signal sources in the mobile device's memory **422**.

[0100] In step **508**, it may be determined whether the mobile device **402** chooses to determine its location coordinates. In instances where the mobile device **402** chooses to determine its location coordinates, control passes to step **510**. In instances where the mobile device **402** chooses not to determine its location coordinates, control passes to step **516**.

[0101] In step **510**, the position module **418** in the mobile device **402** may access the reference database **430** in the POS device **428**, which stores the channel parameters. In some embodiments of the invention, the processor **420** may direct a local server **426** of the mobile device **402** to download a subset of the channel parameters stored in the reference database **430** via a wired or wireless connection using cellular, WLAN, or other wireless method. The approximate location

of the mobile device **402** may be known from prior position calculations or from beacon signals and cell tower signals received by the mobile device **402**. The position module **418** may retrieve a first set of channel parameters measured at the location coordinates near the approximate location of the mobile device **402**.

[0102] In step **512**, the position module **418** may determine the location coordinates of the mobile device **402** based on interpolation or extrapolation and matching. United States Application Serial No. **12/852,443** filed August **6**, **2010**, provides a detailed description of determining the location of a mobile device based on received multipath signals, and is hereby incorporated herein by reference in its entirety.

[0103] Since there are potentially several types of radios, and several channel parameters for any given channel, different procedures may be utilized to calculate the location coordinates of the mobile device **402**. In some embodiments of the invention, the position module **418** may choose a particular radio, for example, WLAN radio **408**, calculate the location coordinates of the mobile device **402** using each of the available channel parameters of that radio, and then weight these location coordinates to calculate final location coordinates using that radio alone. The position module **418** may repeat this procedure for other radios, for example, GPS radio **406**, Bluetooth radio **410**, WiMax radio **412**, and cellular radio **414**. The calculated location coordinates based on the channel parameters for each of those radios may then be weighted. The position module **418** may calculate the location coordinates by averaging the weighted positions of the mobile device **402**.

[0104] In some embodiments of the invention, the weights used in averaging calculated positions of a given radio using different channel parameters may be based on the reliability and accuracy of given channel parameters. For example, when the accuracy of position calculation using channel FFT coefficients are higher than calculations using other channel parameters, the calculated positions using channel FFT coefficients may be given a higher weight. Similarly, in some embodiments of the invention, the weights used in averaging calculated positions using different radios **406-414** may be based on the reliability and accuracy of each radio. For example, if the WLAN radio **408** may provide better positioning accuracies than the GPS radio **406**, the position calculated based on channel parameters of WLAN radio signals may be given a higher weight compared to the position calculated based on channel parameters of GPS radio signals. In some embodiments of the invention, the calculated positions for each radio **406-414** may be normalized based on the sensitivity levels to improve accuracy of position calculation. A sensitivity level is the minimum received signal power required to find channel parameters and/or to decode signals.

[0105] In step **514**, the position module **418** may optionally filter and smooth the calculated location coordinates of the mobile device **402** based on previous positions of the mobile device **402**. The mobile device **402** may calculate the mobile device's position and velocity at various time instances based on using two or more positions at which position calculations were performed and the time the mobile device **402** takes to get to one position from another. The velocity information may also be computed from signal amplitude information and Doppler effects. The previous calculated positions and velocity information may be used to filter and smooth the position of the mobile device **402** calculated using interpolation to further reduce positioning errors. The filtering algorithms may use linear 1-tap filters or Kalman filtering, for example. Control then passes to step **524**.

[0106] In instances where the mobile device **402** chooses not to determine its location coordinates, control passes to step **516**. In step **516**, the mobile device **402** may transfer the extracted channel parameters to a POS device **428**. In step **518**, the location module **432** may access the reference database **430** to obtain the channel parameters stored in the reference database **430**. The location module **432** may download a subset of the data from the reference database **430**. In step **520**, the location module **432** may calculate the location coordinates of the mobile device **402** using interpolation and matching. In step **522**, the location module **432** may optionally filter the calculated location coordinates of the mobile device **402** and communicate the filtered position back to the mobile device **402**. In some embodiments of the invention, the location module **432** may communicate the position information to the mobile device **402** without filtering the position information.

[0107] In step **524**, the mobile device **402** may use its final calculated location coordinates to determine whether the mobile device **402** is within a defined geo-fence around a POS device. Control then passes to end step **526**.

[0108] In some embodiments of the invention, the method disclosed in FIG. **5** may not use triangulation when determining the location of the mobile device **402**. The specific operations described with respect to FIG. **5** need not necessarily be performed in the exact order shown and described. The specific operations need not necessarily be performed in one continuous series of operations, and different specific operations may be performed in different embodiments. Furthermore, the method disclosed in FIG. **5** may be implemented using several sub-processes, or as part of a larger macro process.

[0109] FIG. **6** is an exemplary block diagram illustrating determination of a location of a mobile device based on received signals with known radio transmission patterns, in accordance with an embodiment of the invention.

[0110] Referring to FIG. **6**, there is shown an access point **604** and a mobile device **602**. The access point **604** comprises an antenna **606** for transmitting and/or receiving signals. The mobile device **602** comprises an antenna **608** for transmitting and/or receiving signals. The mobile device **602** further comprises a low noise amplifier (LNA) **610**, a mixer **612**, a filter **614**, an analog to digital converter (ADC) **616**, an automatic gain control (AGC) **618**, a clock **620**, a phase locked loop (PLL) **622**, a N-bit counter register **624**, a known short preamble correlator **626**, a short preamble correlator **628**, a long preamble correlator **630**, a known long preamble correlator **632**, a modulus operator **634**, a peak detector **636**, a memory **638**, a orthogonal frequency division multiplexed (OFDM) FFT **640**, a MAC and transmit time decoder **642**, a plurality of FFTs **644** and **650**, an inverse FFT **648**, and a fuse **648**.

[0111] In one embodiment of the invention, the wireless LAN standard may be used to demonstrate methods of the invention using preamble correlation. However, the disclosed methods may be applied to any system that has a known structure, for example, a known preamble structure, such as, Bluetooth®, GPS, WLAN, cellular, WiMax, HD Radio™, UWB, RFID, ZigBee, 60 GHz standards, and other RF signals with known structures.

[0112] The antenna **606** of the access point **604** may be operable to transmit an RF waveform. The antenna **608** of the mobile device **602** may be operable to receive the RF signal after a delay corresponding to the distance between the mobile device **602** and the access point **604**. The LNA **610** may be operable to amplify the received RF signal without increasing the noise level. The PLL **622** may be operable to

generate a clock for down conversion as well as the sampling clock frequency (f_s) to sample the analog signal at the input of the ADC **616**. The clock of the PLL **622** may also be used for the N-bit counter register **624** that may store time delays. The N-bit counter register **624** may be operable to register counts from 0 to (2N-1) and then wrap around back to zero. Therefore, the size of this register, N, may be large enough to represent the time delays that are expected so that time wrap around may be avoided. It should be noted that once the N-bit counter register **624** wraps around to zero, that portion of the time delay may be lost. For instance, when the N-bit counter register **624** only goes up to 100 ms, a time delay of 115 ms may show up as 15 ms in the N-bit counter register **624**. When T is the largest time delay that may be expected, the N-bit counter register **624** may be designed to be larger than T plus a delta, where delta is the maximum expected time offset error. The access point **604** may also have a counter that may be synchronized with the N-bit counter register **624** of the mobile device **602** through calibration transmissions.

[0113] The mixer **612** may be operable to use the RF output of the LNA **610** and the PLL **622** signal to down convert the RF signal to baseband. The down-converted signal is a complex signal with in-phase (I) and quadrature (Q) components. The filter **614** may be operable to reject unwanted signals. The ADC **616** may be operable to digitize the signal. A time tracking loop may be run so that the ADC sampling points are synchronized with the transmitted waveform to avoid inter-symbol interference. The amplitude of the ADC **616** output may be used by the AGC **618** so that front-end RF block settings may be adjusted and the ADC **616** output captures the main signal.

[0114] The short preamble correlator **628** may be operable to correlate its input signal with the signature of the short preamble received from known short preamble correlator **626**. The output of the short preamble correlator **628** may adjust the gain control settings of the AGC **618**. After the short preamble correlation is complete then the correlation with the long preamble structure is carried out.

[0115] The long preamble may comprise two preamble symbols, T_1 and T_2. The short preamble correlator **628** may also provide a coarse time estimate for the sliding window of the long preamble correlator **630** so that the correlation window starts just before T_1. The long preamble correlator **630** may be operable to correlate the I and Q received signal components against T_1 or against both T_1 and T_2 together by using the signature of the long preamble received from known long preamble correlator **632**. This is a complex correlation and the output of the long preamble correlator **630** therefore is a complex signal with real and imaginary components. The complex output of the long preamble correlator **630** may in some embodiments be stored in memory **638** to represent channel FFT coefficients, or be used together with extracted pilots to calculate more accurate channel FFT coefficients. A modulus operation is then carried out by the modulus operator **634** on the output of the long preamble correlator **630**, where the absolute value magnitude of the complex signal is calculated.

[0116] After a time delay, which may be a system parameter, the OFDM FFT **640** may be operable to perform FFT on the OFDM signal symbol. The MAC address or MAC ID of the device corresponding to the received RF signal may be computed by the OFDM FFT **640** and a MAC and transmit time decoder **642**. The OFDM FFT **640** may be operable to use the output of the long preamble correlator **630** in order to determine when to start the FFT. The OFDM FFT **640** may also discard the cyclic prefix. The MAC address may then be saved in memory **638** so that stored time delays may correspond to a particular access point's MAC address. The transmission time, represented by the transmitter's counter value at transmission, may be stored in the memory **638**. The MAC and transmit time decoder **642** may also retrieve the transmission time with an FFT and store it in memory **638**. The difference between the transmitter's counter value at transmission and the receiver's peak detection counter value may represent time of arrival plus system delays and synchronization offsets, which may be calibrated and compensated for. The data is also decoded with an equalizer, which uses the channel coefficient estimates to perform division and multiplication in the FFT domain to decode the data. The correlators do not have to run all the time and may enter a sleep mode once the peak detector finds the first peak.

[0117] The pilots may be extracted by an FFT **644** and used to improve the channel estimate and update the peak detector's **636** output. The extracted pilots may be fused by the fuse component **648** with the FFT calculated by the FFT module **644** of the previously stored long preamble correlator **630** output. This fusion step may involve using weights to change the values of the FFT of the long preamble correlator **630** output at the pilot locations. The result may then be processed by an inverse FFT (IFFT) **646** step and the improved estimates may then be fed back to the modulus operator **634** and the peak detector **636**. The channel FFT coefficients may be calculated by the FFT module **644** and stored in the memory **638**.

[0118] In accordance with an embodiment of the invention, the location coordinates of the mobile device **602** may be determined based on a calculated time of travel of a received signal from one or more access points **604** to the mobile device **602**. The time of travel of the received signal may be calculated based on correlating the received signal with a corresponding received signal with a similar known radio transmission pattern. For example, the time of travel of the received signal may be calculated based on correlating a preamble of the received signal, for example, signal received at short preamble correlator **628** or long preamble correlator **630** with a preamble of the corresponding received signal with the similar known radio transmission pattern, for example, signal output by the known short preamble correlator **626** or known long preamble correlator **632** respectively.

[0119] U.S. application Ser. No. 12/833,938 filed Jul. 9, 2010, provides a detailed description of determining the location of a mobile device based on received signals with known radio transmission patterns, and is hereby incorporated herein by reference in its entirety. The mobile device **602** may be operable to use correlation with the preamble training structure to determine the time delay between the access point **604** and the mobile device **602**. In this example, the mobile device **602** employs direct conversion where the carrier frequency is directly converted to two baseband signals; in-phase I and quadrature Q, which are then sampled by the ADC **616**. However, other receiver architectures, such as, heterodyne or super heterodyne may be used, where an ADC is used to sample the full signal bandwidth of interest without limiting the scope of the invention.

[0120] FIG. **7** is an exemplary block diagram of a combined GPS and wireless positioning system, in accordance with an embodiment of the invention. Referring to FIG. **7**, there is shown a mobile device **702**, a plurality of satellites **718**$_1$ . . . **718**$_4$, and a plurality of wireless access points **720**.

[0121] The mobile device **702** may comprise a wireless core receiver **704**, a GPS core receiver **706**, a wireless measurement engine **708**, a wireless navigation engine **710**, a GPS measurement engine **712**, a GPS navigation engine **714**, and a combined navigation processor **716**.

[0122] The plurality of wireless access points $\mathbf{720}_1 \ldots \mathbf{720}_4$ may be at fixed locations and equipped with GPS and deployed in towns and cities to provide wireless access to the Internet or to cellular networks, and also provide GPS assistance data via a GPS assistance manager. Since the location of these access points is usually fixed and known, they may also provide GPS differential information via a GPS differential correction manager.

[0123] In accordance with one embodiment of the invention, RFID readers may be used in a similar fashion as the plurality of wireless access points **720** to locate a mobile device **702** that has a tag attached to it. The RFID readers may be fixed location pre-assigned readers or mobile readers that are operable to determine their positions such as by an integrated or coupled GPS or other GNSS device.

[0124] The GPS core receiver **706** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to receive GPS signals from the plurality of satellites $\mathbf{718}_1 \ldots \mathbf{718}_4$. The GPS core receiver **706** may be operable to receive GPS RF signals from all visible satellites $\mathbf{718}_1 \ldots \mathbf{718}_4$, down-convert the signals, correlate and despread the signals using the locally generated codes, and provide the baseband In-phase (I) and Quadrature (Q) symbols to the GPS measurement engine **712**.

[0125] The GPS measurement engine **712** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to process the I and Q symbols and to generate the GPS raw measurements such as the pseudoranges, Dopplers, and integrated carrier phase (ρ, $\dot{\rho}$, ϕ) for all the visible satellites $\mathbf{718}_1 \ldots \mathbf{718}_4$. These raw measurements are then provided to the GPS navigation engine **714**.

[0126] The GPS navigation engine **714** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to receive the GPS raw measurements and calculate position, velocity, and time (P, V, T) based on Kalman filtering to achieve better estimates.

[0127] The wireless core receiver **704** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to determine the location coordinates of the mobile device **702** based on combining the information received from the GPS core receiver **706** with information from other wireless positioning data. The wireless core receiver **704** may implement one or more wireless protocols such as cellular, WLAN, Bluetooth®, WiMax, NFC, HD Radio, RFID, UWB, RFID, 60 GHz or ZigBee®, for example. The wireless positioning data may be obtained with triangulation schemes that use time of arrival or phase with wireless technologies such as WLAN, Bluetooth®, or RFID, for example. By combining positional information from multiple sources the effects of shadowing, fading and multipath interference may be reduced. The wireless core receiver **704** may receive the wireless RF signal, down-convert, demodulate, and decode the signal to generate the baseband I and Q symbols.

[0128] The wireless measurement engine **708** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to receive the I and Q symbols and generate the raw measurements for navigation. Such measurements may include pseudoranges, Dopplers, and integrated carrier phases (ρ, $\dot{\rho}$, ϕ) for all the wireless access points in the region.

[0129] The wireless navigation engine **710** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to receive the raw navigation measurements and calculate position, velocity, and time (P, V, T).

[0130] The combined navigation processor **716** may comprise suitable logic, circuitry, code, and/or interfaces and may be operable to implement various signal processing and optimization algorithms in order to combine different data from the GPS core receiver **706** with the data from the wireless core receiver **704**. Examples of such algorithms may comprise Weighted Least Squares and Extended Kalman Filters. The actual architecture and implementation mechanism of such signal processing algorithms may depend on the type of data provided to the combined navigation processor **716**. Notwithstanding, other suitable algorithms may be utilized without limiting the scope of the invention.

[0131] In accordance with a first embodiment of the invention, the wireless access points **720** may provide GPS assistance data to the mobile device **702**. Such assistance data may comprise reference time, the IDs and ephemerides of the satellites to be tracked, and/or decoded navigation data, for example.

[0132] In accordance with an alternative or complementary second embodiment of the invention, the wireless access points **720** may have its true location and its own GPS measured location. The wireless access points **720** may accordingly calculate the measured range errors for each of the visible satellites $\mathbf{718}_1 \ldots \mathbf{718}_4$. The wireless access points **720** may provide its calculated errors to the mobile device **702**, which may then use the calculated errors as differential correction terms and cancel out the common errors to achieve better accuracy.

[0133] In accordance with an alternative or complementary third embodiment of the invention, the final P, V, T solution of the GPS core receiver **706** may be provided to the combined navigation processor **716**, which may then combine it with the data received from the wireless core receiver **706**.

[0134] In accordance with an alternative or complementary fourth embodiment of the invention, the raw GPS measurements such as pseudoranges, Dopplers, and carrier phases may be directly provided to the combined navigation processor **716**.

[0135] In accordance with an alternative or complementary fifth embodiment of the invention, the combined navigation processor **716** may receive the actual I and Q symbols directly from the GPS core receiver **706** and/or from the wireless core receiver **704**.

[0136] In accordance with an alternative or complementary sixth embodiment of the invention, the final P, V, T solution obtained independently by the wireless core receiver **706** may be provided to the combined navigation processor **716**, which may then combine it with the data received from the GPS core receiver **706**.

[0137] In accordance with an alternative or complementary seventh embodiment of the invention, the raw navigation measurements such as pseudoranges, Dopplers, and carrier phases, generated by the wireless core receiver **704** may be directly provided to the combined navigation processor **716**.

[0138] In accordance with another alternative or complementary embodiment of the invention, the combined navigation processor **716** may be inside one of the wireless access points **720** instead of the mobile device **702**. In such a scenario, the signal processing and optimization algorithms for combining different data from the GPS core receiver **706** with

the data from the wireless core receiver **704** may be carried out inside the wireless access points **720**. This offloads the mobile device **702** from having to perform the processing, but it does require the mobile device **702** to send its data to the wireless access points **720** and the wireless access points **720** to send its processing results back to the mobile device **702**.

[0139] One example of the algorithm implemented by the combined navigation processor **716** may be an extended Kalman filter (EKF). The EKF algorithm is an iterative process by which a vector of parameters is optimally estimated given a dynamical model and a set of measurements at consecutive time steps. It uses a non-linear filter function that effectively tries to combine the measurements in some optimal fashion in order to obtain the intended estimate.

[0140] In accordance with an embodiment of the invention, the location coordinates of the mobile device **702** may be determined based on receiving GPS information from a plurality of GPS satellites **718** and a weighted average of a plurality of assistance data from one or more access points **720**. The weight assigned to each of the plurality of assistance data may be determined based on one or more of a reception characteristic of each of the one or more access points **720**, a relative distance, a relative received power level and/or a relative received phase difference between the mobile device **702** and each of the one or more access points **720**. The plurality of assistance data received from the one or more access points **720** may correspond to one or more standards comprising one or more of WLAN, Bluetooth, WiMax, HD Radio, UWB, GPS, cellular, NFC, and/or 60 GHz standards.

[0141] U.S. application Ser. No. 11/940,219 filed Nov. 14, 2007, provides a detailed description of determining the location of a mobile device based on assisted GPS, and is hereby incorporated herein by reference in its entirety.

[0142] FIG. **8** is another exemplary block diagram of a combined GPS and wireless positioning system, in accordance with an embodiment of the invention. Referring to FIG. **8**, there is shown a mobile device **800**. The mobile device **800** may comprise a WLAN core receiver **810***a*, a cellular core receiver **810***b*, a RFID core receiver **810***c*, and a UWB core receiver **810***d* (collectively receivers **810**), a WLAN controller **812***a*, a cellular controller **812***b*, a RFID controller **812***c*, and a UWB controller **812***d* (collectively controllers **812**), a GPS core receiver **802**, a GPS measurement engine **804**, a GPS navigation engine **806**, and a combined navigation processor **808**.

[0143] The WLAN controller **812***a* may comprise a WLAN assistance data decoder **814***a*, a WLAN differential correction data decoder **816***a*, a WLAN measurement engine **818***a*, and a WLAN navigation engine **820***a*. The cellular controller **812***b* may comprise a cellular assistance data decoder **814***b*, a cellular differential correction data decoder **816***b*, a cellular measurement engine **818***b*, and a cellular navigation engine **820***b*. The RFID controller **812***c* may comprise a RFID assistance data decoder **814***c*, a RFID differential correction data decoder **816***c*, a RFID measurement engine **818***c*, and a RFID navigation engine **820***c*. The UWB controller **812***d* may comprise a UWB assistance data decoder **814***d*, a UWB differential correction data decoder **816***d*, a UWB measurement engine **818***d*, and a UWB navigation engine **820***d*.

[0144] The plurality of assistance data decoders **814***a*. . . d may be collectively referred to as assistance data decoders **814** and may be operable to process the received assistance data from the plurality of access points. The plurality of differential data decoders **816***a* . . . d may be collectively referred to as differential correction data decoders **816** and may be operable to decode differential GPS data based on determining a difference between their known locations and the calculated GPS locations. The plurality of measurement engines **818***a* . . . d may be collectively referred to as measurement engines **818** and may be operable to receive the I and Q symbols and generate the raw measurements for navigation. The plurality of navigation engines **820***a* . . . d may be collectively referred to as navigation engines **820** and may be operable to receive the raw navigation measurements and calculate position, velocity, and time.

[0145] The mobile device **800** may be operable to communicate with different types of GPS-equipped wireless access points, for example, a WLAN access point, a cellular access point, a RFID reader access point, and a UWB access point. The characteristics of these wireless access points may differ in terms of their signal frequency, power, signal source location, and protocol, and may accordingly exhibit different shadowing, fading and multipath effects, and combining their signals may reduce the errors caused by these effects. For example, signals from different locations experience different multipath errors and averaging may reduce the multipath errors. The combining algorithm may use weights based on criteria such as RSSI or power strength, and approximate location, for example. For example, at indoor locations the signals and triangulation methods of WLAN and RFID may receive more weight than GPS because GPS is limited indoors while WLAN and RFID are not. At outdoor locations, however, GPS signals may be weighted more than WLAN and RFID. The access points may have GPS receivers and provide the information they receive to the combined navigation processor **808**. There may also be hybrid approaches where for example, some RFID readers or WLAN access points may have GPS receivers while others may use triangulation or other methods. The access points that have a GPS receiver may have the option of providing differential correction or assistance data.

[0146] The mobile device **800** may download maps related to its position and may use information in the maps to adjust the weights it applies to the position information it receives. The maps may include interior features, for example, walls as well as exterior features, for example, buildings or hills. For example, if the mobile device **800** is in a position that would, based on the configuration of the surrounding buildings, be susceptible to multipath interference of GPS signals, the GPS information may receive a reduced weight by the combined navigation processor **808**. The maps may be provided from a map server that may be a component of an access point.

[0147] The mobile device **800** may also combine assistance data and other information from access points of the same type. This is possible since the wireless communication mechanisms are packet-based and a particular receiver may switch between two access points of the same type. For example, the mobile device **800** may combine the positioning information it receives from two or more UWB access points by weighting their information according to various criteria, for example, signal or power strength, and/or approximate location. For example, higher strength signals may receive larger weights than lower strength signals because they are presumed to be closer to the mobile device **800**. This example may also be applied to other types of access points, for example, averaging information from two or more access points of type RFID or ZigBee® or WLAN or cellular or Bluetooth®.

[0148] FIG. **9** is an exemplary diagram illustrating determination of a location of a mobile device based on receiving positioning assistance data using short range wireless communication protocols, in accordance with an embodiment of the invention. Referring to FIG. **9**, there is shown a user **1** with mobile device **902**, a POS device **904**, a user **2** with a mobile device **906**, a user **3** with a mobile device **908**, a plurality of access points AP**1** **910** and AP**2** **914**, a 60 GHz position reference communicator **912**, a plurality of cellular towers **916** and **918**, a RFID position reference tag **920**, a network **922**, and a plurality of satellites $\mathbf{924}_1 \ldots \mathbf{924}_4$.

[0149] The mobile device **902** may be operable to receive positioning assistance data from a plurality of position reference devices **906-920** via short-range communication protocols and weight their positioning and assistance data based on how far they are from the mobile device **902**. If the positioning reference devices are moving, then the weights may also take into account how recently the positioning reference devices were calibrated. The mobile device **902** of user **1** may use its NFC communicator to power up a passive NFC tag at a POS device **904** and receive positioning assistance data from the POS device **904**. The mobile device **902** may use its RFID reader to receive positioning assistance data from an RFID position reference tag **920**. The mobile device **902** of user **1** may use its WLAN radio to receive positioning assistance data from the access point AP**1** **910** that is transmitting with low power to reduce its range. The mobile device **902** may use its 60 GHz transceiver to receive positioning assistance data from the 60 GHz position reference communicator **912** of a store security gate, for example. The mobile device **902** may use its cellular receiver to receive positioning assistance data from a reference cellular tower **916**. In one embodiment of the invention, user **3** has a mobile device **908** that uses Wi-Fi Direct to transmit positioning assistance data to the mobile device **902** of user **1**. In another embodiment of the invention, a user **2** has a mobile device **906** that uses Bluetooth to transmit positioning assistance data to the mobile device **902** of user **1**. The mobile device **902** of user **1** may then combine the positioning assistance data from different position reference devices based on a confidence measure.

[0150] The accuracy of the positioning assistance data may increase as the position reference device is closer to a mobile device **902**. Accordingly, the mobile device **902** may choose to use the positioning assistance data of the nearest position reference device. For example, the mobile device **902** may select to receive the positioning assistance data from the NFC tag at the POS device **904** and may ignore the remaining positioning assistance data because the range of NFC is small and the mobile device **902** has to be close to the NFC tag in order to be able to communicate with it. Alternatively, rather than ignoring the remaining positioning assistance data from the other position reference devices, the mobile device **902** may assign weights to one or more based on the range of the short-range communication protocol. For example, the reference position and positioning assistance data that is received via an NFC communication protocol may be given the highest weight. Similarly, smaller weights may be given to positioning assistance data that are received from a position reference device via a cellular protocol because of the large range of cellular signals. The weights may also take into account the strength of the received signals. For example, if two position reference devices are using the same short-range protocol but the mobile device **902** receives a stronger signal from one compared to the other, the stronger signal reference may be given a higher weight.

[0151] In accordance with an embodiment of the invention, the time when positioning assistance data was received is noted when the position reference device is moving because the positioning errors may accumulate over time until they are removed or reduced by a nearby position reference device. A greater weight may be assigned to a recently calibrated moving position reference device based on the received timestamp at which they were calibrated. For example, if the position of the mobile device **908** of user **3** has been more recently calibrated compared to the mobile device **906** of user **2**, the mobile device **902** of user **1** may then choose to accept only the positioning assistance data of user **3**'s mobile device **908**, or may assign a higher weight to the positioning assistance data received from mobile device **908**. In another embodiment of the invention, the GPS assistance data of user **3**'s mobile device **908** may be more accurate because it is more recently updated compared to the determined TOA, TDOA, RSSI and/or AOA calculated using one or more methods. The mobile device **908** may then transmit a timestamp for each of its positioning assistance data. The mobile device **902** may then receive the positioning assistance data from mobile device **908** and assign it a higher weight compared to the determined TOA, TDOA, RSSI and/or AOA calculated using one or more methods.

[0152] In accordance with an embodiment of the invention, the determined location coordinates of the mobile device **902** may be recalibrated based on receiving a plurality of positioning assistance data from one or more position reference devices, for example, a POS device **904** via passive and active NFC tags, a mobile device **906** via Bluetooth, a mobile device **908** via Wi-Fi Direct, a plurality of access points AP**1** **910** and AP**2** **914** via WLAN, a 60 GHz position reference communicator **912** via 60 GHz standard or other high frequency narrow beam methods, a plurality of cellular towers **916** and **918** via cellular standards, and/or a passive or active RFID position reference tag **920** using short range wireless communication protocols.

[0153] FIG. **10** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on receiving positioning assistance data using short-range wireless communication protocols, in accordance with an embodiment of the invention. Referring to FIG. **10**, exemplary steps may begin at step **1002**.

[0154] In step **1004**, the mobile device **902** may be within a defined proximity of a plurality of position reference devices, for example, a POS device **904**, a mobile device **906**, a mobile device **908**, a plurality of access points AP**1** **910** and AP**2** **914**, a 60 GHz position reference communicator **912**, a plurality of cellular towers **916** and **918**, and/or a RFID position reference tag **920**. In step **1006**, the mobile device **902** may receive positioning assistance data from the position reference devices via short-range wireless protocols. The positioning assistance information transmitted by the position reference devices may include their identification (ID), general information such as their type and whether they are stationary or moving, their short-range communication protocol, their prestored or calculated position information, the timestamp for when their own reference position was calibrated, and positioning assistance data for different methods such as GPS and/or Wi-Fi.

[0155] In step **1008**, the mobile device **902** may combine the positioning assistance data received from the plurality of position reference devices by weighting them as described with respect to FIG. **9**. In step **1010**, the mobile device **902** may recalibrate its location coordinates for each positioning method based on receiving a plurality of positioning assistance data from one or more position reference devices so that the calculated position from each method coincides with the reference position, and the position of the mobile device **902** is set to the reference position.

[0156] In step **1012**, the mobile device **902** may combine the different positioning assistance data by weighting each appropriately. The normalized weights may use equal weights, use weights based on historical accuracy of each positioning method, or use a confidence measure for each positioning method. For example, the confidence in a GPS positioning method may be high, if many satellites are detected by the GPS receiver of the mobile device's **902**. The steps of determining location coordinates for each positioning method, and computing a combined position of the mobile device **902** may be repeated at regular time intervals, until the mobile device **902** is within a defined proximity of a new position reference device that was not one of the initial plurality of position reference devices. The mobile device **902** may then receive new positioning assistance data from the new position reference device and control may return to step **1006**. In step **1014**, the mobile device **902** may use its final calculated location coordinates to determine whether the mobile device **902** is within a defined geo-fence around a POS device **904**. Control then passes to end step **1016**.

[0157] FIG. **11** is an exemplary block diagram of a RFID location system, in accordance with an embodiment of the invention. Referring to FIG. **11**, there is shown a plurality of RFID readers **1102***a-c*, a POS device **1104**, and a plurality of mobile devices **1110***a-c*. The mobile device **1110***a* may comprise a RFID tag **1111**. The POS device **1104** may comprise a location module **1106**.

[0158] The plurality of RFID readers **1102***a-c* may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to transmit RF signals. The RF signals may address or otherwise specify a particular tag to be accessed. For example, the RFID readers **1102***a-c* may communicate with specific RFID tags, for example, RFID tag **1111** by sending a signal to which all RFID tags respond. The RFID readers **1102***a-c* may detect collisions and request that only specific RFID tags respond. For instance, the RFID readers **1102***a-c* may request responses only from RFID tags with a most significant bit (MSB) in the ID equal to zero. The RFID tags may receive the signals from the RFID readers **1102***a-c* and only respond if certain conditions are met. For instance, a RFID tag may only respond if one or more bits in the RFID tag ID match one or more bits in a RFID reader reference signal.

[0159] The RF signals from each of the plurality of RFID readers **1102***a-c* may be backscattered by the RFID tag **1111** within each RFID reader's range. The backscattered signals **1108***a-c* from the RFID tag **1111** may be modified or modulated to include the RFID tag's identification number or code or the tag ID. Each RFID reader **1108***a-c* may receive the backscattered signals **1108***a-c* and extract the tag ID. Accordingly, each RFID reader **1102***a-c* may determine which tags are within the RFID reader's range. Additionally, each RFID reader **1102***a-c* may associate a backscattered signal with particular tag IDs. The location of a particular RFID tag, or group of RFID tags, may be determined by using measured parameters obtained from the backscattered signals **1108***a-c* that may be used to determine positioning data, for example, received signal phase or signal power, which may be referred to as measured position parameters.

[0160] The location of a RFID tag **1111** may be determined by transmitting three or more RF signals from three or more different locations. For example, RFID reader **1102***a* may transmit a first RF signal, and the RF signal may be received and backscattered by RFID tag **1111**. Accordingly, the RFID reader **1102***a* may receive a backscattered signal in response to the transmitted RF signal as shown at **1108***a*. Similarly, RFID readers **1102***b* and **1102***c* may transmit a second and third RF signals, and the RF signals may be received and backscattered by RFID tag **1111**. Accordingly, the RFID readers **1102***b* and **1102***c* may receive backscattered signals in response to the transmitted RF signals as shown at **1108***b* and **1108***c*.

[0161] The measured position parameters for determining the location of RFID tag **1111** may be obtained by processing each backscattered signal. For example, the RFID readers **1102***a-c* may receive the backscattered signals from RFID tag **1111** and extract information from the backscattered signals **1108***a-c* to determine the distance between the RFID reader and the RFID tag **1111**. In accordance with an embodiment of the invention, one or more of the following position parameters may be measured from the backscattered signals, for example, phase, power or received signal strength, angle of arrival, or time of arrival. One or more of these measured position parameters may be used to determine the distance between the RFID reader and the RFID tag **1111**.

[0162] The results of processing the measured position parameters may be raw or preprocessed location parameters, such as, distances, latitudes, longitudes, altitudes, coordinates (e.g., Cartesian or Polar), a vector, or offsets from one or more known positions or references. The raw location parameters may be used to generate mapped position information, such as, actual locations in rooms, warehouses, hallways, shelves, aisles, streets, or graphic images thereof. The mapped position information may be presented to a user to allow the user to locate items to which the RFID tags are attached, for example.

[0163] In this example, the measured position parameters may be transmitted from each RFID reader **1102***a-c* to a server or POS device **1104** over a communication channel **1112**. The communication channel **1112** may be a wired or wireless channel. For example, the communication channel **1112** may be a wired local area network connection, such as Ethernet, or it may be a wireless channel such as Bluetooth, Zigbee, Wi-Fi (IEEE 802.11 network), cellular (e.g., CDMA, TDMA, GSM), or any other wireless network, for example.

[0164] The measured position parameters from the RFID readers **1102***a-c* may be stored on the POS device **1104**. The location module **1106** may utilize the measured position parameters to determine the location of the RFID tag **1111**. The POS device **1104** and the location module **1106** may be implemented in a plurality of ways. For example, the POS device **1104** may be implemented as stand alone hardware including location module **1106** coupled to the RFID readers **1102***a-c* over a local wired or wireless network. Alternatively, the location module **1106** may be included as a software component on one or more RFID readers **1102***a-c*, and the RFID readers **1102***a-c* may transmit measured position parameters to one of the RFID readers **1102***a-c* for determin-

ing the position of the RFID tag **1111**. In another embodiment of the invention, the POS device **1104** and the location module **1106** may be implemented on a remote computer system coupled to the RFID readers **1102***a-c* over a wide area network, such as the Internet.

[0165] In accordance with an embodiment of the invention, the RFID readers **1102***a-c* may transmit RF signals at the same time but with different modulated frequencies. For example, RFID readers **1102***a-c* may transmit at frequencies f_A, f_B, and f_C, respectively. By using different frequencies, it may be possible for the readers to transmit at the same time and to then recognize the backscattered signal that matches their own frequency. For example, RFID reader **1102***a* may use the time of arrival of the backscattered signal with frequency f_A to represent the range from RFID reader **1102**A to RFID tag **1111** and back to RFID reader **1102***a*. Similarly, RFID reader **1102***b* may use the time of arrival of the backscattered signal with frequency f_B to represent the range from RFID reader **1102***b* to RFID tag **1111** and back to RFID reader **1102***b*. Likewise, RFID reader **1102***c* may use the time of arrival of the backscattered signal with frequency f_C to represent the range from RFID reader **1102***c* to RFID tag **1111** and back to RFID reader **1102***c*. These times of arrival measurements along with the RFID readers' position information may then be transmitted to one of the RFID readers **1102***a-c* or POS device **1104** for calculating the RFID tag **1111** position using triangulation and/or geometric methods.

[0166] In accordance with an embodiment of the invention, the RFID readers **1102***a-c* may repeat their RF signal transmissions at frequent time intervals, for example, as instructed by the POS device **1104** or via synchronized clocks, thereby providing measured RFID tag position parameters at different time instances. The measured position parameters at each time instance may result in a plurality of corresponding raw location parameters and mapped positions. If the RFID tag **1111** is stationary, the location presented to a user may not change with time. However, if the RFID tag **1111** is moving, the location presented to a user may update at each time interval. In one embodiment of the invention, the changing information may be used to determine the rate of movement and direction of movement of a RFID tag **1111**. For example, one mode of display to the user may include displaying the current position of the RFID tag **1111** as well as the velocity magnitude or speed or rate of movement and direction of movement of the RFID tag **1111**. The velocity may be obtained from the current and previous time interval locations. The magnitude of the velocity may be obtained from the distance between current and previous time interval positions divided by the elapsed time interval, for example. The direction of the velocity may be obtained from the direction of the vector from the previous time interval position to the current position. In one embodiment of the invention, the location information may be stored so that the movement of RFID tags over time may be analyzed. For example, the POS device **1104** or the RFID readers **1102***a-c* may store in memory, the current and previous positions of the interrogated RFID tags. In one embodiment of the invention, a user may view the route traveled by the RFID tag over several previous time intervals to research movement patterns of items with attached RFID tags or track the paths traveled by lost or stolen items with attached RFID tags, for example.

[0167] In accordance with an embodiment of the invention, the location coordinates of the mobile device **1110***a* comprising a RFID tag **1111** may be determined based on extracting at least one measured position parameter from each of three or more backscattered signals **1108***a-c* communicated by the mobile device **1110***a*. The three or more backscattered signals **1108***a-c* may be received at one or more RFID readers **1102***a-c* located at three or more different locations in response to communicating by the one or more RFID readers **1102***a-c*, three or more RF signals to the mobile device **1110***a*.

[0168] U.S. application Ser. No. 11/641,624 filed Dec. 18, 2006, provides a detailed description of determining the location of a RFID tag, and is hereby incorporated herein by reference in its entirety.

[0169] FIG. **12** is an exemplary block diagram of a RFID reader, in accordance with an embodiment of the invention. Referring to FIG. **12**, there is shown a RFID reader **1202** and a POS device **1216**.

[0170] The RFID reader **1202** may comprise backscattering circuits **1204**, a GPS **1210**, a position parameter measurement unit **1212**, and a communication unit **1214** for communicating information with the POS device **1216** over a communication channel **1217**.

[0171] The backscattering circuits **1204** may comprise an RFID transmitter **1206** (TX) for generating RF signals, for example, through one or more antennas (not shown) and an RFID receiver **1208** (RX) for receiving backscattered signals from an RFID tag **1111**, for example, through one or more antennas (not shown). The position parameters in the backscattered signals may be extracted using position parameter measurement unit **1212**. The position parameter measurement unit **1212** may be integrated with the backscattering circuits **1204** and may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to extract power from received signals, determine time of arrival, angle of arrival, or phase, for example.

[0172] The GPS **1210** may be operable to determine the location of the RFID reader **1202**. In other embodiments of the invention, the RFID reader **1202** may be located in a fixed position, and its location coordinates may be stored on the RFID reader **1202**. The POS device **1216** may be operable to access each RFID reader's location by issuing a reader location request, which causes each RFID reader **1202** to transmit its location to the POS device **1216**. Alternatively, each RFID reader's location may be stored on the POS device **1216** or on another system accessible by the POS device **1216**. The RFID reader **1202** may communicate its location coordinates via the GPS **1210** and the measured position parameters may be communicated from the position parameter measurement unit **1212** to the communication unit **1214**. The communication unit **1214** may coordinate communications over the communication channel **1217** with the POS device **1216**. The communication channel **1217** may be either a wired or wireless channel, and the communication unit **1214** may implement any of a variety of communication protocols for communicating over communication channel **1217**. The location of the RFID tag **1111** may be determined by location software on the RFID reader **1202**, for example.

[0173] FIG. **13** is an exemplary block diagram of a mobile device with a RFID tag, in accordance with an embodiment of the invention. Referring to FIG. **13**, there is shown a mobile device **1302** and a POS device **1330**.

[0174] The mobile device **1302** may comprise a RFID tag **1301**, backscattering circuits **1304**, a GPS **1324**, a position parameter measurement unit **1316**, a location module **1318**, mapping data **1326**, and a communication unit **1328** for communicating information with the POS device **1330** over a communication channel **1329**.

[0175] The backscattering circuits **1304** may comprise an RFID transmitter **1306** (TX) for transmitting backscattered signals, for example, through one or more antennas (not shown) and an RFID receiver **1308** (RX) for receiving RF signals from a RFID reader **1202**, for example, through one or more antennas (not shown).

[0176] The position parameters in the backscattered signals may be extracted using position parameter measurement unit **1212**. The position parameter measurement unit **1212** may be integrated with the backscattering circuits **1204** and may comprise suitable logic, circuitry, interfaces, and/or code that may be operable to extract power from received signals, determine time of arrival, angle of arrival, or phase, for example.

[0177] In one embodiment of the invention, a user may send and receive three or more backscattered signals from three or more different locations and determine the location of RFID tags independently. In another embodiment of the invention, the mobile device **1302** may receive other location information from other RFID readers to determine the location of the RFID tags. For example, the mobile device **1302** may be coupled to a POS device **1330**. The POS device **1330** may be coupled to other RFID readers in different locations, and the RFID readers may each send measured position parameters to the POS device **1330**. The mobile device **1302** may download the measured position parameters from other RFID readers and the positions of the other RFID readers as stored on the RFID readers or on the POS device **1330**.

[0178] The location module **1318** may receive the measured position parameters and positions of the systems where the position parameters were measured. The location module **1318** may be coupled to a GPS **1324** for determining the position of the mobile device **1302**. The location module **1318** may comprise a position processor **1320** that may be operable to determine the raw location parameters that provide the position of the RFID tag **1301**. For example, the raw location parameters may represent the position of the RFID tag **1301** as longitude, latitude, altitude, in Cartesian coordinates, polar coordinates, such as, distances and angles, or as vectors, for example.

[0179] The location module **1318** may comprise a mapping processor **1322** that may be operable to receive the raw location parameters and mapping data, and transform the raw location parameters into mapping position information. The mapping data **1326** may be used to transform the RFID tag's position from Cartesian coordinates or vector representations, for example, into mapped position information, such as, shelf locations, aisles, rooms, warehouses, hallways, or streets. The mapping software components may receive mapping data that maps raw position parameters into mapped position information. The mapping data **1326** may further comprise images or maps that may be displayed to a user with the RFID tag superimposed on the image. The mapping data **1326** may comprise information for translating raw location parameters into mapped position information, images, or information for translating between RFID tag IDs and the names of items to which the RFID tags are attached. In other embodiments of the invention, some or all of this information may be received from an external source system such as the POS device **1330**, for example. In other embodiments of the invention, mapping data may be stored on the RFID tag **1301** itself. The mapping data **1326** may further comprise navigation information for providing directions to the user based on the user's current location and the location of a RFID tag.

[0180] FIG. **14** is an exemplary block diagram illustrating determination of a location of a mobile device based on measured phase differences and corresponding frequency differences, in accordance with an embodiment of the invention. Referring to FIG. **14**, there is shown a mobile device **1402**, a plurality of electronic devices **1404***a-d,* a network **1406**, and a POS device **1408**.

[0181] The plurality of electronic devices **1404***a-d* may be located at known locations while the location coordinates of the mobile device **1402** may be unknown. The mobile device **1402** may be operable to transmit signals and the plurality of electronic devices **1404***a-d* may be operable to receive signals and communicate the received signals to the POS device **1408** via the network **1406** for determining the distance between the mobile device **1402** at a unknown location and each of the plurality of electronic devices **1404***a-d* at known locations. The network **1406** may be a wired or a wireless network.

[0182] The mobile device **1402** may be operable to transmit signals **1412***a-d* with a plurality of frequencies or tones, for example, (f_0, ϕ_0), (f_1, ϕ_1) . . . (f_{n-1}, ϕ_{n-1}). The plurality of signals **1412***a-d* may comprise same frequencies, different frequencies, or a combination thereof. In accordance with an embodiment of the invention, the plurality of signals **1412***a-d* may be OFDM signals.

[0183] The plurality of electronic devices **1404***a-d* may be operable to receive the plurality of signals **1412***a-d* with a detectable phase change. In accordance with an embodiment of the invention, the received signals may be converted from analog to digital signals and be processed using digital signal processing. In another embodiment of the invention, the phase of the received frequency components, the frequency characteristics of the transmission channel, and the POS device **1408** may determine the phase differences.

[0184] The location module **1410** in the POS device **1408** may be operable to determine the distances between the plurality of electronic devices **1404***a-d* and the mobile device **1402** based on identifying a point on a plurality of circles (or spheres) of radius r_i, where r_i is the distance from any of the electronic devices **1404***a-d* at known locations to the mobile device **1402** at the unknown location, where all four circles (or spheres) intersect. The 2D locating problem may require a minimum of three circles intersecting at one point in 2D. The 3D locating problem may require a minimum of four spheres intersecting at one point in 3D.

[0185] The location module **1410** may be operable to receive either the raw data for the digitized signals or preprocessed data, such as, measured phase differences and corresponding frequency differences associated with each of three or more signals received from the mobile device **1402** to determine the location coordinates of the mobile device **1402**.

[0186] U.S. application Ser. No. 12/843,868 filed Jul. 6, 2010, provides a detailed description of determination of a location of a mobile device based on measured phase differences and corresponding frequency differences, and is hereby incorporated herein by reference in its entirety.

[0187] FIG. **15** is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device based on measured phase differences and corresponding frequency differences, in accordance with an embodiment of the invention. Referring to FIG. **15**, exemplary steps may begin at step **1502**.

[0188] In step **1504**, the mobile device **1402** may be operable to transmit a plurality of pilot tones to a plurality of electronic devices **1404***a-d* at known locations. In step **1506**,

each of the plurality of electronic devices **1404***a-d* may receive and extract the pilot tones. In step **1508**, each of the plurality of electronic devices **1404***a-d* may communicate pilot tone pair phase differences, amplitude of pilot tones, and their location coordinates to the location module **1410** in the POS device **1408**. In step **1510**, the location module **1410** may process the received pilot tone pair phase differences, amplitude of pilot tones, and location coordinates of the plurality of electronic devices **1404***a-d* to determine the location coordinates of the mobile device **1402**. In step **1512**, the POS device **1408** may determine whether the mobile device **1402** is within a defined geo-fence around the POS device **1408** based on the determined location coordinates of the mobile device **1402**. Control then passes to end step **1514**.

[0189] FIG. **16**A is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device by a POS device, in accordance with an embodiment of the invention. Referring to FIG. **16**A, exemplary steps may begin at step **1602**.

[0190] In step **1604**, a POS device **152** in a store may display a map **302** of the store or a defined geo-fence **112** around the POS device **152**. In step **1606**, a user of a mobile device **106** may enter the store or the defined geo-fence **112** around the POS device **152**. In step **1608**, the POS device **152** may be operable to determine the location coordinates of the mobile device **106** based on one or more positioning methods as detailed with respect to FIGS. **4-15**. In step **1610**, in instances where the mobile device **106** is within the defined geo-fence **112** of the POS device **152**, a notification may be triggered on the POS device **152** indicating the presence of the mobile device **106** within a defined proximity of the POS device **152**. In step **1612**, the POS device **152** may track the mobile device **106** while it is within the defined go-fence **112**. The user with the mobile device **106** may choose to purchase one or more items within the store or the defined geo-fence **112**.

[0191] When the mobile device **106** is ready to checkout, the POS device **152** may trigger an authorization request to execute a payment transaction based on the one or more items chosen to be purchased when the mobile device **106** is within the defined geo-fence **112**. In step **1614**, the POS device **152** may receive an authorization response from the mobile device **106** to execute the payment transaction when the mobile device **106** is within the defined geo-fence **112**. In step **1616**, the POS device **152** may execute the payment transaction when the mobile device **106** is within the defined geo-fence **112**. In accordance with an embodiment of the invention, the user with the mobile device **106** may be able to execute the payment transaction without physically using or swiping a credit or debit card, or without physically tapping or holding the mobile device near the POS device **152**. Control then passes to end step **1618**.

[0192] FIG. **16**B is an exemplary flow chart illustrating exemplary steps for determination of a location of a mobile device, in accordance with an embodiment of the invention. Referring to FIG. **16**B, exemplary steps may begin at step **1652**.

[0193] In step **1654**, a POS device **152** in a store may display a map **302** of the store or a defined geo-fence **112** around the POS device **152**. In step **1656**, a user of a mobile device **106** may enter the store or the defined geo-fence **112** around the POS device **152**. In step **1658**, the mobile device **106** may be operable to determine the location coordinates of the mobile device **106** based on one or more positioning methods as detailed with respect to FIGS. **4-15** and communicate the determined location coordinates to the POS device **152**. In step **1660**, in instances where the mobile device **106** is within the defined geo-fence **112** of the POS device **152**, a notification may be triggered on the mobile device **106** indicating its presence within a defined proximity of the POS device **152**. The user with the mobile device **106** may choose to purchase one or more items within the store or the defined geo-fence **112**. When the mobile device **106** is ready to checkout, the POS device **152** may trigger an authorization request to execute a payment transaction based on the one or more items chosen to be purchased when the mobile device **106** is within the defined geo-fence **112**. In step **1662**, the mobile device **106** may trigger an authorization response to the POS device **152** to execute the payment transaction when it is within the defined geo-fence **112**. In step **1664**, the POS device **152** may receive an authorization response from the mobile device **106** to execute the payment transaction when the mobile device **106** is within the defined geo-fence **112** and the POS device **152** may execute the payment transaction when the mobile device **106** is within the defined geo-fence **112**. In an alternative embodiment, a user of the mobile device **106** may give the authorization, for example, the user may say "Put it on my account" which may be video recorded to later resolve any potential disputes of a transaction. Control then passes to end step **1666**.

[0194] In accordance with an embodiment of the invention, a method and system for location based hands-free payment may comprise a network **150** (FIG. **1**B) comprising a plurality of mobile devices **104** (FIG. **1**B), **106** (FIG. **1**B), **108** (FIG. **1**B), **110** (FIG. **1**B), and a plurality of point of sale devices **152** (FIG. **1**B). A first of the plurality of mobile devices, for example, the mobile device **106** may be operable to determine its location coordinates based on one or more positioning methods as detailed with respect to FIGS. **4-15** and communicate the determined location coordinates to a selected one of the plurality of POS devices, for example, the POS device **152**. The mobile device **106** may trigger an authorization to execute a payment transaction when the mobile device **106** is within a defined proximity of the POS device **152**. The mobile device **106** may determine whether it is within the defined proximity of the POS device **152** based on a generated geo-fence **112** (FIG. **1**) around the POS device **152**.

[0195] A mobile device **106**, whose location coordinates need to be determined, may be operable to retrieve a first set of parameters from a reference database **430** (FIG. **4**) corresponding to a plurality of signals received at the location coordinates of the mobile device **106**. The plurality of signals may be received from a plurality of signal sources, such as, a plurality of satellites $\mathbf{434}_1 \ldots \mathbf{434}_4$ (FIG. **4**), a plurality of access points $\mathbf{436}_1 \ldots \mathbf{436}_4$ (FIG. **4**), and/or a cell tower **438** (FIG. **4**). The received plurality of signals may comprise at least one multipath signal. The reference database **430** may store channel parameters corresponding to the plurality of signals received at each of a plurality of location coordinates of the plurality of mobile devices **104**, **108**, and **110** in the network **150** with known location coordinates. The mobile device **106** may determine its location coordinates based on comparing the retrieved first set of parameters with the stored parameters in the reference database **430**. The retrieved first set of parameters and the stored parameters in the reference database **430** may comprise one or more of a time of arrival (TOA) delay extracted using received signal strength indicator (RSSI) transition, a time of arrival delay extracted using signal preamble correlation, a time difference of arrival (TDOA), a transmitted signal strength, an angle of arrival (AOA), equalizer filter coefficients, channel multipath profile, channel fast Fourier transform (FFT) coefficients, beacon signal strength, phase of each pilot tone, amplitude of each pilot tone and/or Doppler shift associated with movement of

the plurality of mobile devices, for example, mobile devices **104**, **108**, and **110**. The received plurality of signals may correspond to one or more standards comprising one or more of WLAN, Bluetooth, WiMax, HD Radio, UWB, GPS, cellular, and/or 60 GHz standards.

[0196] In accordance with an embodiment of the invention, the location coordinates of the mobile device **702** (FIG. **7**) may be determined based on receiving GPS information from a plurality of GPS satellites **718** (FIG. **7**) and a weighted average of a plurality of differential correction and/or assistance data from one or more access points **720** (FIG. **7**). The weight assigned to each of the plurality of differential correction and/or assistance data may be determined based on one or more of a reception characteristic of each of the one or more access points **720**, a relative distance, a relative received power level and/or a relative received phase difference between the mobile device **702** and each of the one or more access points **720**. The plurality of differential correction and/or assistance data received from the one or more access points **720** may correspond to one or more standards comprising one or more of WLAN, Bluetooth, WiMax, HD Radio, UWB, GPS, cellular, NFC, and/or 60 GHz standards.

[0197] In accordance with an embodiment of the invention, the location coordinates of the mobile device **602** (FIG. **6**) may be determined based on a calculated time of travel of a received signal from one or more access points **604** (FIG. **6**) to the mobile device **602**. The time of travel of the received signal may be calculated based on correlating the received signal with a corresponding received signal with a similar known radio transmission pattern. For example, the time of travel of the received signal may be calculated based on correlating a preamble of the received signal, for example, signal received at short preamble correlator **628** (FIG. **6**) or long preamble correlator **630** (FIG. **6**) with a preamble of the corresponding received signal with the similar known radio transmission pattern, for example, signal output by the known short preamble correlator **626** (FIG. **6**) or known long preamble correlator **632** (FIG. **6**) respectively.

[0198] In accordance with an embodiment of the invention, the determined location coordinates of the mobile device **902** (FIG. **9**) may be recalibrated based on receiving a plurality of positioning assistance data from one or more position reference devices, for example, a POS device **904** (FIG. **9**) via passive and active NFC tags, a mobile device **906** (FIG. **9**) via Bluetooth, a mobile device **908** (FIG. **9**) via Wi-Fi Direct, a plurality of access points AP**1** **910** (FIGS. **9**) and AP**2** **914** (FIG. **9**) via WLAN, a 60 GHz position reference communicator **912** (FIG. **9**) via 60 GHz standard or other high frequency narrow beam methods, a plurality of cellular towers **916** (FIGS. **9**) and **918** (FIG. **9**) via cellular standards, and/or a passive or active RFID position reference tag **920** (FIG. **9**) using short range wireless communication protocols.

[0199] In accordance with another embodiment of the invention, a method and system for location based hands-free payment may comprise a network **150** (FIG. **1**B) comprising a plurality of mobile devices **104** (FIG. **1**B), **106** (FIG. **1**B), **108** (FIG. **1**B), **110** (FIG. **1**B), and a plurality of point of sale devices **152** (FIG. **1**B). A first of the plurality of POS devices, for example, the POS device **152** may be operable to determine the location coordinates of a selected one of the plurality of mobile devices, for example, mobile device **106** based on one or more positioning methods as detailed with respect to FIGS. **4-15**. The POS device **152** may trigger a notification when the mobile device **106** is within a defined proximity of the POS device **152**. The POS device **152** may generate a geo-fence **112** (FIG. **1**B) around it to determine whether the mobile device **106** is within the defined proximity of the POS device **152**. The POS device **152** may receive an authorization to execute a payment transaction when the mobile device **106** is within a defined proximity of the POS device **152**. The POS device **152** may receive a speed of movement and a direction of movement of the mobile device **106**.

[0200] In accordance with an embodiment of the invention, the POS device **1104** (FIG. **11**) may determine the location coordinates of the mobile device **1110***a* (FIG. **11**) comprising a RFID tag **1111** (FIG. **11**) based on extracting at least one measured position parameter from each of three or more backscattered signals **1108***a-c* (FIG. **11**) communicated by the mobile device **1110***a*. The three or more backscattered signals **1108***a-c* may be received at one or more RFID readers **1102***a-c* (FIG. **11**) located at three or more different locations in response to communicating by the one or more RFID readers **1102***a-c,* three or more RF signals to the mobile device **1110***a*. The RFID readers **1102***a-c* may be operable to communicate the backscattered signals to the POS device **1104** via a network **1112** (FIG. **11**).

[0201] In accordance with an embodiment of the invention, the POS device **1408** (FIG. **14**) may determine the location coordinates of the mobile device **1402** (FIG. **14**) based on the measured phase differences and corresponding frequency differences associated with each of three or more signals received from the mobile device **1402**. Each of the three or more signals may comprise a plurality of pilot tones, for example, $(f_0, \phi_0), (f_1, \phi_1) \ldots (f_{n-1}, \phi_{n-1})$ that may be received at one or more electronic devices **1404***a-d* (FIG. **14**) located at three or more different known locations via the network **1406** (FIG. **14**). Each of the three or more signals may be OFDM signals that may be received at one or more electronic devices **1404***a-d* located at three or more different known locations via the network **1406**. The POS device **1408** may be operable to determine the location coordinates of the mobile device **1402** based on received pilot tone pair phase differences, amplitude of pilot tones, and coordinates of one or more electronic devices **1404***a-d* located at three or more different known locations.

[0202] Other embodiments of the invention may provide a non-transitory computer readable medium and/or storage medium, and/or a non-transitory machine readable medium and/or storage medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps comprising a network that comprises a plurality of mobile devices and a plurality of point of sale devices. A first mobile device may determine its location coordinates and communicate them to a selected point of sale device. An authorization to execute a payment transaction may be triggered on the first mobile device when it is within a defined proximity of the selected point of sale device. In another embodiment of the invention, a first point of sale device may determine the location coordinates of a selected mobile device and trigger a notification based on a generated geo-fence when the selected mobile device is within a defined proximity of the first point of sale device.

[0203] Accordingly, the present invention may be realized in hardware, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where

different elements may be spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein may be suited. A combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, may control the computer system such that it carries out the methods described herein. The present invention may be realized in hardware that comprises a portion of an integrated circuit that also performs other functions.

[0204] The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

[0205] While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for communication, the method comprising:

in a network comprising a plurality of mobile devices and a plurality of point of sale devices:

determining location coordinates of a first of said plurality of mobile devices;

communicating said determined location coordinates to a selected one of said plurality of point of sale devices; and

triggering an authorization to execute a payment transaction when said first of said plurality of mobile devices is within a defined proximity of said selected one of said plurality of point of sale devices.

2. The method according to claim **1**, comprising determining whether said first of said plurality of mobile devices is within said defined proximity of said selected one of said plurality of point of sale devices based on a generated geofence around said selected one of said plurality of point of sale devices.

3. The method according to claim **1**, comprising retrieving a first set of parameters from a reference database corresponding to a plurality of signals received at said location coordinates of said first of said plurality of mobile devices, wherein said plurality of signals are received from a plurality of signal sources, and said plurality of signals comprises at least one multipath signal.

4. The method according to claim **3**, wherein said reference database stores parameters corresponding to said plurality of signals received at each of a plurality of location coordinates of said plurality of mobile devices in said network with known location coordinates.

5. The method according to claim **4**, comprising determining said location coordinates of said first of said plurality of mobile devices based on comparing said retrieved first set of parameters with said stored parameters in said reference database.

6. The method according to claim **5**, wherein said retrieved first set of parameters and said stored parameters comprises one or more of: a time of arrival delay extracted using received signal strength indicator (RSSI) transition, a time of arrival delay extracted using signal preamble correlation, a time difference of arrival, a transmitted signal strength, an angle of arrival, equalizer filter coefficients, channel multipath profile, channel fast Fourier transform (FFT) coefficients, beacon signal strength, phase of each pilot tone, amplitude of each pilot tone and/or Doppler shift associated with movement of said plurality of mobile devices.

7. The method according to claim **5**, comprising receiving said plurality of signals corresponding to one or more standards comprising one or more of: Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), Global Positioning System (GPS), cellular, and/or 60 GHz standards.

8. The method according to claim **1**, comprising determining said location coordinates of said first of said plurality of mobile devices based on receiving global positioning system (GPS) information from a plurality of GPS satellites and a weighted average of a plurality of differential correction and/or assistance data from one or more access points.

9. The method according to claim **8**, wherein a weight assigned to each of said plurality of differential correction and/or assistance data is determined based on one or more of: a reception characteristic of each of said one or more access points, a relative distance, a relative received power level and/or a relative received phase difference between said first of said plurality of mobile devices and each of said one or more access points.

10. The method according to claim **9**, wherein said plurality of differential correction and/or assistance data received from said one or more access points corresponds to one or more standards comprising one or more of: Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), GPS, cellular, near field communication (NFC), and/or 60 GHz standards.

11. The method according to claim **1**, comprising determining said location coordinates of said first of said plurality of mobile devices based on a calculated time of travel of a received signal from one or more access points to said first of said plurality of mobile devices.

12. The method according to claim **11**, comprising calculating said time of travel of said received signal based on correlating said received signal with a corresponding received signal with a similar known radio transmission pattern.

13. The method according to claim **11**, comprising calculating said time of travel of said received signal based on correlating a preamble of said received signal with a preamble of said corresponding received signal with said similar known radio transmission pattern.

14. The method according to claim **1**, comprising recalibrating said determined said location coordinates of said first of said plurality of mobile devices based on receiving a plurality of positioning assistance data from one or more position reference devices using short range wireless communication protocols.

15. The method according to claim **14**, wherein said one or more position reference devices comprises one or more of: passive near field communication (NFC) tags, active NFC tags, passive radio frequency identification (RFID) tags, active RFID tags, Bluetooth enabled devices, Wi-Fi Direct, 60 GHz enabled devices, and/or Wireless Local Area Network (WLAN) access points.

16. A method for communication, the method comprising:
in a network comprising a plurality of mobile devices and a plurality of point of sale devices:
determining at a first of said plurality of point of sale devices, location coordinates of a selected one of said plurality of mobile devices; and
triggering a notification on said first of said plurality of point of sale devices when said selected one of said plurality of mobile devices is within a defined proximity of said first of said plurality of point of sale devices.

17. The method according to claim **16**, comprising determining said location coordinates of said selected one of said plurality of mobile devices comprising a radio frequency identification (RFID) tag based on extracting at least one measured position parameter from each of three or more backscattered signals communicated by said selected one of said plurality of mobile devices.

18. The method according to claim **17**, wherein said three or more backscattered signals are received at one or more RFID readers located at three or more different locations in response to communicating by said one or more RFID readers, three or more RF signals to said selected one of said plurality of mobile devices.

19. The method according to claim **16**, comprising determining said location coordinates of said selected one of said plurality of mobile devices based on measured phase differences and corresponding frequency differences associated with each of three or more signals received from said selected one of said plurality of mobile devices.

20. The method according to claim **19**, wherein each of said three or more signals comprises a plurality of pilot tones that are received at one or more electronic devices located at three or more different known locations via said network.

21. The method according to claim **19**, wherein each of said three or more signals are orthogonal frequency division multiplexed (OFDM) signals that are received at one or more electronic devices located at three or more different known locations via said network.

22. The method according to claim **16**, comprising determining said location coordinates of said selected one of said plurality of mobile devices based on received pilot tone pair phase differences, amplitude of pilot tones, and coordinates of one or more electronic devices located at three or more different known locations.

23. The method according to claim **16**, comprising receiving an authorization to execute a payment transaction when said selected one of said plurality of mobile devices is within a defined proximity of said first of said plurality of point of sale devices.

24. The method according to claim **16**, comprising generating a geo-fence around said first of said plurality of point of sale devices to determine whether said selected one of said plurality of mobile devices is within said defined proximity of said first of said plurality of point of sale devices.

25. The method according to claim **16**, comprising receiving a speed of movement and a direction of movement of said selected one of said plurality of mobile devices at said selected one of said plurality of point of sale devices.

26. A system for communication, the system comprising:
in a network comprising a plurality of mobile devices and a plurality of point of sale devices, one or more processors and/or circuits in a first of said plurality of mobile devices, said one or more processors and/or circuits being operable to:
determine location coordinates of said first of said plurality of mobile devices;
communicate said determined location coordinates to a selected one of said plurality of point of sale devices; and
trigger an authorization to execute a payment transaction when said first of said plurality of mobile devices is within a defined proximity of said selected one of said plurality of point of sale devices.

27. The system according to claim **26**, wherein said one or more processors and/or circuits are operable to determine whether said first of said plurality of mobile devices is within said defined proximity of said selected one of said plurality of point of sale devices based on a generated geo-fence around said selected one of said plurality of point of sale devices.

28. The system according to claim **26**, wherein said one or more processors and/or circuits are operable to retrieve a first set of parameters from a reference database corresponding to a plurality of signals received at said location coordinates of said first of said plurality of mobile devices, wherein said plurality of signals are received from a plurality of signal sources, and said plurality of signals comprises at least one multipath signal.

29. The system according to claim **28**, wherein said reference database stores parameters corresponding to said plurality of signals received at each of a plurality of location coordinates of said plurality of mobile devices in said network with known location coordinates.

30. The system according to claim **29**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said first of said plurality of mobile devices based on comparing said retrieved first set of parameters with said stored parameters in said reference database.

31. The system according to claim **29**, wherein said retrieved first set of parameters and said stored parameters comprises one or more of: a time of arrival delay extracted using received signal strength indicator (RSSI) transition, a time of arrival delay extracted using signal preamble correlation, a time difference of arrival, a transmitted signal strength, an angle of arrival, equalizer filter coefficients, channel multipath profile, channel fast Fourier transform (FFT) coefficients, beacon signal strength, phase of each pilot tone, amplitude of each pilot tone and/or Doppler shift associated with movement of said plurality of mobile devices.

32. The system according to claim **30**, wherein said one or more processors and/or circuits are operable to receive said plurality of signals corresponding to one or more standards comprising one or more of: Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), Global Positioning System (GPS), cellular, and/or 60 GHz standards.

33. The system according to claim **26**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said first of said plurality of mobile devices based on receiving global positioning system

(GPS) information from a plurality of GPS satellites and a weighted average of a plurality of differential correction and/or assistance data from one or more access points.

34. The system according to claim **33**, wherein a weight assigned to each of said plurality of differential correction and/or assistance data is determined based on one or more of: a reception characteristic of each of said one or more access points, a relative distance, a relative received power level and/or a relative received phase difference between said first of said plurality of mobile devices and each of said one or more access points.

35. The system according to claim **34**, wherein said plurality of differential correction and/or assistance data received from said one or more access points corresponds to one or more standards comprising one or more of: Wireless Local Area Network (WLAN), Bluetooth, WiMax, HD Radio, Ultra-wideband (UWB), GPS, cellular, near field communication (NFC), and/or 60 GHz standards.

36. The system according to claim **26**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said first of said plurality of mobile devices based on a calculated time of travel of a received signal from one or more access points to said first of said plurality of mobile devices.

37. The system according to claim **36**, wherein said one or more processors and/or circuits are operable to calculate said time of travel of said received signal based on correlating said received signal with a corresponding received signal with a similar known radio transmission pattern.

38. The system according to claim **36**, wherein said one or more processors and/or circuits are operable to calculate said time of travel of said received signal based on correlating a preamble of said received signal with a preamble of said corresponding received signal with said similar known radio transmission pattern.

39. The system according to claim **26**, wherein said one or more processors and/or circuits are operable to recalibrate said determined said location coordinates of said first of said plurality of mobile devices based on receiving a plurality of positioning assistance data from one or more position reference devices using short range wireless communication protocols.

40. The system according to claim **39**, wherein said one or more position reference devices comprises one or more of: passive near field communication (NFC) tags, active NFC tags, passive radio frequency identification (RFID) tags, active RFID tags, Bluetooth enabled devices, Wi-Fi Direct, 60 GHz enabled devices, and/or Wireless Local Area Network (WLAN) access points.

41. A system for communication, the system comprising:

in a network comprising a plurality of mobile devices and a plurality of point of sale devices, one or more processors and/or circuits in a first of said plurality of point of sale devices, said one or more processors and/or circuits being operable to:

determine location coordinates of a selected one of said plurality of mobile devices; and

trigger a notification when said selected one of said plurality of mobile devices is within a defined proximity of said first of said plurality of point of sale devices.

42. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said selected one of said plurality of mobile devices comprising a radio frequency identification (RFID) tag based on extracting at least one measured position parameter from each of three or more backscattered signals communicated by said selected one of said plurality of mobile devices.

43. The system according to claim **42**, wherein said three or more backscattered signals are received at one or more RFID readers located at three or more different locations in response to communicating by said one or more RFID readers, three or more RF signals to said selected one of said plurality of mobile devices.

44. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said selected one of said plurality of mobile devices based on measured phase differences and corresponding frequency differences associated with each of three or more signals received from said selected one of said plurality of mobile devices.

45. The system according to claim **44**, wherein each of said three or more signals comprises a plurality of pilot tones that are received at one or more electronic devices located at three or more different known locations via said network.

46. The system according to claim **44**, wherein each of said three or more signals are orthogonal frequency division multiplexed (OFDM) signals that are received at one or more electronic devices located at three or more different known locations via said network.

47. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to determine said location coordinates of said selected one of said plurality of mobile devices based on received pilot tone pair phase differences, amplitude of pilot tones, and coordinates of one or more electronic devices located at three or more different known locations.

48. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to receive an authorization to execute a payment transaction when said selected one of said plurality of mobile devices is within a defined proximity of said first of said plurality of point of sale devices.

49. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to generate a geo-fence around said first of said plurality of point of sale devices to determine whether said selected one of said plurality of mobile devices is within said defined proximity of said first of said plurality of point of sale devices.

50. The system according to claim **41**, wherein said one or more processors and/or circuits are operable to receive a speed of movement and a direction of movement of said selected one of said plurality of mobile devices at said selected one of said plurality of point of sale devices.

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