(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
13 October 2016 (13.10.2016)

WIPO | PCT

(10) **International Publication Number**
WO 2016/164931 A1

(51) **International Patent Classification**:
G06F 7/00 (2006.01) ***G08B 21/18*** (2006.01)
G06Q 30/00 (2012.01) ***G08B 23/00*** (2006.01)

(21) **International Application Number**: PCT/US2016/027000

(22) **International Filing Date**: 11 April 2016 (11.04.2016)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
62/145,309 9 April 2015 (09.04.2015) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: WIRELESS ASSET MANAGEMENT SYSTEM

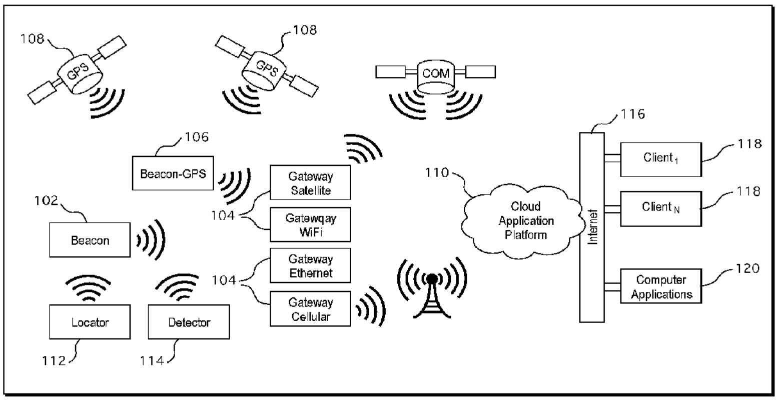


FIG. 1

(57) **Abstract**: A system for determining the real-time and historical location, activity, and sensor information of personnel and fixed and mobile assets. More specifically, a system that associates a wireless transmitter (i.e., Beacon) with a motion sensor and optional other sensors and GPS receivers. The Beacons collect data from the sensors and initiate a transmission process. During this transmission process and prior to transmitting, the Beacons may check GPS coordinates and/or certain frequencies to detect transmitters that represent established locations (Locators) allowing the precise location of the Beacons to be determined. Gateway(s), in the transmission range of the Beacons' signal, communicate the Beacons' information signal strength to a software application platform using wireless or wired communication methods. The software application platform stores the beacon and gateway information and customer specific business logic may be applied, alerts/alarms may be sent, and information is visualized in applications using a computing device.

WO 2016/164931 A1

WIRELESS ASSET MANAGEMENT SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S Provisional Patent Application No. 62/145,309, filed April 9, 2015, titled WIRELESS ASSET MANAGEMENT SYSTEM.

FIELD OF THE DISCLOSURE

[0002] The disclosed invention relates, in general, to wireless asset management. More specifically, the disclosed invention relates to tools and techniques for managing assets using attachable or embedded wireless tracking devices with sensors.

BACKGROUND OF THE INVENTION

[0003] Many companies do not currently have the capability to track real-time and historical knowledge of the location and activity of their assets (equipment, materials, vehicles, personnel, livestock, etc.). Further, they do not have the capability to track the type of environment these assets are in such as temperature, humidity, radiation levels, etc. Different industries that have a significant amount of mobile assets include construction, healthcare and hospitals, airport operations, theme parks, equipment rental and management, building management, shopping malls, movie production, manufacturing and assembly operations, shipping container operations, vaccine and blood supply logistics, and agriculture and livestock operations.

[0004] The assets are often mobile between locations of operations, such as construction sites, and within those locations, such as airports. The mobility of assets creates a challenge when it comes to monitoring the assets and determining the approximate location or precise location of the assets.

[0005] Any physical device used to track these assets may often be subjected to harsh weather conditions. Further, it may not be cost effective to service the devices for years. In addition to the physical wear and tear taken on a device, companies, for cost reasons, may depend on employees with minimal amounts of training or technical knowledge to physically attach a tracking device to an asset and to set up the tracking software and technology.

[0006] Therefore, devices are needed that can withstand harsh weather conditions without requiring frequent maintenance, that can easily be attached to existing assets, and that have a simple software setup. Additionally, because company employees need asset location and associated information while in an office, outdoors at a work site, or in transit, the system providing location and activity information needs to be accessible through mobile devices such as smart phones, tablets and personal computers or laptops.

SUMMARY OF THE INVENTION

[0007] A system for determining the real-time and historical location, activity and sensor information of personnel and fixed and mobile assets (construction equipment, building materials, carts, strollers, wheelchairs, vehicles, movie production equipment, and livestock) is accomplished by associating a wireless transmitter (Beacon) with a motion sensor and optional other sensors and GPS receivers. The Beacons initiate a transmission process upon motion, while there is continued movement and periodically while idle. During this transmission process and prior to transmitting, the Beacons may check GPS coordinates and/or certain frequencies to detect transmitters that represent established locations (Locators) allowing the precise location of the Beacons to be determined. Gateway(s), in the transmission range of the Beacons' signal, communicate the Beacons' information and how strong the Beacon's signal was (Received Signal Strength Indicator (RSSI)) to a software application platform using wireless (satellite, cellular, Wi-Fi, etc.) or wired (Ethernet) communication methods. The software application platform stores the beacon and gateway information and customer specific business logic may be applied (such as location determination), alerts/alarms may be sent (via SMS text, email), and information (such as inventory levels for various locations) is visualized in applications using smart phones, tablets and personal computers/laptops. The information is also accessible using Application Programing Interfaces (API) for integration into other software applications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a diagram of the wireless asset management system, according to one embodiment.

[0009] FIG. 2 is a diagram of Beacons with various sensor configurations communicating to fixed or mobile Gateways.

[0010] FIG. 3 is a diagram of Beacons on trucks and gateways on harvest vehicles for agriculture crop harvest applications.

[0011] FIG. 4 is a diagram of Beacons using Locators for precise location determination and communicating the precise location to Gateways.

[0012] FIG. 5 is a diagram of Beacons with GPS receivers communicating the Beacons' GPS coordinates to Gateways.

[0013] FIG. 6 is a diagram of Beacons, Locators, Gateways and Detectors, where the Detectors are used to identify a unique Beacon in a group.

[0014] FIG. 7 is a schematic block diagram of an example Beacon.

[0015] FIG. 8 is a schematic block diagram of an example Locator.

[0016] FIG. 9 is a schematic block diagram of an example Detector.

[0017] FIG. 10 is a schematic block diagram of an example Gateway.

[0018] FIG. 11 is a block diagram of the Cloud Application Platform

[0019] FIG. 12 is a web application dashboard reflecting location, activity, inventory levels and other metrics.

[0020] FIG. 13 is a web application location dashboard.

[0021] FIG. 14 is a web application location dashboard showing the geographic location of assets, their statuses, and other metrics.

[0022] FIG. 15 is a web application location dashboard showing the location of assets in a site and Zones within a site, their statuses, and other metrics.

[0023] FIG. 16 is a web application timecard report for employees.

[0024] FIG. 17 is a web application site report showing asset inventory over a given time period, utilization, cost metrics, and other metrics.

[0025] FIG. 18 is a diagram of Gateway and Locator deployments to represent fixed and mobile Sites, Zones within a Site, and Areas within a Zone identified by Locators.

[0026] FIG. 19 is a schematic block diagram of an example computing system.

DETAILED DESCRIPTION

[0027] Various embodiments will be described in detail with reference to the drawings, wherein like reference numerals represent like parts and assemblies throughout the several views. Reference to various embodiments does not limit the scope of the claims attached hereto.

Additionally, any examples set forth in this specification are not intended to be limiting and merely set forth some of the many possible embodiments for the appended claims. It is understood that various omissions and substitutions of equivalents are contemplated as circumstances may suggest or render expedient, but these are intended to cover applications or embodiments without departing from the spirit or scope of the claims attached hereto. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting.

[0028] The disclosed system, illustrated in FIG. 1, is designed to provide cost effective location and sensor information for low- to medium-value assets, wherein those assets may be mobile between physical locations and zones, or areas, within physical locations. For example, the disclosed system can be used by shopping establishments, airports, amusement parks, movie production companies, manufacturers, farmers, pharmaceutical companies, blood supply companies, hospitals, other healthcare institutions, railways, trucking companies, and building maintenance businesses to detect location and movement of assets.

[0029] In some embodiments, the system can be deployed by minimally trained employees, be maintenance free for several years, be able to withstand harsh environmental conditions, and allow customers to view the resulting asset information using computing devices that can display web browsers, such as smart phones, tablets, and laptops or personal computers.

[0030] In some embodiments, at least a portion of the disclosed system, such as a wireless Beacon 102, can be attached to, or carried by, assets such as, but not limited to, carts, strollers, airport GSE (Ground Support Equipment), livestock, employees, cold-chain containers (a temperature probe can be in contact with the container to further track temperature for sensitive assets such as blood products, vaccines, and pharmaceuticals), trailers (can further cache GPS information on Beacons), rail cars (can further cache GPS information on Beacons), hospital equipment (can further track temperature and humidity of sensitive equipment), and building maintenance equipment. Attachment of the Beacon 102 to an asset can be via screws, mounting or back plate, adhesive, straps, or, for livestock, an earpiece.

[0031] **Beacons**

[0032] The wireless Beacon 102, illustrated in FIG. 7, can be comprised of a wireless transceiver 702, such as a radio transceiver, an antenna 704, such as an internal radio antenna, internal sensors 706, and a processor, such as a microprocessor 708, and can be sealed in a housing or enclosure 710 and have a power source, such as a battery 712. In some embodiments, the Beacon transceiver 702 is replaced with a transmitter. The sensors 706 included in the Beacon 102 can be, but are not limited to, an accelerometer, a temperature gauge, a push button, a GPS, a radiation sensor, a light sensor, and a humidity sensor. In some embodiments, as illustrated in FIG. 7, the Beacon can have a built-in GPS receiver 714 and antenna 716 to enable it to communicate its coordinates to Gateways using GPS 108.

[0033] In some embodiments, the Beacons also have Light Emitting Diodes 718 that can be viewed through the enclosure on a transparent or translucent label, audio electronics 718 that can, for example, emit noise upon defined events, and General Purpose Input and Output ("GPOI") circuitry and ports 720 that allow for connection to external sensors 722. The Beacons' housing or enclosure 710 may be sealed to prevent moisture entry when exposed to liquids, such as rain or snow. There are a number of different methods with which the Beacon 102 may be attached to, or carried by, assets, as described above.

[0034] The wireless Beacon 102 can broadcast its unique ID and sensor information to Gateways 104 within range of the Beacon 102. The Gateways 104 can receive the Beacons' signal and the Gateways' receivers 1002 can measure the Beacons' transmission RSSI (Received Signal Strength Indicator) and communicate various data over a wide area network (WAN) to a Cloud Application Platform ("CAP") 110. Types of WAN may include, but are not limited to, cellular, satellite, Wi-Fi, Ethernet, or BLE network. The various data can include, but are not limited to, the transmission RSSI, the Gateway's unique ID, any Beacon and Gateway GPS, and sensor information. As illustrated in FIG. 11, the CAP 110 can store this data, apply business rules to the data 1106, send the data over the Internet 116, and present the resulting information to a client 118 in a web application. The CAP 110 can also use application program interfaces (APIs) 1112 to send information through the Internet 116 and present the resulting information in other computer applications 120.

[0035] **Gateways**

[0036] Gateways 104, illustrated in FIG. 10, receive Beacon data and transport it to the CAP 110 with additional Gateway specific information (e.g. Gateway unique ID, GPS coordinates). Gateways 104 can be comprised of Wireless Transceivers 1002 and associated external antennas 1004 to receive Beacon transmissions, connectors for an external power source 1006 with optional internal battery 1008 for backup power, GPS 1010 and associated external antenna 1012, processor 1014, and satellite modem 1016 with associated antenna 1018, Wi-Fi modem 1020 with associated antenna 1022, cellular modem 1024 with associated antenna 1026, or Ethernet modem 1028 to connect to the CAP 110. In some embodiments, the Wireless Transceiver 1002, option internal battery 1008, GPS 1010, processor 1014, and satellite 1016, Wi-Fi 1020, cellular 1024, or Ethernet 1028 modems are encased in a Gateway housing or enclosure 1030.

[0037] **Cloud Application Platform**

[0038] In a preferred embodiment, the data sent from Gateways 104 are transported to the CAP 110, as illustrated in FIGS. 1 and 11, wherein business logic rules are then applied 1106, alerts are sent 1108, and application dashboards 1110 and Application Program Interfaces 1112 are accessible by authorized entities. The dashboards and reports 1110, as illustrated in FIGS. 12, 13, and 14, may be accessible using mobile devices, such as smart phones or tablets, and laptops/personal computers.

[0039] More specifically, the CAP's Data Ingestion layer 1102 can receive data transmitted from the Gateways 104. The data may be stored in a database 1104 and business rules and logic 1106 can be applied. In addition, after the CAP 110 receives data, alerts 1108 may be issued, in the form of a text or email, stating that a threshold (such as low inventory level) was breached. For example, an email can be sent over the Internet 116 to a client 118 or a computer application 120. The information resulting from Business Rules being applied to the data 1106 may be presented in web application Dashboards and Reports 1110 that are accessible using a computing device, such as a smart phone, tablet, laptop, or personal computer. The information may also be used by other computer applications 120 using the CAP's Application Program Interface 1112.

[0040] **Location approaches**

[0041] During deployment, a Gateway's precise location may be determined using the Gateway's Wireless Transceiver 1002, which can report to the CAP 110 or a smart phone application. To report the Gateway's location using a smart phone application, a user can use the smart phone to scan a QR code located on a Gateway label. The smart phone's GPS location reading is then taken and communicated to the CAP 110. In another embodiment, the user can manually enter the location of the Gateway 104 into a web application. Once the location is reported to the CAP 110, the web application can allow for the naming of the Gateway locations (e.g. Warehouse #23 or East Storage Yard Zone #3). A user can repeat this process for each Gateway 104 that a company desires to use.

[0042] With the locations of the Gateways established, the approximate locations of the Beacons 102, and the asset(s) with which they are associated, can be determined by the strength of the Gateways' RSSI reading of the Beacons' transmissions. Sequential number stamping of Beacons' transmissions allows for the comparison of RSSI values from multiple Gateways 104 for potential triangulation calculations. This helps overcome potential delays in Gateways' transmissions to the CAP 110.

[0043] In some embodiments, Beacons may be equipped with GPS receivers 106 to more precisely determine their location and communicate the latitude and longitude through Gateways 104 to the CAP 110.

[0044] **Locators**

[0045] As illustrated in FIG. 18, an additional method for locating Beacons 102 precisely in a Zone, especially in buildings where GPS signals cannot be received, is having Beacons 102 listen to a set frequency for transmission from devices called Locators 112. Locators 112, illustrated in FIG. 8, continuously transmit their unique ID at a different frequency than the Beacons 102 transmit on and at a much smaller (weaker) signal strength (gain). FIG. 4 illustrates a diagram of Beacons 102 using Locators 112 for precise location determination and, thereafter, communicating to Gateways 104.

[0046] The Locators 112, illustrated in FIG. 8, can be comprised of a wireless transceiver 802, such as a radio transceiver, an antenna 804, such as an internal radio antenna, internal sensors 806, and a processor, such as a microprocessor 808, and can be sealed in a housing or enclosure 810 and have an internal power source, such as a battery 812, and/or an external power source 814. In some embodiments, the Locator can have a Mechanical Gain Adjustment 816.

[0047] Prior to transmission, Beacons 102 can listen to the Locators' frequency and, if a signal and/or Locator ID is detected, the Locators' location is recorded in the CAP 110 when it is deployed (e.g. Site 1, Zone 3, Room 1). For example, FIG. 6 illustrates a diagram of Beacons 102, Locators 112, Gateways 104, and Detectors 114, wherein the Detectors 114 are optionally connected to a smartphone 602 and used to identify a unique Beacon 102 in a group. The signal strength of the Locator transmission may be configurable with a mechanical adjustment (e.g. dial) on the Locator 112 or through wireless interaction. The adjustment of the Locator's signal strength allows for Locator signals to be detected by Beacons 102 only in the defined area (e.g. Room 1 in FIG. 18). Consequently, when a Beacon 102 reports detecting a Locator 112, the Beacon's location is determined to be that of the Locator's location.

[0048] Using similar method as with the Gateways 104, the Locators' precise locations are determined when deployed, and the Beacons' 102 detection of Locators' signals can establish close proximity (e.g. within two meters of the Locator in room #45 places the Beacon 102 and associated asset in room #45). The Beacons 102 can either solely detect transmission on the Locators' frequency and communicate this to the CAP 110 or can receive the unique Locator ID on this frequency and communicate this Locator ID to the CAP 110. Locators 112 may be battery powered or powered by an external source. The Locators' signal output (gain) determines how close a Beacon 102 needs to be in order to detect the Locators' signal, which may be configurable.

[0049] **Beacon, Gateway, and Site associations**

[0050] Gateways 104 can be associated with a mobile site (ex: vehicle, shopping cart, or animal) or a fixed site and they can be associated with a Zone within a multi-Zone site (ex: a Gateway is associated with a specific Zone within a site), as illustrated in FIG. 18. Locators 102 may be used to establish Areas or Rooms within a specific Zone, as illustrated in FIG. 18. More specifically, within a first Site 1802 there may be three Zones and, therefore, three corresponding Gateways, wherein each Gateway is associated with one of the three Zones within the Site. Within each Zone, there may be separate Areas or Rooms. For example, within Zone 3 1804, there may be three Rooms and each Room may have a corresponding Locator 112 associated with it. Therefore, Room 1 would be associated with Locator 1 1808, which communicates with Gateway 3 1806 in Zone 3 1804, which is associated with Site 1 1802. FIG. 2 illustrates a diagram of Beacons 102 with various sensor configurations that are communicating to fixed and/or mobile Gateways 104 via GPS 108.

[0051] Beacons 102 and Gateways 104 can be assigned to customers in the CAP 110 when they are shipped to the customer. Authorized customer employees may enter a list of assets and locations that Beacons 102 and Gateways 104 can be associated with using the web application. For example, using a smart phone, an authorized customer employee can log into the web application, type in or scan the QR code reflecting the unique ID of the Beacons 102 and/or Gateways 104, and then select, from the prepopulated menu, or manually enter the asset, employee information, or location that the Beacon 102 or Gateway 104, respectively, should be associated with. This association can be stored in the CAP 110 for reference, which allows for all data generated by a Beacon 102 or Gateway 104 to reflect the asset, employee, or location (site).

[0052] Locators 112, like Beacons 102 and Gateways 104, can have a QR code containing the Locator's unique ID and part number. Using a smart phone application, the QR code can be scanned and, from the web application's preloaded drop down menu, the Site (and/or Zone within a Site) information is selected and/or entered into fields. This information is communicated to the CAP 110 where all data generated by the Gateway 104 is now associated with that Site and/or Zone (Area or Room in the case of Locators 112).

[0053] The Zones can be determined by a range of RSSI readings from a single Gateway 104 or by a combination of readings from multiple Gateways 104 of the same Beacon's transmission. The reading of RSSI from multiple Gateways 104 of the same Beacon's transmission can be accomplished using the transmission's Beacon ID and transmission packet ID. The transmission packet ID can be a unique ID of the Beacon's transmission packet and can be used to ensure that the Gateways 104 are comparing the Beacon's RSSI value from the same transmission.

[0054] **Battery performance**

[0055] In some embodiments, the Beacons 102 can broadcast their information to Gateways 104 and not listen for information from the Gateways 104 (no bi-directional communications). This permits the Beacon transceiver 702 to be in a low power "sleep" state a majority of the time, which can dramatically reduce the power required by Beacons 102, as they do not have to constantly listen for Gateway transmissions. It also reduces the amount of data transferred from the Beacons 102 to the Gateways 104.

[0056] The small number of bytes the Beacons 102 transmit (i.e., the transmission, or data packet, size) as well as minimal transmission time allow for a single frequency to be used for the transmission at the maximum gain (i.e., transmission strength) under FCC regulations. Transmitting larger amounts of data would require the Beacons 102 to change frequencies (frequency hopping) during the course of a single transmission so as not to "block" a single frequency for a pre-determined, regulated period of time and to avoid channel collisions (simultaneous transmissions on the same frequency). Frequency hopping would also require bi-directional communication between the Beacons 102 and Gateways 104 to coordinate which frequencies are being used, resulting in significant power consumption. This increase in power consumption would impact the expected life of the product (for example, requiring a design for battery replacements in the field), and/or a larger form factor to accommodate a larger battery. Therefore, this management of transmission power and size avoids the FCC requirement to frequency hop and allows the Beacons 102 to operate in transmit-only mode, which dramatically reduces power consumption.

[0057] Battery power can also be conserved in some embodiments because Beacon transmissions can be limited to single burst transmissions on a single ISM band frequency at the maximum allowed power. For example, the Beacon 102 can cache information, time stamp the information, and transmit that information periodically or upon a sensor event instead of continuously. In some embodiments, a transmission may occur only when motion is detected. Alternatively, transmission may occur periodically if motion is constantly detected (for example, by an accelerometer) in order to communicate that it is present and capable of transmitting (e.g., a heart beat). In another embodiment, transmission may occur after a transition from a motion state to an idle or non-moving state (also detected by an accelerometer). For example, a Beacon 102 can be located in a feeding troth during animal feeding, and transmission will occur periodically while there is movement (i.e., while the animals are feeding) and then one more time after feeding is over and there is no more movement at the feeding troth. Similarly, a Beacon 102 can be located in pens to determine if animals are in their pens or elsewhere. Lastly, a transmission may occur periodically (e.g., every hour) as a form of an update when the object it is attached to is in an idle or non-moving state.

[0058] **Transmission integrity**

[0059] The Beacon transmission logic has a number of steps to ensure the integrity of the transmission received by Gateways 104, to allow for synchronization of Beacon transmission between Gateways 104, and to conserve battery power.

[0060] To help reduce the probability of Beacons 102 transmitting simultaneously, which creates a “collision” that can impact the Gateways’ ability to decipher the beacon transmissions, a variety of measures can be taken. For example, a cyclical redundancy check (CRC) can be performed to ensure the integrity of the Beacon’s information that was received by the Gateway 104. More specifically, the CRC can be performed to ensure the data was not changed or overwritten during transmission and reception by the Gateway 104. Further, a Clear Channel Assessment (CCA) can be performed before and after the transmission to verify that another Beacon 102 was not transmitting during the transmission. Beacons 102 may listen for transmission on Locator and Detector frequencies and on Beacon transmission frequencies prior to and directly after transmissions (also called Clear Channel Assessment), to ensure no other transmission occurred when the Beacon 102 transmitted. Additionally, Beacons' transmissions can be randomly delayed by fractions of a second to prevent multiple Beacons 102 transmitting simultaneously if moved at the same time. More specifically, Beacon transmissions can be randomized to prevent packet collisions that are possible if simultaneous transmissions occur from a number of Beacons 102 when, for instance, accelerometers detect motion at the same time (e.g. movement of a nested cart) and a transmission is triggered. In some embodiments, transmissions can be sequentially numbered to synchronize Gateways' reception of Beacon transmission and triangulate Beacon locations using RSSI value of the same transmission.

[0061] **Transmission range and obstacle penetration and battery life**

[0062] Beacons 102 may need to be able to be detected by Gateways 104 up to half of a mile away and they may need to be able to transmit through structures. In general, the lower the frequency of a wavelength, the better the transmission distance and penetration characteristics through structures. As a general rule, the transmission range decreases 50% when the frequency is doubled yet maintains the same power output. The FCC limits the frequencies that devices similar to the Beacons 102 may transmit in, such as 2.4GHz used for Wi-Fi, 902Mhz to 928Mhz ISM band and 433.05MHz to 434.79MHz. RFID devices heavily use the narrow 433MHz band of frequencies, which increases the potential for transmission collisions in certain environments. For these reasons, a frequency in the 902MHz to 928MHz range is desirable for the Beacons 102. The Beacons' output power can be around +20dBm or 100mWatts.

[0063] **Beacon identification: Detectors**

[0064] When all of the assets to which Beacons 102 are attached are the same type (such as cattle), and a unique one needs to be identified, a Detector 114 may be used. Detectors 114, illustrated in FIG. 9, are transmitters that interface with a web application, and a user may select or enter the unique asset ID and associated Beacon ID.

[0065] The Detector 114 can transmit on a select frequency that the Beacons 102 listen to prior to transmitting. The Detector 114 can continuously transmit the Beacon ID until the user stops the transmission. Prior to Beacons 102 transmitting their information, they may check the frequency the Detector 114 is transmitting on and, if the Beacon's ID is being broadcast, it can trigger the Beacon 102 to emit an audio signal (e.g. load beep) and/or flash a light for a set period of time, allowing the user to easily select the asset in question from the other similar assets.

[0066] In some embodiments, Detectors 114 may be connected to, and communicate with, a smart phone or other mobile device 602, as illustrated in FIG. 6, and the web application briefly described above. In other embodiments, the Detector 114 may be a stand-alone device that interacts directly with the web application using a Gateway 104 or other means, which can report to the CAP 110.

[0067] As illustrated in FIG. 9, in some embodiments, Detectors 114 are comprised of a Wireless Transceiver 902 with an associated antenna 904, internal sensors 906, and a processor, such as a microprocessor 908, and can be sealed in a housing or enclosure 910 and have a power source, such as a battery 912, with an optional connector for an external power source 914. The Detector 114 may be connected to a smartphone 916 with a smartphone connection 918, which can act as a power source for the Detector 114 and which can enable communication with the web application. For example, the web application can communicate with the Detector 114 using a smartphone and can direct the Detector 114 to identify a particular Beacon 102. The Detector 114 may also independently interact wirelessly with the web application.

[0068] **Embodiment #1**

[0069] In one embodiment of the system, assets are tracked via Beacons 102 and Gateways 104. Assets such as equipment, building materials, vehicles, luggage carts and strollers that are used in construction sites, manufacturing facilities and operations, storage and operations yards, storage warehouses, movie production studios, airports, shopping malls, and theme/amusement parks have Beacons 102 attached to them. Gateways 104 are positioned to represent Sites or are spread throughout a Site to establish Zones. Locators 112 can also be used to establish Areas (or Rooms) within a Zone.

[0070] Gateways 104 and/or Locators 112 may additionally be placed with the machine, room, or facility in which an asset is stored in order to create Inventory Zones, as illustrated in FIG. 15. If the Gateways 104 detect signal strength (RSSI) of a certain strength from a Beacon 102, the asset may be considered "In Inventory." When the assets move from these Inventory

Zones, the Gateways 104 will detect weaker signal strength from the respective Beacon 102. When the signal crosses a defined strength threshold and/or is detected by another Gateway 104 representing a different Zone, the Beacon 102 and associated asset are classified as “Out of Inventory” and shown in the new Zone.

[0071] In order to create an Inventory Area or Room within a Zone, a Locator 112 can be placed in the machine, room, or facility in which these assets are stored, as illustrated in FIG. 18. Therefore, the Beacon 102 “In Inventory” can check the Locator’s transmission frequency prior to transmitting for detection by Gateways 104. If the Beacon 102 detects a specific Locator signal or a Locator 112 establishes the Beacon’s proximity to the Locator 112, the Beacon 102 and associated asset are known to be “In Inventory.”

[0072] Gateways’ locations in the Site or Zone they may represent are established during the Gateways’ deployment process. This Gateway location information is coupled with the Beacons’ signal strength and may be coupled with Locator information to determine the Zone and, possibly, a location within the Zone, such as a Room.

[0073] **Embodiment #2**

[0074] A Beacon with GPS 106, illustrated in FIG. 5, is used to communicate the precise GPS coordinates of the Beacon 102 and associated asset to Gateways 104. In another embodiment, Airport Ground Service Equipment (GSE) is equipped with Beacons 102 that periodically and, upon certain sensor events, report the Beacons’ information, including GPS coordinates, to Gateways 104 within range. Beacons with GPS 106 are used to precisely track assets’ location in any outdoor environment where enough GPS satellites 108 are visible to determine the latitude and longitude coordinates.

[0075] Embodiment #3

[0076] In another embodiment, cargo containers, rail cars, and trailers have Beacons with GPS 106 attached to them that report to Gateways 104 located at Sites and, possibly, Zones within Sites. The Beacons 102 may also have sensors 706, 722 that detect events, such as the presence of hazardous/radiological materials, and/or sensor configurations that detect events, such as when a door has been opened.

[0077] Embodiment #4

[0078] Another embodiment of the system is to track livestock behavior, such as eating, drinking, sleeping, and movement patterns; location of livestock; areas that livestock visit, such as sites where vaccines are administered; when various feed types and vaccines/medications are administered; and also to isolate individual animals amongst a group. A site may be equipped with Gateways 104 and Locators 112 to establish Sites, Zones and Areas, as illustrated in FIG. 18.

[0079] Beacon sensors 706, 722 attached to livestock can detect when livestock are moving and when they are idle. Gateways 104 and/or Locators 112 can be placed in areas where livestock feed and drink, as well as other critical locations where specific activities take place, such as a room where vaccines and medications are administered or where livestock are staged for transport from the Site. Interaction between these Gateways 104, Locators 112, and Beacons 102 allow for the location and activity of the livestock (i.e., asset) to be determined.

[0080] Embodiment #5

[0081] In another embodiment, illustrated in FIG. 3, the system is used to track crop yields and the specific farm acreage from which they originated. Crop harvesters 302 have Gateways 104 attached to them that are periodically establishing GPS coordinates and detecting Beacons 102 that are attached to trucks 304 into which the harvester 302 is unloading the harvested crop. This information establishes the GPS coordinates and associated acreage from which the truck's load of crops originated. The truck's crops are then processed and weighed at a processing facility. When the truck's load yield is combined with the GPS coordinates from which the load was harvested, the yield by acreage can be determined.

[0082] Embodiment #6

[0083] In one embodiment, the system is used to monitor soil conditions (e.g. temperature, humidity, alkalinity) using Beacons 102 equipped with internal 706 and/or external sensors 722 that report to Gateways 104, as illustrated in FIGS. 2 and 7.

[0084] Embodiment #7

[0085] In another embodiment, the system is used to track the temperature and/or humidity of assets such as blood, drugs and vaccines to ensure compliance with regulations, a process also referred to as cold-chain. Beacons 102 are attached to the container where Beacons' external probes/sensors 722 or internal sensors 706 monitor the condition of the vessel and report the findings to Gateways 104. The Beacons 102 may report data to Gateways 102 while in freezer or refrigeration units due to the Beacons' signal strength. The Beacons 102 and

Gateways 104 can additionally report the movement and location as determined by Gateways 104 and/or Locators 112.

[0086] Embodiment #8

[0087] Another embodiment of the system addresses the needs of building maintenance companies. Beacons 102 are attached to equipment for location, movement, and utilization information, and/or placed in fixed locations with internal sensors 706 and/or external sensors 722 to measure environmental conditions (e.g. temperature and humidity). For example, a Beacon 102 may be attached to rodent traps to detect motion, which may indicate that the trap has been triggered and that a rodent is in the trap that needs to be removed. Beacons 102 carried by employees may be detected by the Gateways 104 at the Site and can allow for the automation of cost accounting and customer billing by knowing when and how long the employee was at the site.

[0088] Gateways 104 may be placed throughout building(s) and/or areas to represent Sites and Zones within Sites, as illustrated in FIG. 18. Locators 112 may also be placed within Zones to further refine the location of Beacons 102 within Zones. As described above, Beacons 102 may detect Locator signals, which establish the proximity of the Beacon 102 to the known Locator location within a Site and Zone.

[0089] Embodiment #9

[0090] In another embodiment of the system, employees and/or visitors to all of the above mentioned sites and/or Zones within a site can be tracked by carrying Beacons 102. The Beacon data may be used to automate or verify employee timecards, as illustrated in FIG. 16, to establish the location of employees and visitors, as illustrated in FIGS. 14 and 18, and/or to calculate the cost of a project by knowing the time the employee spent at a particular Site and/or Zone, as illustrated in FIG. 17.

[0091] **Computing System**

[0092] In some embodiments, the system described herein uses a computing system to carry out the various functions described herein. FIG. 19 is a schematic block diagram of an example computing system 1900. The example computing system 1900 includes at least one computing device 1902. In some embodiments the computing system 1900 further includes a communication network 1904 and one or more additional computing devices 1906 (such as a server).

[0093] The computing device 1902 can be, for example, located in a user's home or other place of business. In some embodiments, computing device 1902 is a mobile device. The computing device 1902 can be a stand-alone computing device or a networked computing device that communicates with one or more other computing devices 1906 across a network 1904. The additional computing device(s) 1906 can be, for example, located remotely from the first computing device 1902, but configured for data communication with the first computing device 1902 across a network 1904.

[0094] In some examples, the computing devices 1902 and 1906 include at least one processor or processing unit 1908 and system memory 1912. The processor 1908 is a device configured to process a set of instructions. In some embodiments, system memory 1912 may be a component of processor 1908; in other embodiments system memory 1912 is separate from the processor 1908. Depending on the exact configuration and type of computing device, the system memory 1912 may be volatile (such as RAM), non-volatile (such as ROM, flash memory, etc.) or some combination of the two. System memory 1912 typically includes an operating system 1918 suitable for controlling the operation of the computing device 1902, such as the WINDOWS® operating systems or the OS X operating system, or a server, such as Windows SharePoint Server, also from Microsoft Corporation. The system memory 1912 may also include one or more software applications 1914 and may include program data 1916.

[0095] The computing device 1902 may have additional features or functionality. For example, the computing device 1902 may also include additional data storage devices 1910 (removable and/or non-removable) such as, for example, magnetic disks, optical disks, or tape. Computer storage media 1910 may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data. System memory, removable storage, and non-removable storage are all examples of computer storage media. Computer storage media 1910 includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computing device 1902. An example of computer storage media 1910 is non-transitory media.

[0096] In some examples, one or more of the computing devices 1902 and 1906 can be located in an establishment. In other examples, the computing device 1902 can be a personal computing device that is networked to allow the user to access and utilize the system disclosed herein from a remote location, such as in a user's home, office or other location. In some embodiments, the computing device 1902 is a smart phone tablet, laptop computer, personal digital assistant, or other mobile device. In some embodiments, system operations and functions are stored as data instructions for a smart phone application. A network 1904 facilitates communication between the computing device 1902 and one or more servers, such as an additional computing device 1906, that hosts the system. The network 1904 may be a wide variety of different types of electronic communication networks. For example, the network 1904 may be a wide-area network, such as the Internet, a local-area network, a metropolitan-area network, or another type of electronic communication network. The network 1904 may include wired and/or wireless data links. A variety of communications protocols may be used in the network 1904 including, but not limited to, Wi-Fi, Ethernet, Transport Control Protocol (TCP), Internet Protocol (IP), Hypertext Transfer Protocol (HTTP), SOAP, remote procedure call protocols, and/or other types of communications protocols.

[0097] In some examples, the additional computing device 1906 is a Web server. In this example, the first computing device 1902 includes a Web browser that communicates with the Web server to request and retrieve data. The data is then displayed to the user, such as by using a Web browser software application. In some embodiments, the various operations, methods, and functions disclosed herein are implemented by instructions stored in memory. When the instructions are executed by the processor 1908 of the one or more computing devices 1902 or 1906, the instructions cause the processor 1908 to perform one or more of the operations or methods disclosed herein.

[0098] The various embodiments described above are provided by way of illustration only and should not be construed to limit the claims attached hereto. Those skilled in the art will readily recognize various modifications and changes that may be made without following the example embodiments and applications illustrated and described herein and without departing from the true spirit and scope of the following claims.

CLAIMS

What is claimed is:

1. A wireless asset management system for determining the location of an asset, the system comprising:

a global positioning system;

a beacon configured to attach to the asset, wherein the beacon is comprised of a motion sensor, a built-in global positioning system receiver and antenna for receiving input from the global positioning system and recording location of the beacon, and a transmitter for transmitting data related to the beacon's location on a first predetermined frequency at a first signal strength;

a gateway located within a predetermined range of the beacon and configured to receive the beacon data, determine the strength of a signal produced by the beacon, and transmit the data and signal strength to a cloud application platform that stores the received data and signal strength;

a locator comprised of a transceiver and configured to transmit a unique identification code at a second predetermined frequency that is different than the first predetermined frequency and at a second signal strength that is weaker than the first signal strength, wherein the beacon can receive the unique identification code of the locator and transmit the unique identification code to the gateway; and

a detector comprised of a transceiver and configured to receive instructions to activate and transmit a signal on a third predetermined frequency, wherein the beacon can receive the detector's signal and emit a second signal that is detectable by a user who is physically located near the beacon.

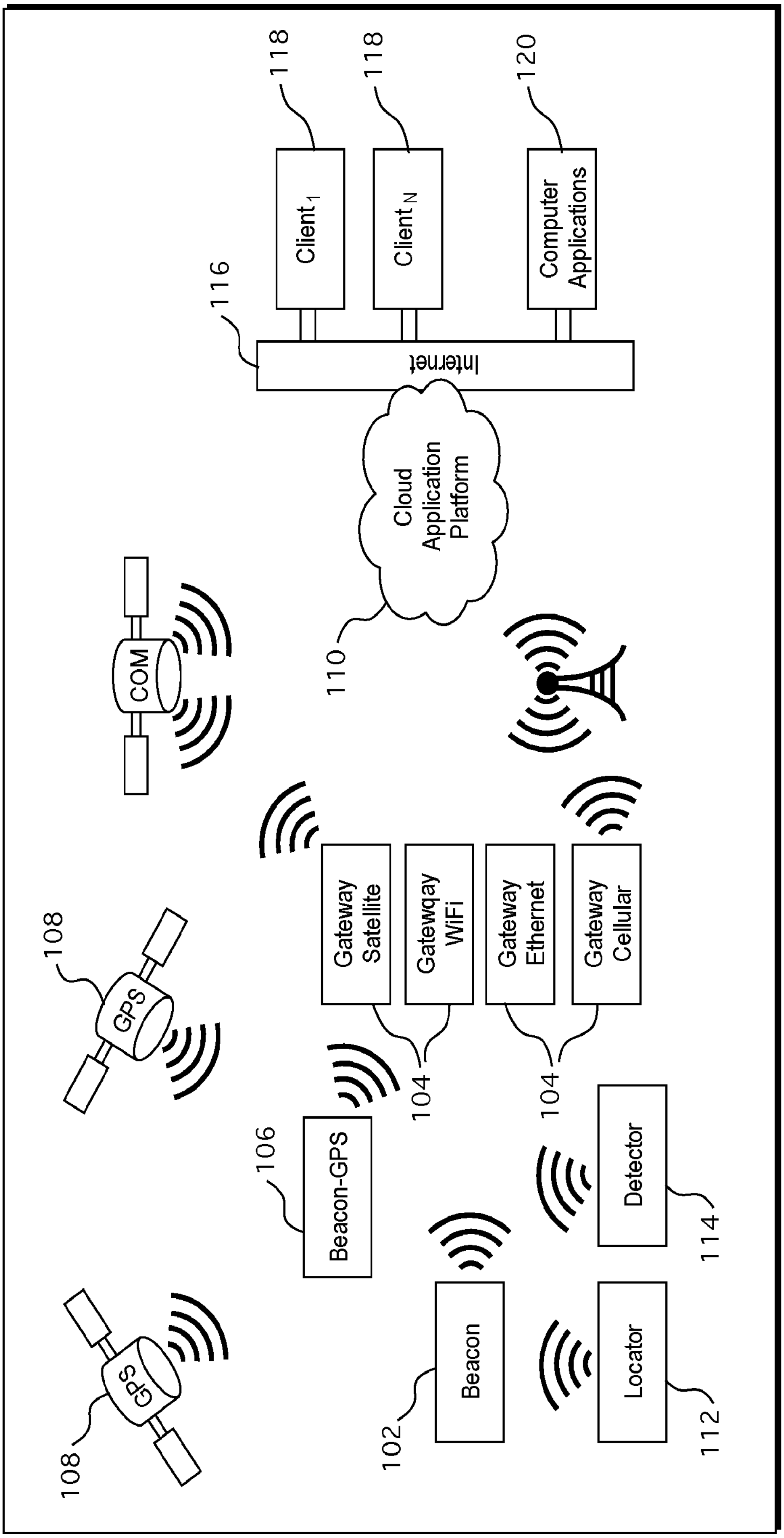

118
118
120
Client 1
Client N
Computer Applications
116
Internet
Cloud Application Platform
110
COM
108
GPS
108
GPS
Gateway Satellite
Gatewqay WiFi
Gateway Ethernet
Gateway Cellular
104
104
106
Beacon-GPS
Beacon
102
Detector
114
Locator
112

FIG. 1

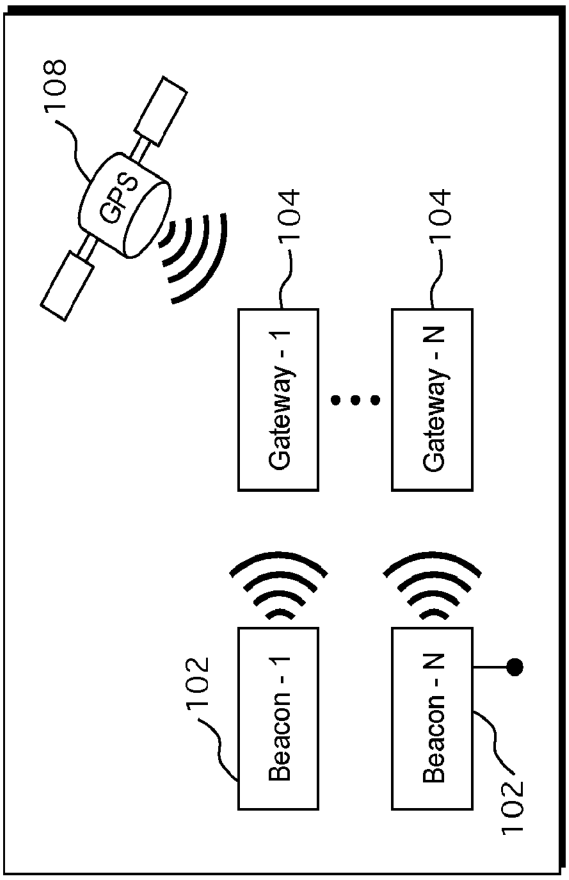


FIG. 2

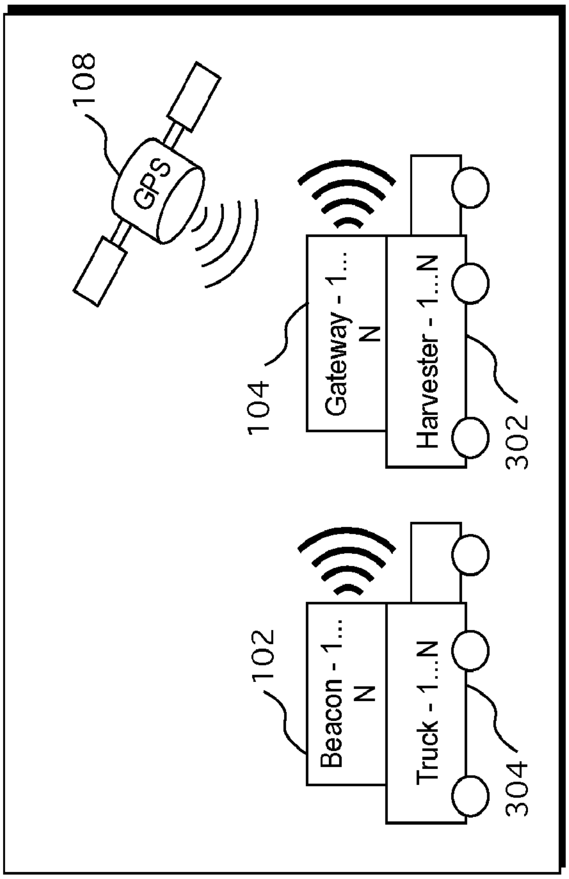


FIG. 3

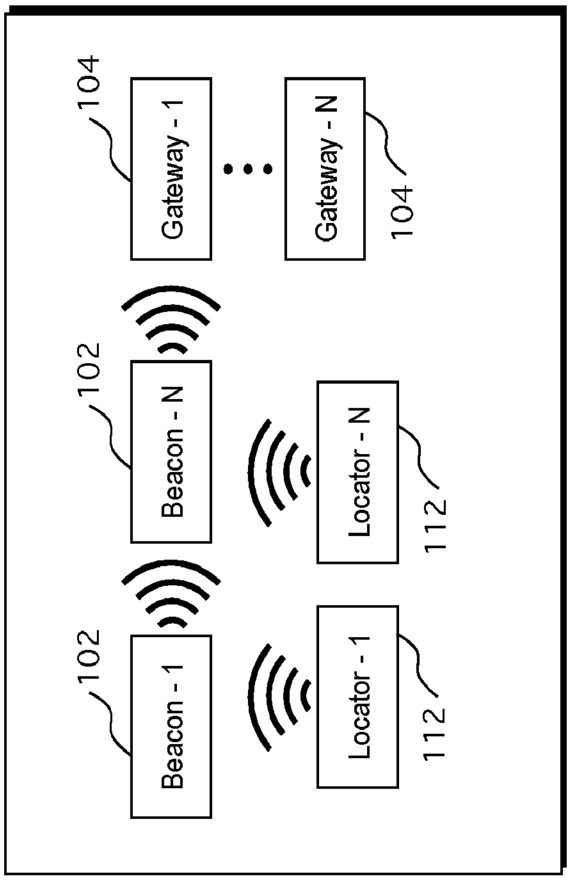


FIG. 4

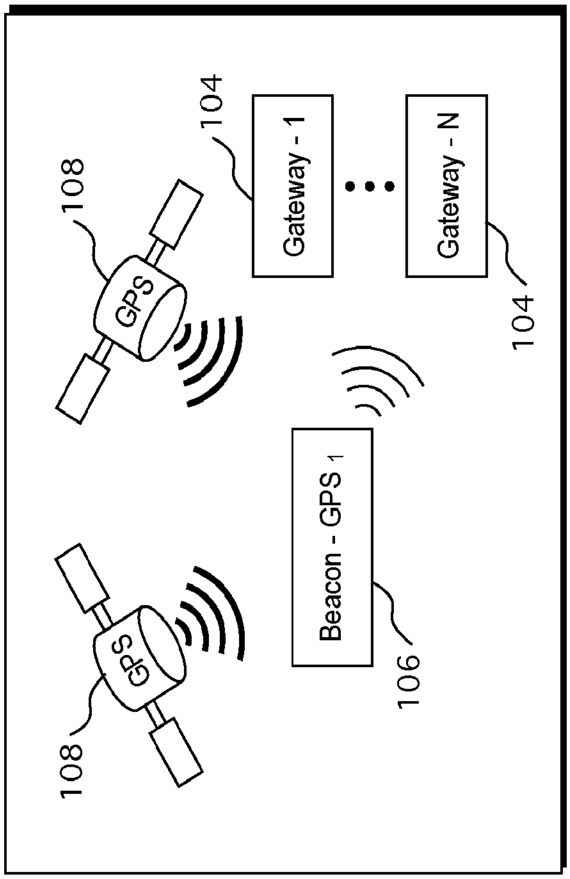


FIG. 5

SUBSTITUTE SHEET (RULE 26)

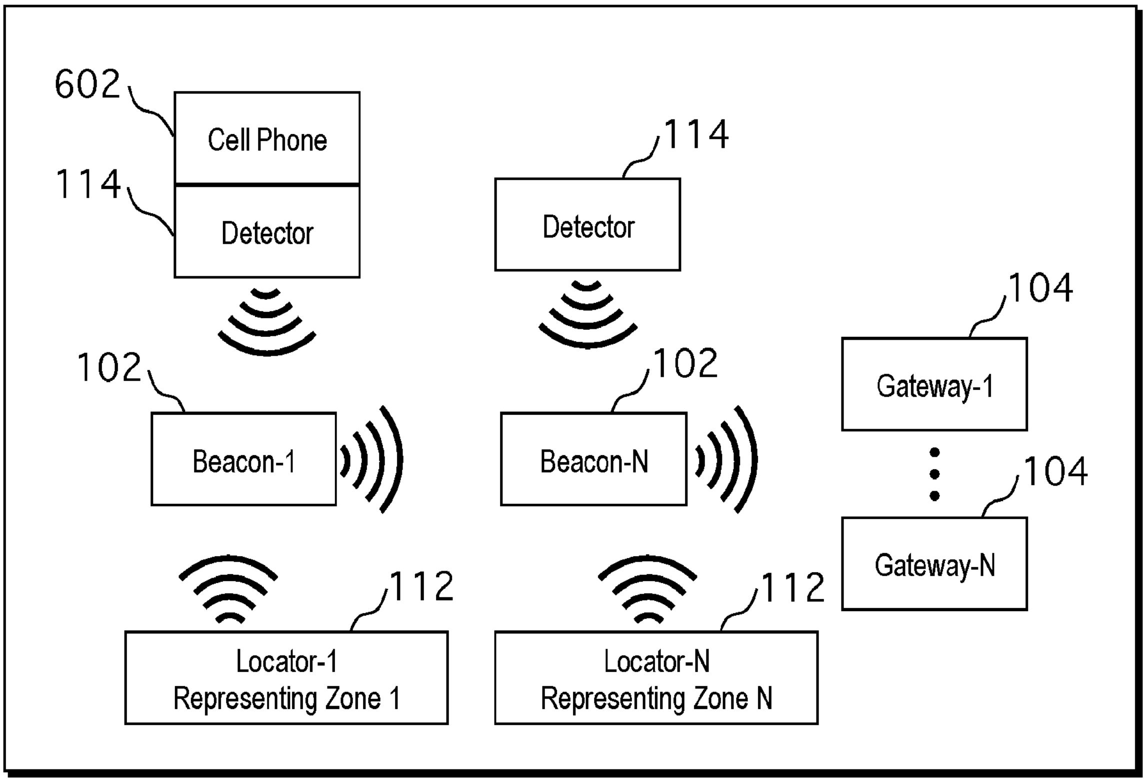

602
Cell Phone
114
Detector
114
Detector
104
Gateway-1
102
Beacon-1
102
Beacon-N
104
Gateway-N
112
Locator-1
Representing Zone 1
112
Locator-N
Representing Zone N

FIG. 6

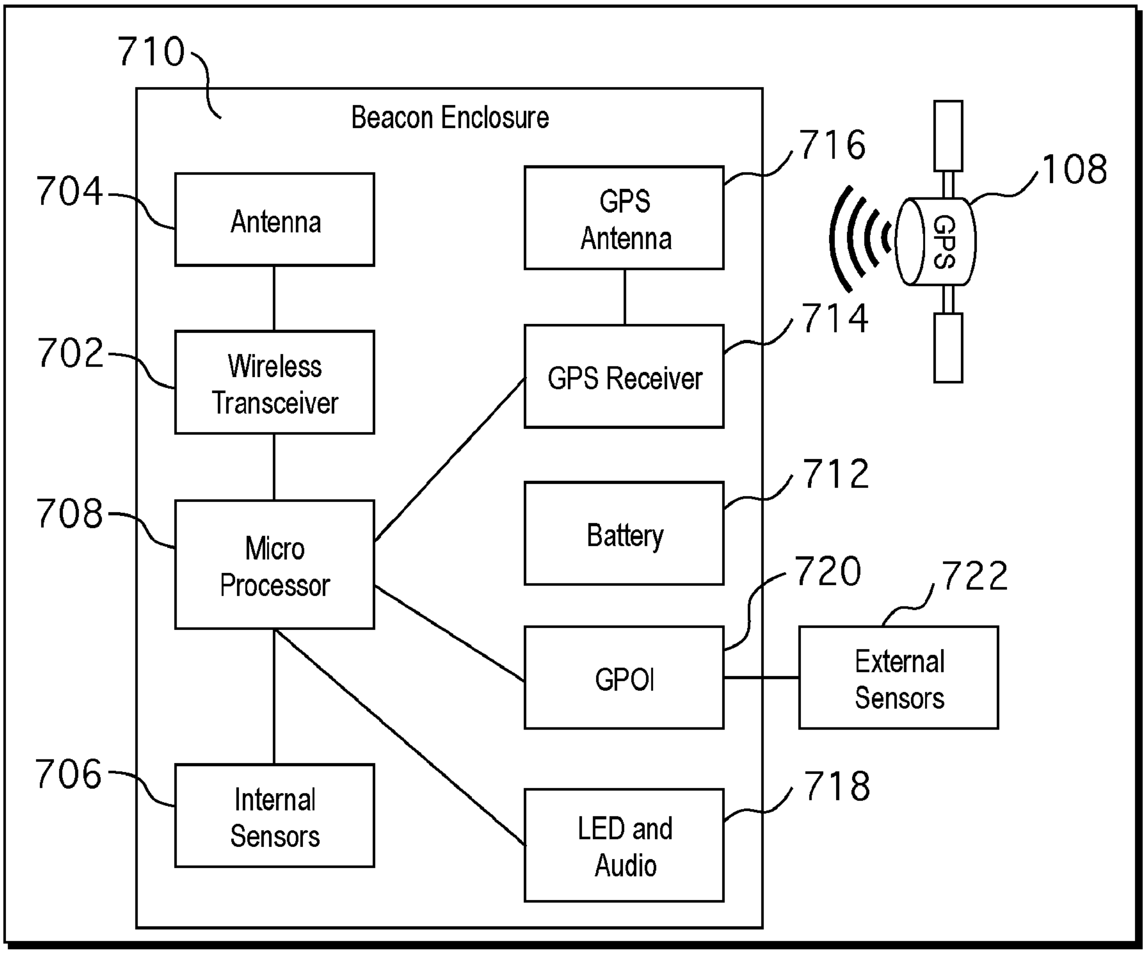

710
Beacon Enclosure
704
Antenna
716
GPS
Antenna
108
GPS
702
Wireless
Transceiver
714
GPS Receiver
712
Battery
708
Micro
Processor
720
722
GPOI
External
Sensors
706
Internal
Sensors
718
LED and
Audio

FIG. 7

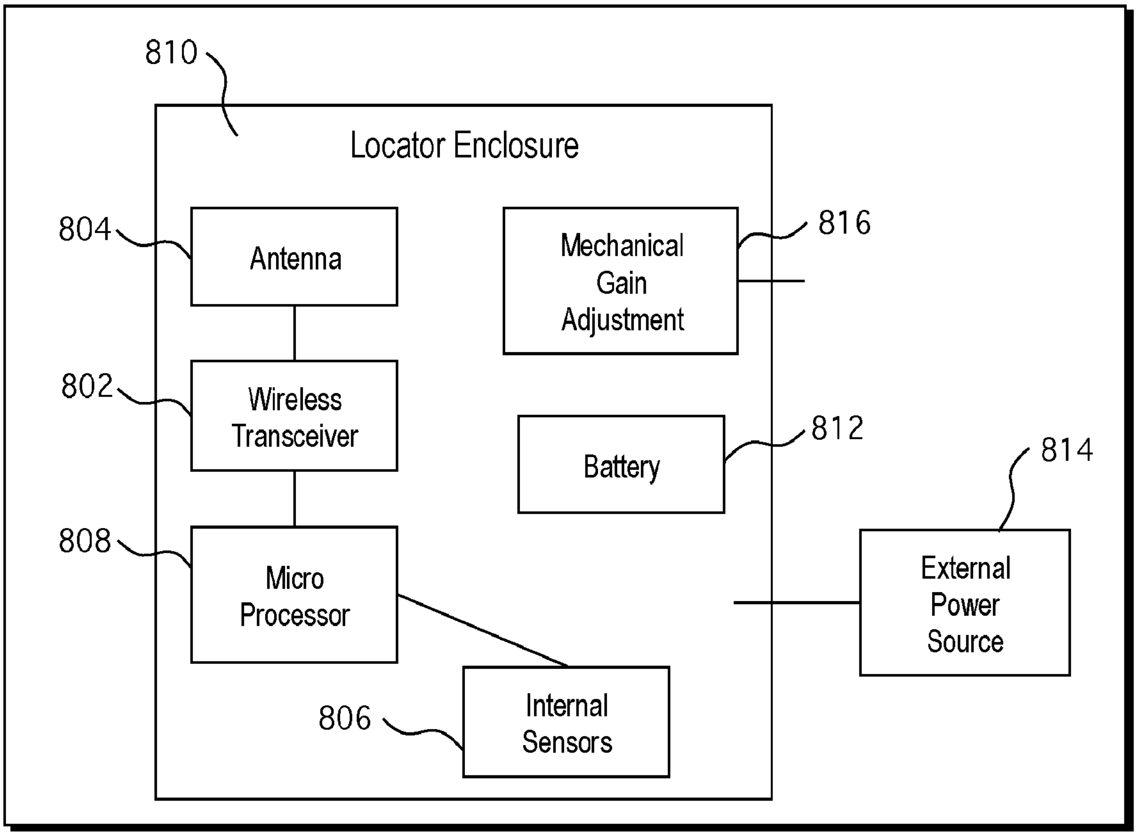

810
Locator Enclosure
804
Antenna
Mechanical Gain Adjustment
816
802
Wireless Transceiver
Battery
812
814
808
Micro Processor
External Power Source
806
Internal Sensors

FIG. 8

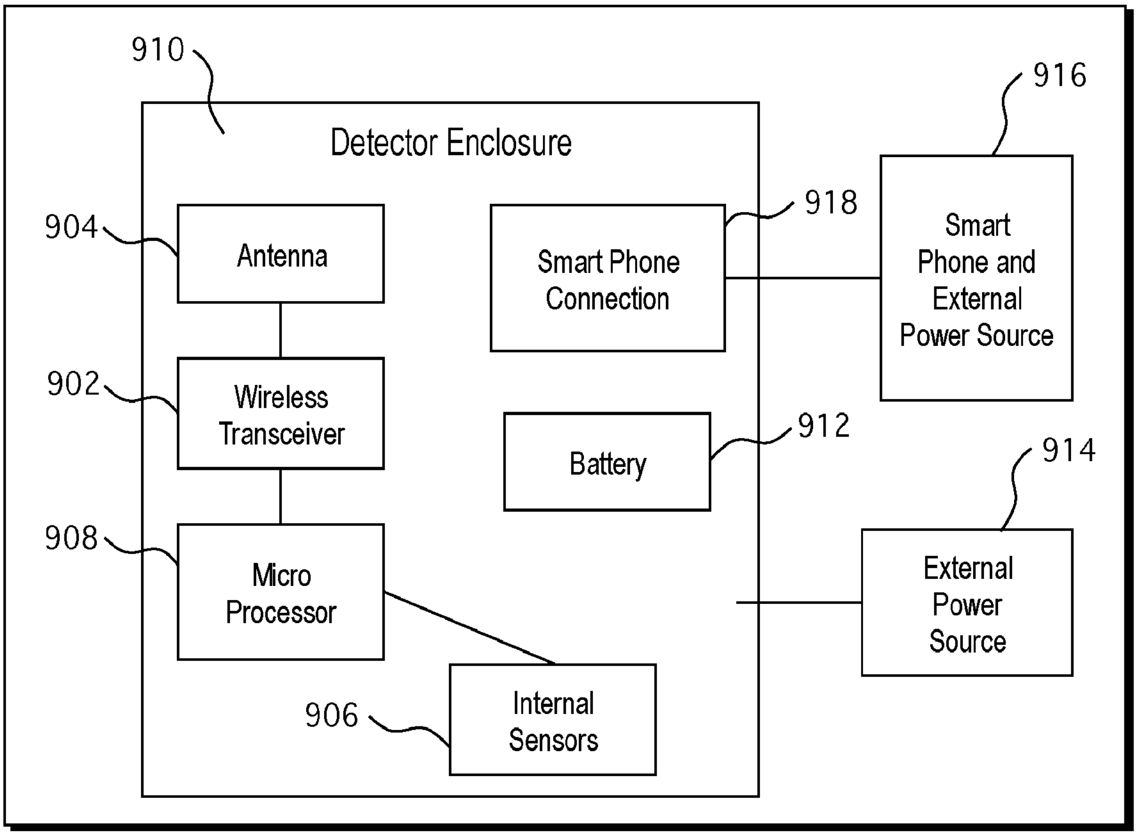

910
Detector Enclosure
916
904
Antenna
Smart Phone Connection
918
Smart Phone and External Power Source
902
Wireless Transceiver
Battery
912
914
908
Micro Processor
External Power Source
906
Internal Sensors

FIG. 9

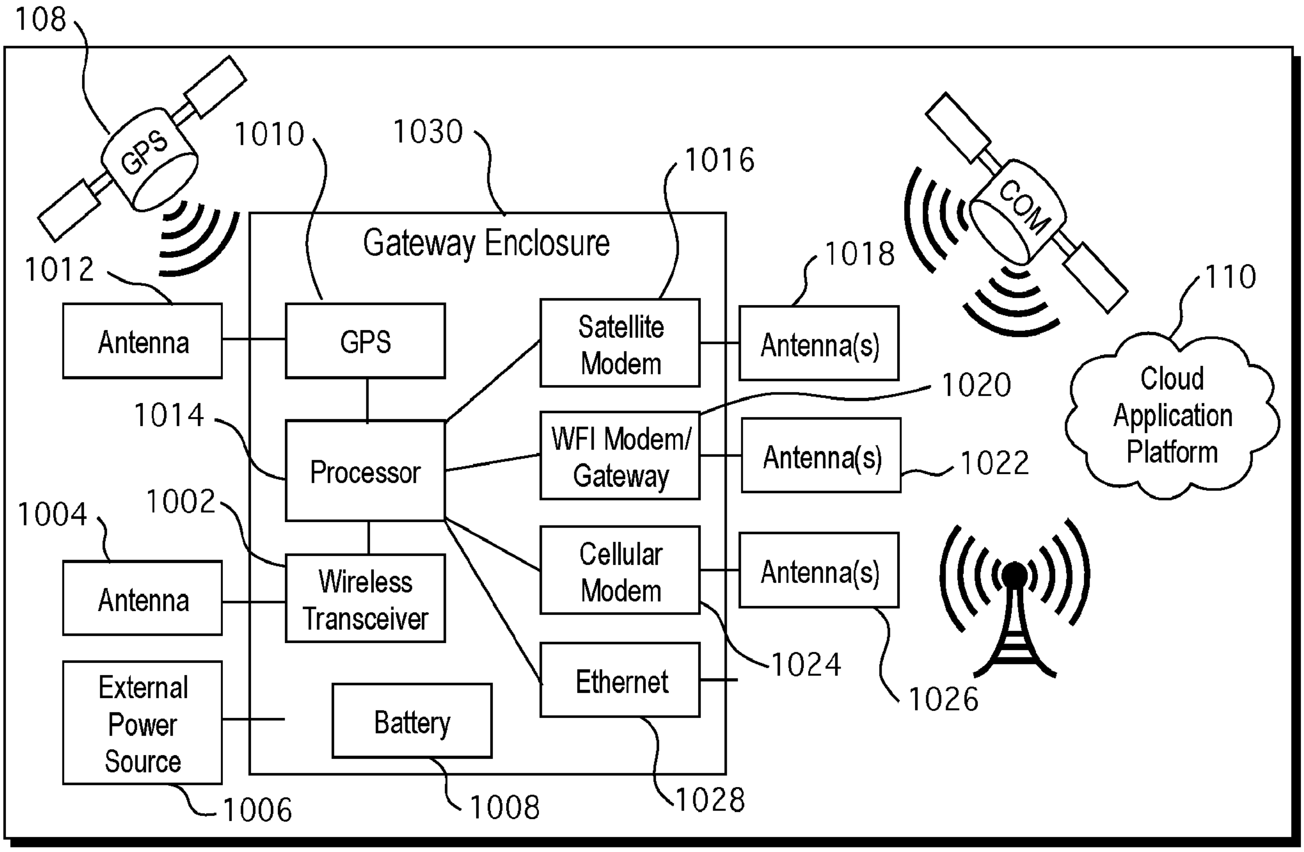

108
GPS
1010
1030
Gateway Enclosure
1016
COM
1018
1012
Antenna
GPS
Satellite Modem
Antenna(s)
110
1020
Cloud Application Platform
1014
Processor
WFI Modem/ Gateway
Antenna(s)
1022
1004
1002
Antenna
Wireless Transceiver
Cellular Modem
Antenna(s)
1024
External Power Source
Battery
Ethernet
1026
1006
1008
1028

FIG. 10

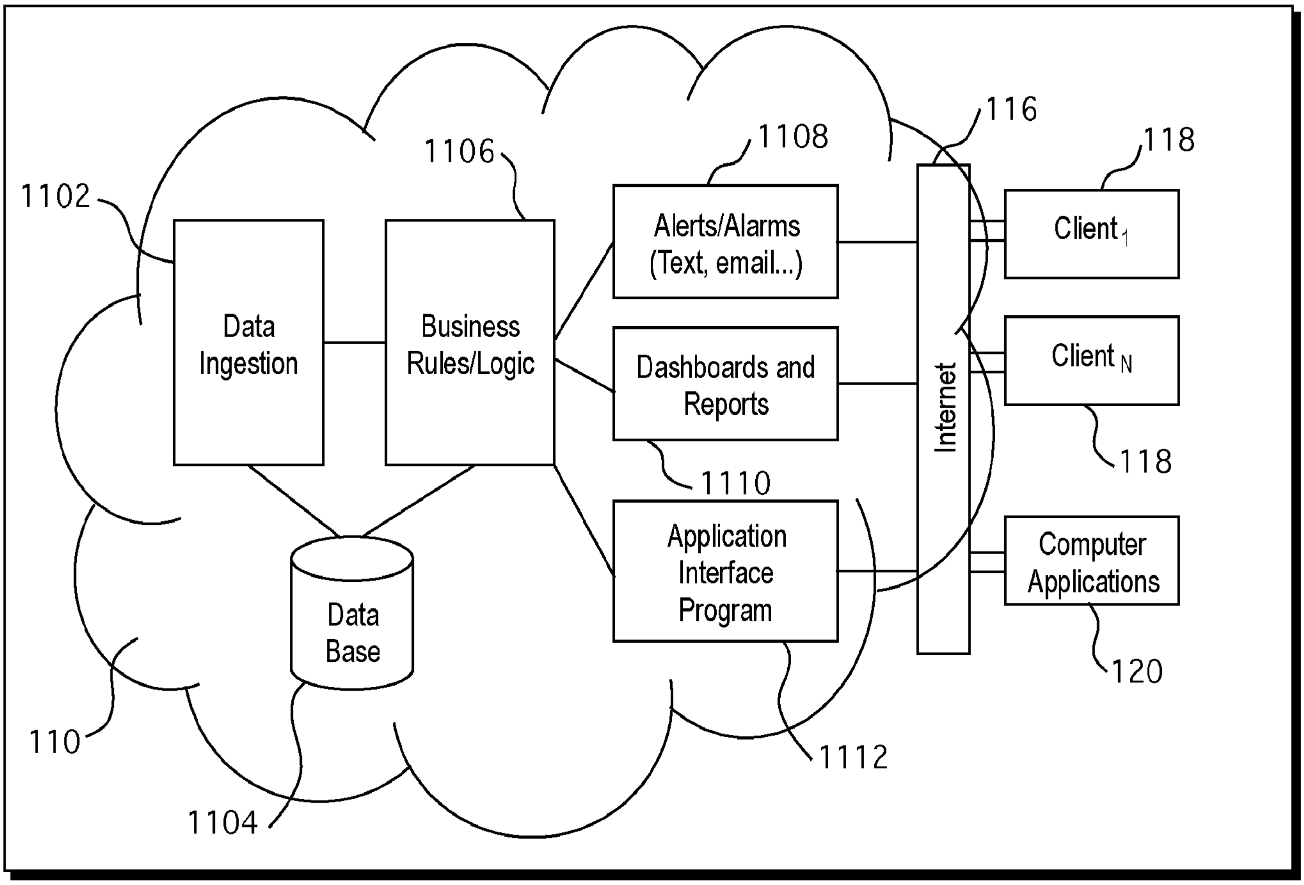

116
118
1108
1106
1102
Alerts/Alarms (Text, email...)
Client 1
Data Ingestion
Business Rules/Logic
Dashboards and Reports
Internet
Client N
118
1110
Computer Applications
Application Interface Program
Data Base
120
110
1112
1104

FIG. 11

SMARTZONE GUI

Generated Sat Nov 08:22:52:26 EST 2014

Zone Summary

	Total	Displayed	Active
Zone 1	0	0	0
Zone 2	0	0	0
Zone 3	0	0	0
Zone 4	0	0	0
Exception	2	N/A	N/A

CMU Summary

CMU 1
Single Strollers

Strollers in CMU	12
Displayed	0
Active	0
Exception	0

CMU 2
Single Strollers

Strollers in CMU	9
Displayed	0
Active	0
Exception	2

Inventory

	Now	Start of Day	End of Day	Previous Day
Total Inventory	23	23	23	23
In Range	21	22	22	22
CMU	21	22	22	22
Displayed	0	0	0	0
Active	0	0	0	0
Exception	2	1	1	1

FIG. 12

CMU 1 (Single strollers)

Generated Sat Dec 13 18:57:33 EST 2014

Details

CMU Inventory	1
Capacity	12
Today's Rents	25
Today's Returns	21

Zone 1: Deployed 0 Active 1 CMU 1: 1 CMU 2: 10	Zone 2: Deployed 0 Active 2
Zone 3: Deployed 0 Active 2	Zone 4: Deployed 0 Active 4

Hourly Summary

Time	Rents	Returns	Inventory
7:00	0	0	8
8:00	0	0	8
9:00	0	0	8
10:00	0	0	8
11:00	0	0	8
12:00	1	3	10
13:00	3	1	8
14:00	6	2	4
1:00	5	5	4
16:00	3	2	3
17:00	5	7	5

FIG. 13

FIG. 14

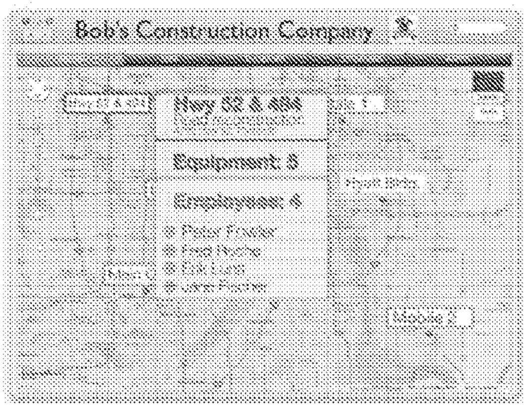


FIG. 15

FIG. 16

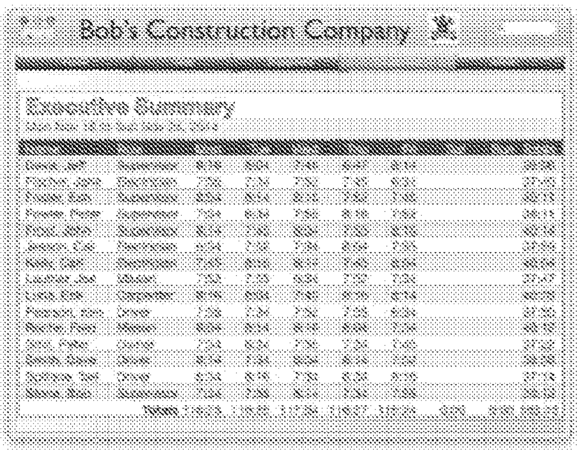


FIG. 17

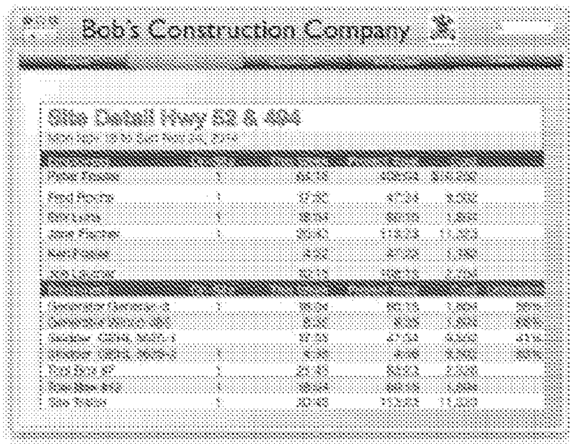
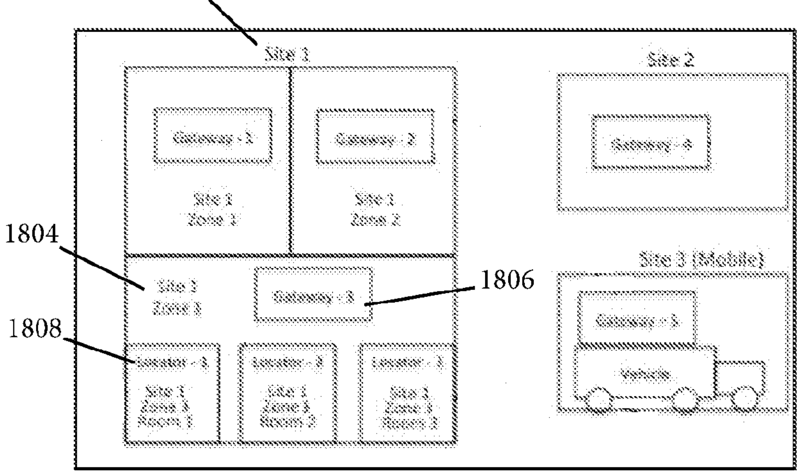
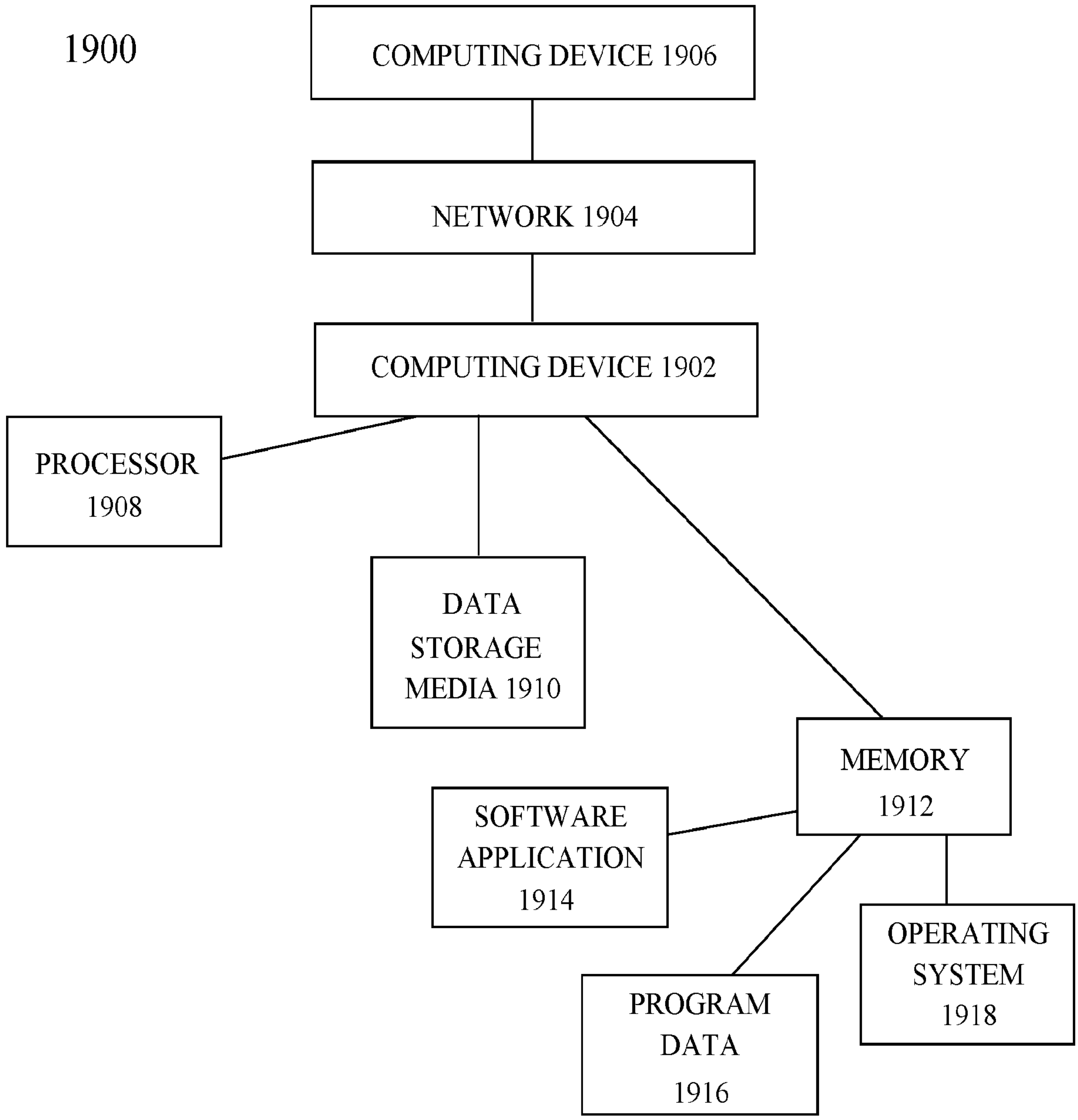


FIG. 18



5/6

FIG. 19


1900
COMPUTING DEVICE 1906
NETWORK 1904
COMPUTING DEVICE 1902
PROCESSOR 1908
DATA STORAGE MEDIA 1910
MEMORY 1912
SOFTWARE APPLICATION 1914
PROGRAM DATA 1916
OPERATING SYSTEM 1918

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/027000

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06F 7/00; G06Q 30/00; G08B 21/18; G08B 23/00 (2016.01)
CPC - G06F 7/00; G06Q 30/00; G08B 21/18; G08B 23/00 (2016.02)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - G06F 7/00; G06Q 30/00; G08B 21/18; G08B 23/00 (2016.01)
CPC - G06F 7/00; G06Q 30/00; G08B 21/18; G08B 23/00 (2016.02)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC 340/539.130; 340/572.100; 701/1 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google Scholar, Google
Search terms used: Beacon, wireless, asset, management, gateway, locator, detector, frequency, strength

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/0266707 A1 (BI Incorporated) 18 September 2014 (18.09.2014) entire document	1
A	US 2011/0148639 A1 (GEISSLER et al) 23 June 2011 (23.06.2011) entire document	1
A	US 2013/0297793 A1 (Elwha Llc) 07 November 2013 (07.11.2013) entire document	1
A	WO 1995003553 A1 (HAY KENNETH HERBERT) 02 February 1995 (02.02.1995) entire document	1
A	US 20110080262 A1 (RICHARDSON et al) 07 April 2011 (07.04.2011) entire document	1
A	WO 2011/013084 A1 (MIX TELEMATICS INTERNATIONAL (PROPRIETARY) LIMITED et al) 03 February 2011 (03.02.2011) entire document	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 June 2016	14 JUL 2016
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774