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(54) Title: LOCATION TRACKING FOR MOBILE TERMINALS AND RELATED COMPONENTS, SYSTEMS, AND METHODS

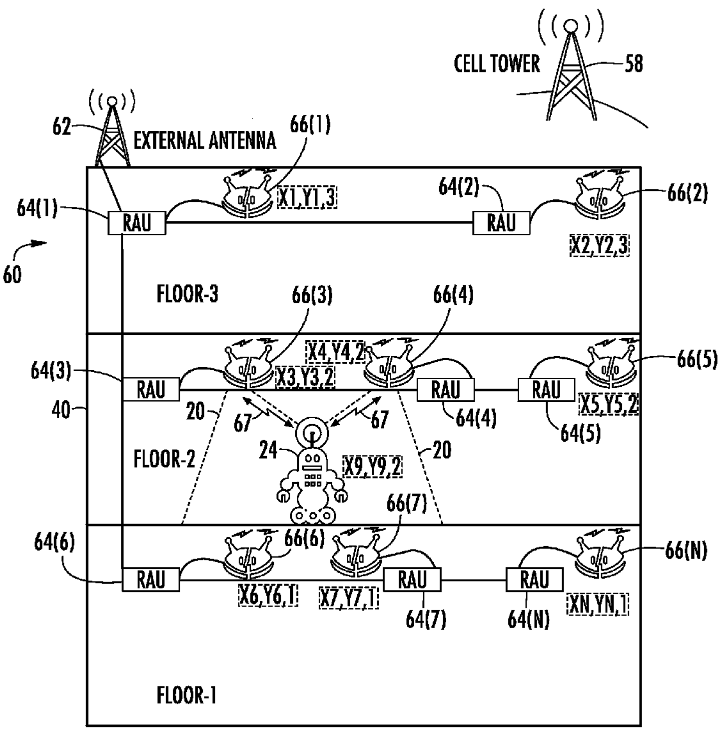

FIG. 3

(57) Abstract: A location tracking for mobile terminals is disclosed. Related components, systems, and methods are also disclosed herein. For example, the systems disclosed herein can provide location information to mobile terminals that may not be able to receive otherwise global positioning system (GPS) information from the GPS satellites, such as, for example, when the mobile terminal is not within line of sight of the GSP satellites. The location information may be provided through a service set identifier (SSID) signal. Providing location information may make location based services, such as emergency (E911) services, for example, possible based on the location information.

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LOCATION TRACKING FOR MOBILE TERMINALS AND RELATED COMPONENTS, SYSTEMS, AND METHODS

PRIORITY APPLICATION

[0001] This application claims the benefit of priority of U.S. Application Serial No. 13/485,038, filed on May 31, 2012, the content of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

Field of the Disclosure

[0002] The technology of the disclosure relates to location based systems used for tracking locations of mobile terminals, including distributed antenna systems.

Technical Background

[0003] Wireless communication is rapidly growing, with ever-increasing demands for high-speed mobile data communication. As an example, so-called "wireless fidelity" or "WiFi" systems and wireless local area networks (WLANs) are being deployed in many different types of areas (e.g., coffee shops, airports, libraries, etc.). Distributed communications or antenna systems communicate with wireless devices called "clients," "client devices," or "wireless client devices," which must reside within the wireless range or "cell coverage area" in order to communicate with an access point device. Distributed antenna systems are particularly useful to be deployed inside buildings or other indoor environments where client devices may not otherwise be able to effectively receive RF signals from a source, such as a base station for example.

[0004] One approach to deploying a distributed communications system involves the use of radio frequency (RF) antenna coverage areas, also referred to as "antenna coverage areas." Antenna coverage areas can have a relatively short range. Combining a number of access point devices creates an array of antenna coverage areas. Because the antenna coverage areas each cover small areas, there are typically only a few users (clients) per antenna coverage area. This allows for minimizing the amount of bandwidth shared among the wireless system users. It may be desirable to provide antenna coverage areas in a building or other facility to provide distributed communications system access to clients within the building or facility. However, it may be desirable to employ optical fiber to distribute communication signals. Benefits of optical fiber include increased bandwidth.

[0005] One type of distributed communications system for creating antenna coverage areas, called "Radio-over-Fiber" or "RoF," utilizes RF signals sent over optical fibers. Such systems can include a head-end station optically coupled to a plurality of remote antenna units that each provides antenna coverage areas. The remote antenna units can each include RF transceivers coupled to an antenna to transmit RF signals wirelessly, wherein the remote antenna units are coupled to the head-end station via optical fiber links. The RF transceivers in the remote antenna units are transparent to the RF signals. The remote antenna units convert incoming optical RF signals from the optical fiber link to electrical RF signals via optical-to-electrical (O/E) converters, which are then passed to the RF transceiver. The transceiver converts the electrical RF signals to electromagnetic signals via antennas coupled to the RF transceiver provided in the remote antenna units. The antennas also receive electromagnetic signals (i.e., electromagnetic radiation) from clients in the antenna coverage area and convert them to electrical RF signals (i.e., electrical RF signals in wire). The remote antenna units then convert the electrical RF signals via electrical-to-optical (E/O) converters. The optical RF signals are then sent to the head-end station via the optical fiber link.

[0006] It may be desired to provide such optical fiber-based distributed communications systems (or other distributed communication systems (e.g., coaxial and/or wirebased) indoors, such as inside a building or other facility, to provide indoor wireless communication for clients. Otherwise, wireless reception may be poor or not possible for wireless communication clients located inside the building. In this regard, the remote antenna units can be distributed throughout locations inside a building to extend wireless communication coverage throughout the building. Other services may be negatively affected or not possible due to the indoor environment. For example, it may be desired or required to provide localization services for a client, such as emergency 911 (E911) services as an example. If the client is located indoors, techniques such as global positioning services (GPS) may not be effective at providing or determining the location of the client. Further, triangulation techniques from the outside network may not be able to determine the location of the client.

SUMMARY OF THE DETAILED DESCRIPTION

[0007] Embodiments disclosed herein include a location tracking for mobile terminals. Related components, systems, and methods are also disclosed herein. For example, the systems disclosed herein can provide location information to mobile terminals that may not be able to receive otherwise global positioning system (GPS) information from the GPS satellites, such as, for example, when the mobile terminal does not receive GPS signals from the GSP satellites. Providing location information to clients inside a building or other location may make location based services, such as emergency (E911) services, for example, possible based on the location information.

[0008] In this regard, in one embodiment, a distributed communications apparatus comprises for example, at least a first downlink input configured to receive downlink communications signals and, for example, at least a first interface configured to receive and provide the downlink communications signals to a remote unit. The remote unit is configured to provide location indicia within a service set identifier (SSID) signal to a wireless client within an antenna coverage area associated with the remote unit.

[0009] In another embodiment, a method comprises receiving downlink communications signals at a downlink input and providing the downlink communications signals to a remote unit. The method further comprises providing from the remote unit location indicia within an SSID signal to a wireless client within an antenna coverage area associated with the remote unit.

[0010] In another embodiment, a wireless client comprises a user interface and a transceiver configured to send and receive wireless uplink and wireless downlink signals to a remote unit. The wireless client further comprises a control system operably connected to the user interface and the transceiver, the control system configured to receive location indicia within an SSID signal from the remote unit.

[0011] As non-limiting examples, the network may be an indoor distributed antenna system or a wireless local area network. The location indicia sent to the wireless client may be three dimensional coordinates including floor level of the building or an address for a server that tells the wireless client the location of remote units from which the wireless client may calculate location.

[0012] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

[0013] **FIG. 1A** is a schematic diagram of an exemplary optical fiber-based distributed communications system;

[0014] **FIG. 1B** is a block diagram of an exemplary wireless client that may be used in a distributed communications system;

[0015] **FIG. 2** is a partially schematic cut-away diagram of an exemplary building infrastructure in which an optical fiber-based distributed communications system is employed;

[0016] **FIG. 3** is a partially schematic cut-away diagram of an exemplary building infrastructure wherein the optical fiber-based distributed communications system employs access points;

[0017] **FIG. 4** is a partially schematic cut-away diagram of an exemplary building infrastructure with a wireless local area network communications system;

[0018] **FIG. 5** is a partially schematic cut-away diagram of an exemplary building infrastructure with a wireless local area network communications system having additional beacon terminals;

[0019] **FIG. 6** is a flow chart of an exemplary communication sequence through which a wireless client may ascertain its location;

[0020] **FIG. 7** is a flow chart of an alternate exemplary communication sequence through which a wireless client may ascertain its location;

[0021] **FIG. 8** is a schematic diagram of a generalized representation of an exemplary computer system that can be included in any of the modules provided in the exemplary distributed antenna systems and/or their components described herein, including but not limited to a head end controller (HEC), wherein the exemplary computer system is adapted to execute instructions from an exemplary computer-readable media.

DETAILED DESCRIPTION

[0022] Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0023] Embodiments disclosed herein include a location tracking for mobile terminals. Related components, systems, and methods are also disclosed herein. For example, the systems disclosed herein can provide location information to mobile terminals that may not be able to receive otherwise global positioning system (GPS) information from the GPS satellites, such as, for example, when the mobile terminal does not receive GPS signals from the GSP satellites. Providing location information may make location based services, such as emergency (E911) services, for example, possible based on the location information.

[0024] Before discussing the exemplary components, systems, and methods of providing localization services in a distributed communications system, which starts at **FIG. 3**, an exemplary generalized optical fiber-based distributed communications is first described with regard to **FIGS. 1A, 1B,** and **2**. In this regard, **FIG. 1A** is a schematic diagram of a generalized embodiment of an optical fiber-based distributed communications system. In this embodiment, the system is an optical fiber-based distributed communications system **10** that is configured to create one or more antenna coverage areas for establishing communications with wireless client devices (sometimes referred to herein as mobile terminals) located in the radio frequency (RF) range of the antenna coverage areas. In this regard, the optical fiber-based distributed communications system **10** includes head-end equipment, exemplified as a head-end unit or HEU **12**, one or more remote antenna units (RAUs) **14** and an optical fiber link **16** that optically couples the HEU to the RAU **14**. The HEU **12** is configured to receive communications over downlink electrical RF signals **18D** from a source or sources, such as a network or carrier as examples, and provide such communications to the RAU **14**. The HEU **12** is also configured to return communications received from the RAU **14**, via uplink electrical RF signals **18U**, back to the source or sources. In this regard, in this embodiment, the optical fiber link **16** includes at least one downlink optical fiber **16D** to carry signals communicated from the HEU **12** to the RAU **14** and at least one uplink optical fiber **16U** to carry signals communicated from the RAU **14** back to the HEU **12**. Note that there are embodiments where both the uplink and downlink signals **18U, 18D** are transmitted on the same optical fiber **16**, albeit at different frequencies. The present disclosure is operable in both situations.

[0025] The optical fiber-based wireless system **10** has an antenna coverage area **20** that can be substantially centered about the RAU **14**. The antenna coverage area **20** of the RAU **14** forms an RF coverage area **21**. The HEU **12** is adapted to perform or to facilitate any one of a number of Radio-over Fiber (RoF) applications, such as radio-frequency identification (RFID), wireless local-area network (WLAN) communication, or cellular phone service. Shown within the antenna coverage area **20** is a client device **24** in the form of a mobile terminal as an example, which may be a cellular telephone, smartphone, tablet computer, or the like as an example. The client device **24** can be any device that is capable of receiving

RF communication signals. The client device **24** includes an antenna **26** (e.g., a wireless card) adapted to receive and/or send electromagnetic RF signals.

[0026] With continuing reference to **FIG. 1A**, to communicate the electrical RF signals over the downlink optical fiber **16D** to the RAU **14**, to in turn be communicated to the client device **24** in the antenna coverage area **20** formed by the RAU **14**, the HEU **12** includes an electrical-to-optical (E/O) converter **28**. The E/O converter **28** converts the downlink electrical RF signals **18D** to downlink optical RF signals **22D** to be communicated over the downlink optical fiber **16D**. The RAU **14** includes an optical-to-electrical (O/E) converter **30** to convert received downlink optical RF signals **22D** back to electrical signals to be communicated wirelessly through an antenna **32** of the RAU **14** to client devices **24** located in the antenna coverage area **20**.

[0027] Similarly, the antenna **32** is also configured to receive wireless RF communications from client devices **24** in the antenna coverage area **20**. In this regard, the antenna **32** receives wireless RF communications from client devices **24** and communicates electrical RF signals representing the wireless RF communications to an E/O converter **34** in the RAU **14**. The E/O converter **34** converts the electrical RF signals into uplink optical RF signals **22U** to be communicated over the uplink optical fiber **16U**. An O/E converter **36** provided in the HEU **12** converts the uplink optical RF signals **22U** into uplink electrical RF signals, which can then be communicated as uplink electrical RF signals **18U** back to a network or other source. The client device **24** could be in range of any antenna coverage area **20** formed by a RAU **14**.

[0028] With reference to **FIG. 1B**, a block diagram of a wireless client is provided. The wireless client device **24** (sometimes referred to as wireless clients) includes the antenna **26** and a wireless transceiver **80**, a control system **82**, computer readable memory **84**, and a user interface **86**. The user interface **86** includes inputs **88** and outputs **90** such as a keypad, touch screen, or the like. The computer readable memory **84** includes software **92** including a location applet **94** which may perform some of the operations of the present disclosure. In an alternate embodiment, the location applet may be stored elsewhere in the wireless client **24**. For example, the location applet may be in the transceiver **80**, or within an element such as a digital signal processor (not shown) within the transceiver **80**. Wireless clients **24** may be cellular phones, smart phones, tablet computers or the like.

[0029] While not explicitly set forth in **FIG. 1B**, the client device **24** may further include one or more of an accelerometer, compass, gyroscope, and/or other internal sensors. These internal sensors may be accessed by a user through the user interface **86** in conjunction with an application stored in memory **84**. Alternatively, such internal sensors may be accessed without user intervention by another application such as location applet **94**.

[0030] To provide further exemplary illustration of how an optical fiber-based distributed communications system can be deployed indoors, **FIG. 2** is a partially schematic cut-away diagram of a building infrastructure **40** employing the optical fiber-based distributed communications system **10** of **FIG. 1A**. The building infrastructure **40** generally represents any type of building in which the optical fiber-based distributed communications system **10** can be deployed. As previously discussed with regard to **FIG. 1**, the optical fiber-based distributed communications system **10** incorporates the HEU **12** to provide various types of communication services to coverage areas within the building infrastructure **40**, as an example. For example, as discussed in more detail below, the optical fiber-based distributed communications system **10** in this embodiment is configured to receive wireless RF signals and convert the RF signals into Radio-over-Fiber (RoF) signals to be communicated over the optical fiber link **16** to the RAUs **14**. The optical fiber-based distributed communications system **10** in this embodiment can be, for example, an indoor distributed antenna system (IDAS) to provide wireless service inside the building infrastructure **40**. The wireless signals can include, but are not limited to, cellular service, wireless services such as RFID tracking, Wireless Fidelity (WiFi), local area network (LAN), and combinations thereof, as examples.

[0031] With continuing reference to **FIG. 2**, the building infrastructure **40** includes a first (ground) floor **42**, a second floor **44**, and a third floor **46**. The floors **42**, **44**, **46** are serviced by the HEU **12** through a main distribution frame **48**, to provide antenna coverage areas **50** in the building infrastructure **40**. Only the ceilings of the floors **42**, **44**, **46** are shown in **FIG. 2** for simplicity of illustration. In the example embodiment, a main cable **52** has a number of different sections that facilitate the placement of a large number of RAUs **14** in the building infrastructure **40**. Each RAU **14** in turn services its own coverage area in the antenna coverage areas **50**. The main cable **52** can include, for example, a riser section **54** that carries all of the downlink and uplink optical fibers **16D**, **16U** to and from the HEU **12**. The main cable **52** can include one or more multi-cable (MC) connectors adapted to connect select downlink and uplink optical fibers **16D**, **16U**, along with an electrical power line, to a number of optical fiber cables **56**.

[0032] The main cable **52** enables multiple optical fiber cables **56** to be distributed throughout the building infrastructure **40** (e.g., fixed to the ceilings or other support surfaces of each floor **42**, **44**, **46**) to provide the antenna coverage areas **50** for the first, second, and third floors **42**, **44**, and **46**. In an example embodiment, the HEU **12** is located within the building infrastructure **40** (e.g., in a closet or control room), while in another embodiment the HEU **12** may be located outside of the building infrastructure **40** at a remote location. A base transceiver station (BTS) **58**, which may be provided by a second party such as a cellular service provider, is connected to the HEU **12**, and can be co-located or located remotely from the HEU **12**. A BTS is any station or source that provides an input signal to the HEU **12** and can receive a return signal from the HEU **12**. In a typical cellular system, for example, a plurality of BTSs is deployed at a plurality of remote locations to provide wireless telephone coverage. Each BTS serves a corresponding cell and when a mobile terminal enters the cell, the BTS communicates with the mobile terminal. Each BTS can include at least one radio transceiver for enabling communication with one or more subscriber units operating within the associated cell.

[0033] **FIGS. 1A** and **2** are directed to optical fiber implementations, but the present disclosure is not so limited. Rather, any distributed antenna system, wire-based or a hybrid of wire and optical fiber cables or the like, may be used with exemplary embodiments of the present disclosure. Likewise, while **FIGS. 1A** and **2** focus on the provision of cellular services and/or the provision of WLAN services “riding” on the fiber network, the present disclosure also is operable with a network that is designed as a WLAN and has a wire-based solution (e.g., twisted pair, CAT5, CAT6, coaxial, pure optical, hybrid (optical and coax), or the like). The present disclosure is likewise operable with composite cabling structures (e.g., where there are DC power wires and fiber strands in a single cable).

[0034] The need for interior distributed antenna systems arises from the fact that many wireless signals are unable to penetrate the walls and interior barriers of a building. In instances where the wireless signals do penetrate the walls and interior barriers of a building, the signals may be so attenuated that the wireless clients are unable to process those signals effectively. DAS and WLAN systems (and combinations of these systems) are effective at providing cellular and WiFi signals to wireless clients, but to date have not proven effective at providing location information. Such location information may be needed to provide E911 services and/or other location based services.

[0035] It may be desirable to leverage the distributed communications systems so as to provide location indicia to the mobile terminals so that a mobile terminal may ascertain its location such that the location may be reported to an E911 service or other location based services may be requested/provided. The present disclosure incorporates location information into a service set identifier (SSID) signal within WLAN access points and beacon terminals that are associated with the wireless communications systems.

[0036] In this regard, **FIG. 3** illustrates an IDAS **60**. The IDAS **60** includes an external antenna **62** that communicates with the BTS **58** via wireless signals as explained above. The IDAS **60** further includes RAUs **64(1)-64(N)** distributed throughout the building infrastructure **40**. One or more of the RAUs **64(1)-64(N)** are coupled to WLAN access points **66(1)-66(N)** as is understood by someone of ordinary skill in the art. The access points communicate wirelessly with the client devices **24** within the antenna coverage areas **20**. Each access point **66(1)-66(N)** transmits a service set identifier (SSID) signal that includes the location of the access point **66**. In an exemplary embodiment, each access point **66** transmits an SSID signal **67** that has the three dimensional coordinates of the access point **66** (e.g., x, y, and z). In a further exemplary embodiment, the z coordinate may be a floor level (e.g., 1st, 2nd, 3rd…). The wireless client **24** may receive a plurality of SSID signals from various ones of the access points **66(1)-66(N)**, although it should be noted that in many building infrastructures **40**, the concrete in the floor causes inter-floor signals to be greatly attenuated. The wireless client **24** may determine a received signal strength indication (RSSI) for each received SSID signal, and coupled with the coordinates embedded in the SSID signal, the wireless client **24** may calculate through any appropriate algorithm (e.g., trilateration or triangulation) the location of the wireless client **24**. The wireless client **24** may include an applet or other software or hardware to effectuate the calculation of the location. Once calculated, the location may then be provided to other programs that can use that location (e.g., provision of E911 services or other location based services). In an exemplary embodiment, trilateration or triangulation may provide location accuracy of approximately five (5) meters to thirty (30) meters depending on the density of access points **66**. The internal sensors of the wireless client **24** (e.g., the accelerometer, compass, and the like) may be used to improve the accuracy of the location calculated. That is, the location applet **94** may interrogate such sensors and use the information so provided to provide additional data points in a location determination algorithm.

[0037] While the IDAS **60** of **FIG. 3** provides high bandwidth capabilities to provide a number of services concurrently, the present disclosure is not so limited. For example, as illustrated in **FIG. 4**, a WLAN system **68** may provide WiFi services to wireless clients **24** without needing an DAS infrastructure. Thus, the WLAN system **68** may comprise one or more access points (AP) **70(1)-70(N)** coupled to hubs **72(1)-72(M)** by cabling **74**. Cabling **74** may, for example, be CAT5, CAT6 or other cabling as desired.

[0038] With continuing reference to **FIG. 4**, the WLAN system **68** may further include a location services server **76**. In the exemplary embodiment of **FIG. 4**, the APs **70(1)-70(N)**

may transmit respective SSID signals **77(1)-77(N)**. As discussed above with respect to **FIG. 3**, the SSID signals may include location information and, in an exemplary embodiment, may include three dimensional coordinates including a floor level. As illustrated, the wireless client **24** may receive multiple SSID signals **77** (as illustrated, the wireless client **24** receives SSID signals **77(1)**-**77(3)**). As noted above, the concrete in the floors may practically preclude reception of an SSID signal **77** by the wireless client **24** from a floor other than the floor on which the wireless client is located (as illustrated, the wireless client will not receive the SSID signal **77(4)** from the AP **70(4)**). As described above with reference to **FIG. 3**, the wireless client **24** may receive multiple SSID signals **77** and ascertain an RSSI for the received SSID signals **77** and from these values calculate a location for the wireless client **24**.

[0039] Instead of receiving the coordinates from the APs **66** or **70**, the wireless client **24** may receive other location information which allows the wireless client to ascertain its location. For example, the SSID signals **67**, **77** may provide a network address (or other unique identifier) of a location services server such as location services server **76**. The SSID signals **67**, **77** may further include a network address for the respective AP **66(1)-66(N)** or **70(1)-70(N)** which transmitted the SSID signal **67**, **77**. The wireless client **24** may then communicate with the location services server **76** (either through the WLAN system **68** or perhaps on a cellular frequency or SNMP) and query the location services server **76** as to the coordinates of the AP **66**, **70** whose address was extracted from the SSID signal **67**, **77**. The location services server **76** may have the coordinates stored in a database or look up table and provide the coordinates of the AP **66**, **70** on receiving the appropriate query from the wireless client **24**. Equipped with the coordinates of the AP **66**, **70** and the RSSI, the wireless client **24** may calculate its location. In another exemplary embodiment, the location services server **76** may perform the calculations and report the location to the wireless client **24**.

[0040] While the embodiments of **FIGS. 3** and **4** are useful in helping provide location based services, the AP **66**, **70** are relatively expensive. To ameliorate the cost, beacon terminals may be seeded into the distributed communications system. In an exemplary embodiment a beacon terminal may be relative “dumb” terminals and thus are relatively inexpensive and may be seeded throughout the distributed communications system heavily. The more heavily these beacon terminals are seeded, the greater potential for highly accurate location determination is achieved. An exemplary embodiment is provided with reference to **FIG. 5**. Here the WLAN system **68’** is substantially similar to WLAN system **68**, but beacon terminals (BTs) **78(1)-78(M)** are provided. The BTs **78(1)-78(M)** likewise have an SSID signal **77’** which includes either the coordinates of the BT **78** or the network address of the location services server **76**. While the WLAN system **68'** is illustrated, it should be appreciated that the beacon terminal may be used in an DAS as well without departing from the scope of the present disclosure. In an exemplary embodiment, the BTs **78(1)-78(M)** do not allow association or data transmission beyond the transmission of the SSID signal **77'** (i.e., they are "dumb" terminals). Note that in some exemplary embodiments, the beacon terminals **78** may be associated with power cables such as a composite cable having both DC power wires and fiber strands in a single cable. In such an exemplary embodiment, the beacon terminals **78** may use the DC power wires for power and/or separate copper wires for communication. In an alternate embodiment, the beacon terminals **78** may use the DC power wires for both power and communication signals.

[0041] **FIGS. 6** and **7** illustrate exemplary methodologies of the present disclosure in flow chart format. With reference to **FIG. 6**, an exemplary embodiment is provided. The initial step of method **99** is the system operator provides access points **66**, **70** in a distributed communications system **60**, **68**, **68'** (block **100**). Each AP **66**, **70** is programmed so that it broadcasts or otherwise transmits a SSID with coordinates (X, Y, Z) including a floor coordinate (block **102**). A user enters a building infrastructure **40** with a wireless client **24** (block **104**). The wireless client **24** communicates with the access points **66**, **70**, receives the coordinates and determines the RSSI of the access points **66**, **70** within range (block **106**). The wireless client **24** then calculates its location through triangulation, trilateration or comparable technique (with or without an algorithm being used (e.g., a look up table) (block **108**). As noted above, the control system **82** may cause the location applet **94** to perform the calculations.

[0042] In an alternate method **109**, illustrated in **FIG. 7**, the system operator provides access points **66**, **70** in a distributed communications system **60**, **68**, **68'** (block **110**). Each AP **66**, **70** is programmed so that it broadcasts or otherwise transmits a SSID with a network address (or other unique identifier) of the location services server **76** (block **112**). Note that while it is contemplated that the AP **66**, **70** is programmed, other techniques may be used to ascertain the location of the AP **66**, **70**. A user enters a building infrastructure with a wireless client **24** (block **114**). The wireless client **24** communicates with one or more access points **66**, **70** and receives the network address of the location services server **76** and calculates the RSSI of each AP **66**, **70** (block **116**). The wireless client **24** communicates with the location services server **76** and gets the coordinates (X, Y, Z) of the access points **66**, **70** with which the wireless client **24** is in communication (block **118**). In an alternate embodiment, instead of the location coordinates of the AP **66**, **70**, other information sufficient to ascertain the location of the wireless client **24** is provided. The wireless client **24** calculates the location of the wireless client **24** through triangulation, trilateration, or other technique (block **120**).

[0043] The location services server **76** may also, in an exemplary embodiment, alert the installer of a potential location change if power at an RAU **14** or BT **78** is cycled. The location services server **76** may also, in an exemplary embodiment, provide a map to the wireless client **24** in addition to the coordinates of the RAU **14**, BT **78**. The location services server **76** may also, in an exemplary embodiment, provide routing information on a map to guide a user from one point to another point. For example, the wireless client **24** may receive a map and instructions on how to get from the food court of a mall to a particular store. The location services server **76** may also, in an exemplary embodiment, receive an initial starting position from the wireless client **24** to assist in the creation of such map and instructions.

[0044] The distributed communications systems **60**, **68**, **68'** disclosed herein can include a computer system (e.g., HEU **12**, RAU **14**, location services server **76**). In this regard, **FIG. 8** is a schematic diagram representation of additional detail regarding such computer systems in the exemplary form of an exemplary computer system **200** adapted to execute instructions from an exemplary computer-readable medium to perform power management functions. In this regard, the computer system **200** may include a set of instructions for causing the computer system **200** to perform any one or more of the methodologies discussed herein may be executed. The computer system **200** may be connected (e.g., networked) to other machines in a LAN, an intranet, an extranet, or the Internet. The computer system **200** may operate in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. While only a single device is illustrated, the term "device" shall also be taken to include any collection of devices that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein. The computer system **200** may be a circuit or circuits included in an electronic board card, such as a printed circuit board (PCB) as an example, a server, a personal computer, a desktop computer, a laptop computer, a personal digital assistant (PDA), a computing pad, a mobile device, or any other device, and may represent, for example, a server or a user's computer.

[0045] The exemplary computer system **200** in this embodiment includes a processing device or processor **204**, a main memory **216** (e.g., read-only memory (ROM), flash memory, dynamic random access memory (DRAM) such as synchronous DRAM (SDRAM), etc.), and a static memory **208** (e.g., flash memory, static random access memory (SRAM), etc.), which may communicate with each other via the data bus **210**. Alternatively, the processing device

204 may be connected to the main memory **216** and/or static memory **208** directly or via some other connectivity means. The processing device **204** may be a controller, and the main memory **216** or static memory **208** may be any type of memory.

[0046] The processing device **204** represents one or more general-purpose processing devices such as a microprocessor, central processing unit, or the like. More particularly, the processing device **204** may be a complex instruction set computing (CISC) microprocessor, a reduced instruction set computing (RISC) microprocessor, a very long instruction word (VLIW) microprocessor, a processor implementing other instruction sets, or processors implementing a combination of instruction sets. The processing device **204** is configured to execute processing logic in instructions for performing the operations and steps discussed herein.

[0047] The computer system **200** may further include a network interface device **212**. The computer system **200** also may or may not include an input **214** to receive input and selections to be communicated to the computer system **200** when executing instructions. The computer system **200** also may or may not include an output **217**, including but not limited to a display, a video display unit (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)), an alphanumeric input device (e.g., a keyboard), and/or a cursor control device (e.g., a mouse).

[0048] The computer system **200** may or may not include a data storage device that includes instructions **218** stored in a computer-readable medium **220**. The instructions **218** may also reside, completely or at least partially, within the main memory **216** and/or within the processing device **204** during execution thereof by the computer system **200**, the main memory **216** and the processing device **204** also constituting computer-readable medium. The instructions **211** may further be transmitted or received over a network **222** via the network interface device **212**.

[0049] While the computer-readable medium **220** is shown in an exemplary embodiment to be a single medium, the term “computer-readable medium” should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term “computer-readable medium” shall also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by the processing device and that cause the processing device to perform any one or more of the methodologies of the embodiments disclosed herein.

[0050] The embodiments disclosed herein include various steps. The steps of the embodiments disclosed herein may be performed by hardware components, software components, and combinations thereof.

[0051] The embodiments disclosed herein may be provided as a computer program product, or software, that may include a machine-readable medium (or computer–readable medium) having stored thereon instructions, which may be used to program a computer system (or other electronic devices) to perform a process according to the embodiments disclosed herein.

[0052] Unless specifically stated otherwise as apparent from the previous discussion, it is appreciated that throughout the description, discussions utilizing terms such as “processing,” “computing,” “determining,” “displaying,” or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system’s registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices.

[0053] The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. In addition, the embodiments described herein are not described with reference to any particular programming language.

[0054] Those of skill in the art would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithms described in connection with the embodiments disclosed herein may be implemented as electronic hardware, instructions stored in memory or in another computer-readable medium and executed by a processor or other processing device, or combinations of both. The components of the distributed antenna systems described herein may be employed in any circuit, hardware component, integrated circuit (IC), or IC chip, as examples. Memory disclosed herein may be any type and size of memory and may be configured to store any type of information desired. To clearly illustrate this interchangeability, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. How such functionality is implemented depends upon the particular application, design choices, and/or design constraints imposed on the overall system.

[0055] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit

(ASIC), a Field Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A controller may be a processor.

[0056] The embodiments disclosed herein may be embodied in hardware and in instructions that are stored in hardware, and may reside, for example, in Random Access Memory (RAM), flash memory, Read Only Memory (ROM), Electrically Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM), registers, a hard disk, a removable disk, a CD-ROM, or any other form of computer-readable medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor.

[0057] It is also noted that the operational steps described in any of the exemplary embodiments herein are described to provide examples and discussion. The operations described may be performed in numerous different sequences other than the illustrated sequences. Furthermore, operations described in a single operational step may actually be performed in a number of different steps.

[0058] Further, as used herein, it is intended that terms “fiber optic cables” and/or “optical fibers” include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like.

[0059] The antenna arrangements may include any type of antenna desired, including but not limited to dipole, monopole, and slot antennas. The distributed antenna systems that employ the antenna arrangements disclosed herein could include any type or number of communications mediums, including but not limited to electrical conductors, optical fiber, and air (i.e., wireless transmission). The distributed antenna systems may distribute and the antenna arrangements disclosed herein may be configured to transmit and receive any type of communications signals, including but not limited to RF communications signals and digital data communications signals, examples of which are described in U.S. Patent Application No. 12/892,424 entitled “Providing Digital Data Services in Optical Fiber-based Distributed Radio Frequency (RF) Communications Systems, And Related Components and Methods,” incorporated herein by reference in its entirety. Multiplexing, such as WDM and/or FDM, may be employed in any of the distributed antenna systems described herein, such as according to the examples provided in U.S. Patent Application No. 12/892,424.

We claim:

1. A distributed communications apparatus, comprising:

at least one downlink input configured to receive downlink communications signals;

at least one interface configured to receive and provide the downlink communications signals to a remote unit; and

the remote unit configured to provide location indicia within an SSID signal to a wireless client within an antenna coverage area associated with the remote unit.

2. The distributed communications apparatus of claim 1, further comprising at least one uplink output configured to receive and communicate uplink communications signals from a communications uplink.

3. The distributed communications apparatus of claims 1 or 2, wherein the remote unit configured to provide location indicia within the SSID signal is configured to provide three dimensional coordinate information.

4. The distributed communications apparatus of claim 3, wherein the remote unit configured to provide three dimensional coordinate information is configured to provide floor information.

5. The distributed communications apparatus of any of claims 1 to 4, wherein the remote unit comprises an access point.

6. The distributed communications apparatus of any of claims 1 to 4, wherein the remote unit comprises a remote antenna unit coupled with an access point.

7. The distributed communications apparatus of any of claims 1 to 4, wherein the remote unit comprises a beacon terminal.

8. The distributed communications apparatus of claim 5, wherein the beacon terminal is configured to couple to a cable.

9. The distributed communications apparatus of claim 8, wherein the beacon terminal is configured to receive power over wires within the cable.

10. The distributed communications apparatus of claim 9, wherein the beacon terminal is configured to use the wires used for power also for communication.

11. The distributed communications apparatus of claim 9, wherein the beacon terminal is configured to use different wires within the cable for communication.

12. The distributed communications apparatus of claim 8, wherein the cable comprises a composite wired and optical cable.

13. The distributed communications apparatus of claim 1, wherein the remote unit configured to provide location information within the SSID signal is configured to provide a network address of a server configured to provide coordinate information relating to the remote unit to the wireless client.

14. The distributed communications apparatus of any of claims 1 to 8, wherein the distributed communications apparatus comprises an optical fiber based distributed antenna system.

15. The distributed communications apparatus of any of claims 1 to 8, wherein the distributed communications apparatus comprises a WLAN system.

16. A method to assist in provision of location based services, comprising:

receiving downlink communications signals at at least one downlink input;

providing the downlink communications signals to a remote unit; and

providing from the remote unit location indicia within an SSID signal to a wireless client within an antenna coverage area associated with the remote unit.

17. The method of claim 16, further comprising receiving uplink communications signals from the wireless client.

18. The method of claims 16 or 17, wherein providing from the remote unit location indicia comprises providing three dimensional coordinate information.

19. The method of claim 18, wherein providing three dimensional coordinate information comprises providing floor information.

20. The method of any of claims 16 to 19, wherein providing from the remote unit comprises providing from a beacon terminal.

21. The method of any of claims 16 to 19, wherein providing from the remote unit comprises providing from an access point.

22. The method of any of claims 16 to 19, wherein providing from the remote unit comprises providing from a remote antenna unit coupled with an access point.

23. The method of claim 16, wherein providing location indicia comprises providing a network address of a server configured to provide coordinate information relating to the remote unit to the wireless client.

24. The method of claim 23, further comprising, providing, from the server, location information relating to the remote unit.

25. The method of any of claims 16 to 24, wherein providing the downlink communications signals to the remote unit comprises using an optical fiber based distributed antenna system.

26. The method of any of claims 16 to 24, wherein providing the downlink communications signals to the remote unit comprises using a WLAN system.

27. The method of any of claims 16 to 26, further comprising generating an alert if power at the remote unit is cycled.

28. The method of claim 16, wherein providing location indicia comprises providing a map to the wireless client.

29. The method of claim 28, further comprising providing routing information related to the map.

30. The method of claim 24, wherein providing, from the server, location information comprises, calculating, at the server a location for the wireless client.

31. A wireless client, comprising:

a user interface;

a transceiver configured to send and receive wireless uplink and wireless downlink signals to a remote unit;

a control system operably connected to the user interface and the transceiver, the control system configured to receive location indicia within an SSID signal from the remote unit.

32. The wireless client of claim 31, wherein the control system configured to receive location indicia within the SSID signal receives three dimensional coordinates.

33. The wireless client of claims 31 or 32, wherein the control system configured to receive location indicia within the SSID signal receives floor information.

34. The wireless client of any of claims 31 to 33, wherein the control system configured to receive location indicia receives an address of a server and the control system is further configured to receive location information associated with the remote unit from the server.

35. The wireless client of any of claims 31-34, further comprising a sensor and wherein the control system is further configured to use data from the sensor in conjunction with the location indicia in calculating a current position of the wireless client.

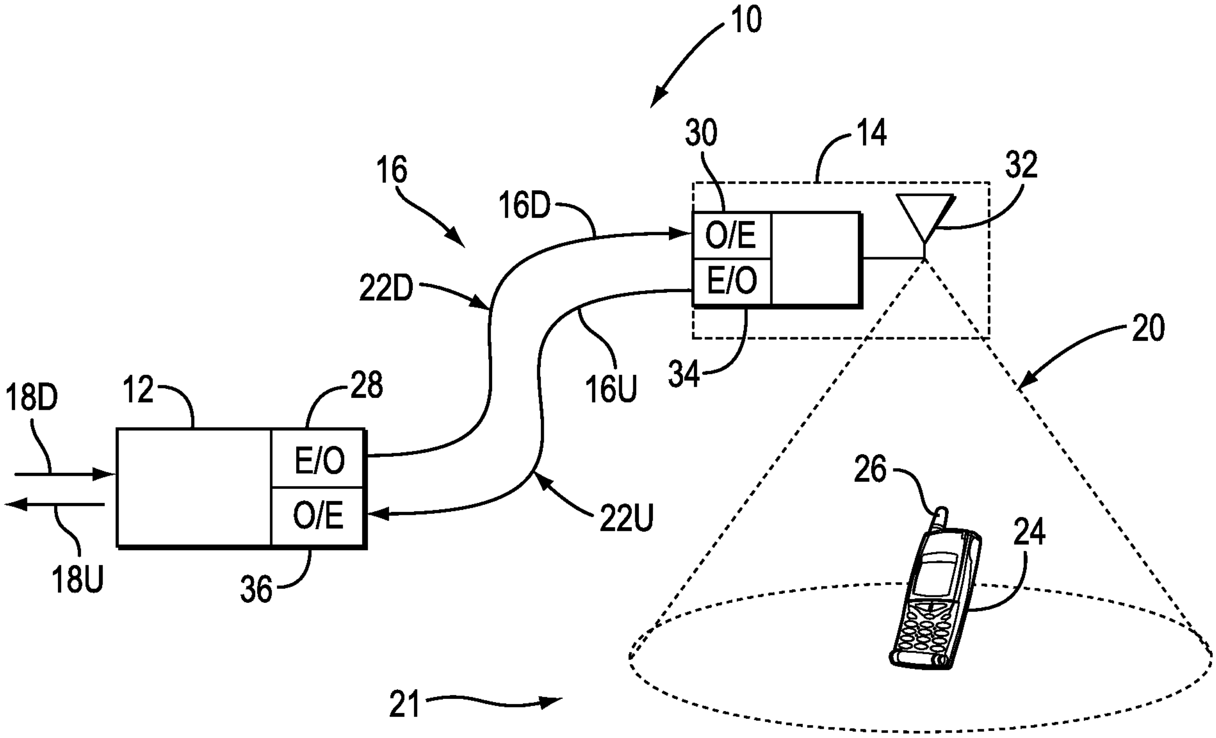
10
16
16D
22D
30
14
32
O/E
E/O
34
16U
20
18D
12
28
E/O
O/E
22U
26
24
18U
36
21

FIG. 1A

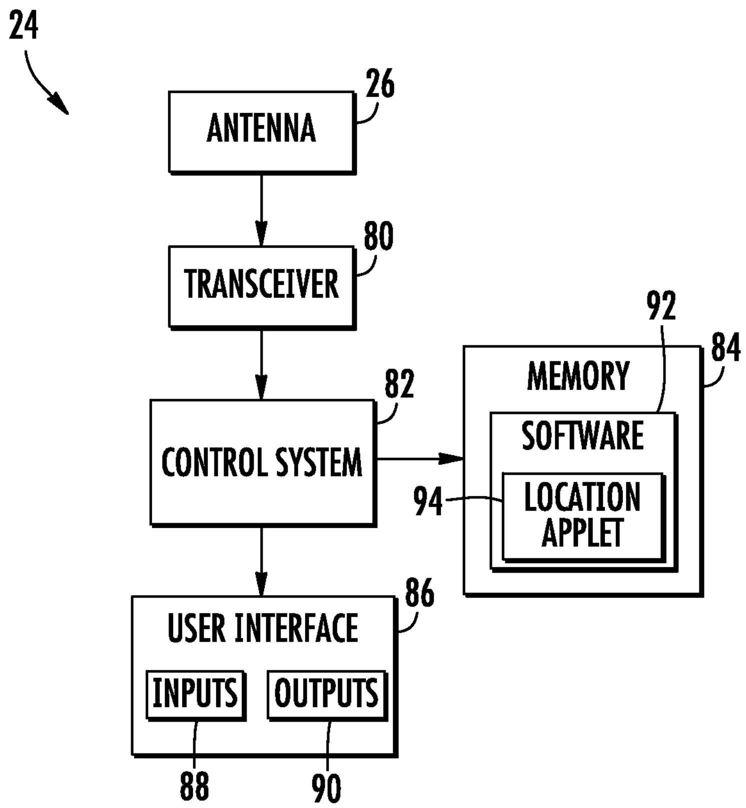
24
ANTENNA
26
TRANSCEIVER
80
CONTROL SYSTEM
82
MEMORY
84
SOFTWARE
92
LOCATION APPLET
94
USER INTERFACE
86
INPUTS
OUTPUTS
88
90

FIG. 1B

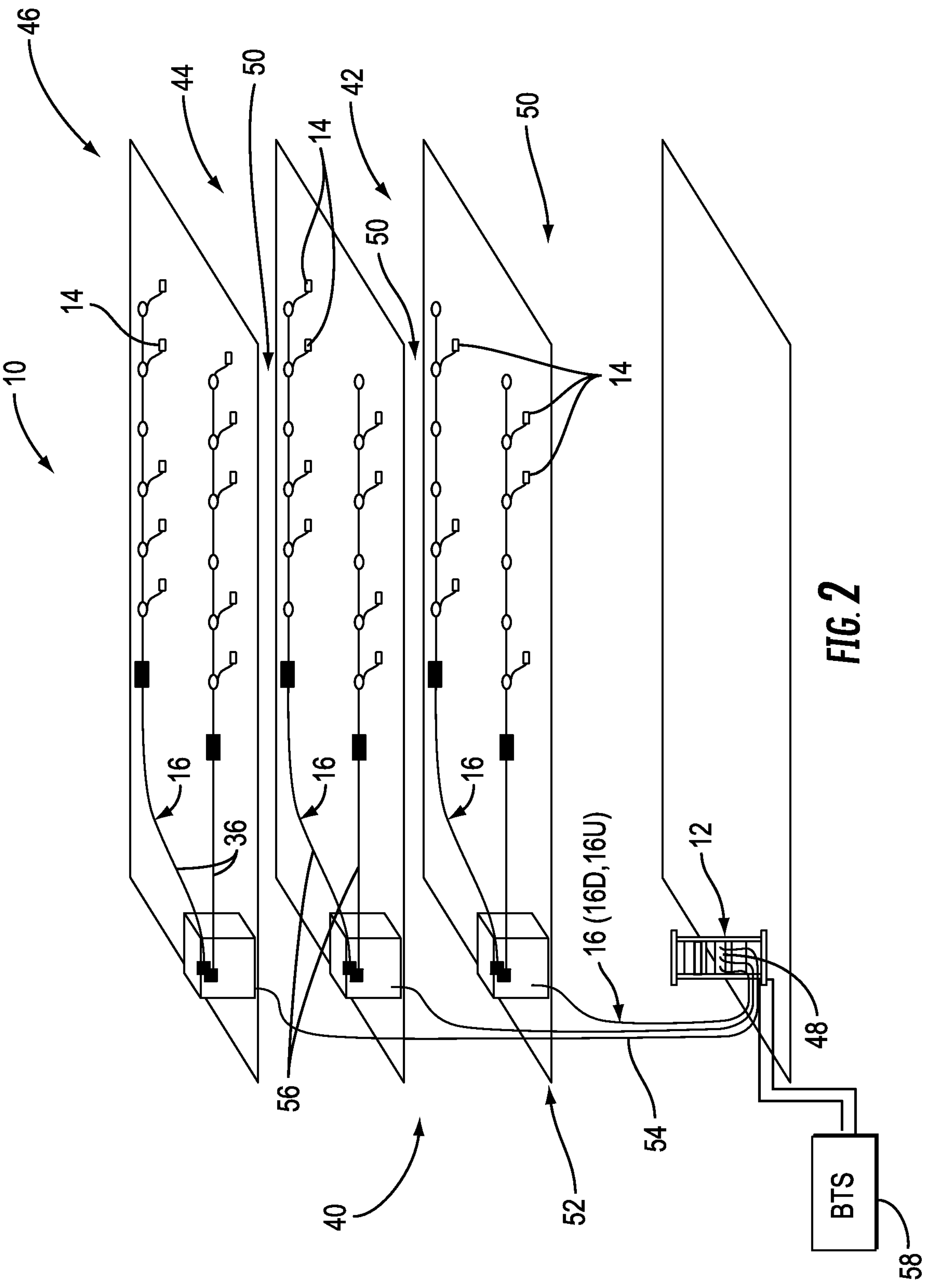
10
46
44
50
42
14
50
50
14
14
16
16
16
36
16 (16D,16U)
12
48
56
54
40
52
BTS
58

FIG. 2

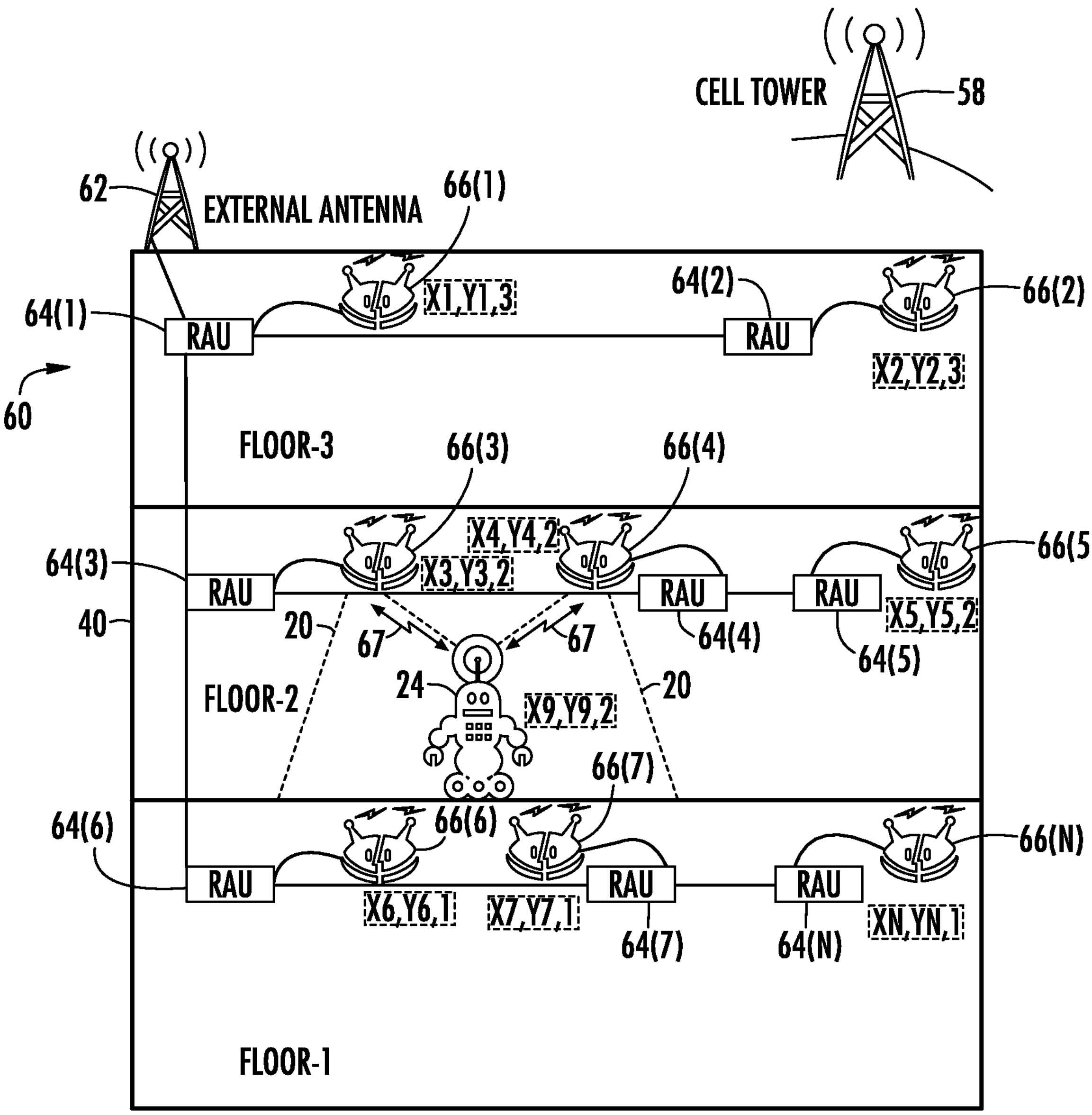
CELL TOWER
58
62
EXTERNAL ANTENNA
66(1)
64(1)
RAU
X1,Y1,3
64(2)
RAU
66(2)
X2,Y2,3
60
FLOOR-3
66(3)
66(4)
64(3)
RAU
X4,Y4,2
X3,Y3,2
RAU
RAU
66(5)
X5,Y5,2
40
20
67
67
64(4)
64(5)
24
FLOOR-2
X9,Y9,2
20
66(7)
64(6)
66(6)
RAU
RAU
RAU
66(N)
X6,Y6,1
X7,Y7,1
64(7)
64(N)
XN,YN,1
FLOOR-1

FIG. 3

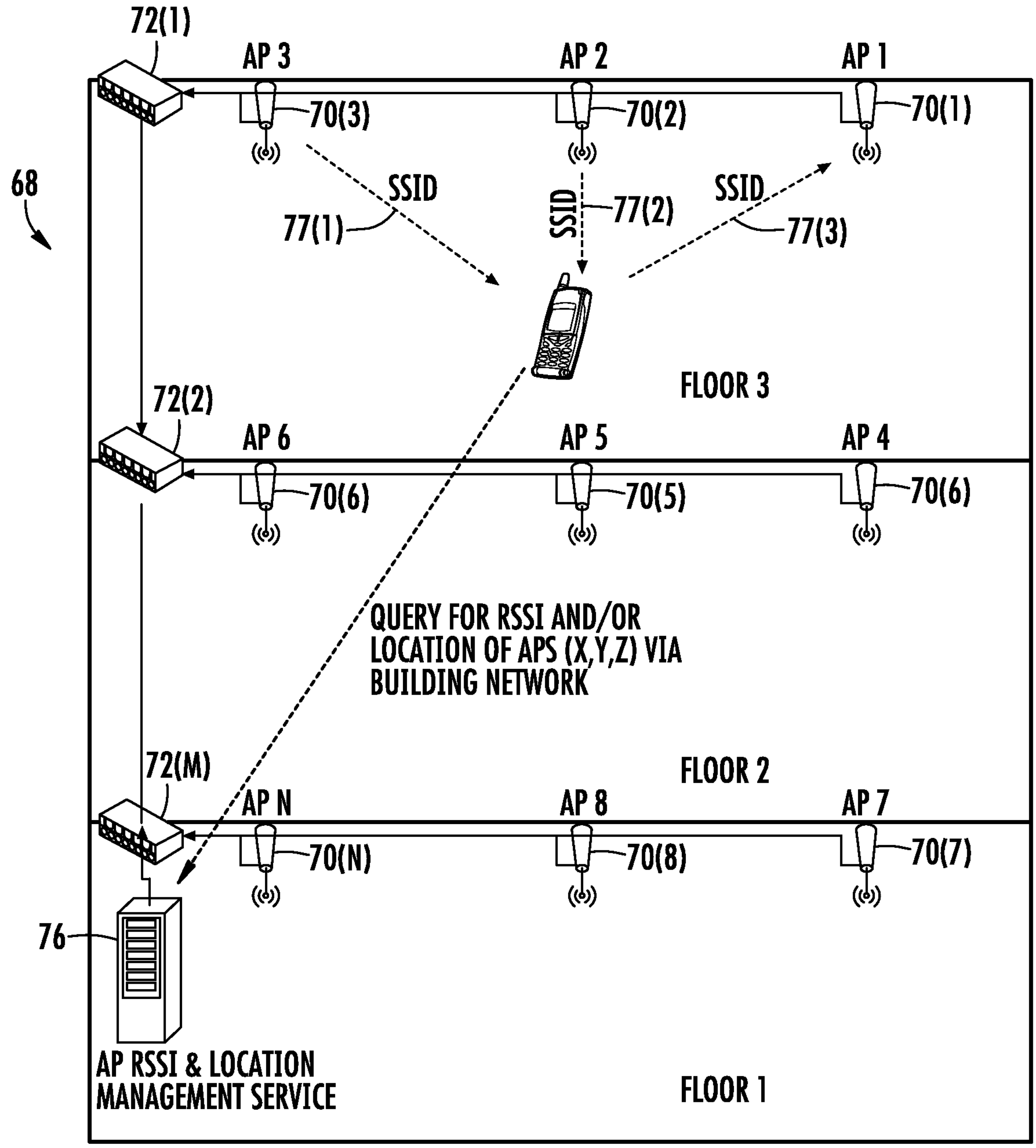
72(1)
AP 3
AP 2
AP 1
70(3)
70(2)
70(1)
68
SSID
77(1)
SSID
77(2)
SSID
77(3)
FLOOR 3
72(2)
AP 6
AP 5
AP 4
70(6)
70(5)
70(6)
QUERY FOR RSSI AND/OR LOCATION OF APS (X,Y,Z) VIA BUILDING NETWORK
72(M)
FLOOR 2
AP N
AP 8
AP 7
70(N)
70(8)
70(7)
76
AP RSSI & LOCATION MANAGEMENT SERVICE
FLOOR 1

FIG. 4

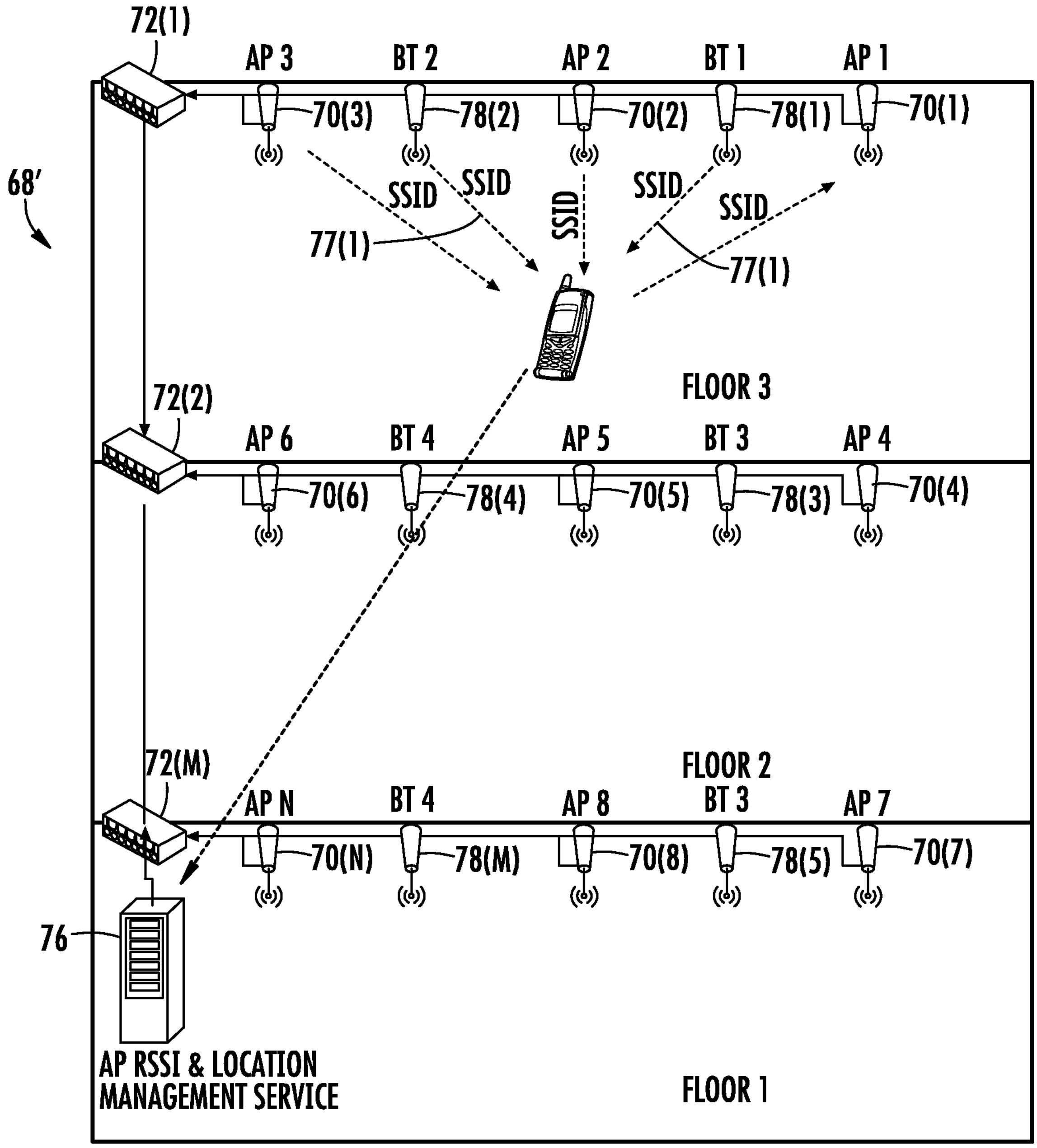
72(1)
AP 3
BT 2
AP 2
BT 1
AP 1
70(3)
78(2)
70(2)
78(1)
70(1)
68'
SSID
SSID
SSID
SSID
SSID
77(1)
77(1)
FLOOR 3
72(2)
AP 6
BT 4
AP 5
BT 3
AP 4
70(6)
78(4)
70(5)
78(3)
70(4)
72(M)
FLOOR 2
AP N
BT 4
AP 8
BT 3
AP 7
70(N)
78(M)
70(8)
78(5)
70(7)
76
AP RSSI & LOCATION
MANAGEMENT SERVICE
FLOOR 1

FIG. 5

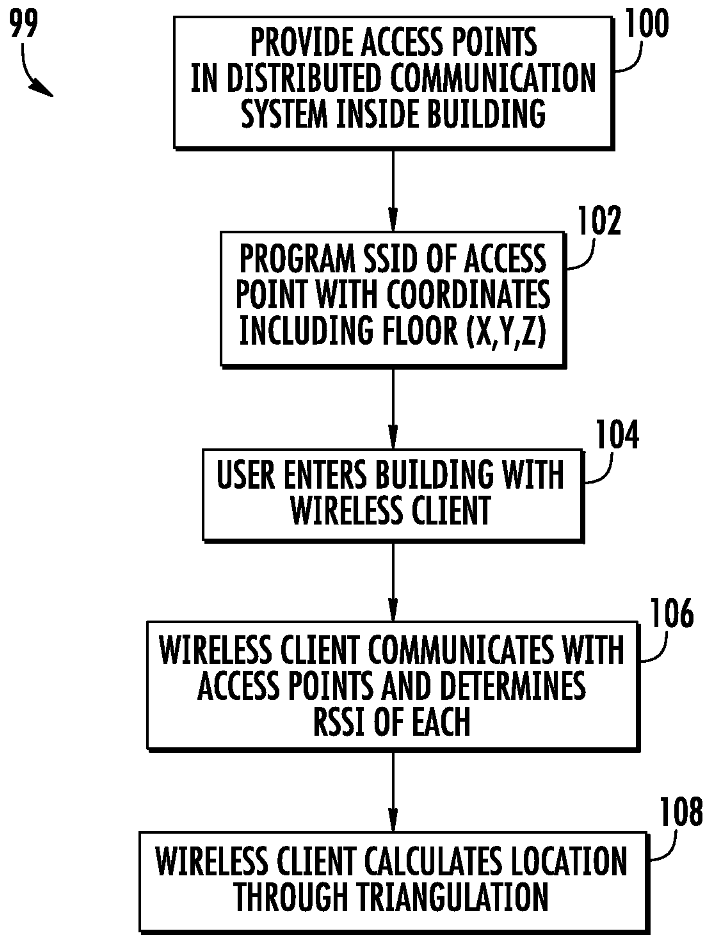
99
PROVIDE ACCESS POINTS IN DISTRIBUTED COMMUNICATION SYSTEM INSIDE BUILDING
100
PROGRAM SSID OF ACCESS POINT WITH COORDINATES INCLUDING FLOOR (X,Y,Z)
102
USER ENTERS BUILDING WITH WIRELESS CLIENT
104
WIRELESS CLIENT COMMUNICATES WITH ACCESS POINTS AND DETERMINES RSSI OF EACH
106
WIRELESS CLIENT CALCULATES LOCATION THROUGH TRIANGULATION
108

FIG. 6

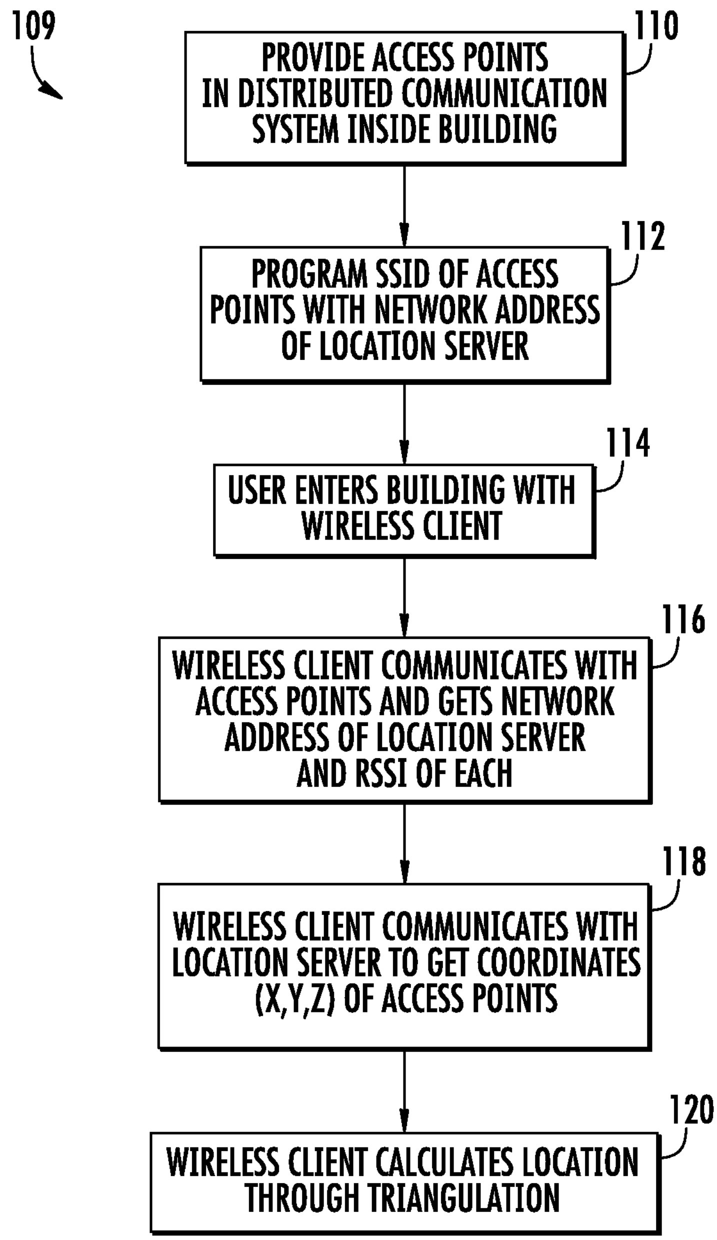
109
110
PROVIDE ACCESS POINTS IN DISTRIBUTED COMMUNICATION SYSTEM INSIDE BUILDING
112
PROGRAM SSID OF ACCESS POINTS WITH NETWORK ADDRESS OF LOCATION SERVER
114
USER ENTERS BUILDING WITH WIRELESS CLIENT
116
WIRELESS CLIENT COMMUNICATES WITH ACCESS POINTS AND GETS NETWORK ADDRESS OF LOCATION SERVER AND RSSI OF EACH
118
WIRELESS CLIENT COMMUNICATES WITH LOCATION SERVER TO GET COORDINATES (X,Y,Z) OF ACCESS POINTS
120
WIRELESS CLIENT CALCULATES LOCATION THROUGH TRIANGULATION

FIG. 7

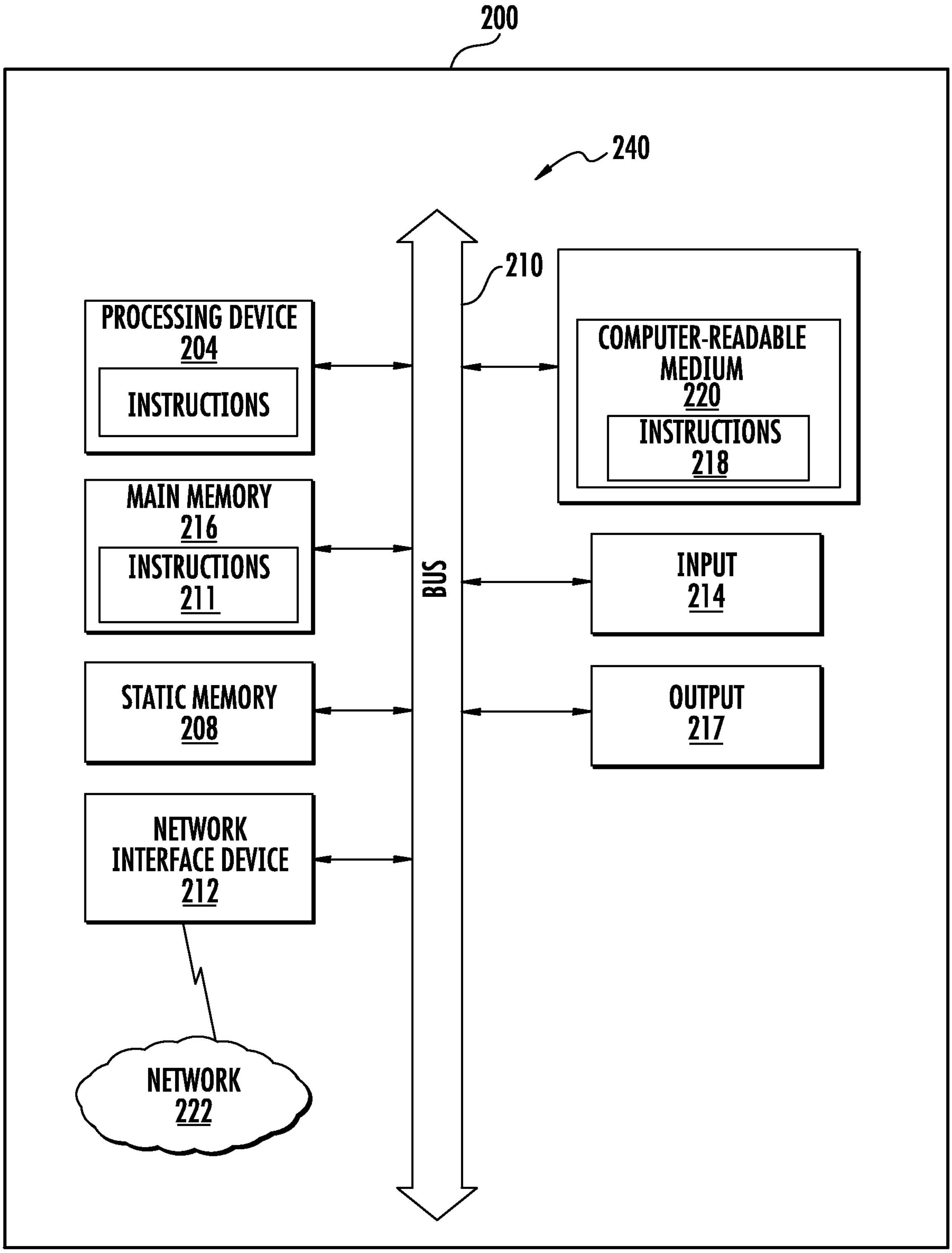
200
240
210
PROCESSING DEVICE
204
INSTRUCTIONS
MAIN MEMORY
216
INSTRUCTIONS
211
STATIC MEMORY
208
NETWORK
INTERFACE DEVICE
212
NETWORK
222
BUS
COMPUTER-READABLE
MEDIUM
220
INSTRUCTIONS
218
INPUT
214
OUTPUT
217

FIG. 8