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(54) Title: WIRELESS DEVICE POSITION DETERMINING AND FREQUENCY ASSIGNING SYSTEMS, DEVICES AND METHODS

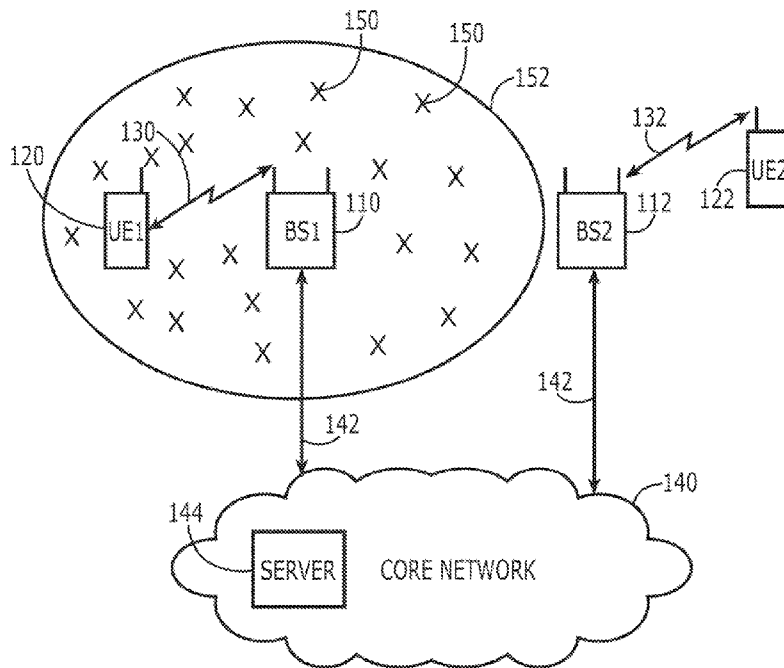


FIG. 1

(57) Abstract: Wireless communication methods determine a position of a first wireless base station. A wireless communication frequency to be used by the first wireless base station is determined by identifying a common frequency that can be used at a plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined. The first wireless base station may be a femto-base station and the frequency may be an unlicensed frequency. Related systems and devices are also described.

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## WIRELESS DEVICE POSITION DETERMINING AND FREQUENCY ASSIGNING SYSTEMS, DEVICES AND METHODS

### TECHNICAL FIELD

5           Various embodiments described herein relate to radio frequency communications and, more particularly, to wireless communication networks and devices, and methods of operating same.

### BACKGROUND

10           Wireless communication networks are increasingly being used for wireless communication with various types of wireless user terminals. The wireless network itself may include a plurality of space-apart wireless base stations, also commonly referred to as "base stations", "radio access nodes" or simply as "nodes", that define a plurality of cells, and a core network that controls the base stations and interfaces the  
15           base stations with other wired and/or wireless networks. The base stations may be terrestrial and/or space-based. The base stations communicate with the wireless user terminals using radio resources that are allocated to the wireless network. The radio resources may be defined in terms of time (for example, in a Time Division Multiple Access (TDMA) system), frequency (for example, in a Frequency Division Multiple  
20           Access (FDMA) system) and/or code (for example, in a Code Division Multiple Access (CDMA) system). The base stations may use licensed and/or unlicensed frequency spectrum. Radio resources may be assigned to wireless user terminals by the wireless network upon initial communication and may be reassigned due to, for example, movement of the wireless user terminals, changing bandwidth requirements, changing  
25           network traffic, etc.

          Various types of base stations have been employed during the evolution of wireless communications networks to define various types and sizes of cells deployed by an operator. The cellular industry refers to specific types of cells using loosely defined terms such as macro-cells, micro-cells and pico-cells in respective order of  
30           decreasing size. While it is difficult to pin down specific characteristics for these categories, cells, now often referred as "macro-cells", are deployed to provide the widest coverage area. Macro-cell base stations may have typical power output ranges

from the tens to hundreds of watts, and macro-cell diameters of up to 10km or more in size may be provided. A typical macro-cell has a site with a tower mounted antenna. Smaller cells, now typically referred to as "micro-cells", were also deployed to provide additional fill-in capacity where needed over relatively short ranges, such as about  
5 300m to about 2,000m, and may have an output power of a few watts. Even smaller and lower power base stations, often referred to as "pico-base stations" have been deployed with a power output of less than about 1 watt and a cell size of about 200m or less. While these definitions are provided to frame the succeeding material, it should be noted that various embodiments described herein relate to a hierarchy with macro-cells  
10 having large coverage areas and pico-cells having smaller coverage areas than macro-cells or micro-cells.

The latest type of base station is often referred to as a "femto-base station". These femto-base stations may be designed primarily for indoor coverage, and may have power output in the range of between about 1/10 to 1/2 watt, and cell size on the  
15 order of about 10-30m. These femto-base stations typically are portable, consumer-deployed units that may use licensed or unlicensed spectrum. Often, the backhaul to the wireless communications network is via a consumer-provided packet data connection, rather than a dedicated or leased line switched circuit backhaul used in the other types of base stations described. Accordingly, femto-base stations are a type of  
20 base station that may be referred to generically as a "re-deployable" base station. Some pico-base stations may be re-deployable as well.

These re-deployable base stations may have various power ranges, backhaul connection mechanisms and/or user terminal frequency spectrum, but can be installed by a customer or user without the need for intervention of a cellular operator. For  
25 example, they can be connected to an individual Digital Subscriber Line (DSL) and/or cable TV line, to provide for a broadband Internet connection. The re-deployable base station may be limited in range, as well as limited to be able to provide service to a limited number of user terminals, for example, only user terminals registered to a single customer or a group of affiliated customers, such as a small business.

30 Since these re-deployable base stations can be connected in numerous locations and be relocated by the customer at any time, it may be desirable to identify an accurate location of the re-deployable base station for purposes of network configuration

management, interference reduction, billing and/or other purposes. Unfortunately, however, many re-deployable base stations do not include a built-in position determination system, such as a Global Positioning System (GPS) or other equivalent system for determining the location thereof. Moreover, even if included, these position  
5 determination systems may not work well indoors.

Re-deployable base stations as well as other mobile devices may be deployed as secondary devices in spectrum that has already been assigned for primary use. The VHF and UHF spectrum assigned for TV in the USA is an example and is also commonly known as “white space” spectrum. In such cases, current rules and expected  
10 future rules for use of such spectrum allow secondary devices to access this spectrum in a license-exempt manner. However, registration with a database that maintains the status of spectrum usage, may be required. This database contains locations of secondary spectrum users. A device intending to use white space spectrum may need to be able to compute its location and then query the database to determine availability of  
15 the spectrum. Use of an available channel may then need to be registered with the database.

## SUMMARY

Wireless communication methods according to various embodiments described  
20 herein, determine a position of a first wireless base station by obtaining a position of a nearby second wireless base station, and determine the position of the first wireless base station from the position of the nearby second wireless base station that was obtained. In some embodiments, a wireless communication frequency to be used by the first wireless base station is determined by identifying a common frequency that can  
25 be used at a plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined. The first wireless base station communicates over the common frequency that was identified.

Various techniques may be used to determine the position of the first wireless base station from the position of the nearby second wireless base station that was  
30 obtained. In some embodiments, the position of the first wireless base station is identified as the position of the nearby second wireless base station that was obtained. In other embodiments, the position of the first wireless base station is determined from

the position of the nearby second wireless base station that was obtained and from the path loss and/or a direction between the first wireless base station and the nearby second wireless base station.

Moreover, the position of the nearby wireless base station may be obtained by  
5 requesting the position of the nearby wireless base station from a core network and obtaining the position of the nearby second wireless base station from the core network. In some embodiments, the core network identifies the nearby second wireless base station using communications from a wireless user terminal that is receiving signals from both the first wireless base station and the nearby second wireless base station. In  
10 other embodiments, the requesting of a position of a nearby second wireless base station from the first wireless base station is communicated to the second nearby wireless base station via the core network and the position of the nearby second wireless base station is communicated from the nearby second wireless base station to the first wireless base station via the core network.

15 Many different techniques also may be used to identify a common frequency that can be used at a plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined. In some embodiments, one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the position of the first wireless base station that  
20 was determined are identified. The one or more frequencies that were identified for the respective ones of the plurality of locations are compared to identify the common frequency that can be used at the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined. In some embodiments, the position of the first wireless base station that was determined defines  
25 a region of position uncertainty and the plurality of locations surrounding and spaced apart from the position of the first wireless base station span the region of position of uncertainty. Additionally, in some embodiments, a database that is external to the wireless base station is queried to identify the one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the  
30 position of the first wireless base station that was determined. These frequencies may be unlicensed frequencies.

Various embodiments have been described above in connection with wireless communication methods. However, analogous wireless communications systems and wireless communications devices, such as wireless base stations, user terminals and/or core network elements such as servers, may also be provided according to various  
5 embodiments described herein. Moreover, the aspects of determining a position of a wireless base station and of determining a wireless communication frequency to be used by a wireless base station may also be used separately according to various embodiments described herein.

For example, a wireless base station may comprise a wireless transceiver and a  
10 processor that is configured to control the wireless transceiver, to obtain a position of a nearby wireless base station and to determine a position of the wireless base station from the position of the nearby wireless base station that was obtained. The processor may be configured to determine the position of the wireless base station from the position of the nearby wireless base station that was obtained, by identifying the  
15 position of the wireless base station as the position of the nearby wireless base station that was obtained, and/or from a path loss and/or a direction between the wireless base station and the nearby wireless base station, as was described above. In other embodiments, the position of the nearby wireless base station may be requested and obtained from the core network and may be communicated from the nearby wireless  
20 base station to the wireless base station via the core network. In some embodiments, the wireless base station and/or the nearby wireless base station are re-deployable wireless base stations, such as femto-base stations.

In another example, a server of a wireless communication system according to other embodiments described herein may include an input/output interface that is  
25 configured to communicate with the core network and a processor that is configured to determine a common frequency that can be used at a plurality of locations surrounding and spaced apart from a wireless base station in response to a measure of a position of the wireless base station that is received from the input/output interface. As was described above, the common frequency may be identified by obtaining one or more  
30 frequencies that can be used at a respective one of a plurality of locations surrounding and spaced apart from the estimated position of the wireless base station, and comparing the one or more frequencies that were obtained to identify the common

frequency. As was also described above, the plurality of locations surrounding and spaced apart from the wireless base station can span a region of position uncertainty. As was also described above, a database may be queried to identify the one or more frequencies.

5           The separate aspects of determining a position of a wireless base station and determining a wireless communication frequency to be used by the wireless base station, were described above in terms of a wireless base station and a server. However, analogous methods may also be provided according to various embodiments described herein. These methods may be performed by the wireless base station, a  
10 wireless user terminal and/or an element of the core network such as a server.

          Accordingly, a position of a wireless base station and/or a wireless communication frequency to be used by the wireless base station may be determined according to various embodiments described herein. These embodiments may be particularly useful for re-deployable wireless base stations, such as femto-base stations,  
15 that can use licensed or unlicensed frequency spectrum.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

          Figure 1 is a block diagram of wireless communication systems, methods and devices according to various embodiments described herein.

20           Figures 2-6 are flowcharts of operations may be performed to provide wireless communication according to various embodiments described herein.

          Figure 7A is a block diagram of a wireless base station according to various embodiments described herein.

          Figure 7B is a block diagram of a server according to various embodiments  
25 described herein.

          Figures 8 and 9 are flowcharts of other operations that may be performed to provide wireless communications according to various other embodiments described herein.

          Figures 10-13 are block diagrams of wireless communication systems, methods  
30 and devices according to yet other embodiments described herein.



**DETAILED DESCRIPTION**

Figure 1 is a block diagram of wireless communication systems, methods and devices according to various embodiments described herein. As illustrated in Figure 1, these wireless communication systems/methods/devices include a first wireless base station (BS1) **110** and a second nearby wireless base station (BS2) **112**. The first base station **110** communicates with a first wireless terminal, also referred to as a User Equipment 1 (UE1) **120**, and the second base station **112** communicates with a second User Equipment 2 (UE2) **122**, via first and second wireless links **130** and **132**, respectively. The first and second base stations **110** and **112** communicate with a core network **140** using backhaul links **142**. The core network **140** may include, or may be connected to, at least one server **144** for position determination and/or frequency assignment. Thus, the server **144** may be included within the core network **140** or may be external thereto.

It will be understood that Figure 1 only illustrates two wireless base stations **110** and **112**, and two pieces of UEs **120** and **122**. However, wireless communication systems and methods typically employ large numbers of base stations and user equipment that can communicate with a core network.

In some embodiments, the wireless base stations **110** and/or **112** comprise re-deployable base stations, such as femto-base stations, that may communicate with the user equipment **120**, **122** using wireless links **130**, **132** that use licensed wireless communication frequencies and/or unlicensed frequencies. As used herein, the term "unlicensed frequency" includes a frequency that is usable by any user in a license-exempt manner and also includes so-called "white space" frequency spectrum that may be used by secondary users in a license-exempt manner when the primary user (e.g. TV stations) owning the license for the spectrum is not using it. Moreover, in a re-deployable wireless base station, the backhaul links **142** with the core network **140** may be IP-based links over a DSL and/or cable modem rather than conventional leased line backhaul links.

Figure 2 is a flowchart of operations that may be performed to provide wireless communication according to various embodiments described herein. These operations may be performed by a wireless base station, such as the wireless base stations **110**,

112 of Figure 1, wireless user terminals, such as user equipment 120, 122 of Figure 1 and/or a core network, such as the core network 140 and/or the server 144 of Figure 1.

Referring now to Figure 2, at Block 210, a position of a first wireless base station, such as the first wireless base station 110 of Figure 1, is determined by  
5 obtaining a position of a nearby second wireless base station, such as base station 112 of Figure 1, and determining the position of the first wireless base station from the position of the nearby second wireless base station that was obtained. It will  
understood that, as used herein, a "nearby" base station means a base station that is sufficiently close to the base station of unknown position, such that the unknown  
10 position of the base station may be determined with a desired degree of accuracy based on a known position of the nearby base station. In some embodiments, a nearby base station comprises a base station that is sufficiently close, such that a common user terminal can directly communicate with both the nearby base station and the base station in question.

15 In some embodiments, as shown at Block 220, a wireless communication frequency to be used by the first wireless base station, such as the base station 110 of Figure 1, may be determined by identifying a common frequency that can be used at a plurality of locations, such as the locations 150 of Figure 1, that are surrounding and spaced apart from the position of the first wireless base station 110 that was  
20 determined. These locations 150 may span a region of position uncertainty 152 that is defined by an amount of uncertainty in the position of the first wireless base station 110 that was determined.

Referring back to Figure 2, at Block 230, the first wireless base station 110 communicates over the common frequency that was identified, for example by using  
25 the common frequency that was identified as the wireless link 130 between user equipment 120 and the first base station 110. Finally, at Block 240, if the position of the base station 110 is changed, for example by unplugging and redeploying the re-deployable base station, then the operations of Blocks 210, 220 and 230 are performed again. Until then, operations can end and communication can continue on the  
30 identified frequency.

Figure 3 is a flowchart of operations that may be performed to determine a position of a first wireless base station, which may correspond to Block 210 of Figure

2. The identity of a second wireless base station may be determined by the first wireless base station by listening for transmissions from nearby base stations. Referring now to Figure 3, at Block **310**, the position of the identified second wireless base station **112** is determined. The position of the second wireless base station **112** may be determined by the second wireless base station **110** and/or by the core network **140** including the server **144**. Then, at Block **320**, the position of the first wireless base station **110** is identified as the position of the nearby second wireless base station **112** that was obtained. In other words, in these embodiments, the position of the first wireless base station **110** is made equal to the position of the second wireless base station **112**. Since, in the case of re-deployable base stations, such as femto-base stations, the transmissions occur over a very small area, such as on the order of 10-30m, this assumption may provide a sufficiently accurate determination of the position of the first wireless base station **110**.

Figure 4 is a flowchart of operations that may be performed to determine a position of the first wireless base station **110** according to other embodiments described herein, and may also correspond to operations of Block **210**. In these embodiments, the position of the second wireless base station **112** is determined as was described above in connection with Block **310**. Then, at Block **410**, a path loss between the first and second wireless base stations and/or a direction between the second wireless base station **112** to the first wireless base station **110** is determined. Finally, at Block **420**, the position of the first wireless base station **110** is determined from the position of the second wireless base station **112** that was obtained and from the path loss and/or direction that were determined. Additional details will be provided below.

Figure 5 is a flowchart of operations that may be performed to determine a position of the second wireless base station **112**, which may correspond to operations of Block **310** of Figures 3 and 4. These operations may be performed by the first and/or second wireless base stations **110** and **112** of Figure 1 and/or by the core network **140** of Figure 1 including server **144**.

Referring to Figure 5, at Block **510**, the first wireless base station **110** requests the position of a nearby base station from the core network. Then, at Block **520**, the core network **140** including the server **144**, identifies the nearby base station and its position. Identification of the nearby base station may be obtained using the UE reports

for nearby base stations. At Block **530**, the core network determines the position of the first wireless base station **110** from the identification of the nearby base station and its position, for example using operations of Blocks **320**, **410** and/or **420** described above. When operations of blocks **410** and **420** are used, measurement data, e.g., may be transferred from the first base station to the core network. Then, at Block **540**, the wireless base station **110** receives its position from the core network.

Various techniques may be used by the core network at Block **520**. For example, as shown in Figure 6 at Block **610**, a wireless user terminal is identified by the core network that can communicate with both the first and the second wireless base stations. Thus, communications with a common wireless user terminal would indicate that the wireless user terminal is receiving signals from both the first wireless base station **110** and the nearby second wireless base station **112** because the two base stations are quite close to one another. Then, at Block **530**, the core network determines the position of the first wireless base station **110** based on the second base station **112** that was identified at Block **610**.

It will be understood that operations of Figures 3-6 have been described above in connection with a wireless communication system/method of Figure 2, wherein a position is determined at Block **210**, and a communication frequency is determined at Block **220**. However, embodiments of Figures 3-6 may also be used independent of determining a wireless communications frequency to be used at Block **220** of Figure 2.

Thus, according to other embodiments described herein, a wireless base station may be provided as illustrated in Figure 7A. The wireless base station, such as the wireless base station **110** of Figure 1, includes a re-deployable housing **710** that is portable and that may be placed, moved, installed and reinstalled by a consumer. A processor **720**, a transmitter **730**, a receiver **740** and an antenna **750** may also be provided. The transmitter and receiver may be at least partially combined in a transceiver **760**. The antenna **750** may include one or more antennas that can communicate with the transceiver **760** through one or more antenna ports. The processor **720** may be coupled to the core network, such as the core network **140** of Figure 1, for example using a link **142** such as an IP link over DSL and/or cable. The processor **720** may be configured, at least in part, to control the wireless transceiver **760**, and to obtain a position of a nearby wireless base station using transceiver **760**

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and/or link **142**. The processor **720** may be further configured to obtain and/or determine a position of the wireless base station from the position of the nearby wireless base station that was obtained. Accordingly, a wireless base station **110** according to embodiments of Figure 7A may be configured to perform operations of Blocks **310**, **320**, **410**, **420**, **510** and/or **540**. In other embodiments, the core network **140** including the server **144** may perform one or more of these operations.

Moreover, according to other embodiments described herein, a server may be provided as illustrated in Figure 7B. The server, such as the server **144** of Figure 1, may be included within the core network **140** or may be external thereto. The server **144** includes an input/output (I/O) interface **790** that is configured to communicate with the core network **140** and/or the wireless base stations **110**, **112** over one or more links **792**, a processor **770** and a database **780**. The processor **770** may be configured, at least in part, to identify a position of a nearby wireless base station and/or to obtain and/or determine a position of a wireless base station from the position of a nearby wireless base station that was obtained. Accordingly, a server **144** according to embodiments of Figure 7B, may be configured to perform operations of Blocks **310**, **320**, **410**, **420**, **510**, **520**, **530**, **540** and/or **610** based on measurements supplied by the wireless base stations and/or wireless user terminals as needed. In other embodiments, the wireless base station may perform one or more of these operations using its own I/O interface and processor.

Figure 8 is a flowchart of operations that may be performed to determine a communications frequency to be used by the first wireless base station, and may correspond to operations of Block **220** of Figure 2. These operations may be performed by the first and/or second wireless base stations **110** and/or **112** of Figure 1, and/or the core network **140** of Figure 1 including by the server **144**. In some embodiments, these operations may only be performed if the accuracy of the estimated position is worse than about 50 meters or some other accuracy value.

Referring now to Figure 8, at Block **810**, a common frequency that can be used at a plurality of locations surrounding and spaced apart from the first wireless base station **110**, is identified if the position estimate of the wireless base station is inaccurate. Determining communications frequency may involve communication with a server on the Internet outside of the core network that may host a database being used

to manage spectrum usage. Specifically, in some embodiments, a server **144** can determine the common frequency in response to a measure of a position of a wireless base station **110** that is received via the input/output interface **790** of Figure 7B. The server may receive the position directly from the wireless base station without direct core network involvement. Although the packets may flow over the core network, the position information may be sent over a TCP/IP interface so that the core network has no knowledge of the communications between the wireless device and the server. In other embodiments, the core network may obtain the position of the wireless base station and provide this position to the server. In some embodiments, the position of the first wireless base station that was determined defines a region of position uncertainty, and the plurality of locations surrounding and spaced apart from the position of the first wireless base station span the region of position of uncertainty. Then, at Block **820**, the first wireless base station communicates over the common frequency that was identified.

Figure 9 is a flowchart of operations that may be performed to identify the common frequency, which may correspond to Block **810** of Figure 8. In some embodiments, these operations are performed by the core network **140** including the server **144**. However, in other embodiments, the operations may be performed, at least in part, by the wireless base station **110**.

Referring now to Figure 9, at Block **910**, one or more frequencies are identified that can be used at a respective one of the plurality of locations, such as the locations **150** surrounding and spaced apart from the position of the first wireless base station that was determined. Then, at Block **920**, the one or more frequencies that were identified for the respective ones of the plurality of locations are compared to one another, to identify the common frequency that can be used at the plurality of locations **150** surrounding and spaced apart from the position of the first wireless base station that was determined. In some embodiments, the operations of Block **910** may be performed by querying a database that is external of the wireless base station **110**, for example the database **780** that is associated with the server **144**, to identify the one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined. Moreover, in other embodiments, the comparison of Block **920** is also

performed at the core network, for example by the server 144, using the results of the database query, and the common frequency that was then determined is provided to the wireless base station 110 via the links 792 and 142.

Various embodiments of Figures 8 and 9 have been described above in connection with embodiments of Figure 2. However, embodiments of Figures 8 and 9 may also be used independent of embodiments of Figure 2. For example, referring back to Figure 7, the processor 720 of the wireless base stations 110 and/or the processor 770 of the server 144 may be configured to identify the common frequency that can be used at the plurality of locations surrounding and spaced apart from the wireless base station 110. The processor may be further configured to control the wireless transceiver 760 to wirelessly communicate over the common frequency that was identified. It will be understood that, in some embodiments, the processor 720 of the wireless base station 110 itself may perform the operations of Block 810, 820, 910 and 920. In other embodiments, the operations of Blocks 810, 910 and 920 may be performed by the core network 140, for example by the server 144, and the processor 720 of the wireless base station 110 may be configured to obtain the common frequency from the core network over links 792 and 142 and to control the transceiver 760 to communicate using the common frequency that is identified at Block 820.

Additional discussion of various embodiments will now be provided. Specifically, demand for mobile broadband services is increasing rapidly and the availability of spectrum is becoming a limiting factor. Among many plans being drawn up by regulatory bodies and wireless communications enterprises to make more spectrum available, the use of so-called spectrum "white spaces" is a technique that is gaining in prominence. Such white spaces are essentially unused parts of spectrum that have been licensed for some other purpose, e.g., digital TV broadcasting. To facilitate the use of such whitespace devices, one technique that is being employed is the use of a database which provides information about possible transmission based on the position of a device intending to use white space spectrum. In the case of the US Federal Communications Commission (FCC), the database contains a list of useable channels at the queried position with the transmission parameters being fixed. The database may provide other transmission parameters, such as antenna pattern, direction, transmit power allowed, etc. In the case of the Cognitive Radio System - White Space (470-

790MHz) Working Group SE43, the database provides the maximum transmit power that may be used at the queried position.

All white space devices need not query the database on their own. A white space device manager or server can query the database on behalf of one or more white space devices with different locations for the white space devices. Alternately, the device manager can query the database for a region potentially containing one or more white space devices. An example of such a group query is one from a base station that inquires about the useable channels for the uplink for all user equipment within range of its cell. At a higher level in the network hierarchy, a network management node may query all the useable channels for the downlink or uplink that may be used by multiple base stations in an area.

A good candidate for use of white spaces are femto-base stations (hereinafter referred to as "femto-BS"). This is true due to at least several reasons. First, femto-BS generally operate indoors and transmit with very low powers so as not to interfere with the macro network. They also can operate as extensions of the outdoor cellular network. However, in order to query a database, a femto-BS needs to know its own position which is not always the case.

Cellular networks provide multiple techniques for computing positions of a wireless terminal (hereinafter referred to as "User Equipment" or "UE") registered with the network. The location techniques may include cell ID, receive signal strength based positioning, time of arrival (TOA) based positioning, time difference of arrival (TDOA) based positioning and/or assisted GPS. In the cell ID technique, the network returns the cell ID of the serving base station or some position derived from this cell ID as the position of the UE. In the receive signal strength based technique, the UE reports the received signal strength from the serving and neighboring base stations. This signal strength signature is compared with a database mapping signal strengths to positions within the coverage area and with further processing a position for the UE is computed. In the TOA and TDOA techniques, the UE computes the time of arrival of signals from multiple base stations. This information may be used to compute the position of the UE either at the UE itself or at a positioning server in the network. For assisted GPS, the cellular network provides side information about the current state of GPS to the UE which helps the GPS receiver inside the UE work at lower signal levels and/or acquire



GPS position more quickly. The assistance information typically includes information such as the almanac and ephemeris that provide coarse and fine information respectively regarding the orbits of the GPS satellites and accurate time information. This information may be used by the GPS receiver to reduce the time-frequency search window within which the receiver must search for signals from GPS satellites. Alternately, time and frequency search windows could be directly provided to the GPS receiver by the cellular network. Lastly, the position may also be computed with a standalone GPS receiver where no assistance information is provided to the GPS receiver by the network. This typically leads to very poor indoor performance and long times to first fix.

However, femto-BSs are typically not installed by operators and are most likely to be installed by private parties. Therefore, the operator generally does not have control over where exactly they may be situated. They may also be relocated after the initial installation. Thus, the position of femto-BS is typically not known. Some femto-BS come with GPS receivers but typically they do not work well indoors. In some cases, femto-BSs come with GPS receivers with instructions that they should be installed near a window so that the GPS receiver may work. This often creates problems due to interference with the outdoor cellular network. From an interference point of view, it is better for the femto-BS to be away from the exteriors of the home or office building. In addition to reducing or minimizing interference, such a central location also provides better coverage inside the premises. When femto-BS are not equipped with GPS, its ability to use white space spectrum is limited since it cannot query the database with its own position.

Various embodiments described herein can provide systems/devices/ methods for a femto-BS to obtain its own position and query a database, or to initiate a query of the database, so as to be able to use white space spectrum. Other systems/devices/methods allow a femto-BS or any other white space device that is unable to position itself accurately to be able to use white space spectrum nevertheless.

Various embodiments described herein allow the position of the femto-BS to be computed so that a database may be queried to determine if whitespace spectrum could be used at the determined position. The database may be queried by the femto-BS itself or by another manager/controller node on its behalf. Various embodiments described

herein also allow a femto-BS or any other whitespace device to use white space spectrum when it is not able to determine its position with the requisite accuracy.

Referring to Figures 10 and 11, the position of the femto-BS **110** may be computed using a separate UE **120** whose position is computed first which then enables the computation of the position of the femto-BS **110**. The position of the UE **120** may be computed in multiple ways. A cellular network **1030** based positioning method such as cell ID, TOA or TDOA based positioning could be used, as illustrated in Figure 11. Alternately, as illustrated in Figure 10, assisted GPS via GPS satellites **1020** may be used if the UE **110** is equipped with a GPS receiver. These techniques were described in detail above and the description will not be repeated. In general, as shown in Figure 10, GPS data may be obtained by the UE **120** from GPS satellites **1020**, and assistance information may be communicated from a position server **144** in a core network **140** over a link **142** via an Internet Service Provider (ISP) network **1040**. Alternatively, as shown in Figure 11, the server **144** may communicate position information over link **142** via the ISP network **1040**, and the UE **120** may communicate assistance information to the femto-BS **110**, as well.

Indoor operation within a structure **1010** is often an issue with the above positioning techniques, especially for GPS. In some embodiments, other sensors such as a gyroscope, compass and/or an accelerometer that may be present in the UE **120** are used to improve performance. In some embodiments, the position of the UE **120** can be computed via GPS while the UE **120** is outdoors and then the accelerometer and compass can be used to monitor the trajectory of the UE **120** as it is carried inside the structure **1010** towards the femto-BS **110**. In this manner, the position of the femto-BS **110** may be obtained using the associated UE **120**.

Once the UE **120** position is computed, the femto-BS **110** position could be assumed to be the same as the positioning UE **120** with some uncertainty, which may be quantified based on the measured path loss to the UE **120**. The measured path loss could also be used to determine a distance from the UE **120**. If the femto-BS **110** has multiple antennas, they may be used to estimate a coarse direction for the UE **120**. The direction and distance estimates could be used together to obtain a rough estimate of the position of the femto-BS **110**, if desired.

There are two possibilities for an associated UE **120**. In the first case, the UE **120** may be a special UE that is provisioned with the femto-BS **110**. In the second case, the UE **120** may be any generic UE that connects to the femto-BS **110**.

A special purpose UE that is provisioned with the femto-BS **110** may be used to  
5 compute its position and then help compute the position of the femto-BS **110**. The UE may be an auxiliary device that does not have all the capabilities of a regular UE. The special purpose UE could also have additional positioning capabilities in comparison to a regular UE. For example, it may have WLAN and/or Bluetooth based positioning. It may also be equipped with multiple antennas to enable direction finding methods. The  
10 special purpose UE could also be equipped with an indicator light which turns green when the UE is getting good GPS or cellular signal strength.

A generic UE could be a UE or a set of UEs that are already owned by the femto-BS user. Alternately, other UEs that may be capable of connecting to the femto-BS may be used as well.

Referring now to Figure 12, in other embodiments, femto-BS **110** can obtain its  
15 position with assistance from another nearby femto-BS **112** that has already computed its own position. The femto-BS **110** position could be assumed to be the same as the nearby femto-BS **112** with some uncertainty which may be quantified based on the measured path loss to the nearby femto-BS **112**, as was described in connection with  
20 Figure 3. The measured path loss could also be used to determine a distance from the nearby femto-BS **112**, as was described in connection with Figure 4. If the femto-BS **110** has multiple antennas, they may be used to estimate a coarse direction for the nearby femto-BS **112**. The direction and distance estimates could be used together to obtain a rough estimate of the position of the femto-BS **110**, if desired.

In other embodiments, as was described in connection with Figure 5, the femto-  
25 BSs **110**, **112** may communicate with each other over the wired backhaul rather than over the air. This may alleviate the need for the femto-BS **110** to have extra RF hardware in the case of frequency division duplexing (FDD) between the uplink and downlink. The femto-BSs **110**, **112** could communicate with one another with  
30 assistance from the core network **140**.

Moreover, as was described in connection with Figure 6, if a UE **120** is in the vicinity of both femto-BS **110**, **112**, the uplink status reports from the UE **120** and/or

other communications can be used by a server **144** in the core network **140** to determine that the two femto-BS **110**, **112** are close to each other. The status reports could take the form of scanned cells and associated signal strengths communicated by the UE **120** to the core network **140**. The core network **140** can then inform the femto-BS **110** with unknown position that it is in proximity to another femto-BS **112** with a known position. The position of this femto-BS can be supplied by the server **144**. The femto-BS **110** can then use the position of the other femto-BS **112** with some uncertainty added or use some of the techniques discussed earlier to determine its own position.

10 In other embodiments, the position of multiple femto-BSs may be computed by propagating the position computation using techniques described herein across many femto-BSs. Hence, for example, there may be multiple femto-BSs in close proximity with only one of them being able to compute their position using GPS. The position of this femto-BS can then be propagated to the other femto-BS(s) with the other femto-BS(s) optionally refining their own position using the techniques described herein.

15 In other embodiments, the position of the femto-BS **110** is computed using information from the ISP that provides the ISP network **1040** through which the femto-BS **110** connects back into the core network **140**. The ISP assigns the IP address for the femto-BS **110**. In some embodiments, the IP address itself may be used to obtain a very coarse estimate of where the femto-BS **110** is located without any information from the ISP. In other embodiments, the ISP network **1040** may provide a more accurate location to the core network **140** which then provides the information to the femto-BS **110**. Alternately, the ISP network **1040** may provide a location directly to the femto-BS.

25 Other embodiments may apply to any white space device, not just a femto-BS. According to US FCC rules, a white space device is required to compute its position to within 50 meters and to query the database to determine which channels are free for use. A portable device may also register with multiple locations and use a free channel or channels that are common to the set of locations. This allows a portable/mobile device to use white space spectrum in a small region rather than at just a single location.

30

As described above, positioning of femto-BS **110** or white space devices may not always have the desired accuracy (e.g., GPS indoors). In some embodiments that were described in connection with Figures 1, 8 and 9, the ability to register with multiple locations for a portable white space device is used to allow such a device to  
5 access white space spectrum even when the accuracy of the device's computed position is worse than the 50 meter requirement. This may be achieved as illustrated in Figure 13.

Referring now to Figure 13, when the position of a white space device **110** is computed, an estimate of the accuracy of the position is also available with cellular  
10 based and GPS positioning methods. Accuracy estimates may be available in terms of uncertainty regions **152** or may at the very least be translated into uncertainty regions **152**. When the uncertainty region **152** is larger than a circle **154** with 50 meter radius centered around the position, the white space device **110** uses a set of multiple locations **150** spanning the larger uncertainty region **152** to query the database. If there is a  
15 common free channel across all of these locations **150**, the whitespace device **110** then uses this channel while the device is stationary, as was described in connection with Figures 8 and 9. If there is no common free channel then white space spectrum is not accessed. If the device is moved, then the procedure needs to be followed once again. A protected region **1310** where transmission is not allowed is thereby not infringed.

20 Thus, embodiments of Figure 13 can exploit the use of the FCC rules allowing multiple locations for a portable device with a degree of mobility to allow the use of a white space device that is stationary but has a higher degree of position uncertainty.

Accordingly, various embodiments described herein can enable the use of white space spectrum that is managed using a database, by femto-BSs that may be easily  
25 deployed, potentially even by the end user. Various embodiments provide ways for the position of the femto-BS to be computed using various positioning methods available in mobile networks, with or without an associated UE that may be a special UE or a generic UE. Various embodiments described herein also allow white space devices with inaccurate position estimates to use white space spectrum.

30 Various embodiments were described herein with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be

construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

It will be understood that, when an element is referred to as being "connected",  
5 "coupled", "responsive", or variants thereof to another element, it can be directly  
connected, coupled, or responsive to the other element or intervening elements may be  
present. In contrast, when an element is referred to as being "directly connected",  
"directly coupled", "directly responsive", or variants thereof to another element, there  
are no intervening elements present. Furthermore, "coupled", "connected",  
10 "responsive", or variants thereof as used herein may include wirelessly coupled,  
connected, or responsive. Like numbers refer to like elements throughout. The  
terminology used herein is for the purpose of describing particular embodiments only  
and is not intended to be limiting of the invention. As used herein, the singular forms  
"a", "an" and "the" are intended to include the plural forms as well, unless the context  
15 clearly indicates otherwise. Well-known functions or constructions may not be  
described in detail for brevity and/or clarity.

It will be understood that, although the terms first, second, etc. may be used  
herein to describe various elements, these elements should not be limited by these  
terms. These terms are only used to distinguish one element from another. For  
20 example, a first element could be termed a second element, and, similarly, a second  
element could be termed a first element, without departing from the scope of the  
present invention. Moreover, as used herein, the term "and/or" includes any and all  
combinations of one or more of the associated listed items.

Unless otherwise defined, all terms (including technical and scientific terms)  
25 used herein have the same meaning as commonly understood by one of ordinary skill in  
the art to which this invention belongs. It will be further understood that terms, such as  
those defined in commonly used dictionaries, should be interpreted as having a  
meaning that is consistent with their meaning in the context of this specification and the  
relevant art and will not be interpreted in an idealized or overly formal sense expressly  
30 so defined herein.

Various embodiments described herein can operate in any of the following  
Radio Access Technologies: Advanced Mobile Phone Service (AMPS), ANSI-136,

Global Standard for Mobile (GSM) communication, General Packet Radio Service (GPRS), enhanced data rates for GSM evolution (EDGE), DCS, PDC, PCS, code division multiple access (CDMA), wideband-CDMA, CDMA2000, Universal Mobile Telecommunications System (UMTS), 3GPP LTE (3<sup>rd</sup> Generation Partnership Project Long Term Evolution) and/or 3GPP LTE-A (LTE Advanced). For example, GSM operation can include reception/transmission in frequency ranges of about 824 MHz to about 849 MHz and about 869 MHz to about 894 MHz. EGSM operation can include reception/transmission in frequency ranges of about 880 MHz to about 914 MHz and about 925 MHz to about 960 MHz. DCS operation can include transmission/reception in frequency ranges of about 1410 MHz to about 1785 MHz and about 1805 MHz to about 1880 MHz. PDC operation can include transmission in frequency ranges of about 893 MHz to about 953 MHz and about 810 MHz to about 885 MHz. PCS operation can include transmission/reception in frequency ranges of about 1850 MHz to about 1910 MHz and about 1930 MHz to about 1990 MHz. 3GPP LTE operation can include transmission/reception in frequency ranges of about 1920 MHz to about 1980 MHz and about 2110 MHz to about 2170 MHz. Other Radio Access Technologies and/or frequency bands can also be used in various embodiments described herein. All these systems are designed to operate in a variety of bands typically known as the International Mobile Telecommunications (IMT) bands that are defined by the International Telecommunications Union – Radio Communication Bureau (ITU-R) and can, in general, be located in frequency ranges between 200 MHz and 5 GHz within the current state of the art. It should, however, be noted that various embodiments described herein are equally applicable for any radio system, and are not restricted in any way to the IMT bands in any way.

For purposes of illustration and explanation only, various embodiments of the present invention were described herein in the context of wireless user terminals or user equipment that are configured to carry out cellular communications (e.g., cellular voice and/or data communications). It will be understood, however, that the present invention is not limited to such embodiments and may be embodied generally in any wireless communication terminal that is configured to transmit and receive according to one or more radio access technologies.

As used herein, the term "wireless user terminal" includes cellular and/or satellite radiotelephone(s) with or without a display (text/graphical); Personal Communications System (PCS) terminal(s) that may combine a radiotelephone with data processing, facsimile and/or data communications capabilities; Personal Digital Assistant(s) (PDA) or smart phone(s) that can include a radio frequency transceiver and a pager, Internet/Intranet access, Web browser, organizer, calendar and/or a global positioning system (GPS) receiver; and/or conventional laptop (notebook) and/or palmtop (netbook) computer(s) or other appliance(s), which include a radio frequency transceiver. As used herein, the term "wireless user terminal" also includes any other radiating user device that may have time-varying or fixed geographic coordinates and/or may be portable, transportable, installed in a vehicle (aeronautical, maritime, or land-based) and/or situated and/or configured to operate locally and/or in a distributed fashion over one or more terrestrial and/or extra-terrestrial location(s). Finally, the term "base station" includes any fixed, portable and/or transportable device that is configured to communicate with one or more user equipment and a core network, and includes, for example, terrestrial cellular base stations (including microcell, picocell, wireless access point and/or ad hoc communications access points) and satellites, that may be located terrestrially and/or that have a trajectory above the earth at any altitude.

As used herein, the terms "comprise", "comprising", "comprises", "include", "including", "includes", "have", "has", "having", or variants thereof are open-ended, and include one or more stated features, integers, elements, steps, components or functions but does not preclude the presence or addition of one or more other features, integers, elements, steps, components, functions or groups thereof. Furthermore, if used herein, the common abbreviation "e.g.", which derives from the Latin phrase *exempli gratia*, may be used to introduce or specify a general example or examples of a previously mentioned item, and is not intended to be limiting of such item. If used herein, the common abbreviation "i.e.", which derives from the Latin phrase *id est*, may be used to specify a particular item from a more general recitation.

Exemplary embodiments were described herein with reference to block diagrams and/or flowchart illustrations of computer-implemented methods, apparatus (systems and/or devices) and/or computer program products. It is understood that a block of the block diagrams and/or flowchart illustrations, and combinations of blocks



in the block diagrams and/or flowchart illustrations, can be implemented by computer program instructions that are performed by one or more computer circuits. These computer program instructions may be provided to a processor circuit of a general purpose computer circuit, special purpose computer circuit such as a digital processor, and/or other programmable data processing circuit to produce a machine, such that the instructions, which execute via the processor of the computer and/or other programmable data processing apparatus, transform and control transistors, values stored in memory locations, and other hardware components within such circuitry to implement the functions/acts specified in the block diagrams and/or flowchart block or blocks, and thereby create means (functionality) and/or structure for implementing the functions/acts specified in the block diagrams and/or flowchart block(s). These computer program instructions may also be stored in a computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instructions which implement the functions/acts specified in the block diagrams and/or flowchart block or blocks.

A tangible, non-transitory computer-readable medium may include an electronic, magnetic, optical, electromagnetic, or semiconductor data storage system, apparatus, or device. More specific examples of the computer-readable medium would include the following: a portable computer diskette, a random access memory (RAM) circuit, a read-only memory (ROM) circuit, an erasable programmable read-only memory (EPROM or Flash memory) circuit, a portable compact disc read-only memory (CD-ROM), and a portable digital video disc read-only memory (DVD/BlueRay).

The computer program instructions may also be loaded onto a computer and/or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer and/or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions/acts specified in the block diagrams and/or flowchart block or blocks.

Accordingly, embodiments of the present invention may be embodied in hardware and/or in software (including firmware, resident software, micro-code, etc.)

that runs on a processor such as a digital signal processor, which may collectively be referred to as "circuitry," "a module" or variants thereof.

It should also be noted that in some alternate implementations, the functions/acts noted in the blocks may occur out of the order noted in the flowcharts.

5 For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved. Moreover, the functionality of a given block of the flowcharts and/or block diagrams may be separated into multiple blocks and/or the functionality of two or more blocks of the flowcharts and/or block diagrams may be at  
10 least partially integrated. Finally, other blocks may be added/inserted between the blocks that are illustrated. Moreover, although some of the diagrams include arrows on communication paths to show a primary direction of communication, it is to be understood that communication may occur in the opposite direction to the depicted arrows.

15 Many different embodiments were disclosed herein, in connection with the following description and the drawings. It will be understood that it would be unduly repetitious and obfuscating to literally describe and illustrate every combination and subcombination of these embodiments. Accordingly, the present specification, including the drawings, shall be construed to constitute a complete written description  
20 of all combinations and subcombinations of the embodiments described herein, and of the manner and process of making and using them, and shall support claims to any such combination or subcombination.

In the drawings and specification, there have been disclosed embodiments of the invention and, although specific terms are employed, they are used in a generic and  
25 descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

**CLAIMS:**

1. A wireless communication method, comprising:
  - determining a position of a first wireless base station by obtaining a position of a nearby second wireless base station and determining the position of the first wireless
  - 5 base station from the position of the nearby second wireless base station that was obtained;
  - determining a wireless communication frequency to be used by the first wireless base station based upon the position of the first wireless base station that was determined; and
  - 10 communicating by the first wireless base station over the frequency that was identified.
2. A method according to Claim 1 wherein determining the position of the first wireless base station from the position of the nearby second wireless base station that
- 15 was obtained comprises identifying the position of the first wireless base station as the position of the nearby second wireless base station that was obtained.
3. A method according to Claim 1 wherein determining the position of the first wireless base station from the position of the nearby second wireless base station that
- 20 was obtained comprises determining the position of the first wireless base station from the position of the nearby second wireless base station that was obtained and from a path loss and/or a direction between the first wireless base station and the nearby second wireless base station.
- 25 4. A method according to Claim 1 wherein obtaining a position of a nearby second wireless base station comprises:
  - requesting the position of a nearby second wireless base station from a core network; and
  - obtaining the position of the nearby second wireless base station from the core
  - 30 network.

5. A method according to Claim 4 further comprising the following:  
after requesting the position of a nearby second wireless base station from the core network, identifying the nearby second wireless base station using communications from a wireless user terminal that is receiving signals from both the first wireless base station and the nearby second wireless base station.
6. A method according to Claim 1:  
wherein determining a wireless communication frequency to be used by the first wireless base station comprises identifying a common frequency that can be used at a plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined; and  
wherein communicating by the first wireless station over the frequency that was identified comprises communicating by the first wireless base station over the common frequency that was identified.
7. A method according to Claim 6 wherein identifying a common frequency that can be used at a plurality of locations surrounding and spaced apart from the position of first wireless base station that was determined comprises:  
identifying one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined; and  
comparing the one or more frequencies that were identified for the respective ones of the plurality of locations to identify the common frequency that can be used at the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined.
8. A method according to Claim 6 wherein the position of the first wireless base station that was determined defines a region of position uncertainty and wherein the plurality of locations surrounding and spaced apart from the position of the first wireless base station span the region of position uncertainty.

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9. A method according to Claim 7 wherein the identifying one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined comprises querying a database that is external of the first wireless base station to identify the one  
5 or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the position of the first wireless base station that was determined.

10. A wireless base station comprising:  
10 a wireless transceiver; and  
a processor that is configured to control the wireless transceiver, to obtain a position of a nearby wireless base station and to determine a position of the wireless base station from the position of the nearby wireless base station that was obtained.

15 11. A wireless base station according to Claim 10 wherein the processor is configured to determine a position of the wireless base station from the position of the nearby wireless base station that was obtained by performing operations comprising identifying the position of the wireless base station as the position of the nearby  
20 wireless base station that was obtained.

12. A wireless base station according to Claim 10 wherein the processor is configured to determine a position of the wireless base station from the position of the nearby wireless base station that was obtained by performing operations comprising determining the position of the wireless base station from the position of the nearby  
25 wireless base station that was obtained and from a path loss and/or a direction between the wireless base station and the nearby wireless base station.

13. A wireless base station according to Claim 10 wherein the processor is configured to obtain a position of a nearby wireless base station by performing  
30 operations comprising:  
requesting the position of the nearby wireless base station from a core network;  
and

obtaining the position of the nearby wireless base station from the core network.

14. A wireless base station according to Claim 13:  
wherein the requesting the position of the nearby wireless base station from a  
5 core network comprises communicating the requesting the position of the nearby  
wireless base station from the wireless base station to the nearby wireless base station  
via the core network; and  
wherein the obtaining the position of the nearby wireless base station from the  
core network comprises communicating the position of the nearby wireless base station  
10 from the nearby wireless base station to the wireless base station via the core network.

15. A wireless base station according to Claim 10 wherein the wireless base station  
and the nearby wireless base station are re-deployable wireless base stations.

- 15 16. A wireless communication system device comprising:  
an input/output interface; and  
a processor that is configured to determine a common frequency that can be  
used at a plurality of locations surrounding and spaced apart from a wireless base  
station in response to a measure of a position of the wireless base station that is  
20 received from the input/output interface, and to communicate the common frequency  
over the input/output interface.

17. A device according to Claim 16 wherein the processor is configured to  
determine a common frequency that can be used at a plurality of locations surrounding  
25 and spaced apart from the wireless base station by performing operations comprising:  
obtaining one or more frequencies that can be used at a respective one of the  
plurality of locations surrounding and spaced apart from the wireless base station; and  
comparing the one or more frequencies that were obtained for the respective  
ones of the plurality of locations to determine the common frequency that can be used  
30 at the plurality of locations surrounding and spaced apart from the wireless base station.

18. A device according to Claim 16 wherein the measure of the position of the wireless base station includes a region of position uncertainty and wherein the plurality of locations surrounding and spaced apart from the wireless base station span the region of position uncertainty.

5

19. A device according to Claim 17 wherein the obtaining one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the wireless base station comprises querying a database to identify the one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the wireless base station.

10

20. A device according to Claim 16 wherein the one or more frequencies that can be used at a respective one of the plurality of locations surrounding and spaced apart from the wireless base station comprise unlicensed frequencies.

15

21. A device according to Claim 16 wherein the input/output interface and the processor are included in a server or are included in the wireless base station.

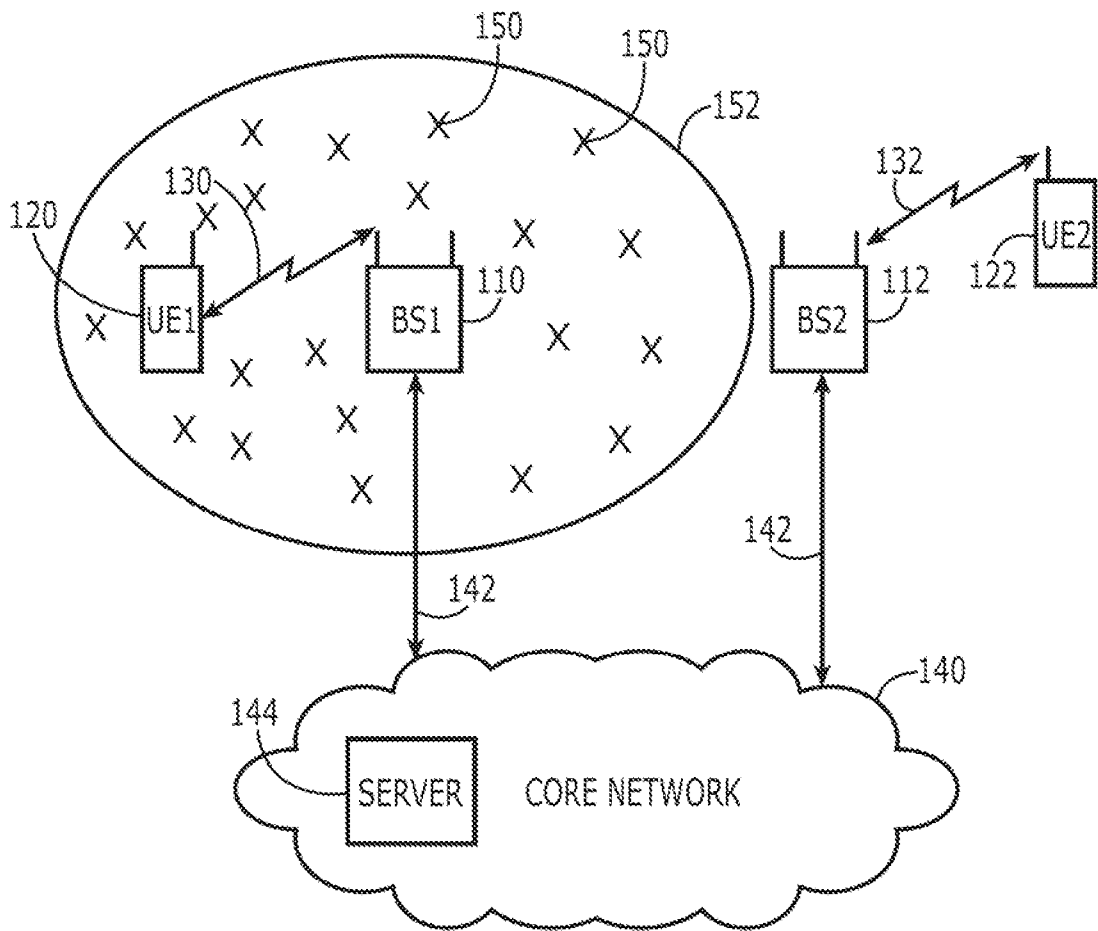


FIG. 1



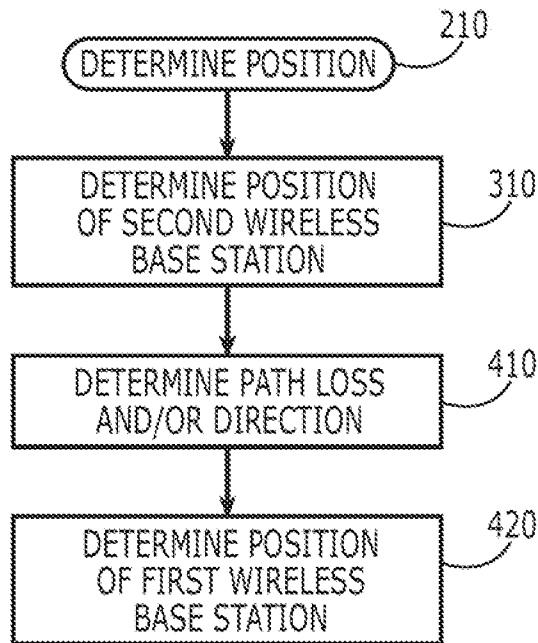
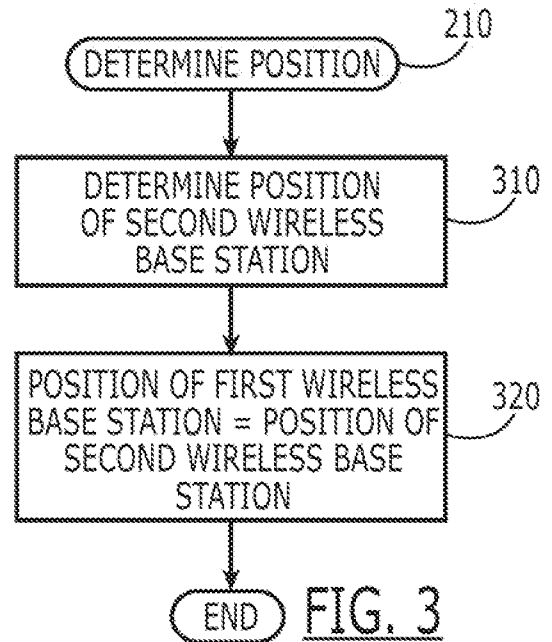
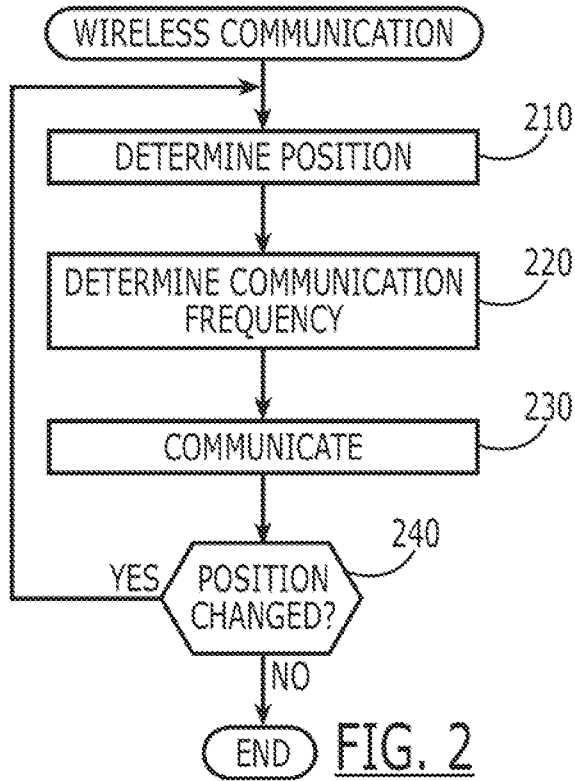
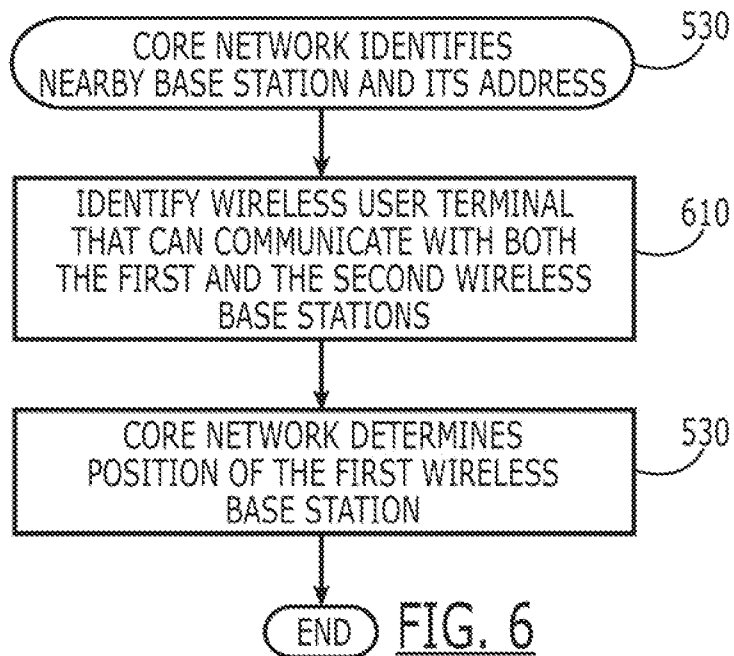
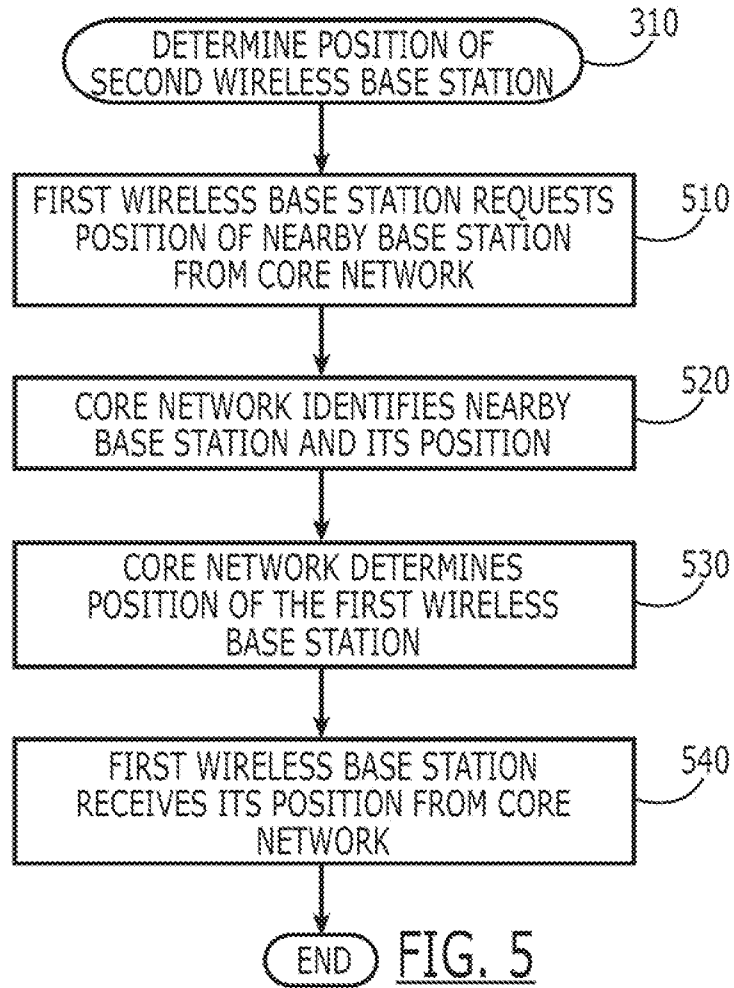


FIG. 4

3/9



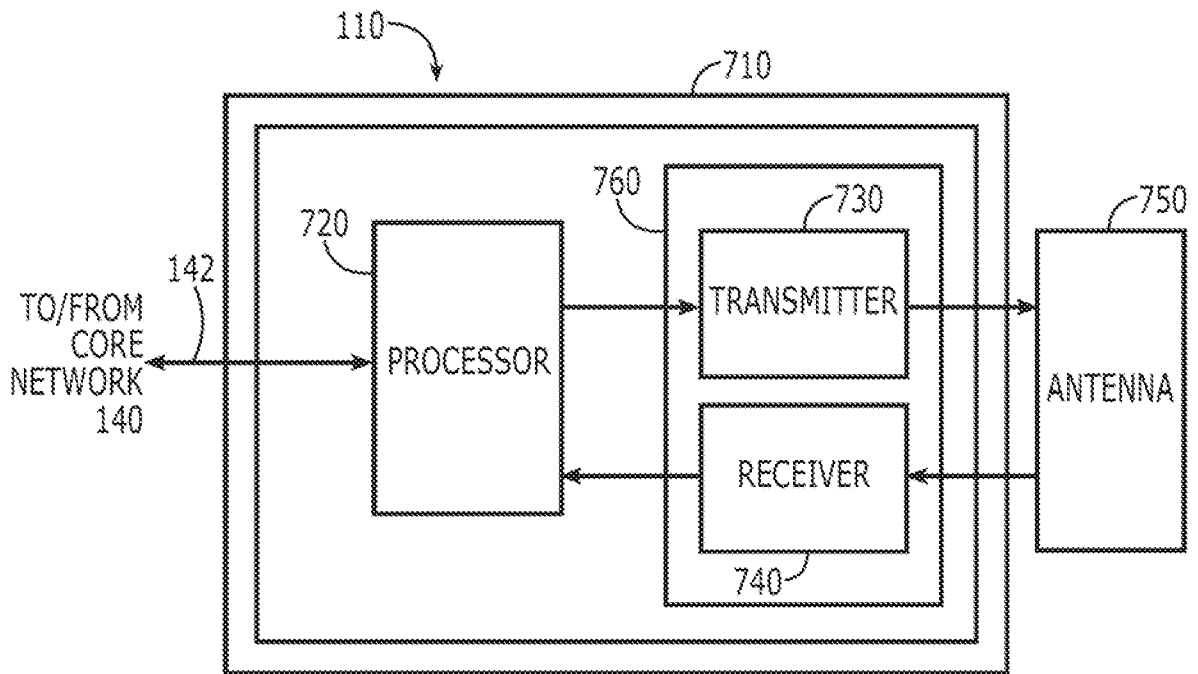


FIG. 7A

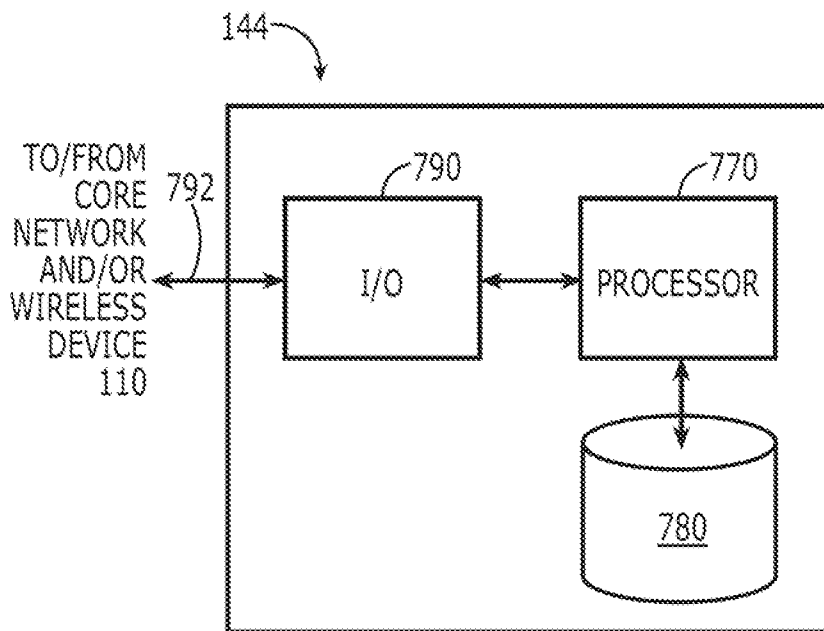
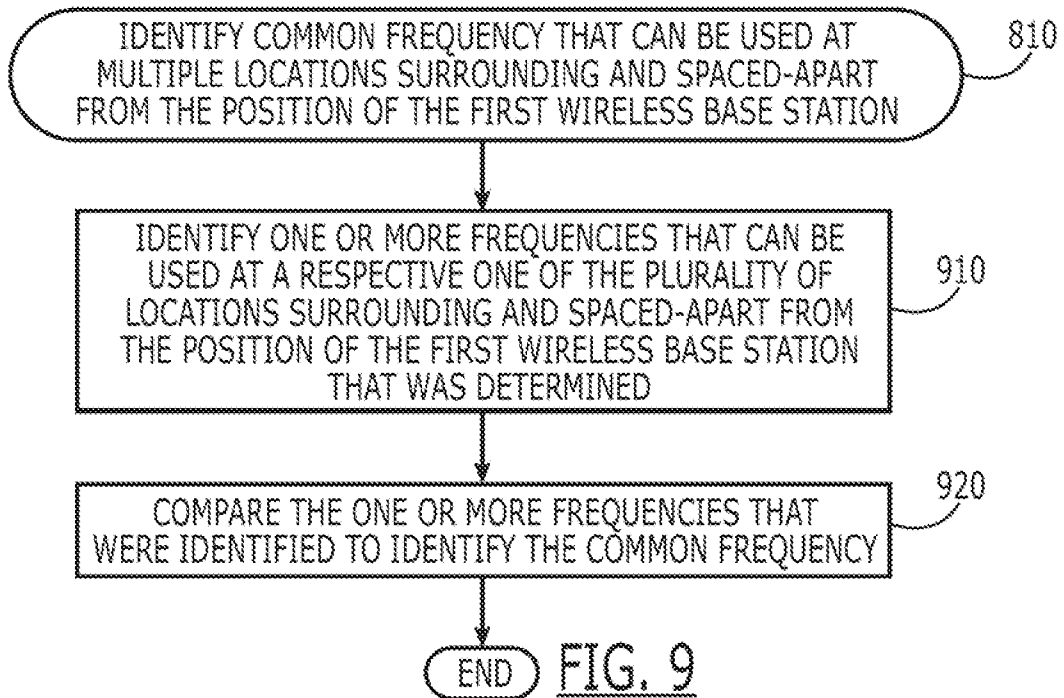
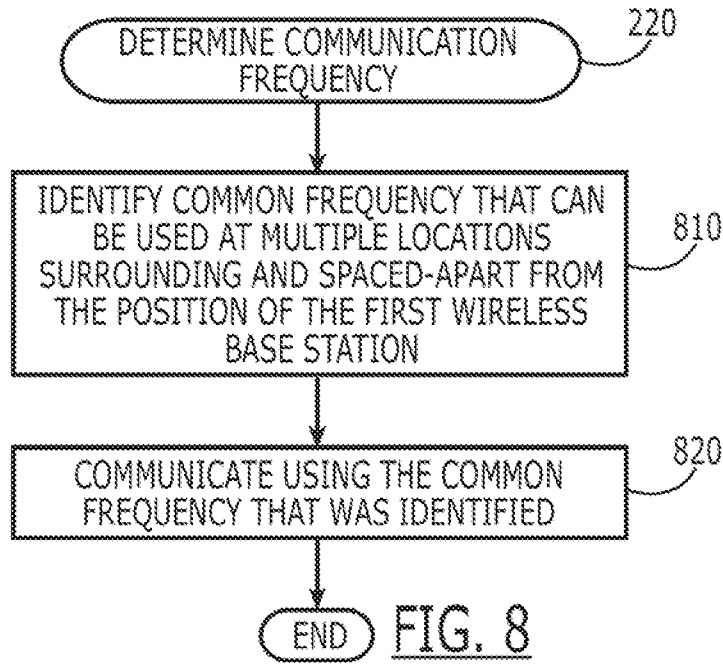


FIG. 7B



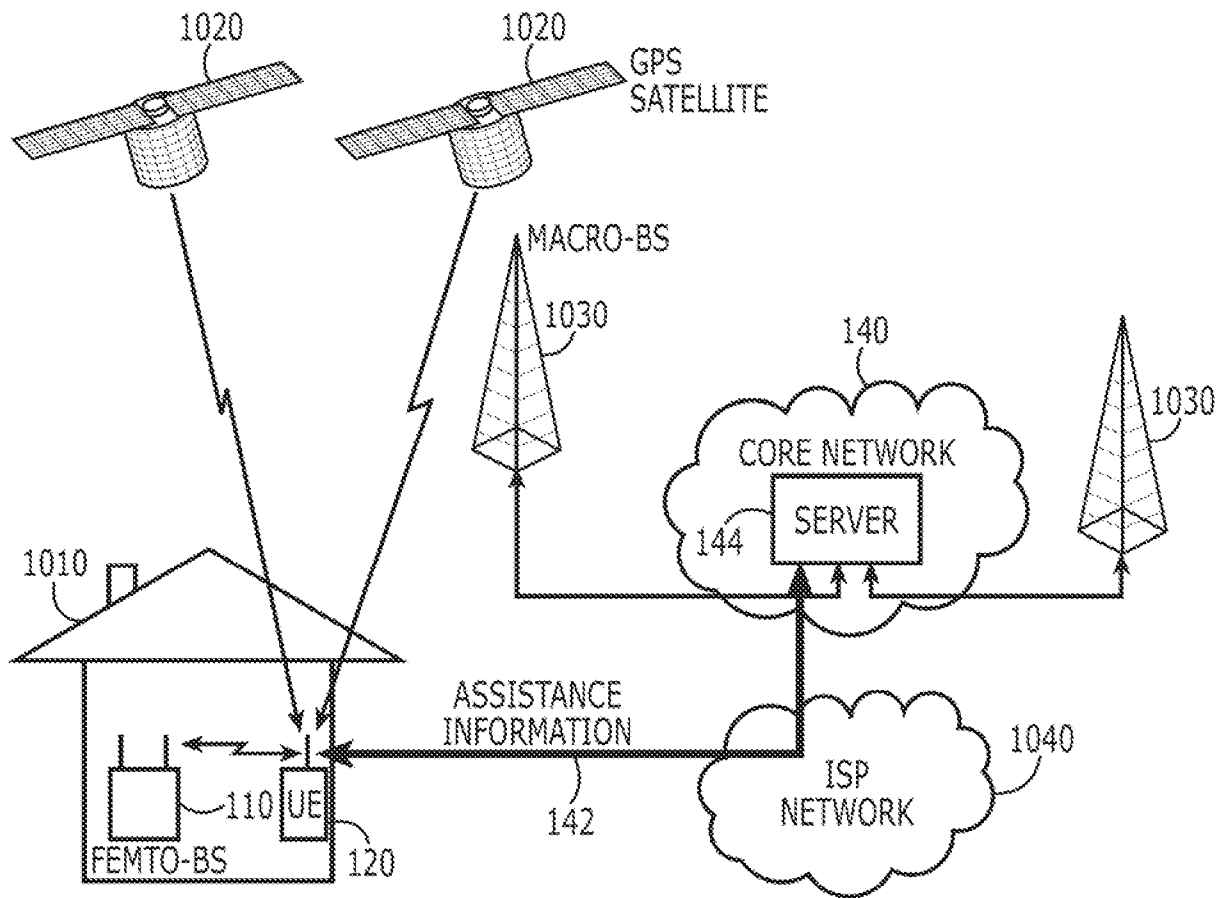


FIG. 10

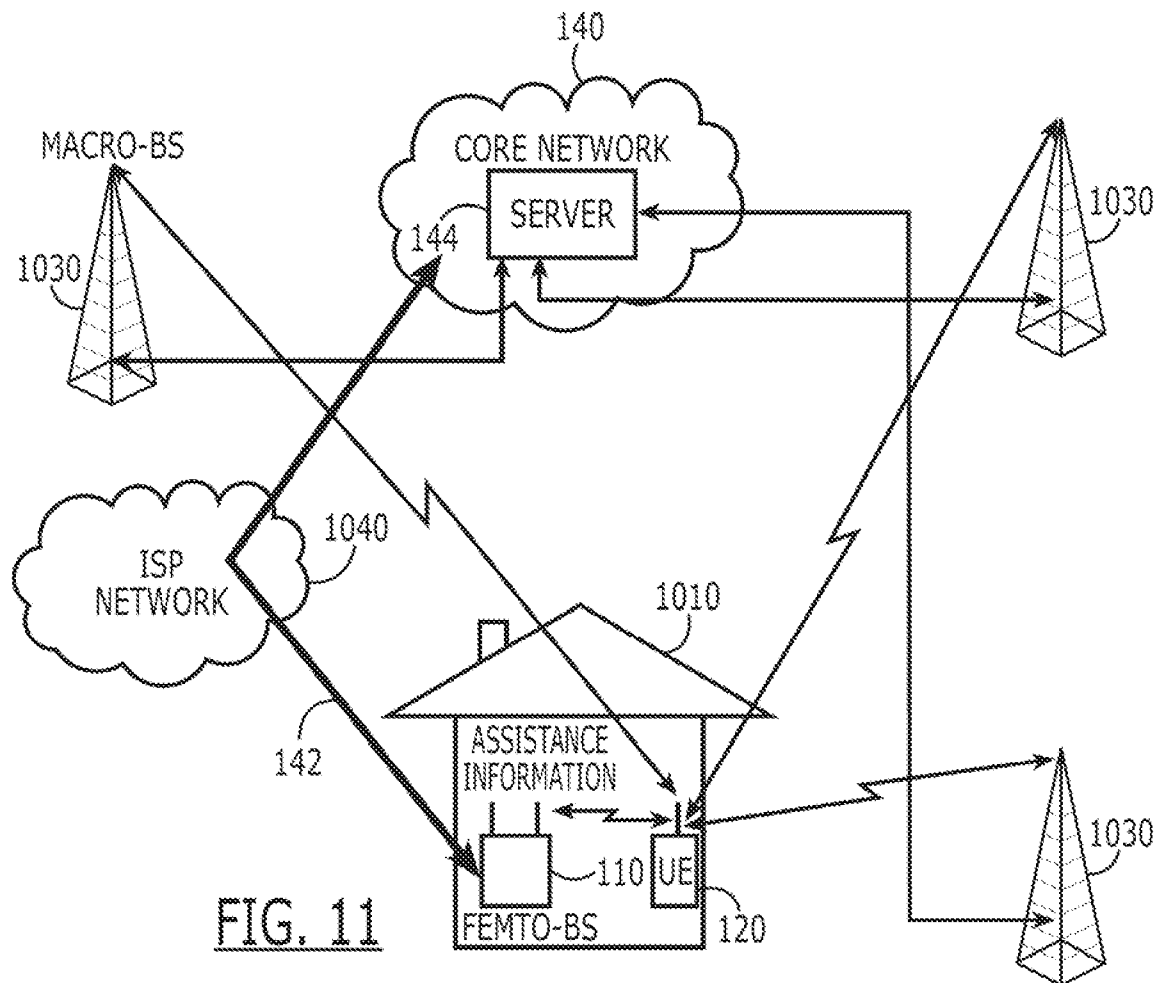


FIG. 11

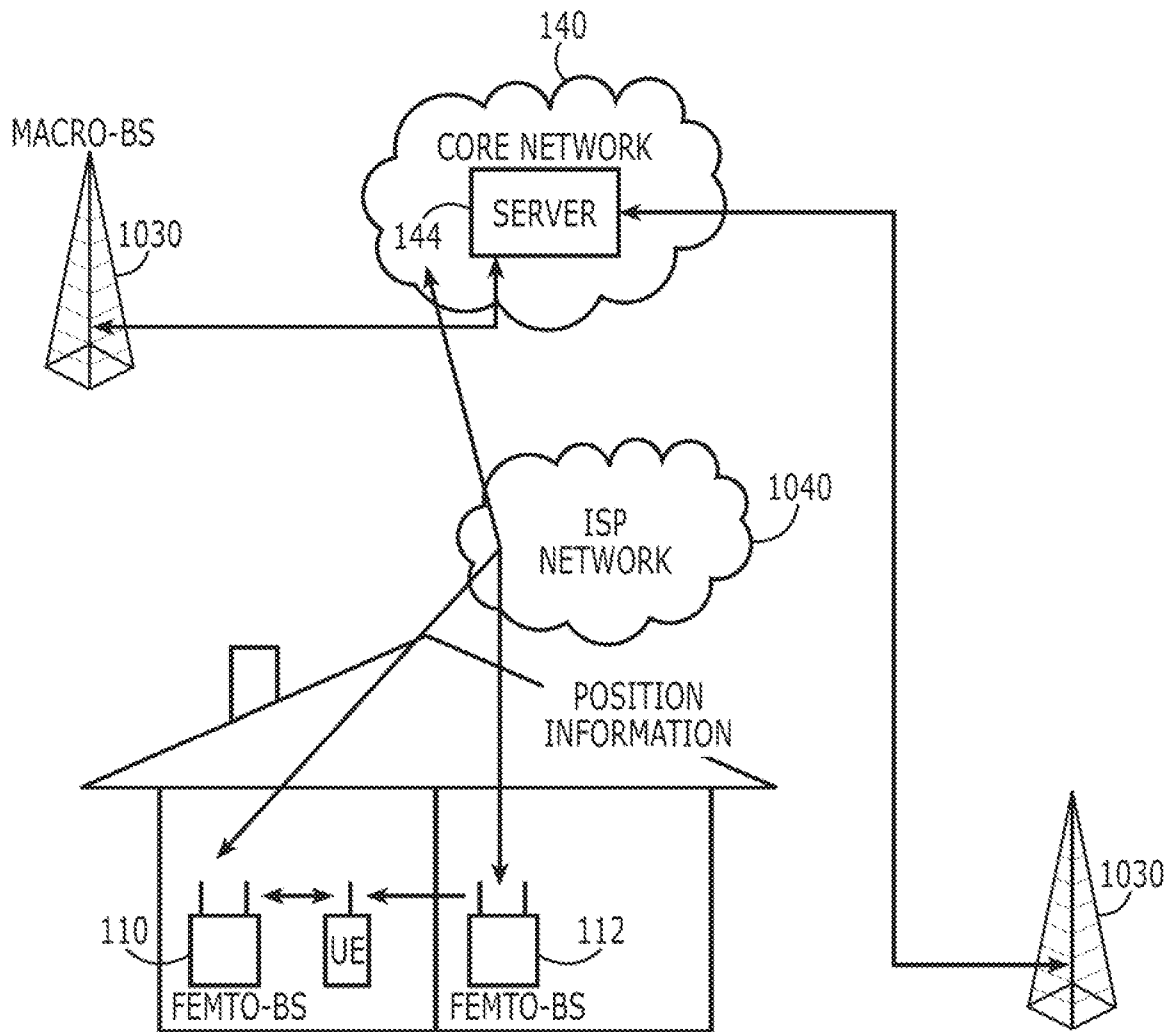


FIG. 12

