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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 April 2008 (17.04.2008)

PCT

(10) International Publication Number
WO 2008/045303 A2

(51) International Patent Classification:
H04Q 7/20 (2006.01)

(21) International Application Number:
PCT/US2007/021358

(22) International Filing Date: 3 October 2007 (03.10.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/850,872 10 October 2006 (10.10.2006) US
11/645,113 21 December 2006 (21.12.2006) US

(71) Applicant (*for all designated States except US*): **RADIOFRAME NETWORKS, INC.** [US/US]; 9461 Willows Road Ne, Suite 100, Redmond, WA 98052 (US).

(72) Inventors: **HIRANO, Mike**; 9461 Willows Road NE, Suite 100, Redmond, WA 98052 (US). **MCMEEKIN, M., Sue**; 9461 Willows Road Ne, Suite 100, Redmond, WA 98052 (US). **WAHLSTROM, Donald, P.**; 9461 Willows Road NE, Suite 100, Redmond, WA 98052 (US). **ZHANG, Yan**; 9461 Willows Road NE, Suite 100, Redmond, WA 98052 (US).

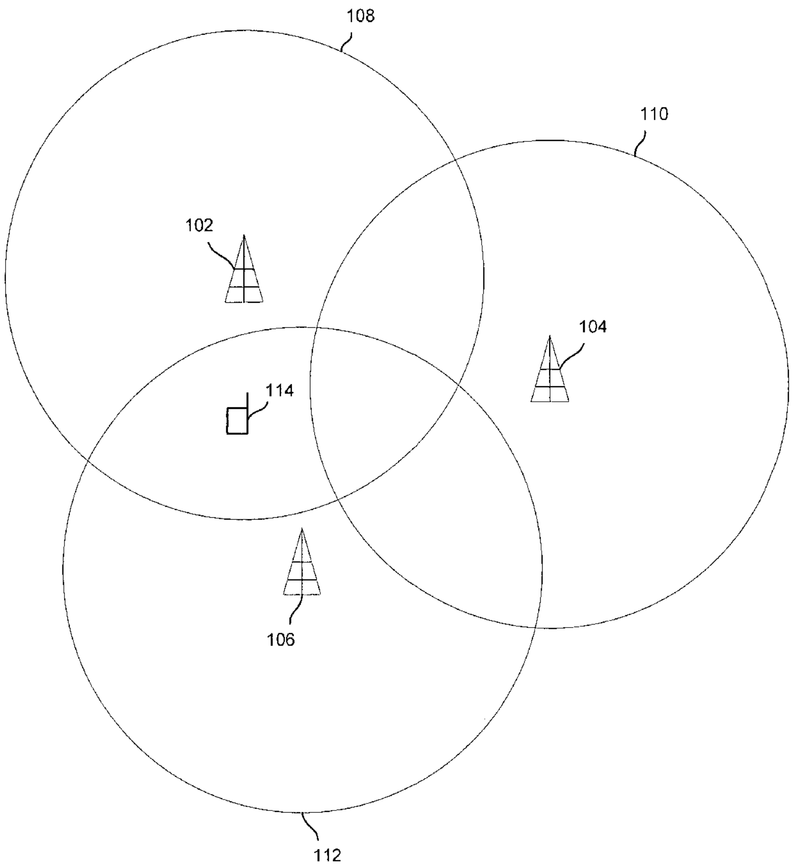
(74) Agent: **JAMES, William, J.**; Van Pelt, Yi & James LLP, 10050 N. Foothill Blvd., Suite 200, Cupertino, CA 95014 (US).

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

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: SENSING RF ENVIRONMENT TO MANAGE MOBILE NETWORK RESOURCES



(57) Abstract: Using radio frequency sensing to manage a mobile network resource is disclosed. A radio frequency environment is sensed to detect one or more base transceiver stations. A resource assignment, such as a frequency or channel assignment, is determined based at least in part on the sensed radio frequency environment.

WO 2008/045303 A2

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

SENSING RF ENVIRONMENT TO MANAGE MOBILE NETWORK RESOURCES

CROSS REFERENCE TO OTHER APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 60/850,872 (Attorney Docket No. RADIP023+) entitled Method of RF Monitoring, filed October 10, 2006, which is incorporated herein by reference for all purposes.

BACKGROUND OF THE INVENTION

[0002] In a traditional mobile telecommunication network, mobile stations (e.g., mobile phones) communicate via an air link with a stationary base transceiver station (BTS), typically a tower or other structure with one or more antennas and associated radio transceivers. A traditional BTS typically relays data between mobile stations and the core mobile network via a dedicated communication link to a base station controller (BSC). However, smaller base transceiver stations have been developed, e.g., for personal use in the home, dedicated use by a small business or other enterprise, dedicated or additional coverage for areas with high user density or demand (such as airports), etc. Such smaller base transceiver stations are sometimes referred to herein and in the industry by a variety of terms, depending on their size and configuration, including without limitation by terms such as "micro-BTS", "pico-BTS", and "femto-BTS", which terms distinguish such smaller installations from a traditional "BTS", which is sometimes referred to as a "macro-BTS" deployed to serve an associated "macro-cell". Deployment of such smaller base transceiver stations poses challenges to mobile telecommunications network operators and equipment providers, including the need for efficient ways to assign resources to such base transceiver stations (e.g., broadcast channels/frequencies) that does not result in such installations interfering with other network elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Various embodiments of the invention are disclosed in the following detailed description and the accompanying drawings.

[0004] Figure 1 is a block diagram illustrating an embodiment of a prior art array of base transceiver stations and their associated coverage areas.

[0005] Figure 2 is a block diagram illustrating an embodiment of base station subsystem elements in a typical prior art macrocellular network.

[0006] Figure 3 is a block diagram illustrating an embodiment of a cellular network in which a small, potentially movable base transceiver station has been deployed.

[0007] Figure 4 is a block diagram illustrating an embodiment of a micro-, pico-, and/or femto- BTS or other small and/or potential movable base transceiver station with IP network backhaul.

[0008] Figure 5A shows an illustrative frequency assignment scheme for the cellular network as shown in Figure 1.

[0009] Figure 5B shows an embodiment of the frequency assignment scheme of Figure 5A as modified to reflect assignment of a fourth frequency range to a small scale base station.

[0010] Figure 6 is a flow chart illustrating an embodiment of a process for assigning mobile network resources, in this example a channel/range of frequencies, at least in part by sensing an RF environment.

[0011] Figure 7 is a flow chart illustrating an embodiment of a process for assigning mobile network resources, in this example a channel/range of frequencies, at least in part by sensing an RF environment.

DETAILED DESCRIPTION

[0012] The invention can be implemented in numerous ways, including as a process, an apparatus, a system, a composition of matter, a computer readable medium such as a computer readable storage medium or a computer network wherein program instructions are sent over optical or communication links. In this specification, these implementations, or any other form that the invention may take, may be referred to as techniques. A component such as a processor or a memory described as being configured to perform a task includes both a general component that is temporarily configured to perform the task at a given time or a specific component that is manufactured to perform the task. In general, the order of the steps of disclosed processes may be altered within the scope of the invention.

[0013] A detailed description of one or more embodiments of the invention is provided below along with accompanying figures that illustrate the principles of the invention. The invention is described in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only by the claims and the invention encompasses numerous alternatives, modifications and equivalents. Numerous specific details are set forth in the following description in order to provide a thorough understanding of the invention. These details are provided for the purpose of example and the invention may be practiced according to the claims without some or all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the invention is not unnecessarily obscured.

[0014] Sensing a radio frequency (RF) environment to manage mobile network resources is disclosed. In some embodiments, a base transceiver station (BTS) or other mobile telecommunications network provider equipment senses a radio frequency environment in a location in which it is located. For example, a BTS or similar equipment that due to its size, weight, form factor, and/or manner of installation is capable of being moved from one location to another, and/or capable of being installed at a location potentially within and/or near the coverage area of one or more other base transceiver stations, such as a macro-BTS, senses the RF environment in the location in which it is located. Any beacon or other broadcast signals detected are used, as applicable, to assign one or more resources to the potentially movable BTS. An example of such a resource is a channel and/or frequency. In various embodiments, the assignment is made either by the potentially movable BTS itself, e.g., based on a selection algorithm in light of the sensed RF environment and/or the detected signal(s), if any, are reported to a coordinating node, such as a BSC and/or the core mobile network, configured to assign resources to the potentially movable BTS based on the RF environment observed and reported by the BTS. In some embodiments, the BTS selects a frequency or channel from a predetermined set of preconfigured and/or configurable options, based at least in part on the sensed RF environment. For example, in some embodiments the BTS selects a channel having an associated frequency or range or set of frequencies that is no closer than a prescribed minimum amount (e.g., 200 kHz) to any adjacent signal that could potential interfere with and/or be interfered with by the potentially movable BTS's signal.

[0015] Figure 1 is a block diagram illustrating an embodiment of a prior art array of base transceiver stations and their associated coverage areas. Each of the base transceiver stations (BTS) 102, 104, and 106 has associated with it a corresponding geographic coverage area 108, 110, and 112, respectively, within which its signal is strong enough to be received and used by a mobile station (MS), such as MS 114, to communicate with the core mobile telecommunication network via that BTS. In areas in which two or more coverage areas overlap, an MS could in theory communicate with the core mobile network via any BTS having coverage in that area. Particularly in such regions in which coverage areas overlap, there is potential for inter-BTS interference. As a result, mobile telecommunications network providers typically have engaged radio frequency engineers to perform frequency planning tasks, such as to determine a scheme for allocating and assigning frequencies to base transceiver stations in the macrocellular network. The actual configuration of the base transceiver stations traditionally has been a largely manual process and the resulting assignments generally static.

[0016] Figure 2 is a block diagram illustrating an embodiment of base station subsystem elements in a typical prior art macrocellular network. In the example shown, the BTS's 102, 104, and 106 of Figure 1 are shown as each being connected to a base station controller (BSC) 202 via a corresponding dedicated communication link, typically a dedicated T-1/E-1 line. In a GSM network, the dedicated link is known as the Abis interface. The BSC 202 provides access to the core mobile network 204, in a GSM network typically via a mobile switching center (MSC) in the case of voice traffic and control messages and a serving GPRS support node (SGSN) in the case of packet data traffic.

[0017] Figure 3 is a block diagram illustrating an embodiment of a cellular network in which a small, potentially movable base transceiver station has been deployed. In the example shown, a micro-, pico-, or femto-BTS 302 having an associated coverage area 304 has been deployed in the cellular network of Figure 1, in a location such that a coverage area 304 overlaps with (and in this example, for clarity, is included entirely within) a region in which the coverage area 110 of BTS 104 and the coverage area 112 of BTS 106 overlap. In various embodiments, the potentially movable BTS 302 may be deployed by a customer or business partner (e.g., reseller, sales representative, retail outlet, etc.) of the mobile network provider, or by a relatively low skilled installation technician of the provider, under circumstances that make it infeasible, impractical, unduly costly, and/or inefficient to include the small scale BTS 302 in a frequency or other resource allocation and/or assignment plan for the cellular network. For example, the BTS 302 may be deployed long after the macrocell BTS's 102, 104, and 106. In addition, while one small scale BTS 302 is shown in Figure 3, numerous such stations may be deployed in a densely populated area, e.g., in a high use area such as an airport or in many subscriber homes throughout a densely populated service area. The number, geographic distribution, and distribution of installation over time may make it impractical to integrate such small scale BTS's into frequency and/or other resource planning.

[0018] In some embodiments, each macrocell BTS supports up to 32 neighboring base stations on its neighbor list and each small scale base station is configured to operate at one of nine preconfigured channels/frequencies, e.g., one of nine absolute radio frequency channel numbers (ARFCN) in a GSM network, reserved in the network frequency planning process for use by micro-, pico-, and/or femto- BTS or other small and/or potential movable base transceiver stations.

[0019] Figure 4 is a block diagram illustrating an embodiment of a micro-, pico-, and/or femto- BTS or other small and/or potential movable base transceiver station with IP network backhaul. As noted above, the macro-BTS's 102, 104, and 106 communicate with the core mobile network via a dedicated land line (e.g., T-1/E-1) to a BSC such as BSC 202. In Figure 4, the small scale BTS 302 of Figure 3 is shown as being connected to BSC 202 via an IP network 402 and an aggregation gateway (AGW) 404. In some embodiments, AGW 404 is configured to support one or more small scale BTS's such as BTS 302, aggregating their traffic and translating traffic sent via the IP network 402 using a suitable protocol, e.g., the real-time transport protocol (RTP) for voice traffic, to the Abis (for GSM) or similar interface to the BSC (or equivalent node in a non-GSM network), and vice versa. As high-speed Internet access for homes and small businesses becomes more and more ubiquitous, it has become and will continue to become more and more possible to deploy small scale base stations in homes and businesses, and use IP backhaul to provide connectivity to the core mobile network, avoiding the cost and waste of bandwidth that would attend if each such base station required a dedicated T-1/E-1 or other high capacity connection.

[0020] Figure 5A shows an illustrative frequency assignment scheme for the cellular network as shown in Figure 1. A first range of frequencies 502 associated with a first channel has been assigned, for example, to BTS 102; a second range of frequencies 504 associated with a second channel has been assigned, for example, to BTS 104; and a third range of frequencies 506 associated with a third channel has been assigned, for example, to BTS 106. The frequency ranges 502, 504, and 506 are spaced from each other by at least a prescribed minimum spacing, e.g., 200 kHz in the case of a GSM network.

[0021] Figure 5B shows an embodiment of the frequency assignment scheme of Figure 5A as modified to reflect assignment of a fourth frequency range to a small scale base station. In the example shown, a fourth frequency range 508 has been assigned to the small scale base station 302 of Figure 3. A frequency range for a small scale, such as fourth frequency range 508 in the example shown, is selected in some embodiments to ensure a prescribed minimum spacing (e.g., 200 kHz) from adjacent macrocellular and/or small scale base stations (BTS's) operating in or near the location in which the small scale base station is located.

[0022] Sensing an RF environment to manage mobile network resources, such as available channels/frequencies, is disclosed. In some embodiments, a small scale BTS such as BTS 302 of Figure 3 includes an RF sensing (or "sniffing") subsystem. On startup (and/or at other prescribed times and/or conditions), the small scale BTS senses the RF environment in the location in which it is located. In some embodiments, the small scale BTS scans a relevant range of frequencies, such as the 900/1800 and 850/1900 MHz bands in the case of a small scale base station or other equipment associated with a GSM network. In some embodiments, the small scale base station or other equipment includes an RF monitor comprising a GSM or other receiver capable of receiving in one or more bands of interest. In some embodiments, the BTS at least partly evaluates the sensed RF environment, e.g., by determining which sensed signals are of interest (e.g., because they are known to be or may be associated with an adjacent BTS from the same or another mobile network). In some embodiments, the determination is made based at least in part on the beacon frequency at which a broadcast channel is transmitted. In some embodiments, the determination is made based at least in part on information included in such a beacon or broadcast channel.

[0023] In some embodiments, the BTS is configured to select, from a preconfigured set of options, a channel to be used by the BTS. In the example described above, a BTS may be configured to select, from one of nine (or more or fewer than nine in other embodiments) preconfigured channels, a channel associated with frequencies that are at least a prescribed minimum spacing (e.g., 200 kHz in a GSM network or other prescribed or desired spacing as required in a network other than a GSM network) from the frequencies associated with the nearest (in frequency) adjacent BTS as determined by sensing the RF environment.

[0024] Figure 6 is a flow chart illustrating an embodiment of a process for assigning mobile network resources, in this example a channel/range of frequencies, at least in part by sensing an RF environment. In some embodiments, the process of Figure 6 is implemented by a small scale BTS, such as BTS 302 of Figure 3. In the example shown, at initial startup 602, the RF environment is sensed 604. A neighbor cell list is populated 606. In various embodiments, 606 is optional and/or omitted. At 608, a broadcast (or other) channel that would result in at least a prescribed minimum (in this example 200 kHz) spacing from the nearest sensed RF source (e.g., macro-BTS) is selected from a set of preconfigured options. If handover is supported 610, the channel selected is reported to the core mobile network 612. If handover is not supported 610 or after the channel selection/assignment has been reported 612, the process ends.

[0025] In some embodiments, the small scale BTS selects and proposes a channel but does not configure itself to broadcast on that channel unless/until an assignment, acknowledgement, and/or confirmation is received from the core mobile network. In some embodiments, the small scale BTS senses the RF environment and reports either the raw and/or at least partly evaluated and/or classified RF environment data to the core mobile network, or some auxiliary element, which then assigns a channel, frequency, and/or other resource(s) based at least in part on the RF environment as sensed and reported by the small scale BTS.

[0026] Figure 7 is a flow chart illustrating an embodiment of a process for assigning mobile network resources, in this example a channel/range of frequencies, at least in part by sensing an RF environment. In some embodiments, the process of Figure 7 is implemented by a small scale BTS, such as BTS 302 of Figure 3. In the example shown, at initial startup 702, the RF environment is sensed 704. A neighbor cell list is populated 706. In various embodiments, 706 is optional and/or omitted. Signals detected at 704 are reported 708, e.g., to a core mobile network via BSC. A channel (and/or other resource) assignment is received, e.g., from the core mobile network, and implemented 710.

[0027] While in many of the examples described in detail above involve frequency assignment in a GSM or similar network, the techniques described herein may be used to manage any resource capable of being managed based at least in part on information obtained by sensing the RF environment, in a GSM or other network.

For example, in a UMTS or other CDMA network the techniques described herein are used in some embodiments to assign codes to a small scale base station or other element. In some embodiments, at startup a small scale UMTS base station senses the RF environment, determines if any signals associated with an adjacent base station are detected, and determine for each detected signal what code(s) is/are being used by the associated base station. The small scale base station in some embodiments selects, from a preconfigured set of options, a code that is not already being used by an adjacent base station, as determined by sensing the RF environment.

[0028] In various embodiments, managing mobile network resources based at least in part on an RF environment as sensed by a small scale BTS or other equipment provides flexibility and saves cost in connection with deploying distributed and/or small scale infrastructure elements, such as small scale base stations intended for home or enterprise use.

[0029] Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed embodiments are illustrative and not restrictive.

[0030] WHAT IS CLAIMED IS:

CLAIMS

1. A method of managing a mobile network resource, comprising:

sensing a radio frequency environment to detect one or more base transceiver stations; and

determining a resource assignment based at least in part on the sensed radio frequency environment.

2. A method as recited in claim 1, wherein the base transceiver station comprises a macrocellular base transceiver station configured to provide access to cellular telecommunication service to mobile stations located in a coverage area of the base transceiver station.

3. A method as recited in claim 1, wherein sensing the radio frequency environment comprises detecting a signal broadcast by one of said one or more base transceiver stations.

4. A method as recited in claim 3, wherein sensing the radio frequency environment further comprises determining a carrier frequency of said signal.

5. A method as recited in claim 1, further comprising populating a neighbor cell list with data associated with said one or more base transceiver stations.

6. A method as recited in claim 1, wherein the resource comprises a frequency.

7. A method as recited in claim 1, wherein the resource comprises a range of frequencies.

8. A method as recited in claim 1, wherein the resource comprises a code.

9. A method as recited in claim 1, wherein the resource comprises a channel.

10. A method as recited in claim 1, wherein determining a resource assignment based at least in part on the sensed radio frequency environment comprises reporting to a mobile network node a data determined based at least in part on the sensed radio frequency environment and receiving the resource assignment from the mobile network node.

11. A method as recited in claim 1, wherein determining a resource assignment based at least in part on the sensed radio frequency environment comprises

determining that the assigned resource is not already in use by one or more of said one or more base transceiver stations.

12. A method as recited in claim 1, wherein determining a resource assignment based at least in part on the sensed radio frequency environment comprises selecting the assigned resource from a set of available resources.

13. A method as recited in claim 12, wherein selecting the assigned resource from a set of available resources comprises comparing the sensed radio frequency environment to one or more resources comprising the set of available resources.

14. A method as recited in claim 1, wherein the assigned resource is determined by a node to which the resource is to be assigned.

15. A method as recited in claim 14, wherein the node reports the assigned resource to the mobile network.

16. A method as recited in claim 1, wherein the mobile network informs one or more of said one or more base transceiver stations of the resource assignment.

17. A method as recited in claim 1, wherein the resource is assigned to one or more of the following: a small scale base transceiver station; a portable base transceiver station; and a micro-, pico-, or femto-cellular base transceiver station.

18. A system configured to manage a mobile network resource, comprising:

an antenna; and

a processor configured to:

use the antenna to sense a radio frequency environment to detect one or more base transceiver stations; and

determine a resource assignment based at least in part on the sensed radio frequency environment.

19. A system as recited in claim 18, wherein the system comprises a base transceiver station.

20. A system as recited in claim 18, wherein the system is configured to determine the resource assignment locally and report the resource assignment to the mobile network.

21. A system as recited in claim 18, wherein the system is configured to determine the resource assignment at least in part by reporting the sensed radio frequency environment to the mobile network and receiving the resource assignment from the mobile network.

22. A computer program product for managing a mobile network resource, the computer program product being embodied in a computer readable medium and comprising computer instructions for:

sensing a radio frequency environment to detect one or more base transceiver stations; and

determining a resource assignment based at least in part on the sensed radio frequency environment.

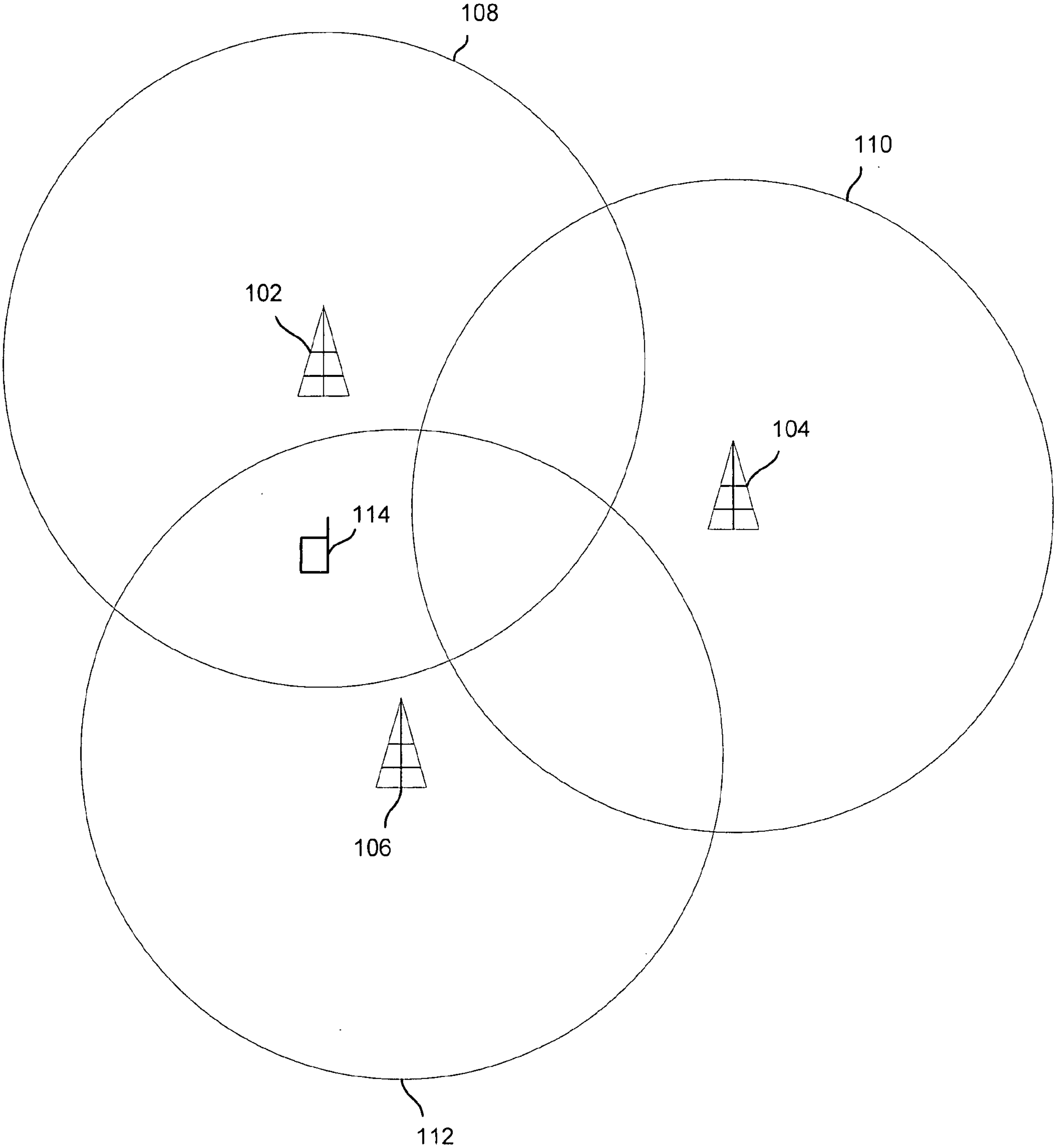


FIG. 1
Prior Art

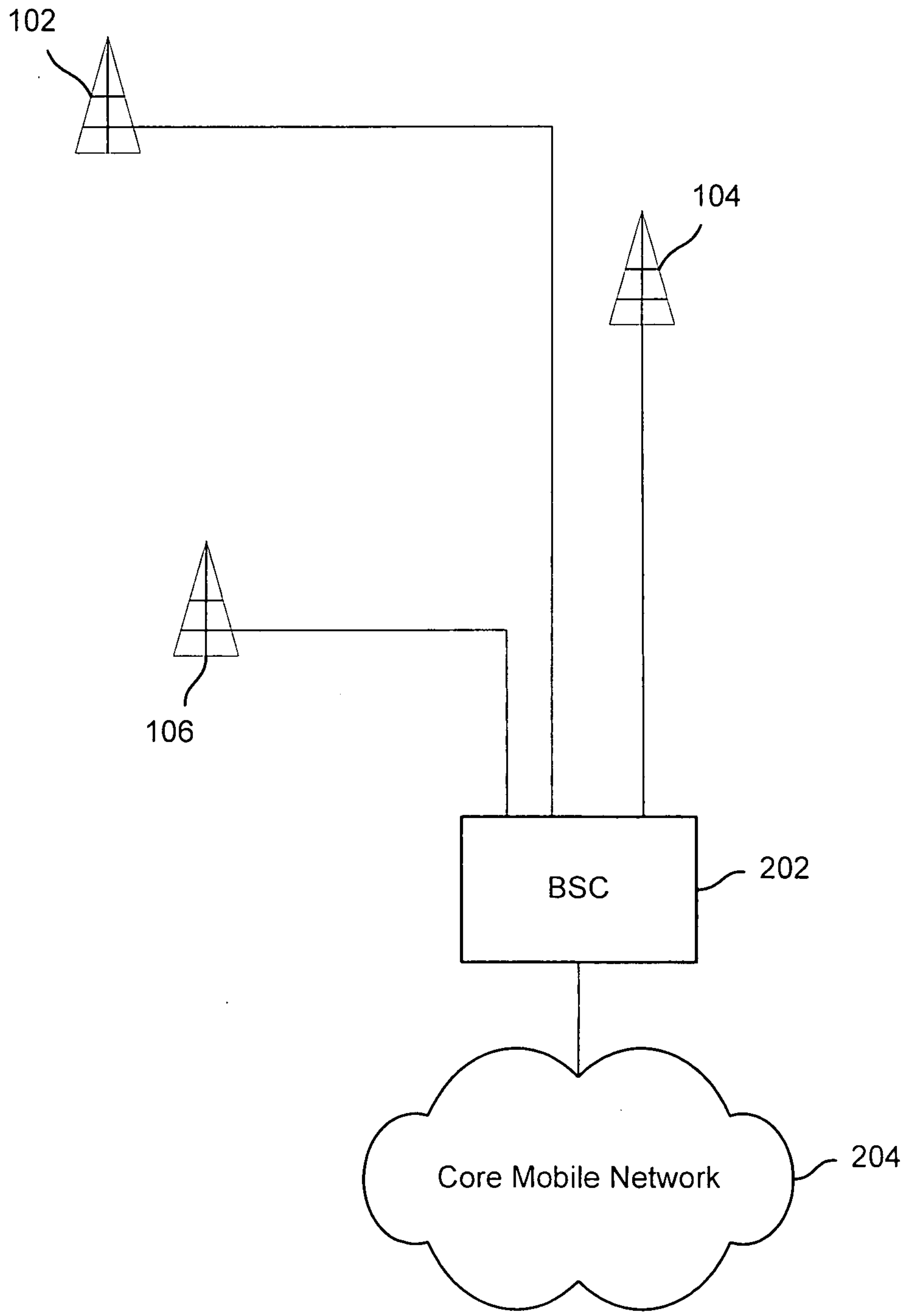


FIG. 2
Prior Art

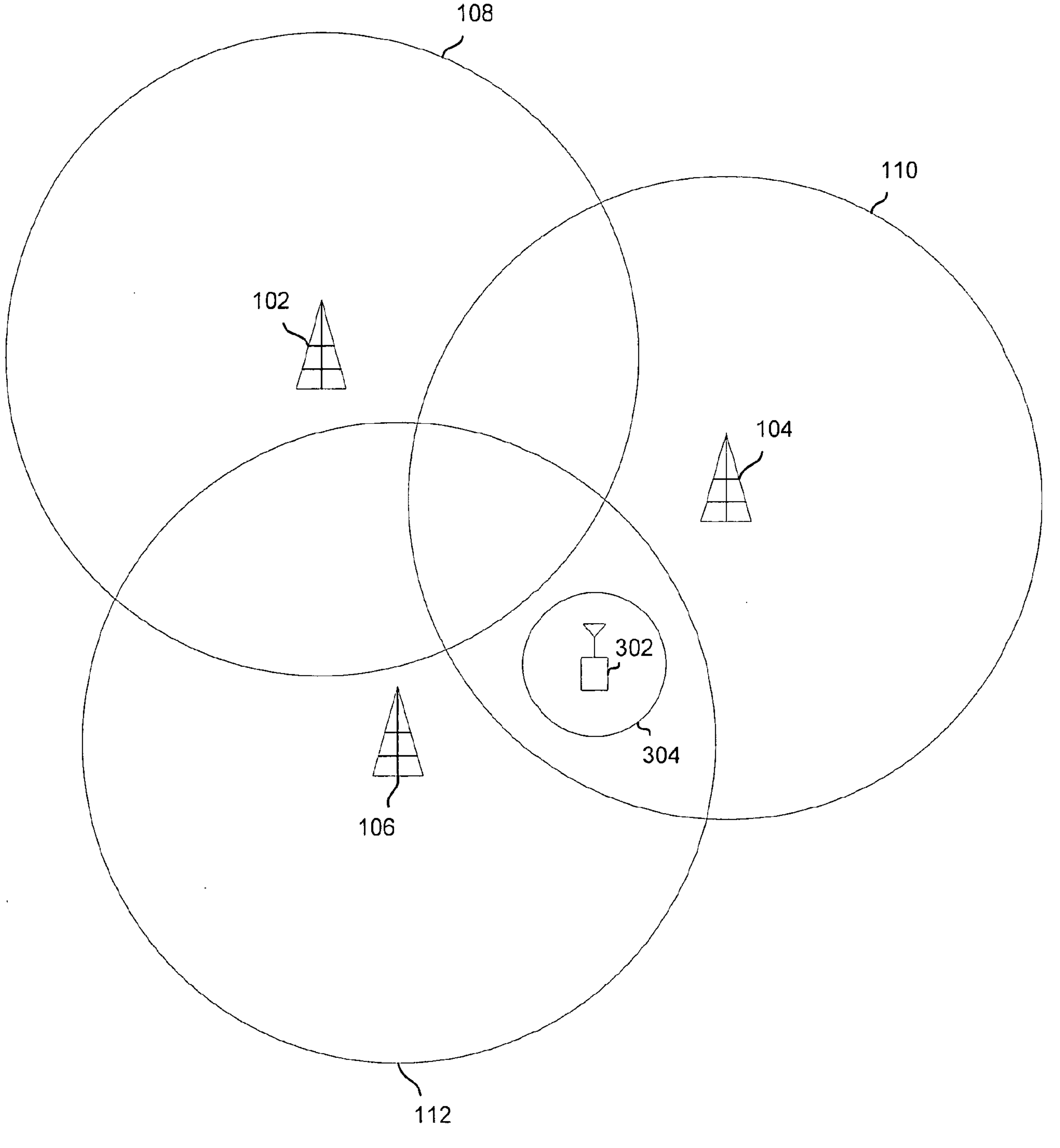


FIG. 3

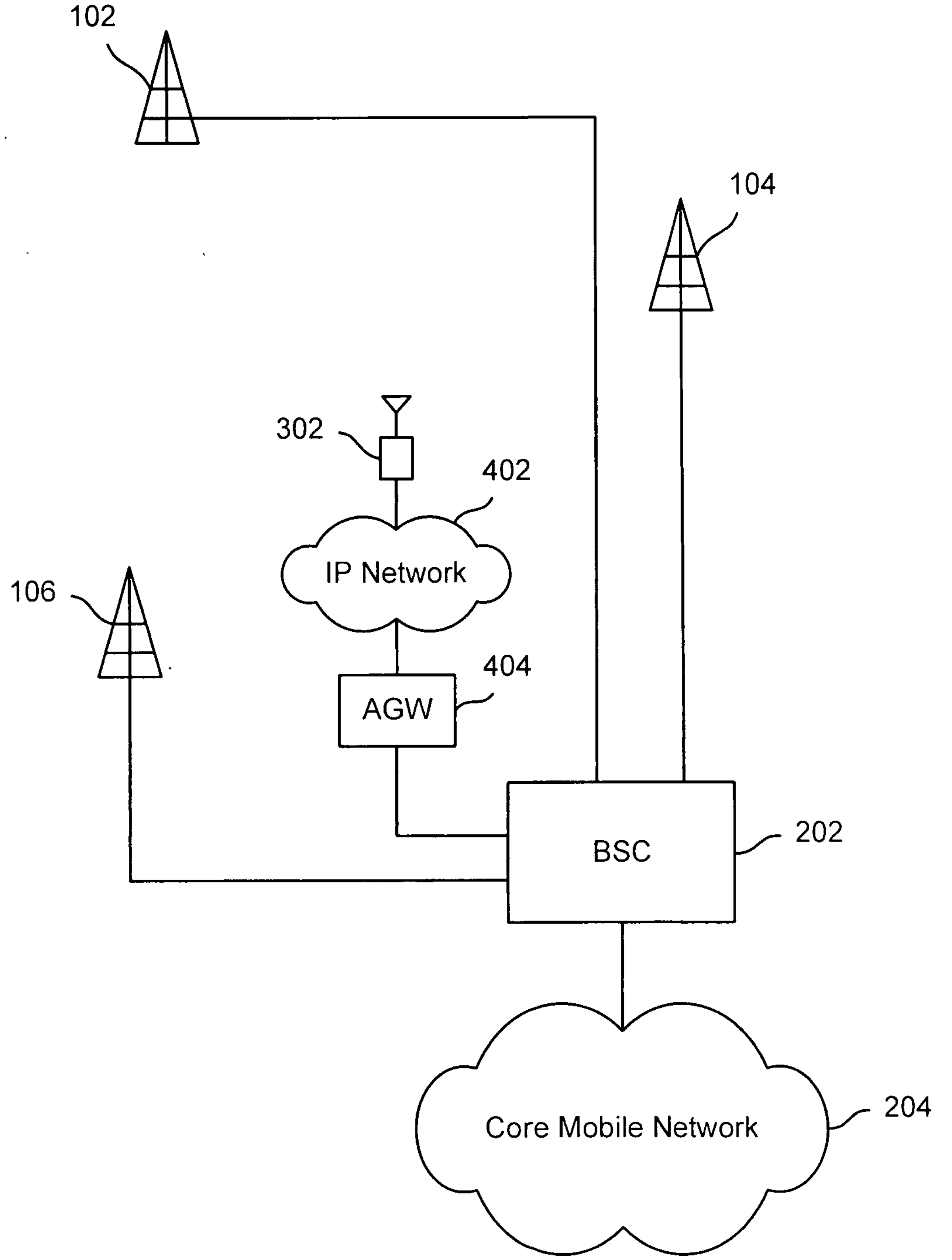

102
104
302
402
IP Network
106
404
AGW
BSC
202
Core Mobile Network
204

FIG. 4

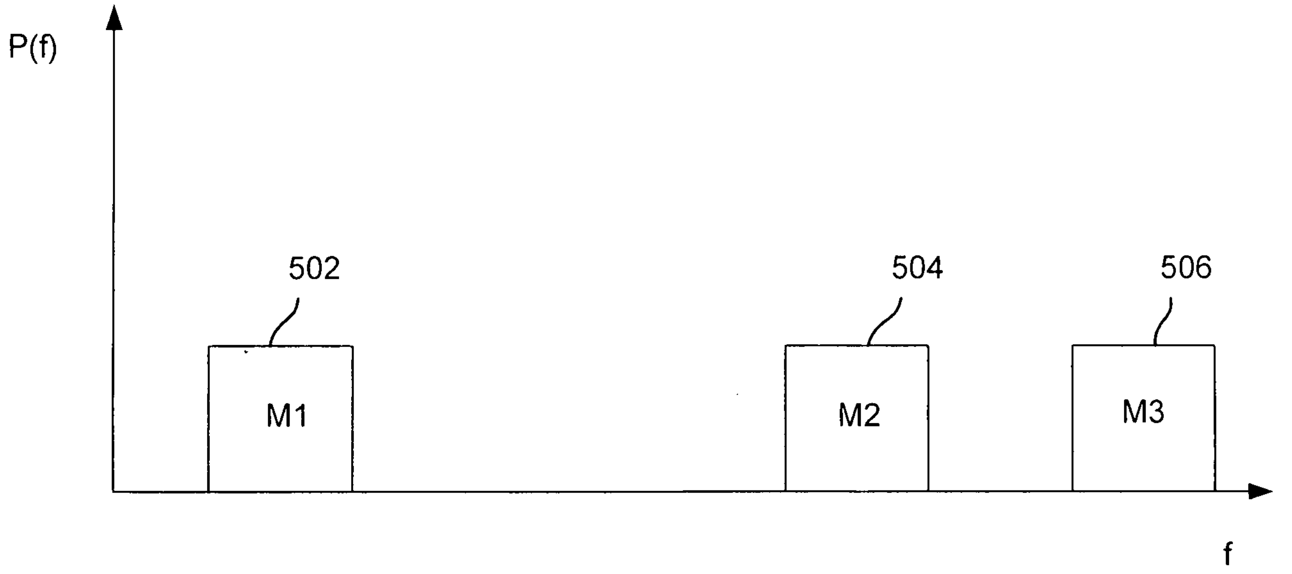


FIG. 5A

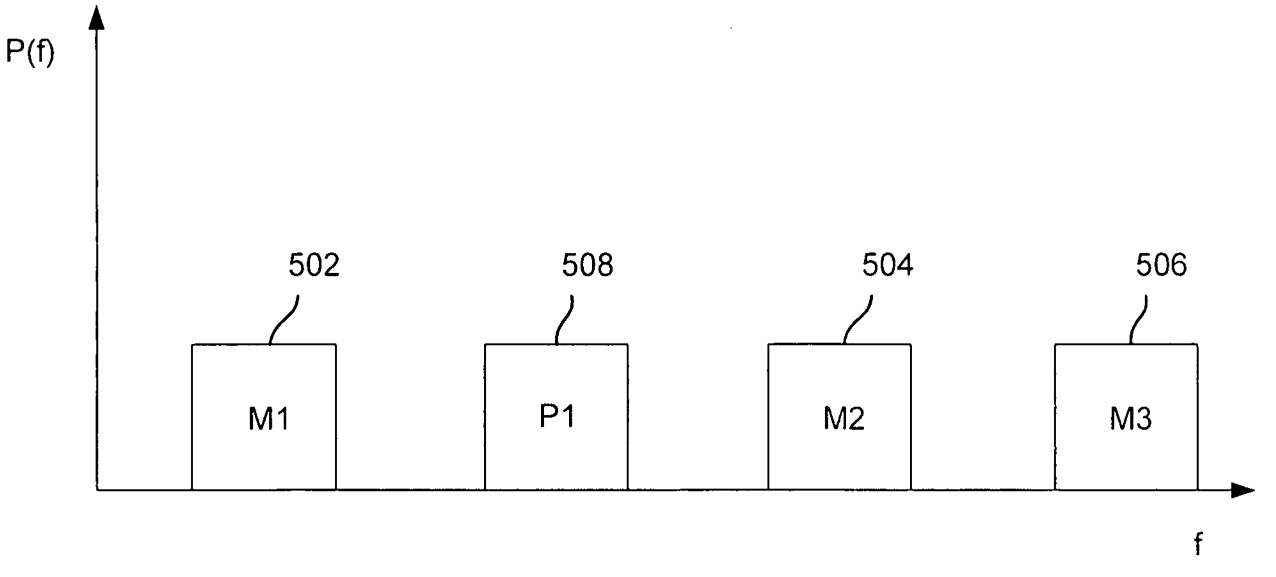
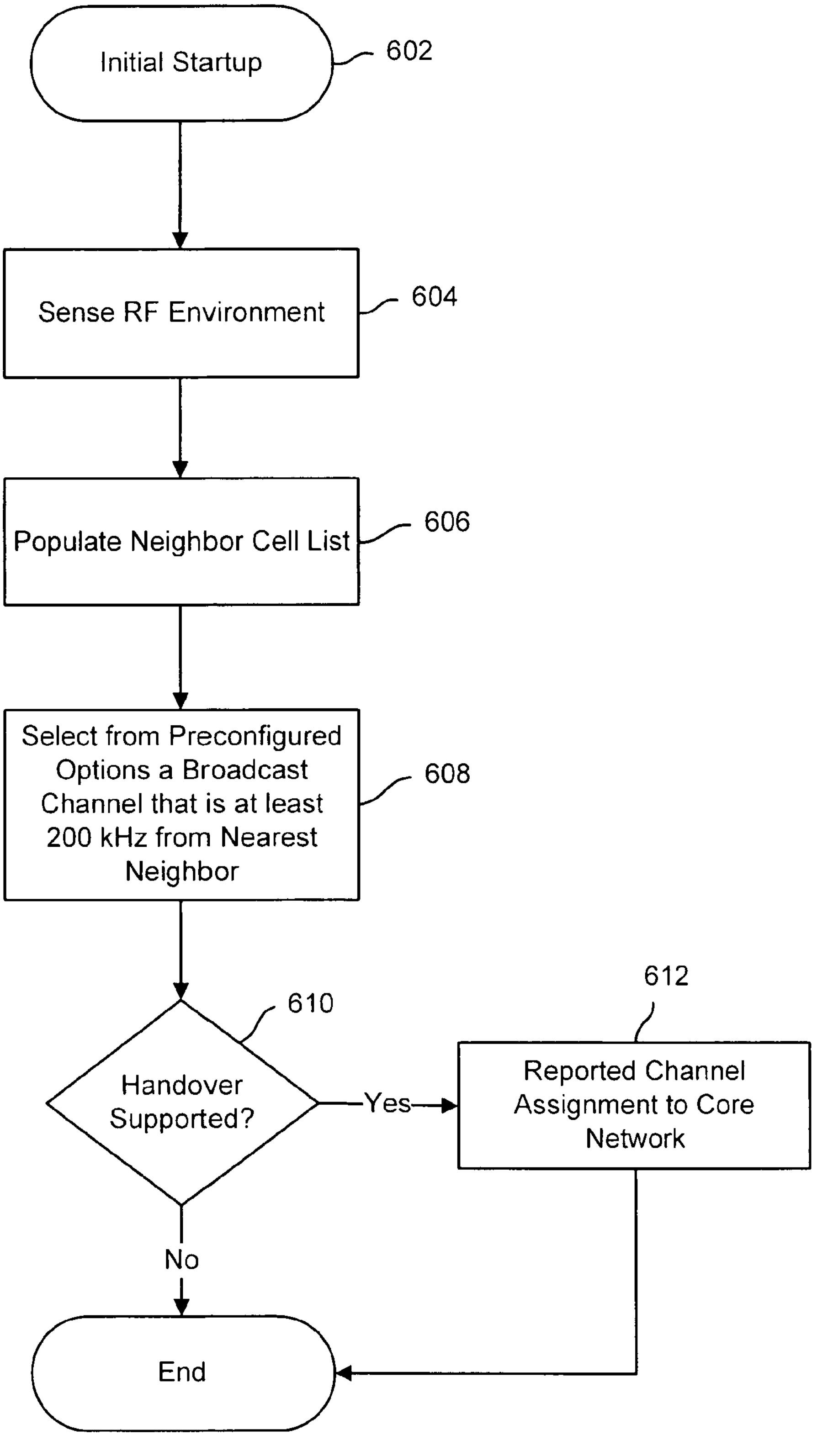


FIG. 5B



Initial Startup
602
Sense RF Environment
604
Populate Neighbor Cell List
606
Select from Preconfigured Options a Broadcast Channel that is at least 200 kHz from Nearest Neighbor
608
610
Handover Supported?
Yes
612
Reported Channel Assignment to Core Network
No
End

FIG. 6

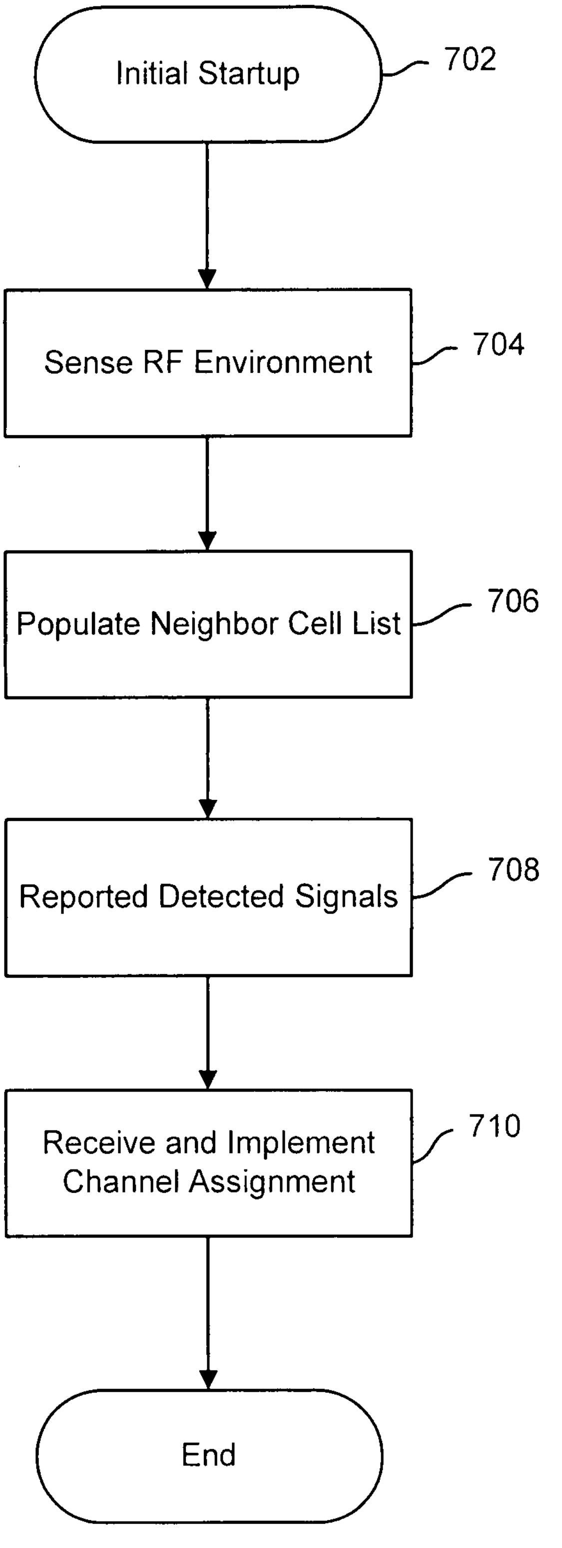

Initial Startup
702
Sense RF Environment
704
Populate Neighbor Cell List
706
Reported Detected Signals
708
Receive and Implement Channel Assignment
710
End

FIG. 7