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(54) Title: AUTO-DISCOVERY AND MANAGEMENT OF BASE STATION NEIGHBORS IN WIRELESS NETWORKS

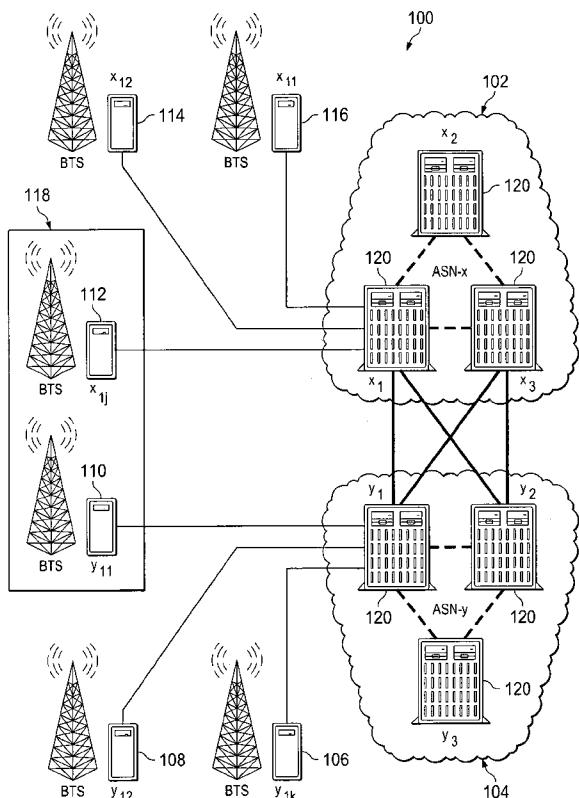


FIG. 1

(57) Abstract: Systems and methods are disclosed that include determining a local node 110 configuration for a local network node 110. The local network node 110 configuration can include a local range and a local location. In addition, these systems and methods can include receiving a remote network node 112 configuration for a remote network node 112 via a communications link. The remote network node 112 configuration can include a remote range and a remote location. Also these systems and methods can further include generating a neighbor list 1402 that includes the remote network node 112 and the local network node 110. The neighbor list can be determined using the local network node 110 configuration and the remote network node 112 configuration.

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AUTO-DISCOVERY AND MANAGEMENT OF BASE STATION NEIGHBORS
IN WIRELESS NETWORKS

CROSS-REFERENCE TO RELATED APPLICATION

5 **[0001]** This application claims priority under 35 USC
119(e) to United States Provisional Application Serial No.
60/954,895, filed on August 9, 2007, which is incorporated
herein by reference.

10

TECHNICAL FIELD

[0002] The present invention relates generally to
wireless communication systems, and more particularly to a
network architecture and methods for base station neighbor
automatic discovery (identification or learning),
15 configuration and/or dynamic tuning to optimize network
performance.

BACKGROUND

[0003] Some of the most challenging and costly tasks undertaken by network operators when introducing new telecommunications infrastructure or adding capacity to existing infrastructure (such as adding access points ("APs" or base transceiver stations ("BTSs", also referred to herein as "base stations")) includes network planning, development and operational efforts. The efforts to setup and optimize such networks are significant and traditionally necessitate lengthy periods until attainment of an optimum and stable system. This is usually done based on initial, manual configuration of the BTSs at the time of deployment.

[0004] Base station neighbor information is critical for wireless network operation, for such information is utilized by base stations, network controllers and access service network ("ASN") gateways (depending upon network architecture) for various applications, including Radio Resource Management (RRM), neighbor BTS communication associated with handoffs (handovers), and multi-step paging based on BTS neighbor topology. This neighbor information is also crucial to the successful operation of emerging, high data rate 4G wireless systems, such as those built (or to be built) in conformance with wireless specifications such as LTE (Long Term Evolution) promulgated by 3GPP (Third Generation Partnership Project) and that promulgated by the Worldwide Interoperability for Microwave Access Forum (WiMAX) for interface auto discovery. This WiMAX specification is also known as the Institute of Electrical and Electronic Engineers (IEEE) 802.16e-2005 standard, and is incorporated herein by reference.

[0005] Access points and base transceiver stations provide users (and their communications devices known as

"subscriber stations") wireless connectivity to wireless access service networks (ASN). These access points have different names depending upon network architecture and the standard to which the network is constructed, but they generally share similar characteristics, such as antenna(s) and base station transceiver(s). In cellular deployments, the antennas are mounted to physical structures, such as towers, buildings and other generally elevated structures.

Once connected to the ASN, users have the ability to move about the ASN, with their call sessions (data or voice) being transferred as necessary from one base station to another. Within the network, each BTS is connected (via wireless or wireline) to a controller node. The controller node can be in the form of a "gateway" (GW) generally responsible for controlling and communicating with a number of BTSs. Such gateways can be connected to a global network, which can be the public switched telephone network ("PSTN"), Internet, or other wired or wireless communications network. It is critical for wireless network operators to ensure that call sessions maintain continuity as these call sessions are handed off from one BTS to another. As noted above, network operators typically populate lists of BTS neighbors at the time of network turn-up, but such manual configuration fails to take into account the inherently dynamic nature of networks, as planned (and unplanned) BTS service outages arise, or BTSs otherwise fully operational become unavailable for relatively short periods of time due to operation at capacities that inhibit participation in call handoffs, as can occur incident to activities such as large gatherings (e.g., major sporting and theatrical/musical events), or extraordinary events (accidents on highways, etc.).

[0006] Deployment and functioning of emerging 4G wireless technologies, such as LTE and WiMAX face many of the challenges existing in cellular/PCS networks. However, some of these challenges are more pronounced in these
5 emerging 4G technologies as a consequence of their deployment, in many instances, at higher frequency bands (1.5 GHz to 11 GHz). One of the problems impacting such deployments concerns "shadowing", a phenomenon involving diffraction around obstacles (such as buildings, water
10 towers, etc.). Such diffraction becomes more problematic at higher frequencies, as the signal wavelength correspondingly diminishes. Moreover, at elevated frequencies (and depending upon prevailing RF conditions), line of sight (LOS) between the BTS and the subscriber
15 terminal can become more of an issue. While urban areas are places where high data rates would be beneficial, these urban areas also exacerbate the LOS problem (e.g., buildings, obstacles, etc). Some locations will have no LOS, while other locations will have acceptable LOS in the vicinity of the cell site (BTS location), with poor LOS in
20 areas further from the cell site.]The 4G wireless technologies are designed for high data rates. Typically, high data rates can only be achieved with high signal-to-noise ratios (SNRs). Because LOS is not possible (or
25 limited) in many locations, many subscriber stations are severely impacted in locations resulting in no LOS with low SNR. Often a subscriber station behind an obstacle may acquire the network (i.e., the control channel can be detected), but data throughput rates are low. A high
30 number of users will be in disadvantaged locations that will not support high data rates between the subscriber station and BTS. Therefore, combating the shadow/LOS problem is a major issue in the deployment and operation of

emerging 4G wireless technologies at higher frequencies in urban and dense urban areas.

[0007] Accordingly, there are needed infrastructure components and methods that provide self-configuration and self-optimization solutions for automatic discovery (identification or learning) of BTS neighbors (and BTS neighbor information) to avoid the individual and manual provisioning of neighbors on each BTS and controller. Such is desirable in instances of initial network deployment, capacity enhancements (such as arise from the addition of further BTSs), service outages and restarts, and other such situations that impact the network. Further, as operating conditions change in the network due to operation limitations as described above, it is important to be able to dynamically tune (i.e., identify) the list of neighbor BTSs available for handoff communications when the network conditions change (e.g., signal degradation due to shadowing (i.e., signal degradation due to physical obstructions in the path between the servicing BTS and the user, limitations in the available line of sight to the user, changes in BTS range, etc.).

SUMMARY

[0008] In accordance with one embodiment, a method is disclosed that includes determining a local node configuration for a local network node. The local network node configuration can include a local range and a local location. In addition, this method can include receiving via a communications link a remote network node configuration for a remote network node. The remote network node configuration can include a remote range and a remote location. Also this method can further include generating a neighbor list that includes the remote network node and the local network node. The neighbor list can be determined using the local network node configuration and the remote network node configuration.

[0009] In accordance with another embodiment, a method is disclosed that includes obtaining a first information about a first base station. The first information can include location and range information relating to the first base station. This method includes sending the first information to a first server. Also disclosed in this embodiment is obtaining a second information about a second base station. The second information comprises location and range information relating to the second base station.

In addition, this method includes sending the second information about the second base station to the server, generating a neighbor list from the first information and the second information, and transmitting the neighbor list to the first base station and the second base station.

[0010] In yet another embodiment, a system is disclosed that includes a first base station. The first base station is capable of storing first identification information relating to the range of the first base station and the location of the first base station and communicating with a

first network. This system may also include a second base station that is capable of storing second identification information relating to the range of the second base station and the location of the second base station. The
5 second base station is also capable of communication with a second network. Thus system may further include a server that is capable of communication with the first network and the second network. The server is capable of receiving the first and second identification information, creating a
10 neighbor list based upon the first and the second identification information, and transmitting the neighbor list to the first base station and the second base station.

[0011] Other technical features may be readily apparent to one skilled in the art from the following
15 figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a more complete understanding of the present disclosure, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

[0013] FIGURE 1 depicts a high level diagram of an example diagram with a plurality of BTSs and ASNs within an illustrative (such as WiMAX) wireless communications network, in accordance with one embodiment of the present disclosure;

[0014] FIGURE 2 is a block diagram of a system used within a ASN shown in FIGURE 1, in accordance with one embodiment of the present disclosure;

[0015] FIGURE 3 is a reference diagram of a BTS, according to one of the disclosed embodiments, in accordance with one embodiment of the present disclosure;

[0016] FIGURE 4 is a reference diagram of the messages transmitted between BTS stations and ASNs shown in FIGURE 1, in accordance with one embodiment of the present disclosure;

[0017] FIGURE 5 is an illustration of informational elements used in determining a list of neighbor BTS, in accordance with one embodiment of the present disclosure;

[0018] FIGURE 6 depicts one method of implementing the disclosed embodiments;

[0019] FIGURE 7 depicts ranges of various BTSs used to create a list of BTS neighbors, according to one of the disclosed embodiments;

[0020] FIGURE 8 is an illustration of the coverage angle of a BTS, according to one of the disclosed embodiments;

[0021] FIGURE 9 is an example of the coverage area between two neighbors, according to one of the disclosed

embodiments; and

[0022] FIGURE 10 depicts priority messages based upon a neighbor list.

DETAILED DESCRIPTION

[0023] FIGURE 1 illustrates an example of a communications network architecture or system 100 in accordance with the present disclosure. The network or system 100 shown in FIGURE 1 is for illustration purposes only, and represents a plurality of cells or sectors. Other embodiments of the system 100, constructed in conformance of any of a multitude of standards, may be used without departing from the scope of this disclosure. Reference to "standards" as used herein is meant to encompass existing and future versions of the referenced standards, as well as standards encompassing the principles of the subject matter disclosed and claimed herein.

[0024] In this example, the system 100 is part of a larger access services network (not shown), and the system 100 includes a base station (BTS) 112, a BTS 114 and a BTS 116 each communicating with an access service network (ASN) 102. Also shown in system 100 are a BTS 106, a BTS 108 and a BTS 110 each communicating with an ASN 104. The ASN 102 communicates with the ASN 104 (via wireless or wireline communications). Included as a part of each ASN 102, 104 is one or more BTS controllers, in the form of gateways or servers 120 (Figure 1 illustrates gateways X1 through X3 within ASN 102 and Y1 through Y3 within ASN 104).

[0025] One problem prevalent in wireless communications, irrespective of the protocol or standard upon which it is based, is that when a communication device (such as a subscriber station, also referred to as a mobile station) moves from one area to another area, the signal strength may vary and ultimately may decline to a level insufficient to maintain communications or, in any event, high data rates. Even when a mobile station is within the theoretical range of one BTS, physical obstacles or other

conditions may inhibit communication with the BTS. In such a case, communications may be disrupted or lost. In response to movement outside the BTS coverage area or when other factors inhibit or reduce reliability of communications with the BTS, the BTS (or network) may initiate a communications handoff from the servicing BTS to another BTS to improve the communications link to the communications device. This necessarily requires knowledge of the BTS's neighbors.

10 **[0026]** As described above, the identification and provisioning of each BTS's neighbors within the system is usually performed manually within each BTS and/or the ASNs at the time of initial network setup or when a resource is added to, or removed from, the existing network. This manual provisioning is time-consuming, expensive and relatively static. In addition, network operating conditions (e.g., coverage range of a base station, which is based on various factors) may change substantially over time and as a result, coverage area of a given BTS may be different than that relied upon when the BTS neighbors were initially provisioned for each BTS. Therefore, those BTSs identified as neighbors for a given BTS may not truly be neighbors and problems with handoffs may occur.

25 **[0027]** One disclosed method (or methods) to overcome these problems is the use of automatically discovered and/or dynamically updated neighbor relations to configure the system 100. A neighbor's relation 118 is shown as a box that illustrates that the BTS 112 and the BTS 110 are neighbors. Details as to the manner by which automatic discovery is implemented are provided in the below specification. The automatically discovered and dynamically updated relations promote automatic configuration and optimization of the network 100. For

instance, traffic among a plurality of mobile stations (MS) can be balanced among a plurality of BTSs. Moreover, signal loss or interruptions may be anticipated based upon empirical signal conditions to promote a handoff from one
5 BTS to another BTS prior to the detection of a signal loss.

Network operating conditions can be measured periodically to provide for generation of an updated neighbor list for a given BTS, thus allowing for a high degree of dynamic BTS neighbor tuning and/or optimization. These, and other
10 innovative and unique aspects of the present disclosure, will be discussed in more detail below.

[0028] The ASN 102 and the ASN 104 may include one or more local area networks ("LAN"), metropolitan area networks ("MAN"), wide area networks ("WAN"), all or
15 portions of a global network, or any other communication system or systems at one or more locations, or combination of these, including the public switched telephone network (PSTN), Internet, packet networks and the like. The ASN typically also includes a BTS backhaul network (not shown)
20 which is a data network utilized for communications between the BTSs and ASNs. These networks may be configured to include Internet, packet networks and the like. In one embodiment, the ASNs 102, 104 (or portions thereof) are Internet Protocol (IP) based networks, and in another
25 specific embodiment, the system or network 100 operates in accordance with the WiMAX standard (IEEE 802.16). It is understood that one or more servers (not shown) may communicate through the ASN 102 and the ASN 104.

[0029] Other components, devices or networks may be
30 included in the system 100, and FIGURE 1 only illustrates but one exemplary configuration to assist in describing the system and operation to those skilled in the art. The system 100 represented in FIGURE 1 may be described using

different nomenclature or system terminology, such as use of the terms access terminal (AT) or mobile subscriber terminals (MS or MT) or subscriber stations (SS), base station (BS) or base transceiver station (BTS) (as well as
5 Node B, enhanced Node B and so forth), and the use of any given nomenclature to describe a device within the system
100 is not intended to limit the scope of this disclosure.

As will be understood by those skilled in the art, air interface technologies utilized by BTSs in the system 100
10 may encompass technologies or standards such as, by way of non-limiting example, 2G, 2.5G, 3G, GSM, IMT-2000, UMTS, iDEN, GPRS, 1xEV-DO, EDGE, DECT, PDC, TDMA, FDMA, CDMA, W-CDMA, LTE, TD-CDMA, TD-SCDMA, GMSK, OFDM, WiMAX, the family of IEEE 802.11 standards, the family of IEEE 802.16
15 standards, IEEE 802.20, etc. For example, the WiMAX standard defines two network architectures or modes: point-to-multipoint (PMP) mode and mesh mode. In the PMP mode, every subscriber station directly communicates with a BTS and may indirectly communicate with another subscriber
20 station but only through a BTS first. This network mode has a star structure with the BTS at the center of the star. In the mesh mode, every subscriber station is operable to directly communicate with every other subscriber station - the BTS is not required. The
25 architecture illustrated in FIGURE 1 implements the PMP mode, as subscriber stations receive instructions from the BTS unit they are communicating with. However, it is expressly understood that the innovative elements of the present disclosure could be implemented in either a PMP
30 mode or other modes and, as noted previously, the teachings of the present invention are independent of air interface standard and technology.

[0030] The BTSs (e.g., 106, 108, 110, 112, 114, 116)

have coupled thereto one or more subscriber stations (not shown). The subscriber stations are operable for communicating wirelessly with (or to) the BTSs over an air interface. In the system 100, any number of subscriber stations may be present up to the capacity of the network.

Each subscriber station within the system 100 may be fixed or mobile (including nomadic) communication devices. It is to be understood for the purpose of this detailed description that subscriber station data rate transmission/reception is not limited to any specific rate and that mobility of mobile subscriber stations is not limited to any specific rate of movement.

[0031] A conventional BTS generally includes various components such as processing units, controllers and network interfaces, which necessarily include but are not limited to, microprocessors, microcontrollers, memory devices, and/or logic circuitry, and these may be adapted to implement various algorithms and/or protocols. No additional description of the conventional components and software processes (functionality) of a BTS, other than as noted herein or relevant for an understanding of the present disclosure, is provided, as these are known to those of ordinary skill in the art. It will be understood that the BTSs may be constructed or configured from any suitable hardware, software, firmware, or combination thereof for providing the functionality known to those of ordinary skill in the art. The BTSs will include additional functionality as described below in accordance with one or more embodiments.

[0032] Now turning to FIGURE 2, there is shown a block diagram of an ASN gateway or server 120 within the ASN 102 or the ASN 104 in accordance with the present disclosure. The gateway 120 includes a processor (which may include a

digital signal processor) 200, a memory 202, a transceiver 204, input/output devices 206, and an antenna 208. Other components may be included, but are not shown. Details of the operation and structure of these components, except as
5 necessary to illustrate the operations and methods described herein, have been omitted. The gateway includes a scheduler 210. Though shown as a separate component, the scheduler 210 is normally a software process (or logical entity) that controls and manages scheduling of data.

10 **[0033]** Now turning to FIGURE 3, exemplary BTS 106 (and BTSs 108, 110, 112, 114 and 116) is a medium to high-power multi-channel, two-way radio in a fixed location. Such BTSs are typically provided for communication with subscriber stations in the form of relatively low-power,
15 single-channel, two-way radios or wireless devices such as mobile phones, portable phones, wireless computer networking cards (such as PCM/CIA and other wireless connectivity devices) and wireless routers. The BTS 106 may comprise a signal controller 300 that is coupled to a
20 transmitter 302 and a receiver 304. The transmitter 302 and the receiver 304 (or combined transceiver) may further be coupled to an antenna 306. In the BTS 106, digital signals are processed in channel processing circuitry 308 and the digital signals may be signals for a wireless
25 communication system, such as signals that convey voice or data intended for a mobile terminal (not shown). The signal controller 300 sends the digital signals to the transmitter 302 which includes the channel processing circuitry 308 that encodes each digital signal and a radio frequency (RF)
30 generator 310 that modulates the encoded signals onto an RF signal. The resulting RF output signal is transmitted over the antenna 306 to a subscriber station (not shown).

[0034] In addition, the antenna 306 also receives

signals sent to the BTS 106 from subscriber stations. The antenna 306 couples the received signals to the receiver 304 that demodulates them into digital signals and transmits them to the signal controller 300 and relayed to an associated gateway 120. The BTS 106 may also include auxiliary equipment such as cooling fans or air exchangers for the removal of heat from the BTS 106. As will be understood by those skilled in the art, the BTS 106 may employ any suitable wireless technologies or standards such as 2G, 2.5G, 3G, GSM, IMT-2000, UMTS, iDEN, GPRS, 1xEV-DO, EDGE, DECT, PDC, TDMA, FDMA, CDMA, W-CDMA, LTE, TD-CDMA, TD-SCDMA, GMSK, OFDM, WiMAX, the family of IEEE 802.11 standards, the family of IEEE 802.16 standards, IEEE 802.20 and the like, and can be used in a variety of applications, including cellular, WLAN, MAN and Femtocell communications networks.

[0035] FIGURE 4 is a simplified diagram of communication paths and messages between the BTS 110, the BTS 112, the ASN 102, and the ASN 104 in a WiMAX compliant network. With concurrent reference to FIGURES 1 and 4, the BTS 110 exchanges information with the gateway 120 (Y1) within ASN 102 and the BTS 112 exchanges information with the gateway 120 (X1) within ASN 104. Each of these communication paths is referred to as an "R6 interface" (as defined in the WiMAX standard). The ASN 102 and the ASN 104 exchange information over an "R4 interface" (as defined in the WiMAX standard). Though these paths are described as the R6 and R4 interfaces in accordance with WiMAX, other communication protocols or standards may be utilized. It is explicitly understood that the ASN 102 and the ASN 104 may each include one or more gateways 120, routers, servers, and other communication devices that make up an autonomous system. Communications over these paths and interfaces may

include information as shown in FIGURE 5.

[0036] FIGURE 5 is a chart 500 that describes information elements (IE), status of those elements (e.g., M for mandatory and O for optional), and notes describing the contents of each element comprised within traffic exchanged by BTSs and ASNs. The information includes IEs 510, 520, 530, 540, and 550.. The IE 510 includes BTS location::latitude information while the IE 520 includes BTS location::longitude information. The IE 530 includes BTS coverage range information (range in meters). In addition, the IE 540 includes BTS antenna center angle direction information (direction antenna associated with the BS is pointing) while the IE 550 includes BTS antenna coverage angle information (angle over which the antenna associated with the BS can receive and transmit RF signals). The information exchanged between BTSs and ASNs may further include (not shown): IP address of each BTS (IP Address), a unique BTS identifier (BTS ID), preamble index and center frequency.

[0037] As will be appreciated, a given BTS may include one or more "sectors". Conventional BTSs generally include three or six sectors (approximately 120 or 60 degrees each) and therefore, may be described as including three or possibly six sectors. Therefore, each sector within a BTS has a set of IEs that can be utilized to describe it. As will be appreciated, some information, such as location, is typically the same for each sector within a given BTS (e.g., each sector would have the same location information) while other information, such as coverage range, antenna coverage angle, and antenna center direction parameters, could be different.

[0038] It will be understood that each IE 510, 520, 530, 540 and 550 may be transmitted in separate packets or

messages, or two or more IEs may be transmitted collectively within a single packet or message. Though not shown, each packet or message will typically include an identification field that identifies the included data as latitude, longitude, coverage range, or antenna angle
5 information. In one embodiment, the BTS location::latitude information and BTS location::longitude information each includes four octets (32 bits) of data representing degrees, minutes, seconds as integer values. The BTS
10 coverage range information may be provided using four octets (32 bits) in a single integer denoting the range in meters. The BTS antenna center direction information and the BTS antenna coverage angle information may be provide using at total of four octets (32 bits) with two integer
15 values (alternatively, each parameter could be transmitted separately). For each of the above, all 0's may be used to represent an unknown status.

[0039] It is understood that these packets or messages will be used within communications between BTSs and their associated ASNs (or gateways) and also between ASNs using
20 the communication paths R6 and R4, respectively, as more fully described below.

[0040] Moving from the hardware and information elements described above used to implement the disclosed systems and
25 methods, one method of performing automatic identification and learning of base station neighbors is illustrated in FIGURE 6.

[0041] As previously described, BTS neighbor determination in a conventional wireless network is
30 provisioned manually. This approach requires a BTS neighbor list to be provisioned for each BTS and a change to BTS neighbor lists when the BTS topology changes (BTS added or removed). Further, there is no method to update

neighbor lists based on BTS operational status (up/down).

[0042] In accordance with the present disclosure, automatic determination of BTS neighbor lists provides significant advantages over prior art provisioning methods.

5 As the network topology or operating conditions change, BTS neighbor lists can be generated and/or updated automatically and dynamically (e.g. periodically or event-based driven).

[0043] In general terms, the present disclosure provides
10 a method of generating neighbor lists when there is a change in the number and/or operational status of BTSs within the system 100. The neighbor list provides the given BTS with knowledge of its neighboring BTSs. Neighbor lists allows BTSs to proactively avoid interruptions in
15 service by handing subscriber station communications off to a neighbor BTS when there are communication problems or for the purpose of balance BTS loads during times of high demands (e.g., where a first BTS and second BTS are neighbors, if the first BTS has a very high usage, and the
20 second BTS has a low usage, the first BTS can hand over all or a portion of its ongoing call sessions to the second BTS). In the instance of a newly added BTS to the system, the newly added BTS transmits its configuration parameters (IEs) (e.g., one or more of location, coverage range,
25 antenna direction and coverage angle, IP address, BTS ID, preamble index and center frequency) to its associated gateway 120 within a respective ASN. After collecting this information, the gateway 120 propagates some or all of this information to peer gateway(s) 120 within the system 100.
30 The gateway(s) 120 utilize the received BTS attributes, such as IEs, (received from its own BTSs and the other gateways 120) and generate BTS neighbor lists for the added BTS and any BTSs associated with it (i.e., having overlapping

coverages). The gateway(s) 120 then send the BTS neighbor lists to the newly added BTS and its associated BTSs.

[0044] It is expressly understood that a neighbor list may be created by any member of system 100. In some
5 embodiments, each gateway may create a neighbor list for each BTS in communication with the gateway. In other embodiments, a single gateway will create a neighbor list for each BTS in system 100. In yet other embodiments, each
10 BTS may have sufficient information sent to the BTS through a gateway to allow for the creation of its own neighbor list. These neighbor lists allow for the handoff of communications from one BTS to another BTS, according to the neighbor list.

[0045] In another method, BTS neighbor lists may be
15 dynamically updated periodically to take into account network operating conditions. This may be done globally or within a specified region of the network. In yet another method, BTS neighbor lists may be dynamically updated in response to a change in network operating conditions.
20 Similarly, this may be performed on a global basis, regionally, or at or around a given BTS. In either method, the gateway(s) 120 collect the BTS configuration parameters and information, generate neighbor lists, and propagate the neighbor lists to its associated BTSs. This allows for
25 dynamic tuning, enhancement and optimization of BTS neighbor lists. FIGURE 6 illustrates a method 1000 of creating a neighbor list for a given BTS. In this method, configuration parameters (such as Information Elements (IEs)) or other information concerning a given BTS (such as
30 BTS 112) is determined (step 1002) and transmitted to its associated gateway (such as gateway 120(X1)) (step 1004). Such determination can be undertaken by one or both of the BTS and associated gateway 120. The gateway 120 (X1)

generates a neighbor list on the basis (at least in part) of the transmitted received BTS configuration parameter information and BTS configuration parameter information of other BTSs, such as BTS 110 (step 1006). The BTS configuration parameter information of the other BTSs is/was obtained directly from the BTSs or via their associated gateways, such as gateway 120(Y1). In an optional step, the generated neighbor list may be optimized (step 1008) through a single or iterative process. The generated BTS neighbor list is sent to the BTS 112.

[0046] The above described method 100 illustrates the generation of the neighbor list for a single BTS 112. It will be understood that the method may be performed for additional BTSs, where each gateway 120 retrieves BTS configuration parameter information from each BTS it manages, each gateway 120 sends this information to the other gateways 120, each gateway 120 creates neighbor lists and sends a respective list to each managed BTSs.

[0047] In one embodiment, BTS neighbor list generation may occur without antenna direction and coverage angle information, and utilizes BTS location and coverage range information. This approach considers the BTS coverage area as a circle defined by the BTS location and coverage range.

Two BTSs are defined as neighbors if their coverage areas are intersecting circles. In another embodiment, BTS neighbor list generation further utilizes antenna direction and coverage angle information. This approach considers the BTS coverage area as a convex polygon defined by the BTS location, coverage range and antenna direction and coverage angle information. Two BTSs are defined as neighbors if their coverage areas are intersecting polygons. It is understood that elements from both embodiments might be used together, and these embodiments

are presented solely for the purpose in aiding in understanding the present disclosure.

[0048] In a first embodiment, the gateway 120(Y1) receives the following information directly from the BTS
 5 110:

- BTS 110:
- Longitude (in radians): *LONGa*
 - Latitude (in radians): *LATa*
 - Coverage range (in km): *Ra*

10

and also receives the same type of information from BTS 106 and BTS 108. The gateway 120(Y1) propagates this information to the gateway 120(X1). Similarly, the gateway 120(X1) receives the following information directly
 15 from the BTS 112:

- BTS 112:
- Longitude (in radians): *LONGb*
 - Latitude (in radians): *LATb*
 - Coverage range (in km): *Rb*

20

and also receives the same type of information from BTS 114 and BTS 116. The gateway 120 (X1) similarly propagates this information to the gateway 120(Y1). In one aspect of the invention, each gateway 120 uses equation (1) below to
 25 determine whether any pair of BTSs are neighbors (if the inequality is true, the base stations are neighbors, if it is false they are not):

$$\text{DISTANCE (BSa, BSb)} < Ra + Rb \tag{1}$$

where DISTANCE (BSa, BSb) is defined by Equation (2) below:

30

$$\begin{aligned} \text{DISTANCE (BSa, BSb)} = & \\ & \cos(\cos(\text{LONGa}) * \cos(\text{LATa}) * \cos(\text{LONGb}) * \cos(\text{LATb}) + \\ & \cos(\text{LONGa}) * \sin(\text{LATa}) * \cos(\text{LONGb}) * \sin(\text{LATb}) + \\ & \sin(\text{LONGa}) * \sin(\text{LONGb})) * 6378 \tag{2} \end{aligned}$$

In the example illustrated in FIGURE 1 and described above, BTS 110 and BTS 112 are neighbors.

[0049] This approach is useful when looking at a plurality of BTS stations. FIGURE 7 shows a plurality of
5 BTSs 1102, 1104, 1106, 1108, 1110, and 1112. Using Equation (1) the following neighbor list may be created:

```

BTS: Neighbors
1102: 1104
10 1104: 1102, 1106, 1110
1106: 1104, 1108
1108: 1110, 1106
1110: 1104, 1108, 1102
1112: 1110
```

15

[0050] It is explicitly understood that any or all of the BTS may be connected to separate ASNs.

[0051] The first embodiment is useful in the initial configuration of the system 100 or when network operating
20 conditions affect one or more BTS coverage ranges. When BTS coverage ranges change due to operating conditions and the BTS (or its managing gateway) has functionality to calculate its own BTS coverage range, the first embodiment may be utilized to dynamically tune or update the neighbor
25 list(s). BTS coverage range may be calculated based on any factors that may affect range, including power level, receiver sensitivity, modulation efficiency (no variation with frequency), shadow margin, path loss, physical environment, and cable loss (variation with frequency). As
30 noted above, this technique may be done periodically (whether or not any BTS coverage ranges have been detected as having changed) or in direct response to a coverage range detection. The network 100 may initiate a periodic

neighbor list update process that causes each BTS (or its associated gateway) to calculate its coverage area and transmit it (along with its location) to the gateways (which then generate updated or dynamically tuned neighbor
5 lists).

[0052] It will be understood that additional information about BTS configurations may be useful in tuning and optimizing the network. For instance, further information may be gathered and used including, but not limited to,
10 antenna direction angle, antenna coverage angle, power level, receiver sensitivity, modulation efficiency (no variation with frequency), shadow margin, path loss, physical environment, cable loss (variation with frequency) with location and range information. This information may
15 be used to determine range of the BTS.

[0053] FIGURE 8 is an example showing a BTS 1200 at the center with a plurality of antenna center angles within a coverage area. As shown by FIGURE 8 there may be a plurality of antenna center angles (created by a plurality
20 of antennas located on the BTS) present within the coverage range of the BTS 1200. This figure also shows a plurality of sectors shown within the coverage range.

[0054] By intelligently determining and using sector information, a number of factors may be determined. For
25 instance, location within the coverage area may be blocked by a physical barrier to a signal that renders a subscriber station unable to communicate with the BTS 1200 even though the subscriber station is located within the range of the BTS 1200. Through tracking of dropped calls or loss of
30 signal to the BTS 1200, the BTS 1200 can determine that an impediment exists in a particular sector and adjust the coverage range that it transmits to the gateway 120 for that sector. Through this intelligent determination of

sector information, the true range and capability of the BTS 1200 can be determined. When a subscriber station enters a sector where there is such an impediment, the BTS 1200 checks the neighbor list to determine if there is a suitable neighbor BTS for handoff of the communication. Therefore, the neighbor list promotes maintenance of communications sessions between mobile devices and BTSs.

[0055] FIGURE 9 illustrates an overlap of a sector from a BTS 1302 and a sector from a BTS 1304. As shown, the range and coverage angle may be used to determine the area in which the BTS has effective coverage. The BTS 1302 and the BTS 1304 also are shown to have a limited area of overlap. Through the identification of this overlap, the location and timing of handoffs between the BTS 1302 and the BTS 1304 may be determined and optimized prior to a subscriber station entering the coverage area. This type of novel tuning, that exists prior to any real MS entering the coverage area of the BTS 1302 or the BTS 1304, allows for the optimization of a network based upon the plurality of factors above without the need to manually tune a network (i.e., manually adjust the neighbor lists). In addition, it can be identified where a BTS has no effective coverage simply by determining areas where signal losses consistently occur.

[0056] The BTS 1302 and the BTS 1304 are neighbors only for some of the sectors that are present within the BTS 1302 and the BTS 1304. In the more complex model, a list can be generated that includes both the BTS and the sector of the BTS that is a neighbor of another BTS:

```
BTS: Neighbors (SECTOR)
1302: 1304(4)
1304: 1302(2)
```

[0057] The information obtained through the methods described in the more complex model may be used to tune and optimize the network. As illustrated by FIGURE 6, the tuning and optimizing of the network may be performed
 5 through an iterative process that allows for constant retuning and updating based upon the actual capabilities of each BTS within the network. FIGURE 10 is an example of the neighbor list that may be generated by a gateway 120.

[0058] In the example shown in FIGURE 10, blocks 1402
 10 are a list of the BTSs within the network 100. Blocks 1404 relate to the relative weight of each BTS for communication with a first BTS. Blocks 1406 relate to the relative weight of each base station for communication with a second BTS. For instance, using the example shown in FIGURE 11,
 15 the blocks in 1402 might appear as 1102, 1104, 1106, 1108, 1110, and 1112. The weights for block 1104 might be 1102 (50), 1106 (30), and 1110 (20). Therefore, BTS 1102 has the highest communication priority with BTS 1104. As is shown by FIGURE 6, each BTS has its own neighbor list and
 20 priority list. This priority list could further be expanded to consider the sector for which the transmission is in. In such a case, blocks 1404 would include BTS sector information as well as weights. For example, the following list could be used using the example from FIGURE
 25 9:

```

    BTS (SECTOR):    Neighbors (SECTOR),
                    Weight
    1302(1): 1104, 50
    1302(2): 1104, 0
    
```

30

[0059] Even though BTS 1302 and BTS 1304 are neighbors, it does not follow that every sector of BTS 1302 is within the range of every sector within BTS 1304. Through the more

complex method, a precise sector-to-sector neighbor list may be created.

[0060] The neighbor list and weights of the neighbor list may be created through a plurality of messages from both gateways 120 and BTSs. One method of creating weights is by incrementing the weight of the BTS based upon successful or unsuccessful communication. In this example, if a subscriber station has a successful communication session with the BTS, the weight of the BTS may be increased. If the communication with the BTS was unsuccessful, the weight of the BTS may be decreased.

[0061] The neighbor list, and weights of the neighbor list, may also be created through a plurality of messages from the ASN 102 and the BTS 114. In one example, a mobile station is within the range of the BTS 110 and the BTS 114 and the mobile station transmits a list of all BTSs within the range of the mobile station to BTS 110. This information is then relayed to the ASN 102 through BTS 110.

A HO_Req message may then be sent from BTS 110 comprising the list of target candidate BTSs seen by the mobile station to other BTSs, including BTS 114. This candidate list can be used as feedback to dynamically tune the BTS 114 at runtime, by providing the BTS 114 a list of BTSs that the mobile station is aware of. It may be assumed if the mobile station is aware of a plurality of BTSs, each of the BTSs must share at least some coverage area (e.g., in this example, the BTS 110 and the BTS 114 would share some coverage area). The ASN 102 may also send a HO_Cnf message that comprises a list of all BTSs for a mobile station that are within the range of the mobile station to all of the BTSs within the range of the mobile station. It is understood that the HO_Req and Ho_Cnf are R6 messages which can be sent from the BTS to the ASN.

[0062] In addition to the BTS 110 sending the list of target BTSS seen by the mobile station to the ASN 102, the mobile device may send a MOS_MSHO_REQ message with a list of target BTSS identified by the mobile devices to other
5 BTSS within the range of the mobile device (e.g. BTS 114).

The mobile device may also send an individual message, MOS_MSHO_IND, to the BTS that has been selected for communication with the mobile device. If the target BTS reports successful communication or handoff, the weights of
10 the BTS may be adjust accordingly. Therefore, these messages may be used to determine the weight for each BTS to communicate with another BTS. It is understood that the MOS_MSHO_REQ and MOS_MSHO_IND are messages sent from the mobile device to the BTS. Messages that are sent between a
15 mobile device and a BTS may be referred to as R1 messages.

[0063] The neighbor list, and weights of the neighbor list, may also be created through a plurality of messages from the ASN 102 and the BTS 114. In one example, a mobile station is within the range of the BTS 110 and the BTS 114
20 and the mobile station transmits a list of all BTSS within the range of the mobile station to BTS 110. This information is then relayed to the ASN 102 through BTS 110.

A HO_Req message may then be sent from ASN 102 comprising the list of target candidate BTSS seen by the mobile
25 station to other BTSS, including BTS 114. This candidate list can be used as feedback to dynamically tune the BTS 114 at runtime, by providing the BTS 114 a list of BTSS that the mobile station is aware of. It may be assumed if the mobile station is aware of a plurality of BTSS, each of
30 the BTSS must share at least some coverage area (e.g., in this example, the BTS 110 and the BTS 114 would share some coverage area). The ASN 102 may also send a HO_Cnf message that comprises a list of all BTSS for a mobile station that

are within the range of the mobile station to all of the BTSs within the range of the mobile station.

[0064] In addition to the BTS 110 sending the list of target BTSs seen by the mobile station to the ASN 102, the
5 BTS 110 may send a MOS_MSHO_REQ message with a list of target BTSs identified by the mobile devices to other BTSs within the range of the mobile device (e.g. BTS 114). BTS 110 may also send an individual message, MOS_MSHO_IND, to the BTS that has been selected for communication with the
10 mobile device. If the target BTS reports successful communication or handoff, the weights of the BTS may be adjust accordingly. Therefore, these messages may be used to determine the weight for each BTS to communicate with another BTS.

[0065] In some embodiments, some or all of the functions or processes of the one or more of the devices are implemented or supported by a computer program that is formed from computer readable program code and that is embodied in a computer readable medium. The phrase
20 "computer readable program code" includes any type of computer code, including source code, object code, and executable code. The phrase "computer readable medium" includes any type of medium capable of being accessed by a computer, such as read only memory (ROM), random access
25 memory (RAM), a hard disk drive, a compact disc (CD), a digital video disc (DVD), or any other type of memory.

[0066] It may be advantageous to set forth definitions of certain words and phrases used throughout this patent document. The terms "include" and "comprise," as well as
30 derivatives thereof, mean inclusion without limitation. The term "or" is inclusive, meaning and/or. The phrases "associated with" and "associated therewith," as well as derivatives thereof, mean to include, be included within,

interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like. While this disclosure has described certain embodiments and generally associated methods, alterations and permutations of these 5 embodiments and methods will be apparent to those skilled in the art. Accordingly, the above description of example embodiments does not define or constrain this disclosure.

10 Other changes, substitutions, and alterations are also possible without departing from the spirit and scope of this disclosure, as defined by the following claims.

WHAT IS CLAIMED IS:

1. A method, comprising:
determining a local node configuration for a local network node, wherein the local network node configuration
5 comprises a local range and a local location;
receiving via a communications link a remote network node configuration for a remote network node, wherein the remote network node configuration comprises a remote range and a remote location; and
10 generating a neighbor list comprising the remote network node and the local network node, wherein the neighbor list is determined using the local network node configuration and the remote network node configuration.
- 15 2. The method of claim 1, wherein the node configurations further comprises sector information.
3. The method of Claim 1, wherein the neighbor list comprises the angles in which the local network node is a
20 neighbor to a remote network node.
4. The method of Claim 1, wherein the local network node is a base transceiver station.
- 25 5. The method of Claim 1, further comprising updating the network list based upon usage information.
6. The method of Claim 1, wherein the local network node is configured to use data including the signal
30 strength from mobile stations to determine the range of the local network node.

7. A method, comprising:

obtaining a first information about a first base station, wherein the first information comprises location and range information relating to the first base station;

5 sending the first information to a first server;

obtaining a second information about a second base station, wherein the second information comprises location and range information relating to the second base station;

10 sending the second information about the second base station to the server;

generating a neighbor list from the first information and the second information;

transmitting the neighbor list to the first base station and the second base station; and

15 storing the neighbor list in the first base station and the second base station.

8. The method of Claim 7, wherein the first information further comprises information related to the signal strength of the first base station.

9. The method of Claim 8, further comprising updating the neighbor list based upon usage information.

25 10. The method of Claim 7, wherein the first information further comprises angle information.

11. The method of Claim 7, wherein the first information further comprises transmission power information of the first base station.

30

12. The method of Claim 9, further comprising handing off communication between a mobile station from the first base station to the second base station based upon the neighbor list.

5

13. The method of Claim 7, wherein the sending of the first wireless communication is preformed through a wireless communication channel.

10 14. The method of Claim 7, wherein the server is part of a packet switched network.

15. The method of Claim 14, wherein the server is a gateway.

15

16. The method of Claim 7, further comprising a second server, wherein the server transmits the neighbor list to the first base station, and the second server transmits the neighbor list to the second base station.

20

17. The method of Claim 16, wherein the handoff is based upon sector information.

18. A system, comprising:

a first base station, wherein the first base station is capable of storing first identification information relating to the range of the first base station and the location of the first base station, and wherein the first
5 base station is capable of communication with a first network;

a second base station, wherein the second base station is capable of storing second identification information relating to the range of the second base station and the
10 location of the second base station, and wherein the second base station is capable of communication with a second network;

a server, wherein the first server is capable of
15 communication with the first network and the second network, and wherein the server is capable of receiving the first and second identification information, creating a neighbor list based upon the first and the second identification information, and transmitting the neighbor
20 list to the first base station and the second base station.

19. The system of Claim 18, wherein the first base station unit further stores angle information relating the first base station coverage angle.

25

20. The system of Claim 18, wherein the first base station unit further stores direction information relating the first base station centre angle.

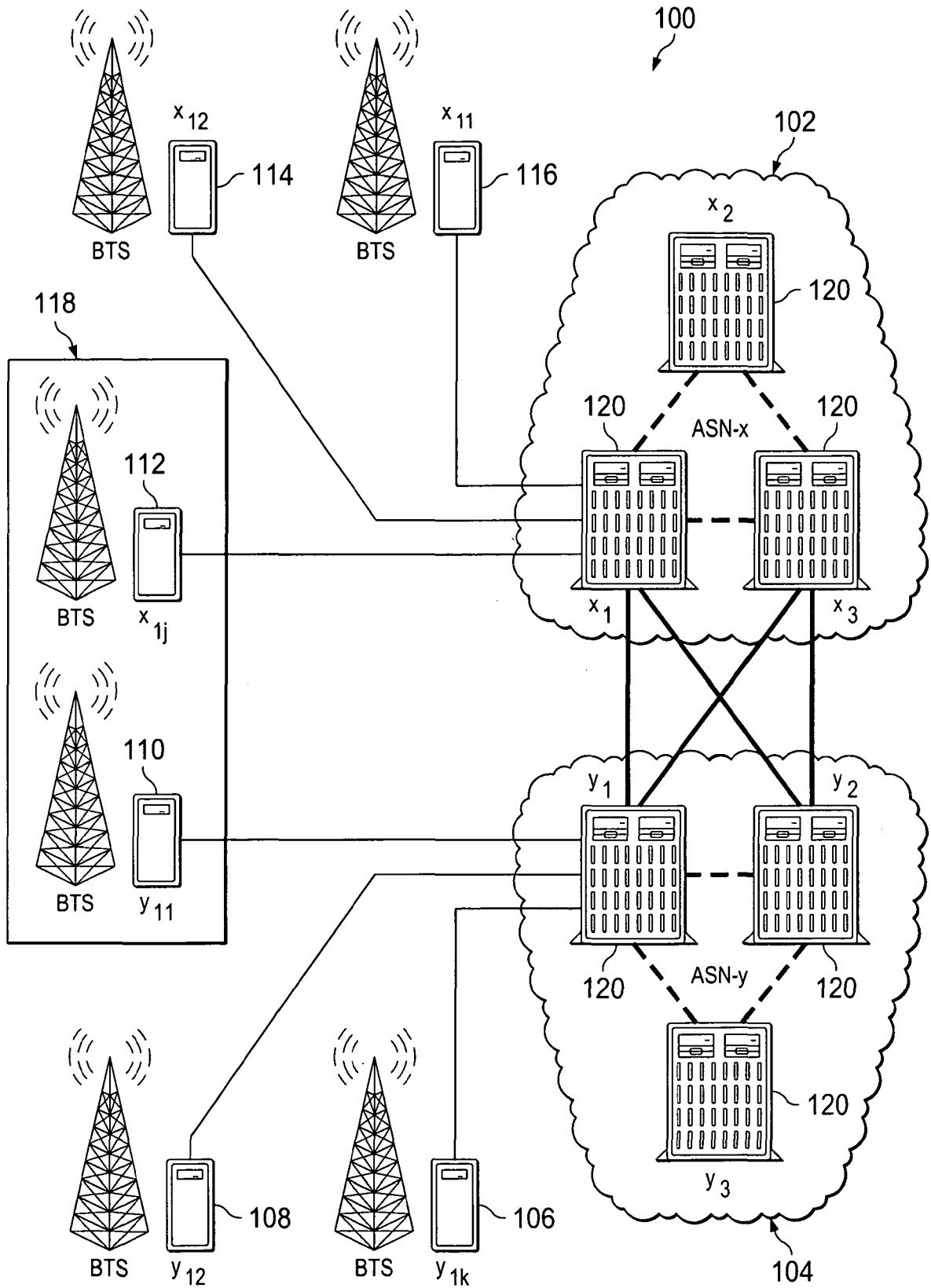


FIG. 1

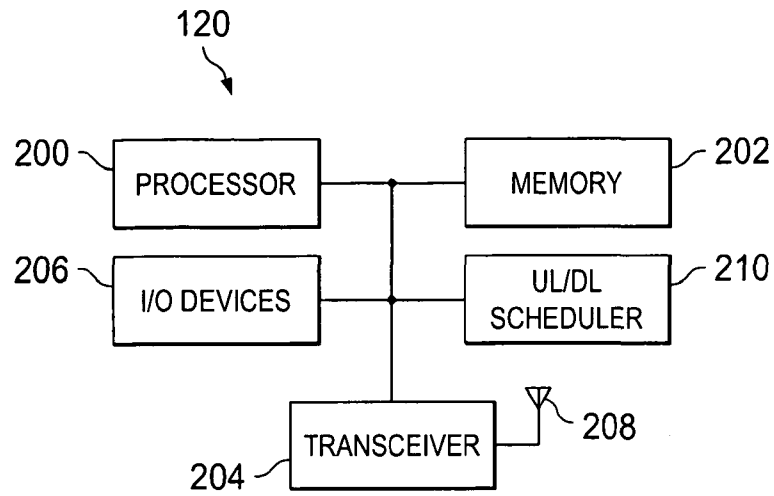


FIG. 2

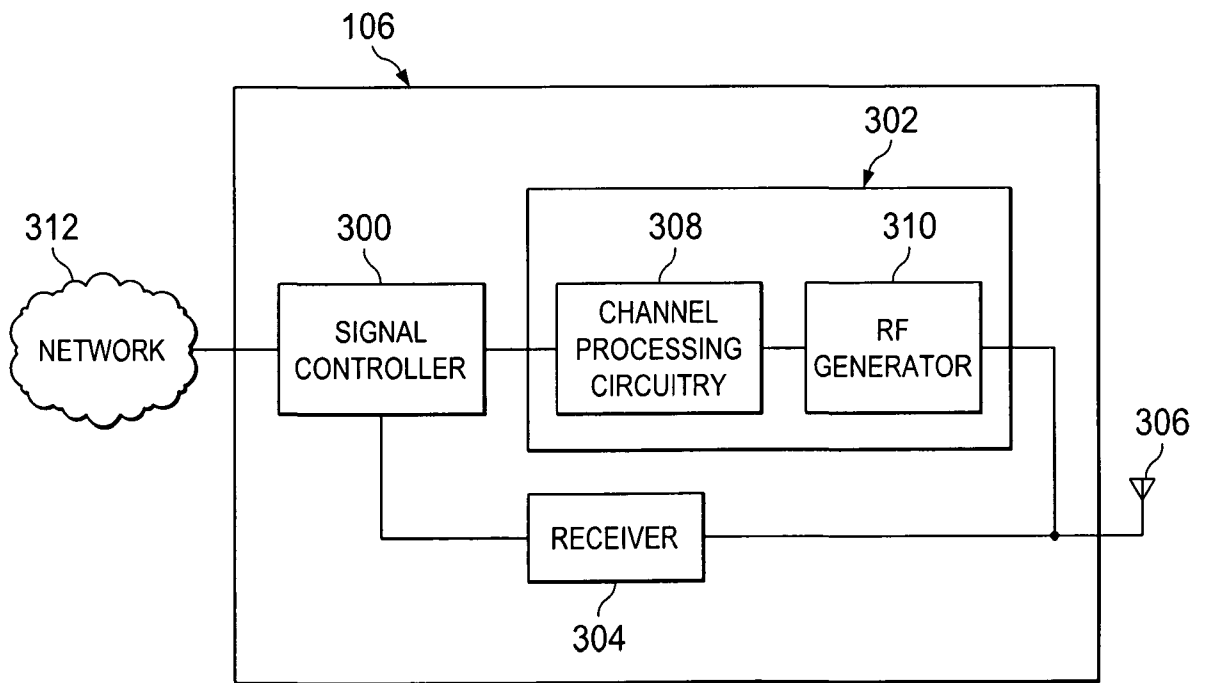


FIG. 3

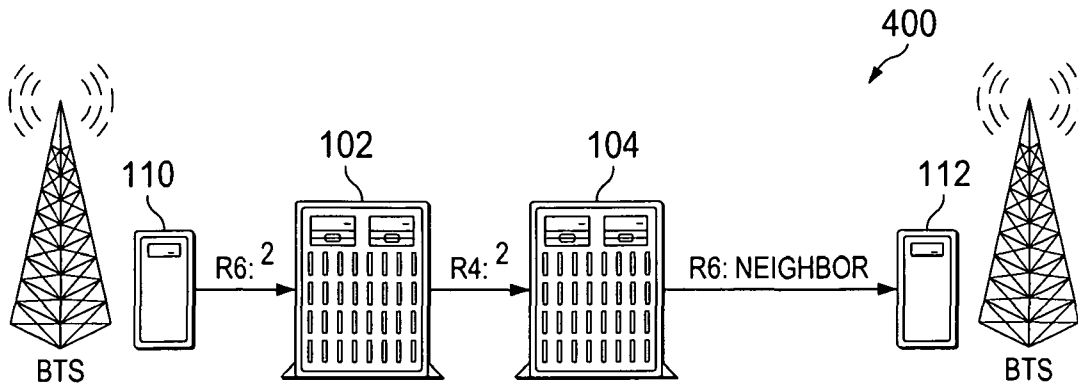


FIG. 4

500

IE	M/O	NOTES
510 LOCATION :: LATITUDE	M	BS LATITUDE. ALONG WITH LONGITUDE SPECIFIES LOCATION
520 LOCATION :: LONGITUDE	M	BS LONGITUDE
530 RANGE	M	BS RANGE
540 DIRECTION	O	CENTRE ANGLE
550 ANGLE	O	COVERAGE ANGLE

FIG. 5

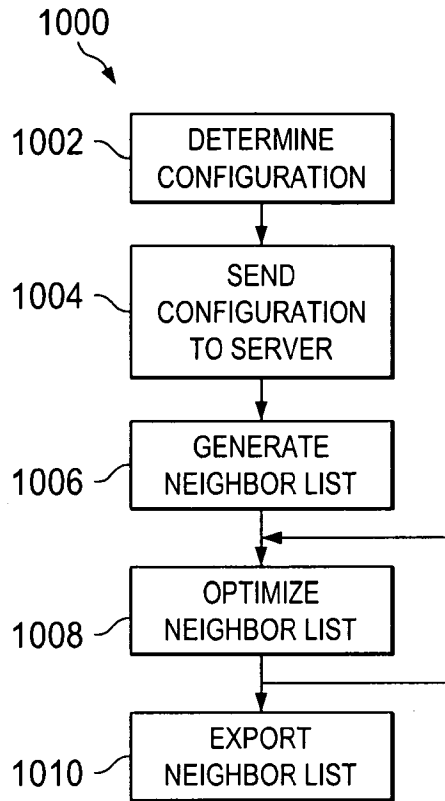


FIG. 6

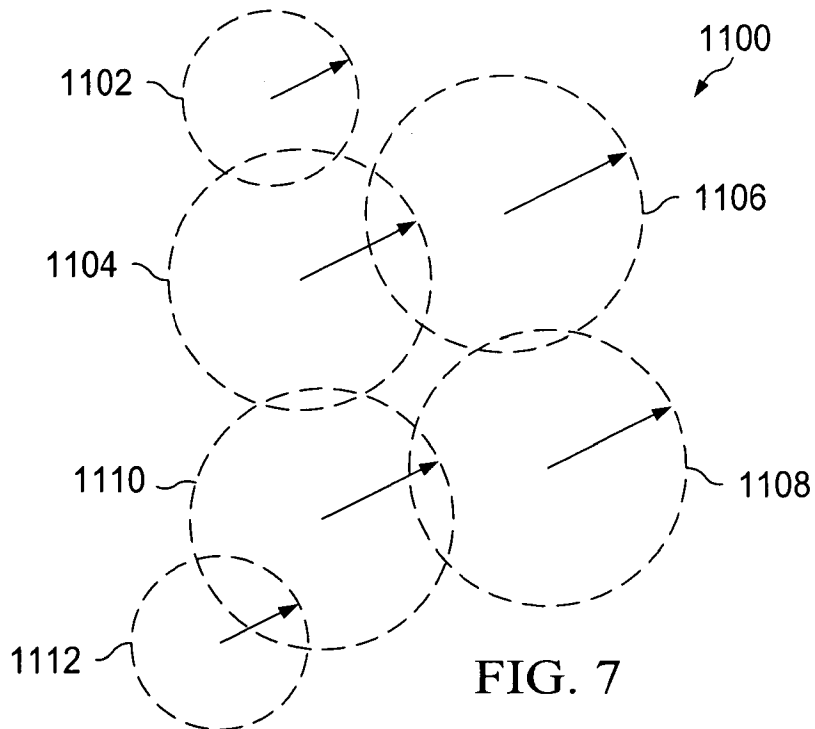


FIG. 7

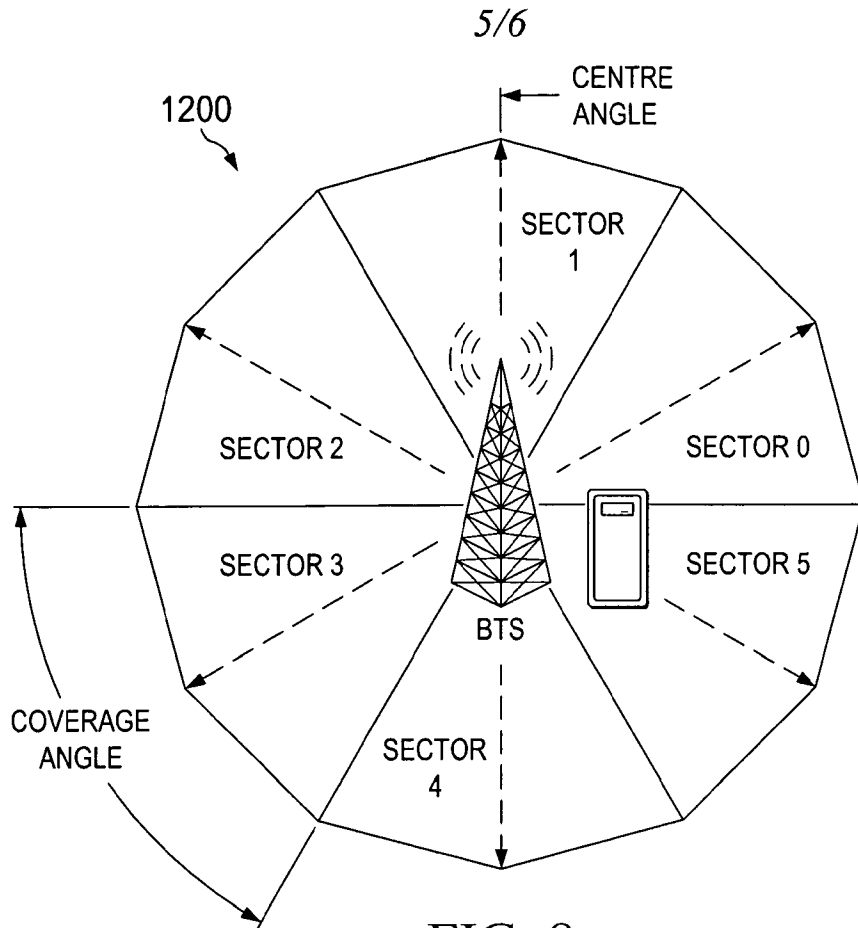


FIG. 8

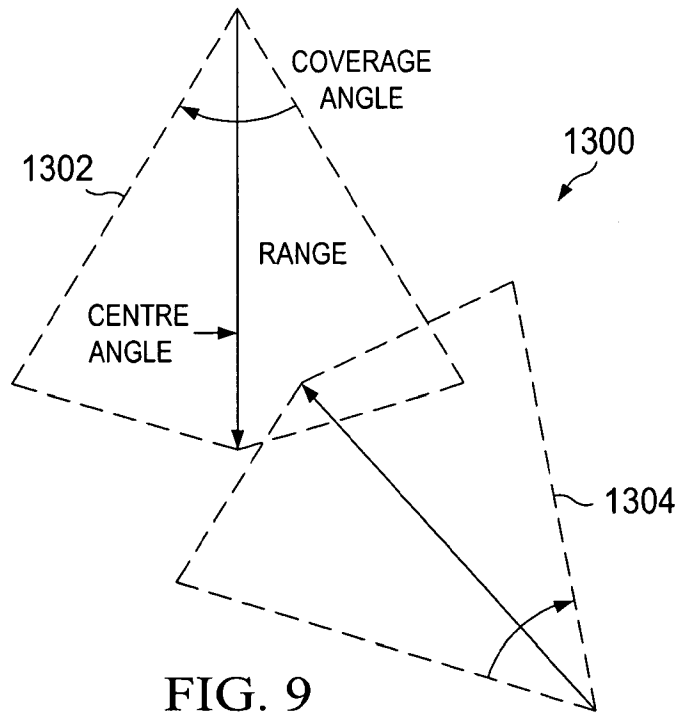


FIG. 9

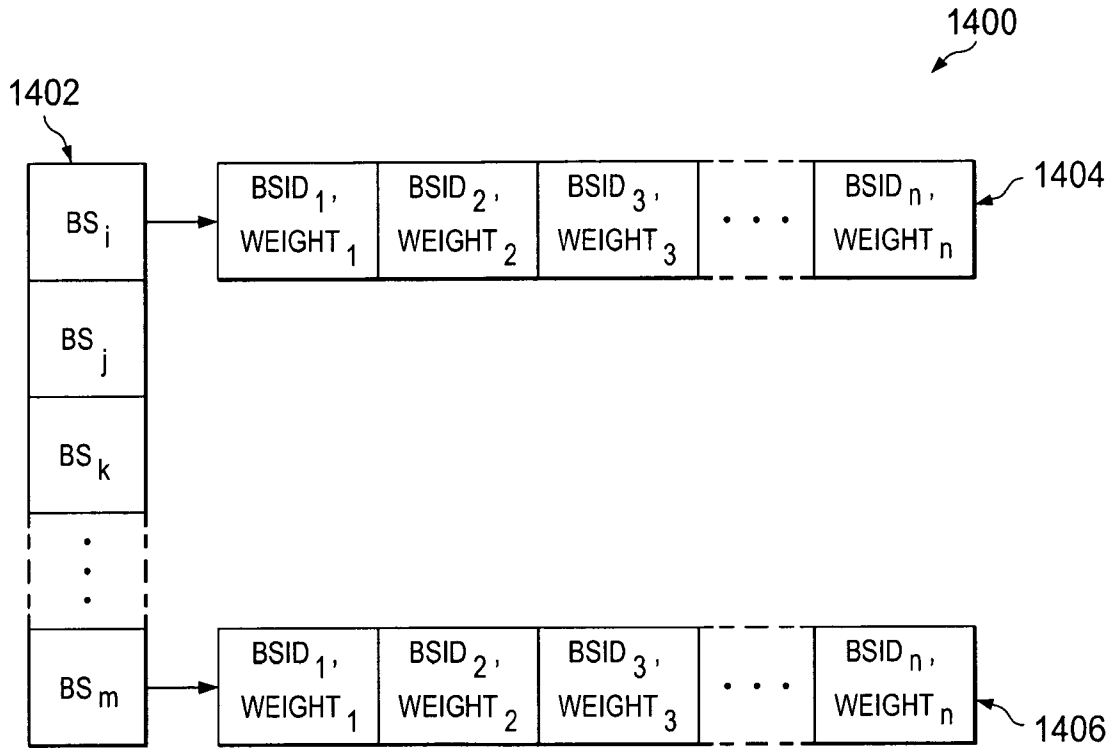


FIG. 10