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(54) **Title:** SECTORIZED BASE STATIONS AS MULTIPLE ANTENNA SYSTEMS

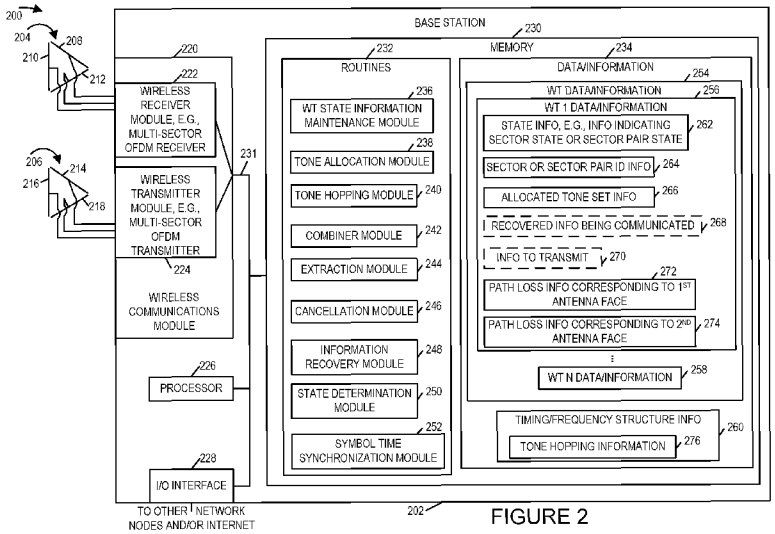


FIGURE 2

(57) **Abstract:** Methods and apparatus for improved utilization of air link resources are discussed in wireless communications systems employing multi-sector base stations and wireless terminals with multiple antennas. Timing synchronization is maintained across the base station sectors, and the same set of tones are used in adjacent sectors. In a sector boundary region, which is typically a high interference region, a wireless terminal is set to a sector pair state and operated in a MIMO mode of operation, communicating with two adjacent base station antenna faces of the same base station concurrently, the two different adjacent base station antenna faces corresponding to different adjacent sectors. Thus, typically high interference sector boundary regions, are converted into high capacity regions by having the sectors coordinated and utilizing MIMO techniques.

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SECTORIZED BASE STATIONS AS MULTIPLE ANTENNA SYSTEMS

RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Patent Application S.N. 60/940,658, filed May 29, 2007 titled "SECTORIZED BASE STATIONS AS MULTIPLE ANTENNA SYSTEMS", which is assigned to the assignee of the present application and which is hereby expressly incorporated by reference.

FIELD

[0002] The present invention relates to wireless communications methods and apparatus and, more particularly, to methods and apparatus for improving utilization of air link resources in a wireless communications system including a sectorized base station.

BACKGROUND

[0003] In wireless communications systems sectors are often treated as independent entities. The boundaries between sectors, where receivers receive both sectors at comparable power suffer from the inherent interference. It would be advantageous if methods and apparatus were developed which provided for improved communications in these high interference sector boundary regions.

SUMMARY

[0004] In accordance with various embodiments, the notion of a sector boundary is replaced with that of a MIMO enabled region. In the sector boundary region, mobiles have effective access to two base station sectors, and the system can be treated as a MIMO system. When the mobile has two antennas the setup is inherently 2x2, but it could be Xx2, where X is the number of antennas the mobile has and X is an integer greater than 2. Thus, in accordance with various embodiments, a high interference sector boundary region is converted in a high capacity region, e.g., a high capacity MIMO region, by having the sectors coordinated.

[0005] In some embodiments, a base station operates synchronized sectors, e.g., three synchronized sectors. If in sector boundary regions one takes a MIMO view, one likely discovers a notion of soft sectors. Abstractly, the system behaves like 3 base station antenna MIMO but, a priori, it is known that mobiles typically see only one base station antenna or pairs of base station antennas, e.g., antenna face A, antenna face B, antenna face C or antenna face pair AB, antenna face pair BC, antenna face pair CA - corresponding to six different channel type conditions. A mobile in AB, BC or CA is considered to be in a sector pair state and can be operated to exploit the two sectors as a MIMO system. A mobile that see only a single base station antenna face is considered to be in a sector state and would only have the capabilities supported by that face, e.g. non- MIMO capabilities. Thus the exemplary three sector base station acts more like a big MIMO system with prior knowledge that only the six states are possible, e.g., sector state corresponding to base station antenna face A, sector state corresponding to base station antenna face B, sector state corresponding to base station antenna face C, sector pair state corresponding to antenna face pair AB, sector pair state corresponding to antenna face pair BC, and sector pair state corresponding to antenna face pair CA. Handoff between the six areas is soft and not so critical and typically only between certain pairs. Mobiles that do not have multiple antennas can go into a soft-handoff mode near sector boundaries.

[0006] In the uplink a mobile can be assigned in both sectors when in the two sector state, sometimes referred to a sector pair state. Two mobiles can be assigned the same air link resource, e.g., the same OFDM tone-symbols, if at least one of them is in the two sector region. MIMO techniques can be used at the base station to process both signals. To support this, the mobiles should be MIMO aware, i.e., aware of the fact that they are participating in a MIMO transmission.

[0007] The system idea is characterized by the existence of MIMO states across sectors and non-MIMO states for mobiles isolated to one sector.

[0008] An exemplary method of operating a base station in a sectorized cell will be described in which each sector is adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized. The exemplary method of operating the base station

comprises: for each of a plurality of wireless terminals in said cell, maintaining information indicating whether said wireless terminal is in a sector or sector pair state. The exemplary method of operating the base station further comprises communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

[0009] An exemplary base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized, will be described. The exemplary base station includes: a wireless terminal state information maintenance module for maintaining information indicating whether a wireless terminal is in a sector or sector pair state for each of a plurality of wireless terminals in said cell; and a communications module for communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

[0010] A method of operating a wireless terminal in accordance with various embodiments includes: maintaining information indicating whether the wireless terminal is in a sector or sector pair state; and communicating with a base station, e.g., a multi-sector base station, in one of a MIMO mode of operation and a non-MIMO mode of operation, the mode of operation used for communicating being a function of whether said maintained information indicates that said wireless terminal is in a sector or sector pair state. In various embodiments communicating with a multi-sector base station in a MIMO mode of operation includes communicating simultaneously with two adjacent base station sector antenna faces using at least some of the same tones, wherein the sectors at the base station are timing synchronized. An exemplary wireless terminal in accordance with various embodiments includes: a state information maintenance module for maintaining information indicating whether said wireless terminal is in a sector or sector pair state; a plurality of antennas; a mode determination module for determining whether said wireless terminal is to operate in a MIMO or non-MIMO mode of operation as a function of said maintained information indicating whether said wireless terminal is in a sector or sector pair state; a MIMO module for communicating

with said base station in a MIMO mode of operation; and a non-MIMO mode module for communicating with said base station in a non-MIMO mode of operation.

[0011] While various embodiments have been discussed in the summary above, it should be appreciated that not necessarily all embodiments include the same features and some of the features described above are not necessary but can be desirable in some embodiments. Numerous additional features, embodiments and benefits are discussed in the detailed description which follows.

BRIEF DESCRIPTION OF THE FIGURES

[0012] Figure 1 is a drawing of an exemplary wireless communications system in accordance with various embodiments.

[0013] Figure 2 is a drawing of an exemplary base station coupled to a multi-face receive antenna and a multiple face transmit antenna in accordance with various embodiments.

[0014] Figure 3 is a drawing of an exemplary wireless terminal, e.g., mobile node, in accordance with various embodiments.

[0015] Figure 4 comprising the combination of Figure 4A, Figure 4B and Figure 4C is a flowchart of an exemplary method of operating a base station in accordance with various embodiments.

[0016] Figure 5 comprising the combination of Figure 5A and Figure 5B is a flowchart of an exemplary method of operating a wireless terminal in accordance with various embodiments."

[0017] Figures 6 and 7 illustrate exemplary MIMO signaling in accordance with various embodiments between a wireless terminal with multiple antennas and a base station utilizing a pair of base station adjacent sector antenna faces.

[0018] Figure 8 is a drawing illustrating exemplary air link resources corresponding to different sectors of a base station and exemplary tone allocation to wireless terminals in accordance with various embodiments.

[0019] Figure 9 is a drawing illustrating sector nulls corresponding to pilot tones in an exemplary OFDM wireless communications system implementing synchronized sectors.

DETAILED DESCRIPTION

[0020] Figure 1 is a drawing of an exemplary wireless communications system 100, e.g., a multiple access orthogonal frequency division multiplexing (OFDM) wireless communications system in accordance with various embodiments. Exemplary wireless system 100 includes a plurality of base stations including multi-sector base station 1 102. Base station 1 102 is coupled to other network nodes, e.g., other base stations, routers, AAA nodes, home agent nodes, etc., and/or the Internet via network link 101, e.g., a fiber optic link. Base station 1 102 has a corresponding cellular coverage area represented by cell 1 104 which includes a sector A region 112, a sector B region 114 and a sector C region 116. Base station 1 102 is a three sector base station including: a base station sector A module 106 which interfaces with sector A antenna face 118; a base station sector B module 108 which interfaces with sector B antenna face 120; and a base station sector C module 110 which interfaces with sector C antenna face 122. Base station 1 102, has synchronized symbol timing with respect to its sectors.

[0021] Exemplary wireless communications system 100 also includes a plurality of wireless terminal, e.g. mobile nodes. In this example, exemplary wireless terminals (WT 1 124, WT 2 126, WT 3 128, WT 4 130, WT 5 132) are currently coupled to base station 1 102 and using BS 1 102 as a point of network attachment. WT 1 is currently in a sector state of operation and is communicating with BS 1 102 via antenna face 120 as illustrated by arrow 134. WT 2 is currently in a sector pair state of operation and is communicating with BS 1 102 via antenna face 118 as illustrated by arrow 136 and via antenna face 122 as indicated by arrow 138. WT 3 is currently in a sector pair state of operation and is communicating with BS 1 102 via antenna face 118 as illustrated by arrow 140 and via antenna face 122 as indicated by arrow 142. WT 4 is currently in a sector pair state of operation and is communicating with BS 1 102 via antenna face 120 as illustrated by arrow 144 and via antenna face 122 as indicated by arrow 146. WT 5 is currently in a sector state of operation and is communicating with BS 1 102 via antenna face 122 as illustrated by arrow 148.

[0022] Now consider an example, WT 2 and WT 3 are both in a sector pair state corresponding to same sector pair. BS 1 102 may, and sometimes does, allocate the same tones to be used concurrently in both sector A and sector C by both WT 2 and WT

3 for at least some signaling. WT 4 130 is in a sector pair state and WT 5 132 is in a sector state. BS 1 102 may, and sometimes does, allocate the same tones to be used concurrently in sector C by WT 5 132 and by WT 4 130. WT 4 130 is in a sector pair state and WT 1 124 is in a sector state. BS 1 102 may, and sometimes does, allocate the same tones to be used concurrently in sector B by WT 4 130 and by WT 1 124.

[0023] The wireless terminals in a sector pair state, e.g., wireless terminal 4 130, includes a plurality of antennas and are communicating in a MIMO mode of operation with the base station 102. Figures 6 and Figure 7 provide more detailed exemplary illustrations. The sectors of the base station 102 are symbol timing synchronized facilitating such operations.

[0024] Figure 2 is a drawing 200 of an exemplary base station 202 coupled to a multi-face receive antenna 204 and a multiple face transmit antenna 206 in accordance with various embodiments. In some embodiments, the same antenna is used for receive and transmit signaling. In this exemplary embodiment base station 200 is a three sector base station; however in other embodiments, the base station includes a different number of sectors, e.g., two, four, five, six, or more than six.

[0025] Exemplary base station 202 includes a wireless communications module 220, a processor 226, an I/O interface 228 and a memory 230 coupled together via a bus 231 over which the various elements may interchange data and information. Memory 230 includes routines 232 and data/information 234. The processor 226, e.g., a CPU, executes the routines 232 and uses the data/information 234 in memory 230 to control the operations of the base station 202 and implement methods, e.g., the method of flowchart 400 of Figure 4.

[0026] Wireless communications module 220 communicates with a plurality of wireless terminals, wherein communication with an individual wireless terminal uses a number of faces determined by the state corresponding to the wireless terminal. For example, if the communication is uplink communication and the wireless terminal being communicated with is in a sector state, one antenna face of receive antenna faces (208, 210, 212) is used; however if the wireless terminal in a sector pair state 2 adjacent receive antenna faces are used, which is one of receive antenna face pairs (208, 210), (210, 212) and (212, 208). Continuing with the example, if the communication is downlink communication and the wireless terminal being communicated with is in a

sector state, one antenna face of transmit antenna faces (214, 216, 218) is used; however if the wireless terminal in a sector pair state 2 adjacent transmit antenna faces are used, which is one of transmit antenna face pairs (214, 216), (216, 218) and (218, 214).

[0027] Wireless communications module 220 includes a wireless receiver module 222 and a wireless transmitter module 224. The wireless receiver module 222, e.g., a multi-sector OFDM receiver, is coupled to multi-face receive antenna 204 via which the base station receives uplink signals from wireless terminals. Multi-face receive antenna 204 is a three face receive antenna, each face (208, 210, 212) of said antenna 204 corresponding to a different sector of a cell. In this exemplary embodiment, the sectors are timing synchronized. Consider that receive antenna face (208, 210, 212) corresponds to sector (A, B ,C), respectively. Antenna faces (208, 210) correspond to a first sector pair of (sector A and sector B); antenna faces (210, 212) correspond to a second sector pair of (sector B and sector C); antenna faces (212, 208) correspond to a third sector pair of (sector C and sector A). Wireless receiver module 222 receives uplink signals from wireless terminals. Receiver module 222 receives a signal using the same set of tones from two adjacent antenna faces. Operations of receiver module 222 include receiving a signal on a first set of tones from first antenna face, e.g., antenna face 208, corresponding to the first sector, and concurrently receiving a signal on the first set of tones from the second antenna face, e.g., antenna face 210, corresponding to the second sector.

[0028] Receiver module 222 also receives from a wireless terminal path loss information corresponding to multiple adjacent sectors. For example, receiver module 222 receives path loss information corresponding to a first antenna face in antenna face pair and path loss information corresponding to a second antenna face in the antenna face pair. For example, a wireless terminal may be situated in a region such that it can receive downlink signals from both transmit antenna face 214 and transmit antenna face 216, and the wireless terminal receives pilot channel signals from each antenna face (214, 216) and generates a channel condition feedback report conveying path loss information, which is transmitted in uplink signals and received by receiver module 222. In some embodiments, the received path loss information is a power measurement of a signal transmitted on a tone during a period of time during which the adjacent antenna face does not transmit on the same tone. For example, in one exemplary

embodiment, at least one pilot tone signal transmitted into a first sector via one transmit antenna face corresponds, in time and frequency, to an intentional transmit null in a second sector, the first and second sectors being adjacent; and at least one pilot tone signal transmitted into the second sector via a second transmit antenna face, said second antenna face being adjacent said first antenna face, corresponds, in time and frequency, to an intentional transmit null in said first sector.

[0029] The wireless transmitter module 224, e.g., a multi-sector OFDM transmitter, is coupled to multi-face transmit antenna 206 via which the base station transmits downlink signals to wireless terminals. Multi-face transmit antenna 206 is a three face transmit antenna, each face (214, 216, 218) of said antenna 206 corresponding to a different sector of a cell. In this exemplary embodiment, the sectors are timing synchronized. Consider that transmit antenna face (214, 216, 218) correspond to sector (A, B ,C), respectively. Antenna faces (214, 216) correspond to a first sector pair of (sector A and sector B); antenna faces (216, 218) correspond to a second sector pair of (sector B and sector C); antenna faces (218, 214) correspond to a third sector pair of (sector C and sector A). Operations of wireless transmitter module 224 include transmitting downlink signals to wireless terminal. For example, the transmitter module 224 can, and sometimes does, transmit the same information from each of the antenna faces of a sector pair, e.g., antenna faces 214, 216, to a first wireless terminal. During some times, the transmitter module 224 transmits different information to first and second wireless terminals using the same set of tones and using both antenna faces of antenna pair at the same time, said first and second wireless terminals each being in a sector pair state.

[0030] Routines 232 include a wireless terminal state information maintenance module 236, a tone allocation module 238, a tone hopping module 240, a combiner module 242, an extraction module 244, a cancellation module 246, an information recovery module 248, a state determination module 250, and a symbol time synchronization module 252. Wireless terminal state information maintenance module 236 maintains information indicating whether a wireless terminal is in a sector or sector pair state for each of a plurality of wireless terminals in the base station's cell which are using the base station as a point of network attachment.

[0031] Tone allocation module 238 allocates sets of tones to wireless terminals. Tone allocation module 238 allocates a first set of tones for communication with a first wireless terminal in a sector pair state, the first set of tones being allocated to the first wireless terminal in each of a first and second sector of a sector pair. The tone allocation module 238 further allocates the first set of tones to a second wireless terminal in said first sector during at least a portion of time in which said first set of tones are allocated to the first wireless terminal. The second wireless terminal is in one of a sector state and a sector pair state.

[0032] Tone hopping module 240 hops sets of tones in a time synchronized manner in the sectors of the cell. For example, tone hopping module 240 hops a first set of tones over time in a time synchronized manner in a sector pair of the cell. In various embodiments, different hopping schemes are utilized for uplink and for downlink signals. In some embodiments, the downlink is hopped at a faster rate than the uplink is hopped. Tone hopping may, and sometimes does, represents hopping of indexed tones in a logical channel structure to indexed physical tones used for transmission purposes.

[0033] Combiner module 242 combines a signal received on a first antenna face with a signal received on a second antenna face. Extraction module 244 extracts a signal corresponding to one of a first and second wireless terminal from a combined signal from combiner module 242, to recover at least some information transmitted by at least one of said first and second wireless terminals. Cancellation module 246 cancels the extracted signal from the signal received on one of the antenna faces to generate a processed signal. Information recovery module 248 recovers information communicated by the second wireless terminal from the processed signal.

[0034] State determination module 250 determines if a wireless terminal is in a sector state or sector pair state based on received path loss information, e.g., a channel condition feedback report corresponding to two adjacent sectors. Symbol time synchronization module 252 maintains symbol timing synchronization between the different sectors of the cell, e.g., OFDM symbol timing synchronization.

[0035] Data information 234 includes wireless terminal data/information 254 and timing frequency structure information 260. Wireless terminal data/information 254 includes information corresponding to a plurality of wireless terminals using the base station as point of network attachment (WT 1 data information 256, ..., WT N

data/information 258). WT 1 data/information 256 includes state information 262, sector or sector pair identification information 264, allocated tone set information 266, path loss information corresponding to a 1st antenna face 272, and path loss information corresponding to a 2nd antenna face 274. Data/information 256 also includes one or more of recovered information being communicated 268 and information to transmit 270. State information 262 includes information indicating whether wireless terminal 1 is in a sector state or sector pair state. State information 262 represents an output of state determination module 250. Sector or sector pair identification information 264 includes information identifying, for a wireless terminal in a sector state, the sector, the transmit antenna face, and the receive antenna face to which the sector state corresponds. Sector or sector pair identification information 264 includes information identifying, for a wireless terminal in a sector pair state, the pair of adjacent sectors, the pair of adjacent transmit antenna faces, and the pair of receive antenna faces to which the sector pair state corresponds. Sector or sector pair identification information 264 also includes information identifying which sectors and antenna faces received path loss information corresponds to. Allocated tone set information 266 includes information identifying a set of tones currently allocated to wireless terminal 1 by tone allocation module 240. The set of allocated tones can correspond to a downlink set of tones or an uplink set of tones. Path loss information corresponding to 1st antenna face 272 is, e.g., feedback information received from WT 1 indicative of channel conditions between a 1st antenna face and WT 1. Path loss information corresponding to 2nd antenna face 274 is, e.g., feedback information received from WT 1 indicative of channel conditions between a 2nd antenna face and WT 1, the second antenna face being adjacent said first antenna face. Path loss information (272, 274) is used by state determination module 250 in deciding the state for WT 1, e.g., sector state or sector pair state. In general, for a wireless terminal near a sector boundary, the wireless terminal is in a sector pair state, while for a wireless terminal far away from a sector boundary the wireless terminal is in a sector state.

[0036] Recovered information being communicated 268 includes information output from extraction module 244 and/or information output from information recovery module 248.

[0037] Timing/frequency structure information 260 includes downlink timing/frequency structure information and uplink timing frequency structure information. Downlink timing/frequency structure information includes information identifying and/or defining: downlink channel structure including logical channel segments, downlink frequency bands, downlink tone set information, subsets of tones which can be allocated to a wireless terminal, pilot signal information corresponding to each of the sectors, and downlink timing structure information including information defining symbol transmission timing intervals, groupings of symbols, e.g., into slots, superslots, beaconslots, ultraslots, etc., and recurring pattern information.

[0038] Uplink timing/frequency structure information includes information identifying and/or defining: uplink channel structure including logical channel segments, uplink frequency bands, uplink tone set information, subsets of tones which can be allocated to a wireless terminal, and uplink timing structure information including information defining symbol transmission timing intervals, groupings of symbols, e.g., into dwells and recurring pattern information.

[0039] Timing/frequency structure information 260 also includes tone hopping information 276. In various embodiments, different tone hopping information is used for the downlink and the uplink.

[0040] Figure 3 is a drawing of an exemplary wireless terminal 300, e.g., mobile node, in accordance with various embodiments. Exemplary wireless terminal 300 is, e.g., one of the wireless terminals in system 100 of Figure 1. Exemplary wireless terminal 300 is for use in a sectorized cell, each sector of said sectorized cell being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station coupled to a multi-face antenna, each face of said base station antenna corresponding to a different sector of said cell, said sectors being timing synchronized. In some embodiments, the base station has three sectors.

[0041] Exemplary wireless terminal 300 includes a wireless receiver module 302, a wireless transmitter module 304, a processor 308, user I/O devices 310 and memory 312 coupled together via bus 314 over which the various elements interchange data and information. Memory 312 includes routines 316 and data/information 318. The processor 308, e.g., a CPU, executes the routines 316 and uses the data/information

318 in memory 312 to control the operation of the wireless terminal 300 and implement methods, e.g., the method of flowchart 500 of Figure 5.

[0042] Wireless terminal 300 also includes a plurality of antennas (antenna 1 303, ..., antenna N 305), and a duplex module 306. The duplex module 303 couples one or more of the antennas (antenna 1 303, ..., antenna N 305) to wireless receiver module 302. The duplex module 303 also couples one or more of the antennas (antenna 1 303, ..., antenna N 305) to wireless transmitter module 304. In some other embodiments, different antennas are used for transmission and reception.

[0043] Wireless receiver module 302, e.g., an OFDM receiver with MIMO capabilities, is used for receiving downlink signals from a base station. Wireless transmitter module 304, e.g., an OFDM transmitter with MIMO capabilities, is used for transmitting uplink signals to a base station. Information transmitted by transmitter module 304 includes path loss information corresponding to a first antenna face of an antenna face pair and path loss information corresponding to a second antenna face in the antenna face pair, wherein said first and second antenna faces are adjacent antenna faces. Information transmitted by transmitter module 304 also includes uplink user data, e.g., uplink traffic channel segment data.

[0044] User I/O devices 310, e.g., microphone, keypad, keyboard, mouse, camera, switches, speaker, display, etc., are used to receive input from the user of wireless terminal 300 and output information to the user of wireless terminal 300. In addition, user I/O devices 310 allow a user of wireless terminal 300 to control at least some functions of the wireless terminal, e.g., initiate a communications session.

[0045] Routines 316 includes a state information maintenance module 320, a mode determination module 322, a MIMO module 324, a non-MIMO mode module 326, a tone allocation determination module 328, a tone hopping module 330, a state information recovery module 332, a power measurement module 334, and a path loss determination module 336. State information maintenance module 320 maintains information indicating whether said wireless terminal is in a sector state or sector pair state. Mode determination module 322 determines whether the wireless terminal is to operate in a MIMO or non-MIMO mode of operation as a function of the maintained information indicating whether said wireless terminal is in a sector state or sector pair state.

[0046] MIMO module 324 is used for communicating with a base station when the wireless terminal 300 is in a MIMO mode of operation, as determined by module 322. Non-MIMO mode module 326 is used for communicating with a base station when the wireless terminal 300 is in a non- MIMO mode of operation, e.g., a SISO mode of operation, as determined by module 322. Modules 324 and 326 control various operations of wireless receiver module 302, wireless transmitter module 304, and duplex module 306 to implement a determined mode of operation. In various embodiments, communicating with a base station in a MIMO mode of operation includes using at least two wireless terminal antennas from the set of antennas (303, ..., 305) in communications with two adjacent base station antenna faces. In some such embodiments, communicating with the base station in a MIMO mode of operation further includes using a first set of tones for communicating with both base station antenna faces of two adjacent base station antenna faces during the same time.

[0047] Tone allocation determination module 328 determines from received signal that a wireless terminal has been allocated a first set of tones for communicating. During some times, the tone allocation determination module 328 determines from received signals, e.g., received assignment signals, that the wireless terminal has been allocated a first set of tones for communication with both a first antenna face of the multi-face base station antenna and a second antenna face of the multi-face base station antenna, said first and second faces being adjacent.

[0048] Tone hopping module 330 uses stored information, e.g., stored tone hopping information 364 corresponding to base station 1 to implement tone hopping, wherein the first set of tones allocated to wireless terminal 300 are hopped over time in a synchronized manner in a sector pair.

[0049] State information recovery module 332 recovers from a received signal a base station determination indicating whether said wireless terminal is to be in a sector state or sector pair state, wherein said base station determination is based upon received path loss information communicated from the wireless terminal to the base station.

[0050] Power measurement module 334 performs a power measurement of a signal received on a tone during a period of time during which a first base station antenna face transmits a pilot tone signal and a second base station antenna face intentionally does not transmit on that tone, said first and second base station antenna

faces being adjacent. This use of pilot signals from one base station antenna face intentionally paired with an intentional null from an adjacent base station antenna face, facilitates wireless terminal determination of path loss information with respect to individual base station antenna faces. Path loss determination module 336 determines path loss information as a function of power measurement information from module 334.

[0051] Data/information 318 includes state information 338, base station identification information 340, sector or sector pair identification information 342, allocated tone set information 344, recovered information being communicated 346, information to transmit 348, pilot/sector null measurement information 350, path loss information corresponding to a 1st antenna face 352, path loss information corresponding to a 2nd antenna face 354, and system data/information 356. State information 338 includes information indicating whether the wireless terminal 300 is currently in a sector state or in a sector pair state. Base station identification information 340 includes information identifying which base station, from the plurality of base stations in the communications system, the wireless terminal is currently using as its point of network attachment. Sector or sector pair identification information 342 includes information identifying the particular sector of the base station for which tones are allocated to the wireless terminal when in the sector state and information identifying the pair of adjacent sectors of the base station for which tones are allocated to the wireless terminal for concurrent use when in the sector pair state. Information 342 also includes information identifying the sectors used to which the path loss information being communicated corresponds. Recovered information being communicated 346 includes user data recovered using a MIMO decoding operation of the receiver module 302 when the wireless terminal is in a sector pair state. Recovered information being communicated 346 also includes user data recovered using a SISO decoding operation of the receiver module 302 when the wireless terminal is in a sector state. Information to be transmitted 348 includes user data to be transmitted which is subjected to MIMO encoding operations by wireless transmitter module 304, when the wireless terminal is in a sector pair state. Information to be transmitted 348 also includes user data to be transmitted which is subjected to SISO encoding operations by wireless transmitter module 304, when the wireless terminal is in a sector state.

[0052] Pilot/sector null measurement information 350 represents output of power measurement module 334 and an input to path loss determination module 336. Path loss information corresponding to 1st base station antenna face 352 and path loss information corresponding to 2nd base station antenna face 354 represents outputs of path loss determination module 336. In some embodiments, the path loss information 352 is communicated independently from the path loss information 354; while in other embodiments, the information (352, 354) is transmitted in a jointly coded single report. In some embodiments, the report is a sector boundary report, e.g., as part of an uplink dedicated control channel reporting structure.

[0053] System data information 356 includes a plurality of sets of base station information (base station 1 data/information 358, ..., base station N data/information 360). Base station 1 data/information 358 includes base station identification information, base station sector identification information and timing/frequency structure information 362. Timing frequency structure information 362 includes, e.g., downlink carrier frequency information, uplink carrier frequency information, downlink frequency band information, uplink frequency band information, downlink tone block information, uplink tone block information, individual tone definition information, recurring downlink timing information, recurring uplink timing information, OFDM symbol transmission timing information, information identifying grouping of OFDM symbols into, e.g., slots or dwells, downlink channel structure information and uplink channel structure information. Timing/frequency structure information 362 also includes tone hopping information 364. Tone hopping information 364, in some embodiments, includes different tone hopping information corresponding to the uplink and downlink. For example, the tone hopping, can be and sometimes is, different in both the hopping equations used and the rate of the hopping, e.g., tone hopping between successive OFDM transmission time intervals for the downlink and tone hopping based on dwells of seven successive OFDM symbol transmission time intervals for the uplink.

[0054] Figure 4 comprising the combination of Figure 4A, Figure 4B and Figure 4C is a flowchart 400 of an exemplary method of operating a base station in accordance with various embodiments. The base station is, e.g., a base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectoring forming sector pairs, said base station being coupled to a multi-face antenna, each face

of said antenna corresponding to a different sector or said cell, said sectors being timing synchronized. In some embodiments, the base station has three sectors. The base station is, e.g., base station 200 of Figure 2. In some other embodiments, the base station has six sectors. Multi-sector base stations with different numbers of sectors are also possible. In various embodiments, said base station is a base station in an OFDM communications system and said timing synchronization is OFDM symbol time synchronization.

[0055] Operation of the exemplary method starts in step 402, where the base station is powered on and initialized and proceeds to steps 404, 408, 410, and 436. Operation proceeds to step 404, for each of a plurality of wireless terminals. In step 404, the base station receives path loss information corresponding to a first antenna face in an antenna face pair, and in step 405, the base station receives path loss information corresponding to a second antenna face in an antenna face pair. In various embodiments, the received path loss information is a power measurement of a signal transmitted on a tone during a time during which the adjacent antenna face does not transmit on said tone. For example, in some OFDM embodiments, there are at least some sector null and some corresponding pilot signals using the same tone at the same time in adjacent sectors. Operation proceeds from step 405 to step 406, in which the base station determines if said wireless terminal is in a sector state or sector pair state based on the received path loss information. Wireless terminal state information 407, identifying one of a sector state or sector pair state, is output from step 406 and input to step 408. Operation proceeds from step 406 to step 404, where the base station receives additional path loss information corresponding to the same wireless terminal.

[0056] In step 408, which is performed for each of a plurality of wireless terminals, on an ongoing basis, the base station maintains information indicating whether the wireless terminal is in a sector state or sector pair state.

[0057] Operation proceeds from start step 402 to step 410 for a receive opportunity corresponding to a pair of wireless terminals. In step 410, the base station allocates a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of sector pair state. In some embodiments, the tones of the first set of tones are hopped in a synchronized manner in the sector pair. Operation proceeds from step 410 to step

412. In step 412, the base station allocates said first set of tones to a second wireless terminal in said first sector during at least a portion of time in which said first set of tones are allocated to the first wireless terminal. In some embodiments, the base station allocates said first set of tones to a second wireless terminal in said first sector during the same time in which said first set of tones are allocated to the first wireless terminal. Operation proceeds from step 412 via connecting node A 414 to step 416.

[0058] In step 416 the base station communicates with wireless terminals, wherein communication with a particular wireless terminal uses a number of antenna faces determined by the state corresponding to the particular wireless terminal. In some such embodiments, the number is one or two. Step 416 includes sub-steps 418, 426, 428 and 434. In sub-step 418, the base station communicates with said first wireless terminal using two antenna faces. Sub-step 418 includes sub-steps 420, 422 and 424. In sub-step 420, the base station receives a signal on said first set of tones from a first antenna face corresponding to a first sector and concurrently receives a signal on said first set of tones from a second antenna face corresponding to a second sector. Then, in sub-step 422, the base station combines the signal received from the first antenna face with the signal received from the second antenna face. Operation proceeds from sub-step 422 to sub-step 424. In sub-step 424, the base station extracts a signal corresponding to said first wireless terminal from said combined signal to recover at least some information communicated by the first wireless terminal. Operation proceeds from sub-step 418 to sub-step 426.

[0059] In sub-step 426 the base station determines whether the second wireless terminal is in the sector state or sector pair state. If the second wireless terminal is in the sector state, then operation proceeds from sub-step 426 to sub-step 428; however, if the second wireless terminal is in the sector pair state, then operation proceeds from sub-step 426 to sub-step 434. In sub-step 428 the base station communicates with said second wireless terminal using one antenna face. Sub-step 428 includes sub-step 430 and sub-step 432. In sub-step 430, the base station cancels the extracted signal, obtained in sub-step 424, from the signal received on one of the antenna faces to generate a processed signal. Operation proceeds from sub-step 430 to sub-step 432. In sub-step 432, the base station recovers information communicated by the second wireless terminal from the processed signal. Returning to sub-step 434, in sub-step 434,

the base station communicates with said second wireless terminal using two antenna faces.

[0060] Operation proceeds from start step 402 to step 436 for a transmit opportunity corresponding to a pair of wireless terminals. In step 436, the base station allocates a second set of tones for communication with a third wireless terminal in said sector pair state, the second set of tones being allocated in each of a first and second sector of sector pair state. In some embodiments, the second set of tones are hopped over time in a synchronized manner in the sector pair. Operation proceeds from step 436 to step 438. In step 438, the base station allocates said second set of tones to a fourth wireless terminal in said first sector during at least a portion of time in which said second set of tones are allocated to the third wireless terminals. In some embodiments, the base station allocates said second set of tones to a fourth wireless terminal in said first sector during the same time in which said second set of tones are allocated to the third wireless terminals. Operation proceeds from step 438 via connecting node B 440 to step 441.

[0061] In step 441 the base station communicates with wireless terminals, wherein communication with a particular wireless terminal uses a number of antenna faces determined by the state corresponding to the particular wireless terminal. Step 441 includes sub-steps 442, 446, 448 and 452. In sub-step 442, the base station communicates with said third wireless terminal using two antenna faces. Sub-step 442 includes sub-step 444. In sub-step 444, the base station transmits the same information from each of two antenna faces to said third wireless terminal using the second set of tones.

[0062] In sub-step 446 the base station determines whether the fourth wireless terminal is in the sector state or sector pair state. If the fourth wireless terminal is in the sector state, then operation proceeds from sub-step 446 to sub-step 448; however, if the fourth wireless terminal is in the sector pair state, then operation proceeds from sub-step 446 to sub-step 452. In sub-step 448 the base station communicates with said fourth wireless terminal using one antenna face. Sub-step 448 includes sub-step 450. In sub-step 450, the base station transmits to the fourth wireless terminal using one antenna face and using the second set of tones. Returning to sub-step 452, in sub-step 452, the base station communicates with said fourth wireless terminal using two antenna faces.

Sub-step 452 includes sub-step 454. In sub-step 454, the base station transmits different information to the fourth wireless terminal than the information being transmitted to the third wireless terminal using the second set of tones and uses both faces of the antenna pair at the same time.

[0063] Figure 5 comprising the combination of Figure 5A and Figure 5B is a flowchart 500 of an exemplary method of operating a wireless terminal in accordance with various embodiments. The exemplary wireless terminal is a wireless terminal in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station, e.g., a three sector base station, coupled to a multi-face antenna, each face of said base station antenna corresponding to a different sector of the cell, said sectors being timing synchronized. The exemplary wireless terminal includes at least two antennas and supports MIMO signaling. In various embodiments, the wireless terminal is part of an OFDM wireless communications system and the sectors of a cell corresponding to a base station are OFDM symbol timing synchronized Operation starts in step 502, where the wireless terminal is powered on and initialized and proceeds to step 504. Operation proceeds from start step 502 to step 504, step 508, step 526 via connecting node A 510, and step 540 via connecting node B 512.

[0064] In step 526, the wireless terminal performs power measurements of pilot tone signals and sector null signals. Step 526 includes sub-steps 528 and 530. In sub-step 528, the wireless terminal performs a power measurement of a signal received on a tone during a period of time during which a first base station antenna face transmits a pilot tone signal and a second base station antenna face intentionally does not transmit on that tone, said first and second antenna faces being adjacent. In sub-step 530, the wireless terminal performs a power measurement of a signal received on a tone during a period of time during which said second base station antenna face transmits a pilot tone signal and said first base station antenna face intentionally does not transmit on that tone. Operation proceeds from step 526 to step 532, in which the base station determines path loss information as a function of said power measurement information. Operation proceeds from step 532 to step 534. In step 534, the base station transmits path loss information. Step 534 includes sub-step 536 and sub-step 538. In sub-step 536, the base station transmits path loss information corresponding to said first base

station antenna face and in step 538, the base station transmits path loss information corresponding to said second base station antenna face, said first and second base station antenna faces being part of antenna pair face. In some embodiments, path loss information corresponding to the first antenna face is transmitted independently of the path loss information corresponding to the second antenna face. In some embodiments, path loss information corresponding to the first antenna face is communicated in the same report as path loss information corresponding to the second antenna face.

[0065] Returning to step 504, in step 504, which is performed on an ongoing basis, the wireless terminal monitors for state assignment signals. Operation proceeds from step 504 to step 506 for a received state assignment signal intended for the wireless terminal. In step 506, the wireless terminal receives a base station determination as to whether said wireless terminal is to be in a sector state or sector pair state. The base station determination is based upon received path loss information from the wireless terminal. WT state information 507, e.g., an indication of either sector state or sector pair state, is an output from step 506 which is used an input in step 508.

[0066] In step 508, which is performed on an ongoing basis, the wireless terminal maintains information indicating whether said wireless terminal is in a sector state or sector pair state. Operation proceeds from step 508 to step 514. In step 514, the wireless terminal communicates with said base station in one of a MIMO mode of operation and a non-MIMO mode of operation, the mode of operation used for communication being a function of whether said maintained information indicates that said wireless terminal is in a sector state or sector pair state. Step 514 includes sub-steps 516, 518 and 520.

[0067] In sub-step 516, the wireless terminal checks if the wireless terminal is in a sector state or sector pair state. If the wireless terminal is determined to be in a sector pair state operation proceeds from sub-step 516 to sub-step 518; otherwise operation proceeds from sub-step 516 to sub-step 520. In sub-step 518, the wireless terminal communicates with said base station in a MIMO mode of operation. Sub-step 518 includes sub-steps 522 and 524. In sub-step 522, the wireless terminal uses at least two wireless terminal antennas to communicate with two adjacent base station antenna faces. In sub-step 524, the wireless terminal uses a first set of tones to communicate with both faces of said two adjacent base station antenna faces during the same time.

Returning to step 520, in step 520, the wireless terminal communicates with the base station in a non-MIMO mode of operation, e.g., a SISO mode of operation or a mode of operation or a mode of operation using two or more wireless terminal antennas communicating with a single base station antenna face.

[0068] Returning to step 540, in step 540, which is performed on an ongoing basis, the wireless terminal monitors for tone allocation information. Operation proceeds from step 540 to step 542 in response to detected tone allocation information intended for the wireless terminal. In step 542, the wireless terminal receives tone allocation information indicating that said wireless terminal has been allocated a first set of tones. Step 542 includes sub-step 544 for some tone allocations, e.g., a tone allocation when said wireless terminal is in a sector pair state. In sub-step 544, the wireless terminal receives tone allocation information indicating that said wireless terminal has been allocated a first set of tones for communication with both a first antenna face of said multi-face base station antenna and second antenna face of said multi-face base station antenna, said first and second antenna faces being adjacent. In various embodiments, the first set of tones are hopped in a time synchronized manner in the sector pair.

[0069] Figure 6 is a drawing 600 illustrating an exemplary embodiment corresponding system 100 of Figure 1 in which WT 4 130 includes two antennas (antenna 1 602, antenna 2 604). Communications 144 between base station sector B antenna face 120 and WT 4 130 includes a first portion 144a corresponding to antenna 1 602 and a second portion 144b corresponding to antenna 2 604. Similarly, communications 146 between base station sector C antenna face 122 and WT 4 130 includes a first portion 146a corresponding to antenna 1 602 and a second portion 146b corresponding to antenna 2 604.

[0070] Figure 7 is a drawing 700 illustrating an exemplary embodiment corresponding system 100 of Figure 1 in which WT 4 130 includes three antennas (antenna 1 702, antenna 2 704, antenna 3 706). Communications 144 between base station sector B antenna face 120 and WT 4 130 includes a first portion 144c corresponding to antenna 1 702, a second portion 144d corresponding to antenna 2 704, and a third portion 144e corresponding to antenna 3 706. Similarly, communications 146 between base station sector C antenna face 122 and WT 4 130 includes a first

portion 146c corresponding to antenna 1 702, a second portion 146d corresponding to antenna 2 704, and a third portion 146e corresponding to antenna 3 706. Embodiments, with wireless terminals having more than three antennas are also possible.

[0071] Figure 8 is a drawing 800 illustrating exemplary air link resources corresponding to different sectors of a base station and exemplary tone allocation to wireless terminals in accordance with various embodiments. Drawing 800 includes a first graph 802 corresponding to sector A, a second graph 804 corresponding to sector B, and a third graph 806 corresponding to sector C. Each graph (802, 804, 806) includes a vertical axis 810 representing frequency, e.g., OFDM tone index in frequency band A, and a horizontal axis 812 of time, e.g., OFDM symbol index. It should be noted that the three sectors of the base station are synchronized in terms of both time and frequency. In this exemplary embodiment, tone hopping, e.g., in terms of logical channel tone index designation to physical tone index designation, is also synchronized with respect to the sectors.

[0072] Block 814 in graph 802 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector A and illustrates exemplary allocation of those resources. Block 816 in graph 804 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector B and illustrates exemplary allocation of those resources. Block 818 in graph 806 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector A and illustrates exemplary allocation of those resources.

[0073] Legend 808 indicates that a tone-symbol allocated to WT 2, which is in sector pair state with the sectors of the pair being A and C, is indicated by diagonal line shading with descending slope from left to right as shown in example small block 820. Legend 808 indicates that a tone-symbol allocated to WT 3, which is in sector pair state with the sectors of the pair being A and C, is indicated by diagonal line shading with ascending slope from left to right as shown in example small block 822. Legend 808 indicates that a tone-symbol allocated to WT 4, which is in sector pair state with the sectors of the pair being B and C, is indicated by horizontal line shading as shown in example small block 824. Legend 808 indicates that a tone-symbol allocated to WT 5, which is in sector state with the sector being C, is indicated by vertical line shading as shown in example small block 826. Legend 808 indicates that a tone-symbol allocated

to WT 1, which is in sector state with the sector being B, is indicated by dotted shading as shown in example small block 828.

[0074] Figure 9 is a drawing 900 illustrating sector nulls corresponding to pilot tones in an exemplary OFDM wireless communications system implementing synchronized sectors. Drawing 800 includes a first graph 902 corresponding to sector A, a second graph 904 corresponding to sector B, and a third graph 906 corresponding to sector C. Each graph (902, 904, 906) includes a vertical axis 910 representing frequency, e.g., OFDM tone index in downlink frequency band, and a horizontal axis 912 of time, e.g., OFDM symbol index. It should be noted that the three sectors of the base station are synchronized in terms of both time and frequency.

[0075] Block 914 in graph 902 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector A and illustrates exemplary allocation of those resources with regard to pilot tone signals and intentional nulls. Block 916 in graph 904 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector B and illustrates exemplary allocation of those resources with regard to pilot tone signals and intentional nulls. Block 918 in graph 906 represents 64 basic units of air link resources, e.g., 64 OFDM tone-symbols, used by sector C and illustrates exemplary allocation of those resources with regard to pilot tone signals and intentional nulls.

[0076] Legend 908 indicates that a tone-symbol allocated to convey a pilot tone signal is represented by a small box including an **O,** as shown in example element 920; while a tone-symbol allocated to convey an intentional sector null is represented by a small box including an **X,** as shown in example element 922**.**

[0077] In various embodiments one or more channel quality measurements and/or indicators are used by state determination module 250 in deciding the state for a wireless terminal WT, e.g., sector state or sector pair state. In the above description, the channel quality indicator used by the state determination module 250 has been described as path loss information. However, other types of channel quality information may, and in some embodiments are, used in the place of path loss information. Consider for example SNR measurements which are used in the place of path loss information by the state determination module 250 in making the state determination in some embodiments. Such an embodiment is particularly well suited when an uplink

transmission SNR value is available for use. In such a case, the SNR value is dependent on path loss but may also be dependent on other factors such as sector interference. The SNR may, and in some embodiments is, measured separately from sector interference measurements. Sector interference is an example of a channel quality measurement upon which the state determination may be made instead of path loss however, as can be appreciated, other channel quality indicates may be used instead or in addition to SNR and/or path loss information.

[0078] It should also be appreciated that while determining path loss has been described in the above example as being done, at least in some embodiments by measuring path loss through the use of sector pilots and/or sector nulls other approaches may be used for determining path loss. For example, in some embodiments rather than have the mobile determine and communicate path loss information to the base station, the base station may determine path loss by monitoring one or more persistent, periodic or otherwise recurring uplink signals from the mobile transmitted at, e.g., a power level known to the base station. In one particular embodiment, the base station monitors a dedicated uplink control channel between the mobile and the base station and estimates path loss based on measurements of signals received from the mobile node which correspond to the dedicated uplink control channel. Other base station centric ways of measuring and/or estimating path loss could be used depending on the particular embodiment and the above examples are intended to facilitate an understanding of various embodiments but not limit the scope of subject matter thereto.

[0079] While described in the context of an OFDM system, the methods and apparatus of various embodiments are applicable to a wide range of communications systems including many non-OFDM and/or non-cellular systems.

[0080] In various embodiments nodes described herein are implemented using one or more modules to perform the steps corresponding to one or more methods, for example, maintaining information indicating a sector state or sector pair state, communicating with a wireless terminal using a number of base station antenna faces determined by the state corresponding to the wireless terminal, determining a state for a wireless terminal as a function of received path loss information, maintaining timing synchronization between sectors, transmitting pilots in conjunction with sector nulls, etc. In some embodiments various features are implemented using modules. Such

modules may be implemented using software, hardware or a combination of software and hardware. Many of the above described methods or method steps can be implemented using machine executable instructions, such as software, included in a machine readable medium such as a memory device, e.g., RAM, floppy disk, etc. to control a machine, e.g., general purpose computer with or without additional hardware, to implement all or portions of the above described methods, e.g., in one or more nodes. Accordingly, among other things, various embodiments are directed to a machine-readable medium including machine executable instructions for causing a machine, e.g., processor and associated hardware, to perform one or more of the steps of the above-described method(s).

[0081] In some embodiments, the processor or processors, e.g., CPUs, of one or more devices, e.g., communications devices such as wireless terminals are configured to perform the steps of the methods described as being as being performed by the communications device. Accordingly, some but not all embodiments are directed to a device, e.g., communications device, with a processor which includes a module corresponding to each of the steps of the various described methods performed by the device in which the processor is included. In some but not all embodiments a device, e.g., communications device, includes a module corresponding to each of the steps of the various described methods performed by the device in which the processor is included. The modules may be implemented using software and/or hardware.

[0082] Numerous additional variations on the methods and apparatus described above will be apparent to those skilled in the art in view of the above descriptions. Such variations are to be considered within scope. The methods and apparatus of various embodiments may be, and in various embodiments are, used with CDMA, orthogonal frequency division multiplexing (OFDM), and/or various other types of communications techniques which may be used to provide wireless communications links between access nodes and mobile nodes. In some embodiments the access nodes are implemented as base stations which establish communications links with mobile nodes using OFDM and/or CDMA. In various embodiments the mobile nodes are implemented as notebook computers, personal data assistants (PDAs), or other portable devices including receiver/transmitter circuits and logic and/or routines, for implementing the methods of various embodiments.

CLAIMS

WHAT IS CLAIMED IS:

1. A method of operating a base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the method comprising:

for each of a plurality of wireless terminals in said cell, maintaining information indicating whether said wireless terminal is in a sector or sector pair state; and

communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

2. The method of claim 1, wherein said number is one or two.

3. The method of claim 2, wherein said base station has 3 sectors.

4. The method of claim 1, further comprising;

allocating a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of said sector pair.

5. The method of claim 4, wherein said first set of tones are hopped over time in a synchronized manner in the sector pair.

6. The method of claim 4, further comprising allocating said first set of tones to a second wireless terminal in said first sector during at least a portion of time in which said first set of tones are allocated to the first wireless terminal.

7. The method of claim 6, wherein said second wireless terminal is in one of a sector state and a sector pair state.

8. The method of claim 6, wherein said communication includes:

receiving a signal on said first set of tones from a first antenna face corresponding to said first sector and receiving a signal on said first set of tones from a second antenna face corresponding to said second sector; and

combining the signal received from said first antenna face with the signal received from said second antenna face; and

extracting a signal corresponding to one of said first and second wireless terminals from said combined signal to recover at least some information transmitted by at least one of said first and second wireless terminals.

9. The method of claim 8, further comprising:

canceling the extracted signal from the signal received on one of said antenna faces to generate a processed signal; and

recovering information communicated by the second wireless terminal from said processed signal.

10. The method of claim 1, wherein communicating with one of said wireless terminals includes transmitting the same information from each the antenna faces of a sector pair to a first wireless terminal.

11. The method of claim 10, wherein communicating includes transmitting different information to first and second wireless terminals using the same set of tones and using both antenna faces of an antenna pair at the same time, said first and second wireless terminals each being in a sector pair state.

12. The method of claim 1, further comprising:

receiving path loss information corresponding to a first antenna face in an antenna face pair;

receiving path loss information corresponding to a second antenna face in said antenna face pair; and

determining if said wireless terminal is an a sector state or sector pair state based on the received path loss information.

13. The method of claim 12, wherein said received path loss information is a power measurement of a signal transmitted on a tone during a period of time during which the adjacent antenna face does not transmit on said tone.

14. The method of claim 2, wherein said base station is a base station in an OFDM system and said timing synchronization is OFDM symbol time synchronization.

15. A base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the base station comprising:

a wireless terminal state information maintenance module for maintaining information indicating whether a wireless terminal is in a sector or sector pair state for each of a plurality of wireless terminals in said cell; and

a communications module for communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

16. The base station of claim 15, wherein said number is one or two.

17. The base station of claim 15, further comprising;

a tone allocation module for allocating a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of said sector pair.

18. The base station of claim 17, wherein said tone allocation module further allocates said first set of tones to a second wireless terminal in said first sector during at least a portion of time in which said first set of tones are allocated to the first wireless terminal.

19. The base station of claim 18, wherein said communication module includes:

a receiver module for receiving a signal on said first set of tones from a first antenna face corresponding to said first sector and for receiving a signal on said first set of tones from a second antenna face corresponding to said second sector; the base station further comprising:

a combiner module for combining the signal received from said first antenna face with the signal received from said second antenna face;

an extraction module for extracting a signal corresponding to one of said first and second wireless terminals from said combined signal to recover at least some information transmitted by at least one of said first and second wireless terminals;

a cancellation module for canceling the extracted signal from the signal received on one of said antenna faces to generate a processed signal; and

an information recovery module for recovering information communicated by the second wireless terminal from said processed signal.

20. A base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the base station comprising:

means for maintaining wireless terminal state information for maintaining information indicating whether a wireless terminal is in a sector or sector pair state for each of a plurality of wireless terminals in said cell; and

means for communicating for communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

21. The base station of claim 20, further comprising;

means for allocating tones for allocating a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of said sector pair; and

means for hopping sets of tones, and

wherein said means for hopping tones hops said first set of tones over time in a synchronized manner in the sector pair.

22. A computer readable medium embodying machine executable instructions for operating a base station to perform a method, the base station being a base station in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, said base station being coupled to a multi-face antenna, each face of said antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the method comprising:

for each of a plurality of wireless terminals in said cell, maintaining information indicating whether said wireless terminal is in a sector or sector pair state; and

communicating with one of said wireless terminals using a number of antenna faces determined by the state corresponding to said wireless terminal.

23. The computer readable medium of claim 22, further embodying machine executable instructions for:

allocating a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of said sector pair; and

hopping said first set of tones over time in a synchronized manner in the sector pair.

24. An apparatus comprising:

a processor configure to:

for each of a plurality of wireless terminals, maintain information indicating whether an individual wireless terminal is in a sector or sector pair state; and

communicate with a wireless terminal using a number of antenna faces determined by the state corresponding to said wireless terminal.

25. The apparatus of claim 24, wherein said processor is further configured to:

allocate a first set of tones for communication with a first wireless terminal in said sector pair state, the first set of tones being allocated in each of a first and second sector of said sector pair; and

hop said first set of tones over time in a synchronized manner in the sector pair.

26. A method of operating a wireless terminal in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station coupled to a multi-face antenna, each face of said base station antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the method comprising:

maintaining information indicating whether said wireless terminal is in a sector or sector pair state; and

communicating with said base station in one of a MIMO mode of operation and a non-MIMO mode of operation, the mode of operation used for communicating being a function of whether said maintained information indicates said wireless terminal is in a sector or sector pair state.

27. The method of claim 26, wherein communicating with said base station in a MIMO mode of operation includes using at least two wireless terminal antennas communicating with two adjacent base station antenna faces.

28. The method of claim 27, wherein communicating with said base station in a MIMO mode of operation further includes using a first set of tones for communicating with both antenna faces of said two adjacent base station antenna faces during the same time.

29. The method of claim 27, wherein said base station has 3 sectors.

30. The method of claim 26, wherein said wireless terminal is in a sector pair state: the method further comprising:

receiving tone allocation information indicating that said wireless terminal has been allocated a first set of tones for communication with both a first antenna face of said multi-face base station antenna and a second antenna face of said multi-face base station antenna, said first and second faces being adjacent.

31. The method of claim 30, wherein said first set of tones are hopped over time in a synchronized manner in the sector pair.

32. The method of claim 36, further comprising:

transmitting path loss information corresponding to a first antenna face in an antenna face pair;

transmitting path loss information corresponding to a second antenna face in said antenna face pair, wherein said first and second antenna faces are adjacent antenna faces; and

receiving a base station determination as to whether said wireless terminal is to be in an a sector state or sector pair state, wherein said base station determination is based upon received path loss information from said wireless terminal.

33. The method of claim 32, further comprising:

performing a power measurement of a signal received on a tone during a period of time during which a first base station antenna face transmits a pilot signal on said tone and a second base antenna face does not transmit on said tone, said first and second base station antenna faces being adjacent; and

determining path loss information as a function of said power measurement.

34. The method of claim 27, wherein said wireless terminal is a wireless terminal in an OFDM system and said timing synchronization is OFDM symbol time synchronization.

35. A wireless terminal for use in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station coupled to a multi-face antenna, each face of said base station antenna

corresponding to a different sector of said cell, said sectors being timing synchronized, the wireless terminal comprising:

a state information maintenance module for maintaining information indicating whether said wireless terminal is in a sector or sector pair state;

a plurality of antennas;

a mode determination module for determining whether said wireless terminal is to operate in a MIMO or non-MIMO mode of operation as a function of said maintained information indicating whether said wireless terminal is in a sector or sector pair state;

a MIMO module for communicating with said base station in a MIMO mode of operation; and

a non-MIMO mode module for communicating with said base station in a non-MIMO mode of operation.

36. The wireless terminal of claim 35, wherein communicating with said base station in a MIMO mode of operation includes using at least two wireless terminal antennas communicating with two adjacent base station antenna faces.

37. The wireless terminal of claim 36, wherein communicating with said base station in a MIMO mode of operation further includes using a first set of tones for communicating with both antenna faces of said two adjacent base station antenna faces during the same time.

38. The wireless terminal of claim 35, further comprising:

a tone allocation determination module for determining from received signals that said wireless terminal has been allocated a first set of tones for communication with both a first antenna face of said multi-face base station antenna and a second antenna face of said multi-face base station antenna, said first and second faces being adjacent.

39. The wireless terminal of claim 38, further comprising:

stored information indicating tone hopping corresponding to at least one base station; and

a tone hopping module for implementing tone hopping, wherein said first set of tones are hopped over time in a synchronized manner in the sector pair.

40. The wireless terminal of claim 35, further comprising:

a transmitter for transmitting path loss information corresponding to a first antenna face in an antenna face pair and for transmitting path loss information corresponding to a second antenna face in said antenna face pair, wherein said first and second antenna faces are adjacent antenna faces; and

a state information recovery module for recovering from a received signal a base station determination indicating whether said wireless terminal is to be in an a sector state or sector pair state, wherein said base station determination is based upon received path loss information from said wireless terminal;

a power measurement module for performing a power measurement of a signal received on a tone during a period of time during which a first base station antenna face transmits a pilot signal on said tone and a second base antenna face does not transmit on said tone, said first and second base station antenna faces being adjacent; and

a path loss determination module for determining path loss information as a function of said power measurement.

41. The wireless terminal of claim 40, wherein said wireless terminal is a wireless terminal in an OFDM system and said timing synchronization is OFDM symbol time synchronization.

42. A wireless terminal for use in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station coupled to a multi-face antenna, each face of said base station antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the wireless terminal comprising:

means for maintaining state information for maintaining information indicating whether said wireless terminal is in a sector or sector pair state;

a plurality of at least one of means for radiating electromagnetic waves and means for recovering electromagnetic waves;

means for determining whether said wireless terminal is to operate in a MIMO or non-MIMO mode of operation as a function of said maintained information indicating whether said wireless terminal is in a sector or sector pair state;

means for communicating with said base station in a MIMO mode of operation; and

means for communicating with said base station in a non-MIMO mode of operation.

43. The wireless terminal of claim 42, wherein communicating with said base station in a MIMO mode of operation includes using at least two of said plurality of at least one of means for radiating electromagnetic waves and means for recovering electromagnetic waves communicating with two adjacent base station antenna faces.

44. The wireless terminal of claim 43, wherein communicating with said base station in a MIMO mode of operation further includes using a first set of tones for communicating with both antenna faces of said two adjacent base station antenna faces during the same time.

45. The wireless terminal of claim 42, further comprising:

means for determining tone allocation for determining from received signals that said wireless terminal has been allocated a first set of tones for communication with both a first antenna face of said multi-face base station antenna and a second antenna face of said multi-face base station antenna, said first and second faces being adjacent.

46. A computer readable medium embodying machine executable instructions for implementing a method of operating a wireless terminal in a sectorized cell, each sector being adjacent at least one other sector in the cell, adjacent sectors forming sector pairs, the cell including a base station coupled to a multi-face antenna, each face of said base station antenna corresponding to a different sector of said cell, said sectors being timing synchronized, the method comprising:

maintaining information indicating whether said wireless terminal is in a sector or sector pair state; and

communicating with said base station in one of a MIMO mode of operation and a non-MIMO mode of operation, the mode of operation used for communicating being a function of whether said maintained information indicates said wireless terminal is in a sector or sector pair state.

47. The computer readable medium of claim 46, wherein communicating with said base station in a MIMO mode of operation includes using at least two wireless terminal antennas communicating with two adjacent base station antenna faces.

48. The computer readable medium of claim 47, wherein communicating with said base station in a MIMO mode of operation further includes using a first set of tones for communicating with both antenna faces of said two adjacent base station antenna faces during the same time.

49. An apparatus comprising:

a processor configured to:

maintain information indicating whether said apparatus is in a sector or sector pair state; and

communicate with a base station in one of a MIMO mode of operation and a non-MIMO mode of operation, the mode of operation used for communicating being a function of whether said maintained information indicates said apparatus is in a sector or sector pair state.

50. The apparatus of claim 49,

wherein communicating with said base station in a MIMO mode of operation includes using at least two antennas communicating with two adjacent base station antenna faces;

wherein communicating with said base station in a MIMO mode of operation further includes using a first set of tones for communicating with both antenna faces of said two adjacent base station antenna faces during the same time;

wherein said first set of tones are hopped over time in a synchronized manner in the sector pair

wherein said base station has 3 sectors; and

wherein said first set of tones are hopped over time in a synchronized manner in the sector pair.

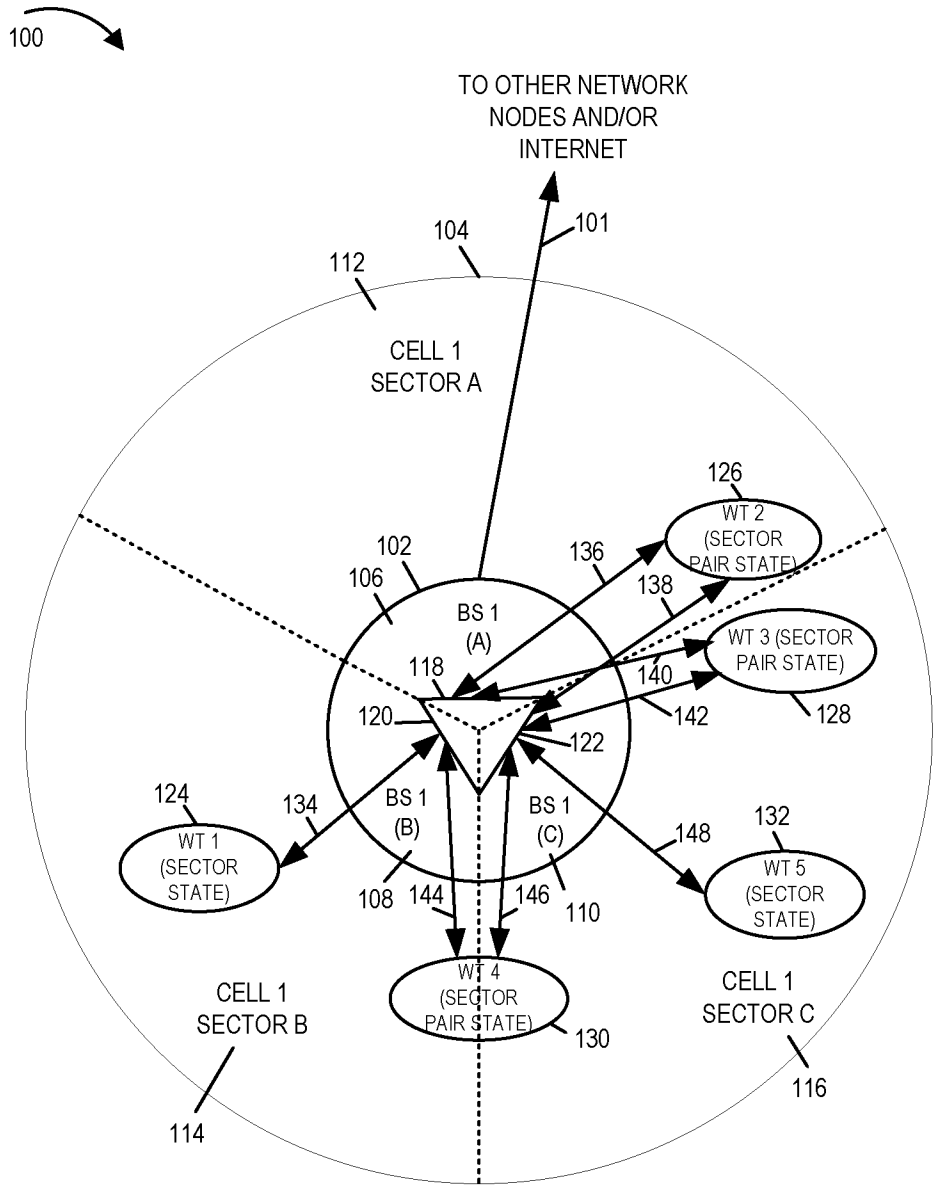

100
TO OTHER NETWORK NODES AND/OR INTERNET
101
104
112
CELL 1 SECTOR A
126
WT 2 (SECTOR PAIR STATE)
102
106
136
138
BS 1 (A)
WT 3 (SECTOR PAIR STATE)
118
140
120
142
128
122
124
134
BS 1 (B)
BS 1 (C)
148
132
WT 1 (SECTOR STATE)
WT 5 (SECTOR STATE)
108
144
146
110
WT 4 (SECTOR PAIR STATE)
130
CELL 1 SECTOR B
CELL 1 SECTOR C
114
116

FIGURE 1

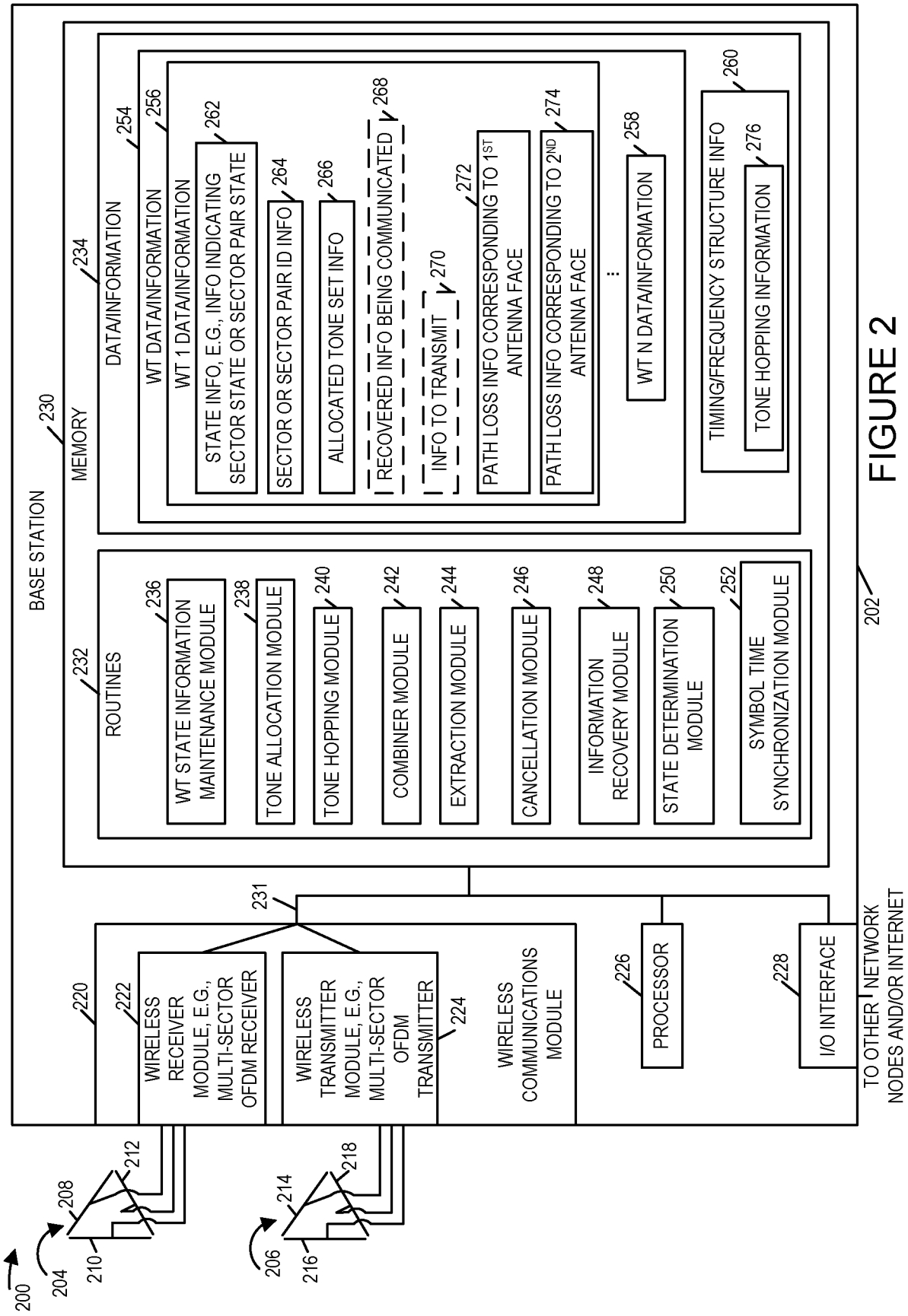

BASE STATION
230
MEMORY
234
DATA/INFORMATION
254
WT DATA/INFORMATION
256
WT 1 DATA/INFORMATION
STATE INFO, E.G., INFO INDICATING SECTOR STATE OR SECTOR PAIR STATE
262
SECTOR OR SECTOR PAIR ID INFO
264
ALLOCATED TONE SET INFO
266
RECOVERED INFO BEING COMMUNICATED
268
INFO TO TRANSMIT
270
PATH LOSS INFO CORRESPONDING TO 1ST ANTENNA FACE
272
PATH LOSS INFO CORRESPONDING TO 2ND ANTENNA FACE
274
WT N DATA/INFORMATION
258
TIMING/FREQUENCY STRUCTURE INFO
260
TONE HOPPING INFORMATION
276
ROUTINES
232
WT STATE INFORMATION MAINTENANCE MODULE
236
TONE ALLOCATION MODULE
238
TONE HOPPING MODULE
240
COMBINER MODULE
242
EXTRACTION MODULE
244
CANCELLATION MODULE
246
INFORMATION RECOVERY MODULE
248
STATE DETERMINATION MODULE
250
SYMBOL TIME SYNCHRONIZATION MODULE
252
202
231
220
WIRELESS RECEIVER MODULE, E.G., MULTI-SECTOR OFDM RECEIVER
222
WIRELESS TRANSMITTER MODULE, E.G., MULTI-SECTOR OFDM TRANSMITTER
224
WIRELESS COMMUNICATIONS MODULE
PROCESSOR
226
I/O INTERFACE
228
TO OTHER NETWORK NODES AND/OR INTERNET
200
204
208
210
212
206
214
216
218

FIGURE 2

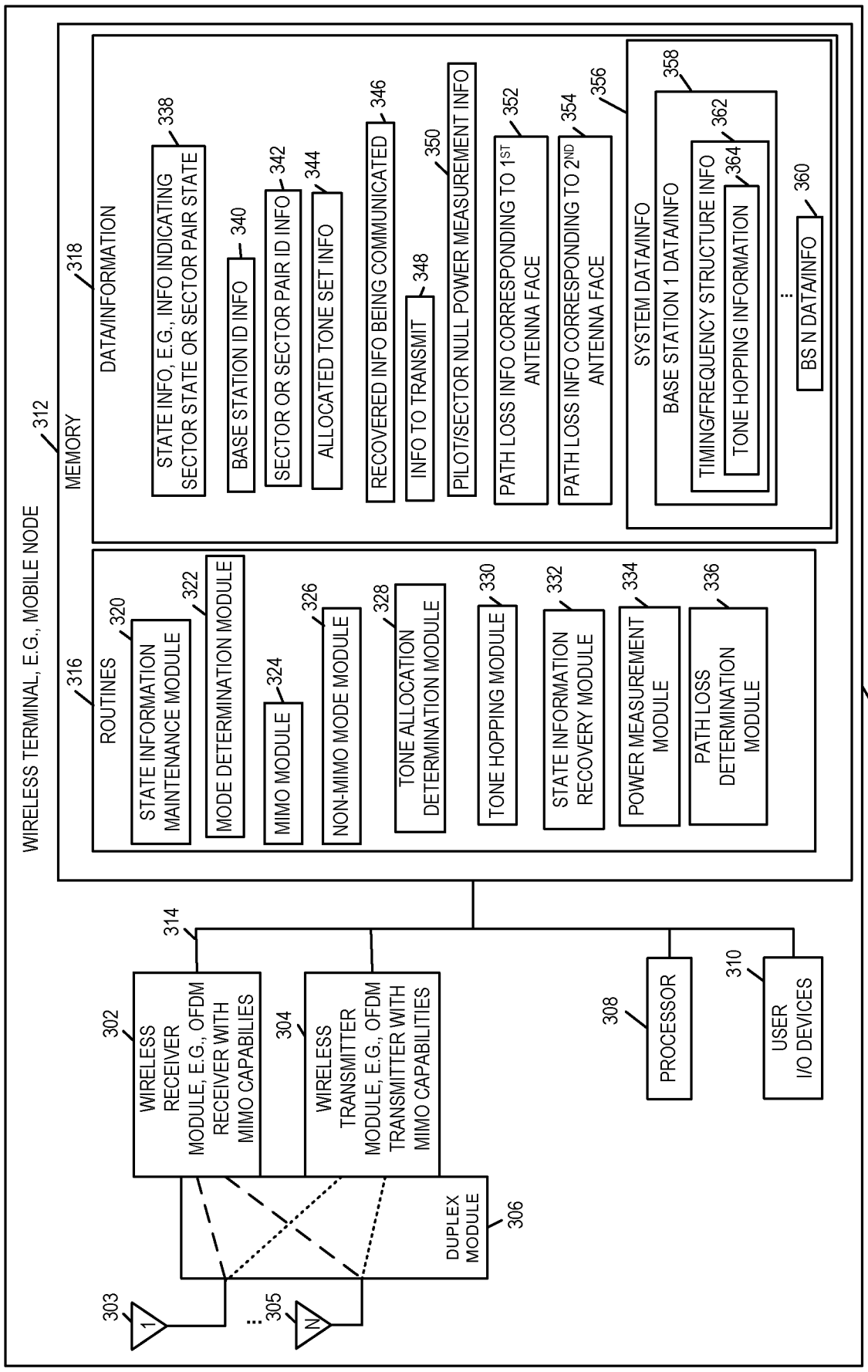

WIRELESS TERMINAL, E.G., MOBILE NODE
300
MEMORY
312
DATA/INFORMATION
318
STATE INFO, E.G., INFO INDICATING SECTOR STATE OR SECTOR PAIR STATE
338
BASE STATION ID INFO
340
SECTOR OR SECTOR PAIR ID INFO
342
ALLOCATED TONE SET INFO
344
RECOVERED INFO BEING COMMUNICATED
346
INFO TO TRANSMIT
348
PILOT/SECTOR NULL POWER MEASUREMENT INFO
350
PATH LOSS INFO CORRESPONDING TO 1ST ANTENNA FACE
352
PATH LOSS INFO CORRESPONDING TO 2ND ANTENNA FACE
354
SYSTEM DATA/INFO
356
BASE STATION 1 DATA/INFO
358
TIMING/FREQUENCY STRUCTURE INFO
362
TONE HOPPING INFORMATION
364
BS N DATA/INFO
360
ROUTINES
316
STATE INFORMATION MAINTENANCE MODULE
320
MODE DETERMINATION MODULE
322
MIMO MODULE
324
NON-MIMO MODE MODULE
326
TONE ALLOCATION DETERMINATION MODULE
328
TONE HOPPING MODULE
330
STATE INFORMATION RECOVERY MODULE
332
POWER MEASUREMENT MODULE
334
PATH LOSS DETERMINATION MODULE
336
314
WIRELESS RECEIVER MODULE, E.G., OFDM RECEIVER WITH MIMO CAPABILITIES
302
WIRELESS TRANSMITTER MODULE, E.G., OFDM TRANSMITTER WITH MIMO CAPABILITIES
304
DUPLEX MODULE
306
303
1
305
N
PROCESSOR
308
USER I/O DEVICES
310
TO OTHER NETWORK NODES AND/OR INTERNET

FIGURE 3

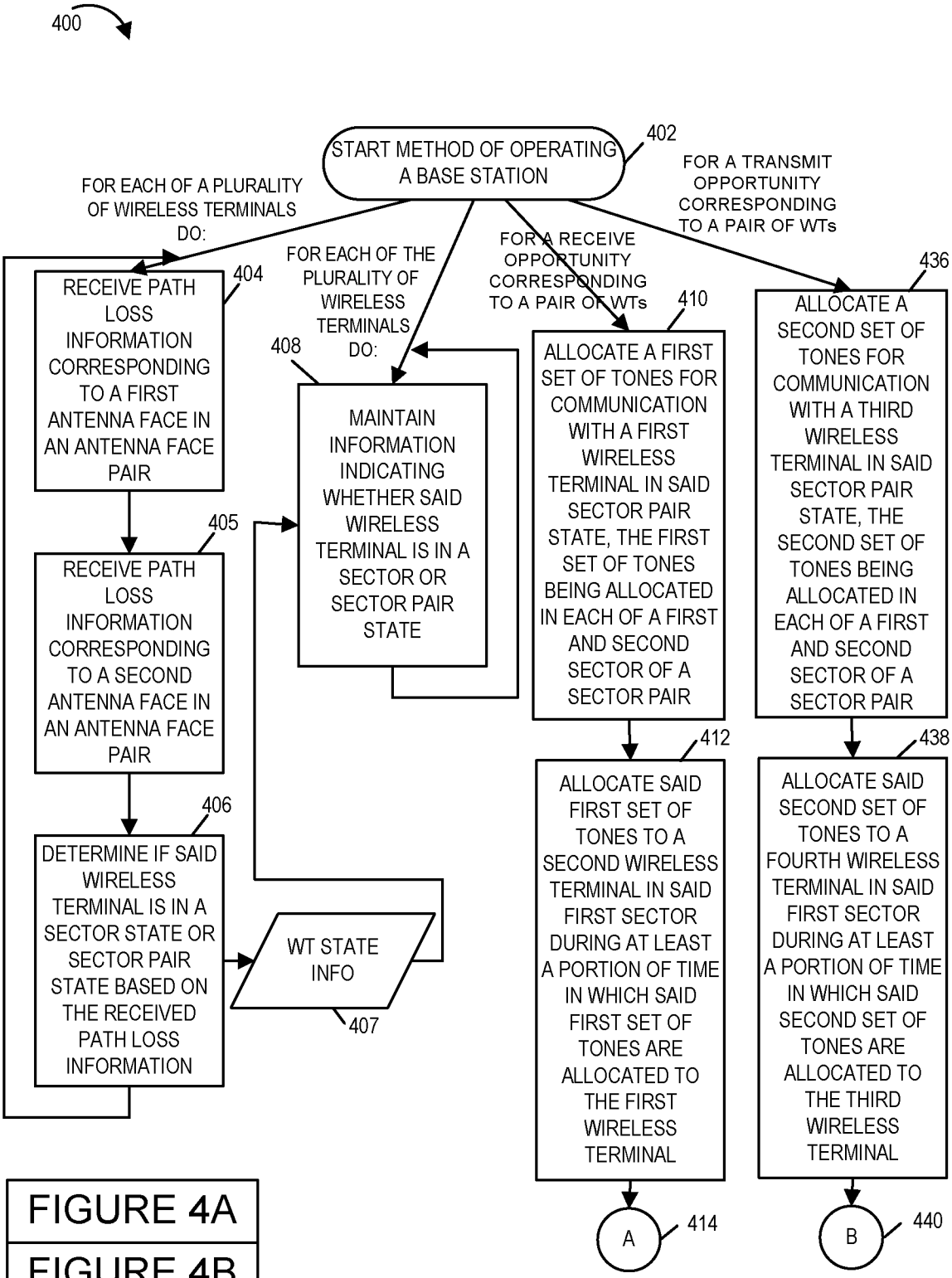


FIGURE 4A

FIGURE 4A
FIGURE 4B
FIGURE 4C

FIGURE 4

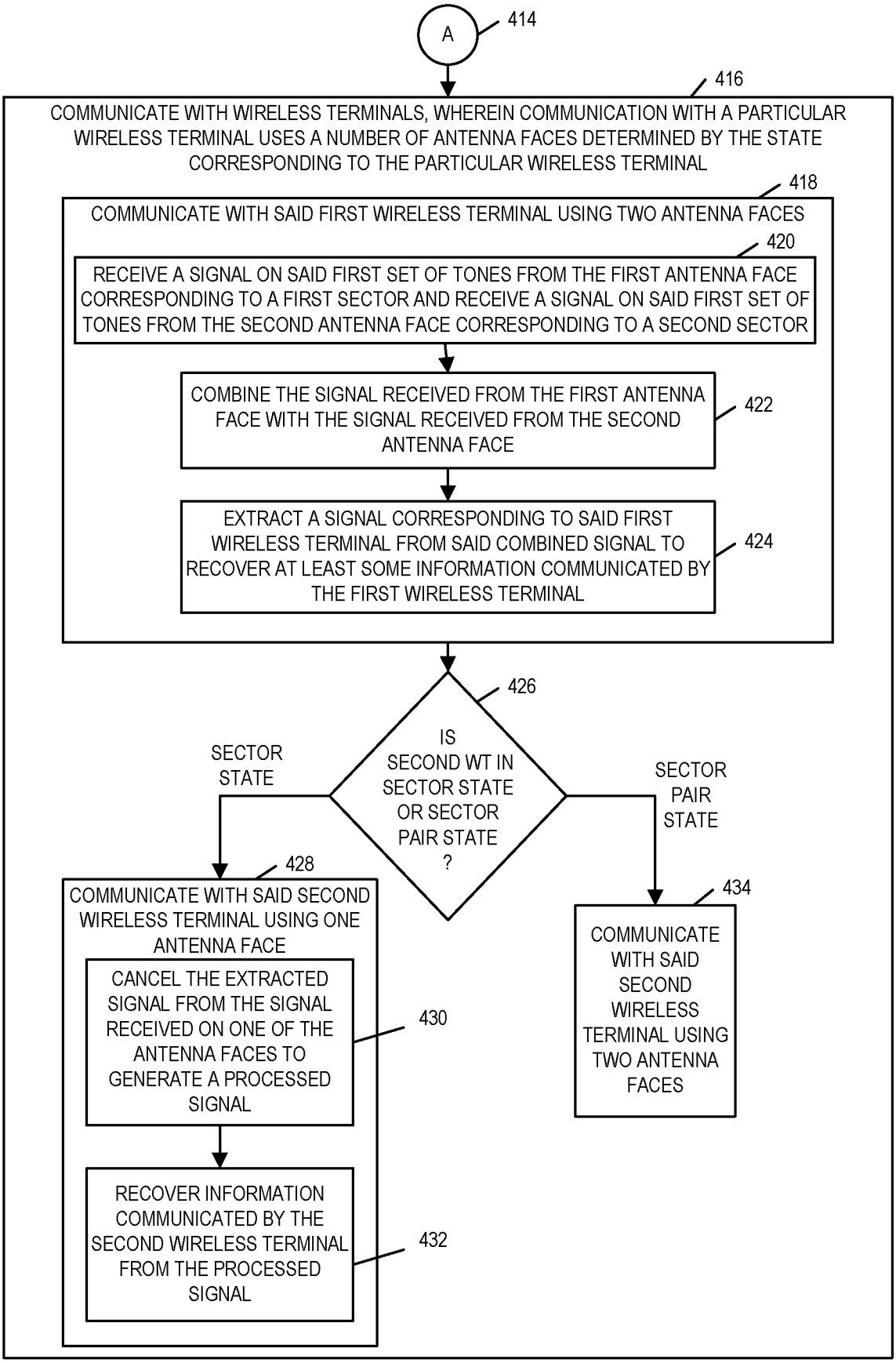

A
414
416
COMMUNICATE WITH WIRELESS TERMINALS, WHEREIN COMMUNICATION WITH A PARTICULAR WIRELESS TERMINAL USES A NUMBER OF ANTENNA FACES DETERMINED BY THE STATE CORRESPONDING TO THE PARTICULAR WIRELESS TERMINAL
418
COMMUNICATE WITH SAID FIRST WIRELESS TERMINAL USING TWO ANTENNA FACES
420
RECEIVE A SIGNAL ON SAID FIRST SET OF TONES FROM THE FIRST ANTENNA FACE CORRESPONDING TO A FIRST SECTOR AND RECEIVE A SIGNAL ON SAID FIRST SET OF TONES FROM THE SECOND ANTENNA FACE CORRESPONDING TO A SECOND SECTOR
COMBINE THE SIGNAL RECEIVED FROM THE FIRST ANTENNA FACE WITH THE SIGNAL RECEIVED FROM THE SECOND ANTENNA FACE
422
EXTRACT A SIGNAL CORRESPONDING TO SAID FIRST WIRELESS TERMINAL FROM SAID COMBINED SIGNAL TO RECOVER AT LEAST SOME INFORMATION COMMUNICATED BY THE FIRST WIRELESS TERMINAL
424
426
IS SECOND WT IN SECTOR STATE OR SECTOR PAIR STATE ?
SECTOR STATE
SECTOR PAIR STATE
428
COMMUNICATE WITH SAID SECOND WIRELESS TERMINAL USING ONE ANTENNA FACE
CANCEL THE EXTRACTED SIGNAL FROM THE SIGNAL RECEIVED ON ONE OF THE ANTENNA FACES TO GENERATE A PROCESSED SIGNAL
430
RECOVER INFORMATION COMMUNICATED BY THE SECOND WIRELESS TERMINAL FROM THE PROCESSED SIGNAL
432
434
COMMUNICATE WITH SAID SECOND WIRELESS TERMINAL USING TWO ANTENNA FACES

FIGURE 4B

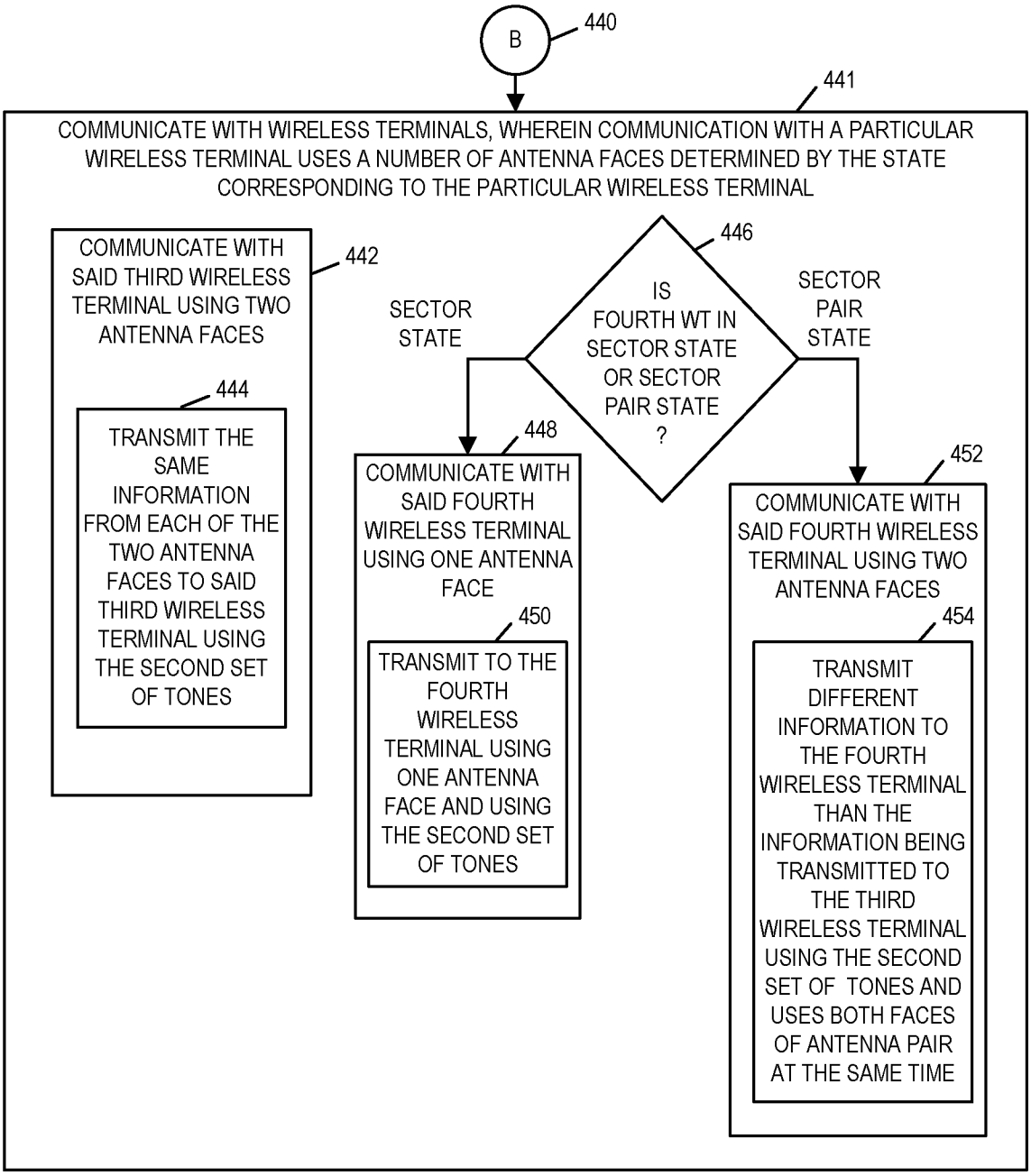

B
440
441
COMMUNICATE WITH WIRELESS TERMINALS, WHEREIN COMMUNICATION WITH A PARTICULAR WIRELESS TERMINAL USES A NUMBER OF ANTENNA FACES DETERMINED BY THE STATE CORRESPONDING TO THE PARTICULAR WIRELESS TERMINAL
COMMUNICATE WITH SAID THIRD WIRELESS TERMINAL USING TWO ANTENNA FACES
442
444
TRANSMIT THE SAME INFORMATION FROM EACH OF THE TWO ANTENNA FACES TO SAID THIRD WIRELESS TERMINAL USING THE SECOND SET OF TONES
446
IS FOURTH WT IN SECTOR STATE OR SECTOR PAIR STATE ?
SECTOR STATE
SECTOR PAIR STATE
448
COMMUNICATE WITH SAID FOURTH WIRELESS TERMINAL USING ONE ANTENNA FACE
450
TRANSMIT TO THE FOURTH WIRELESS TERMINAL USING ONE ANTENNA FACE AND USING THE SECOND SET OF TONES
452
COMMUNICATE WITH SAID FOURTH WIRELESS TERMINAL USING TWO ANTENNA FACES
454
TRANSMIT DIFFERENT INFORMATION TO THE FOURTH WIRELESS TERMINAL THAN THE INFORMATION BEING TRANSMITTED TO THE THIRD WIRELESS TERMINAL USING THE SECOND SET OF TONES AND USES BOTH FACES OF ANTENNA PAIR AT THE SAME TIME

FIGURE 4C

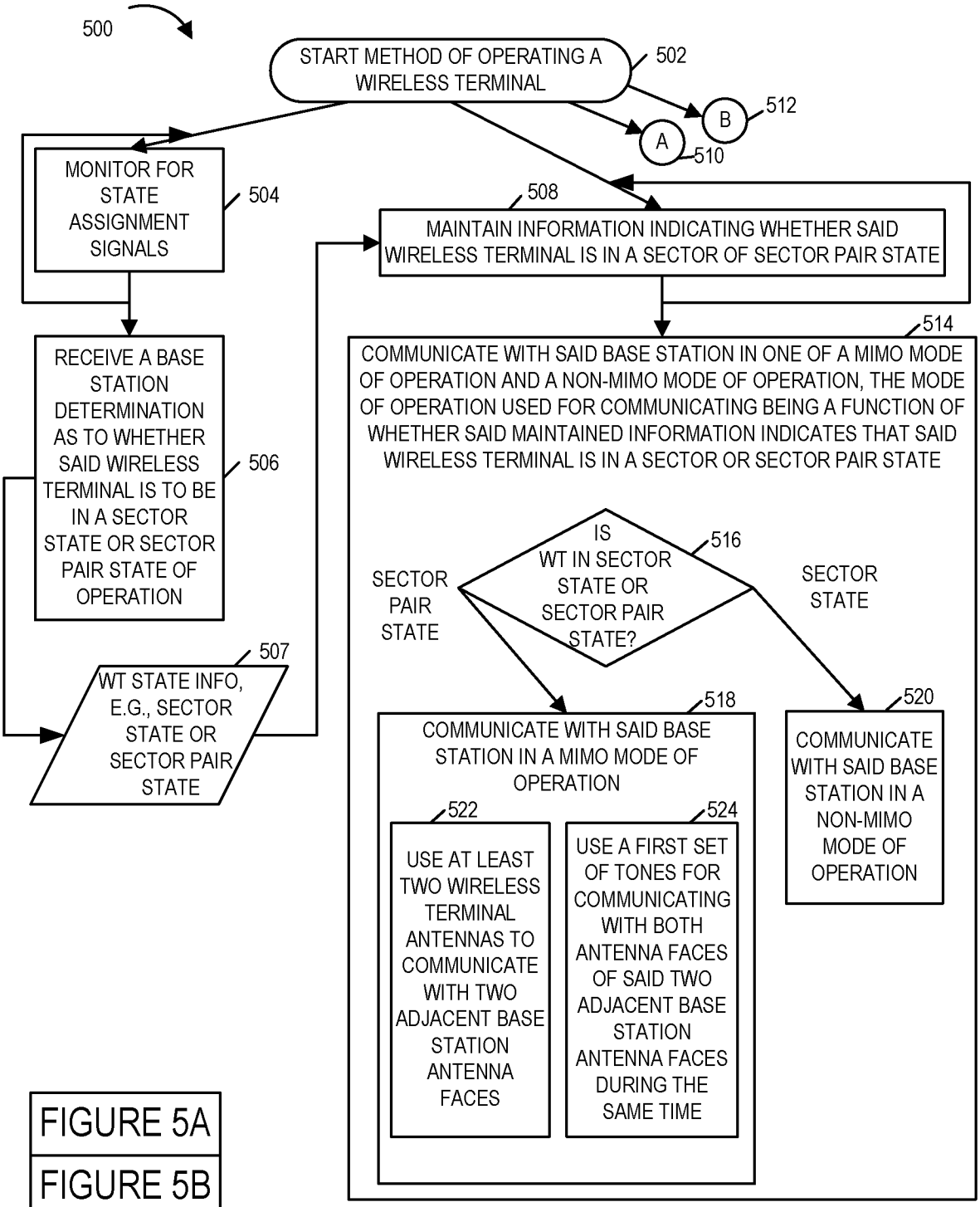


FIGURE 5A

FIGURE 5B

FIGURE 5

FIGURE 5A

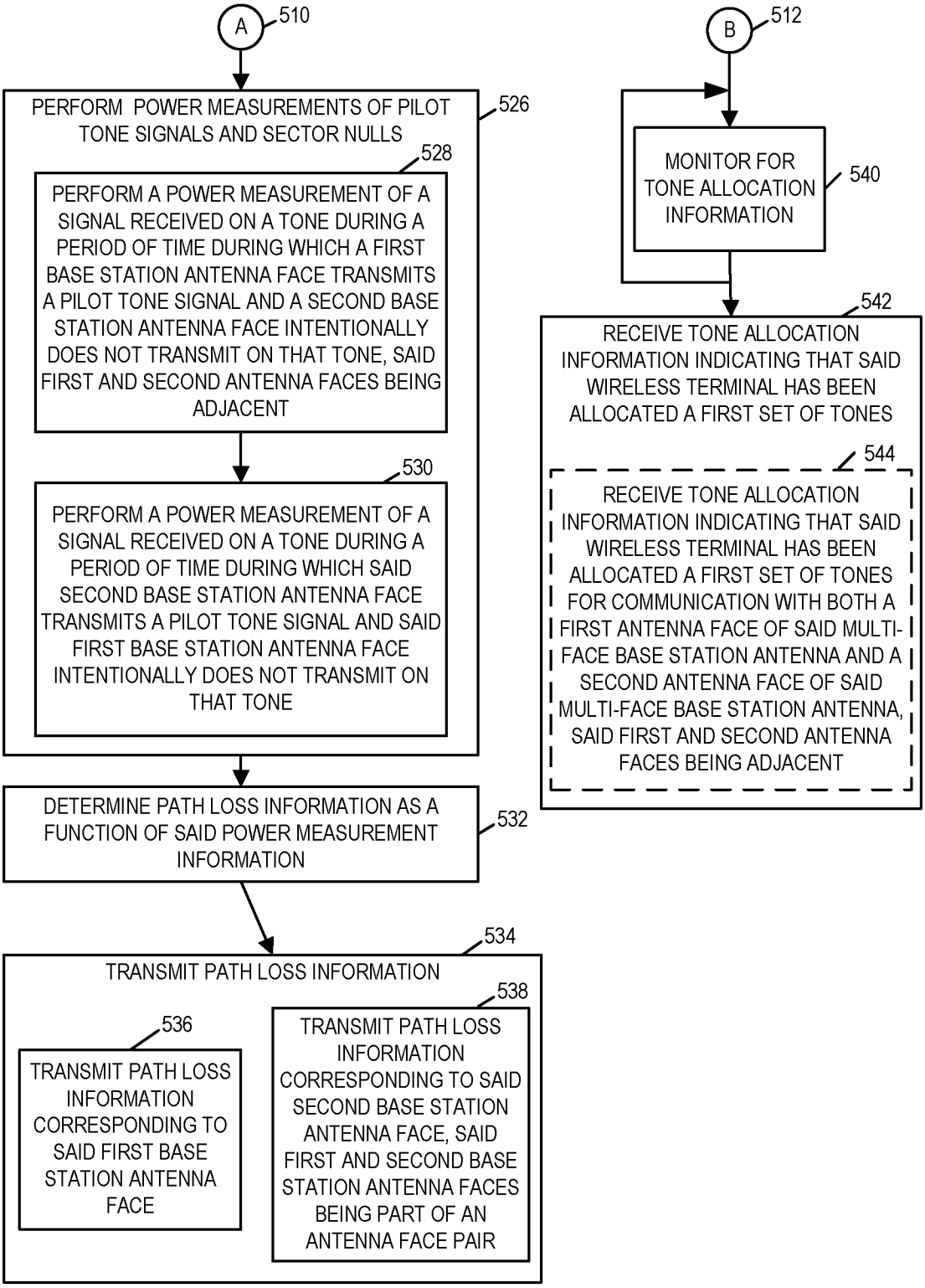

A
510
PERFORM POWER MEASUREMENTS OF PILOT TONE SIGNALS AND SECTOR NULLS
526
528
PERFORM A POWER MEASUREMENT OF A SIGNAL RECEIVED ON A TONE DURING A PERIOD OF TIME DURING WHICH A FIRST BASE STATION ANTENNA FACE TRANSMITS A PILOT TONE SIGNAL AND A SECOND BASE STATION ANTENNA FACE INTENTIONALLY DOES NOT TRANSMIT ON THAT TONE, SAID FIRST AND SECOND ANTENNA FACES BEING ADJACENT
530
PERFORM A POWER MEASUREMENT OF A SIGNAL RECEIVED ON A TONE DURING A PERIOD OF TIME DURING WHICH SAID SECOND BASE STATION ANTENNA FACE TRANSMITS A PILOT TONE SIGNAL AND SAID FIRST BASE STATION ANTENNA FACE INTENTIONALLY DOES NOT TRANSMIT ON THAT TONE
DETERMINE PATH LOSS INFORMATION AS A FUNCTION OF SAID POWER MEASUREMENT INFORMATION
532
534
TRANSMIT PATH LOSS INFORMATION
536
TRANSMIT PATH LOSS INFORMATION CORRESPONDING TO SAID FIRST BASE STATION ANTENNA FACE
538
TRANSMIT PATH LOSS INFORMATION CORRESPONDING TO SAID SECOND BASE STATION ANTENNA FACE, SAID FIRST AND SECOND BASE STATION ANTENNA FACES BEING PART OF AN ANTENNA FACE PAIR
B
512
MONITOR FOR TONE ALLOCATION INFORMATION
540
542
RECEIVE TONE ALLOCATION INFORMATION INDICATING THAT SAID WIRELESS TERMINAL HAS BEEN ALLOCATED A FIRST SET OF TONES
544
RECEIVE TONE ALLOCATION INFORMATION INDICATING THAT SAID WIRELESS TERMINAL HAS BEEN ALLOCATED A FIRST SET OF TONES FOR COMMUNICATION WITH BOTH A FIRST ANTENNA FACE OF SAID MULTI-FACE BASE STATION ANTENNA AND A SECOND ANTENNA FACE OF SAID MULTI-FACE BASE STATION ANTENNA, SAID FIRST AND SECOND ANTENNA FACES BEING ADJACENT

FIGURE 5B

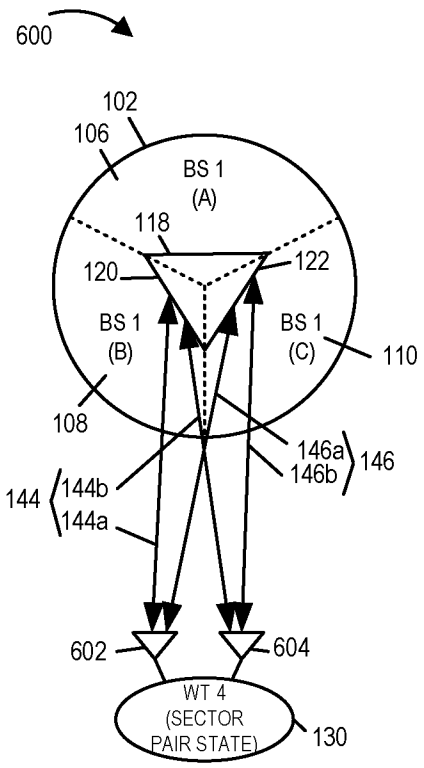


FIGURE 6

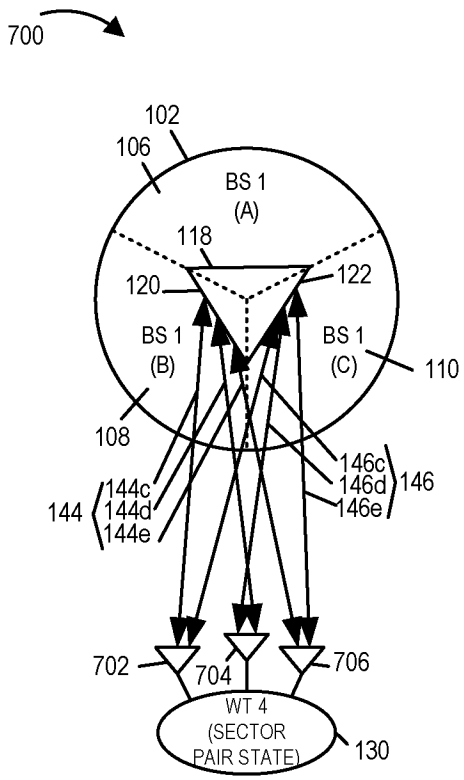


FIGURE 7

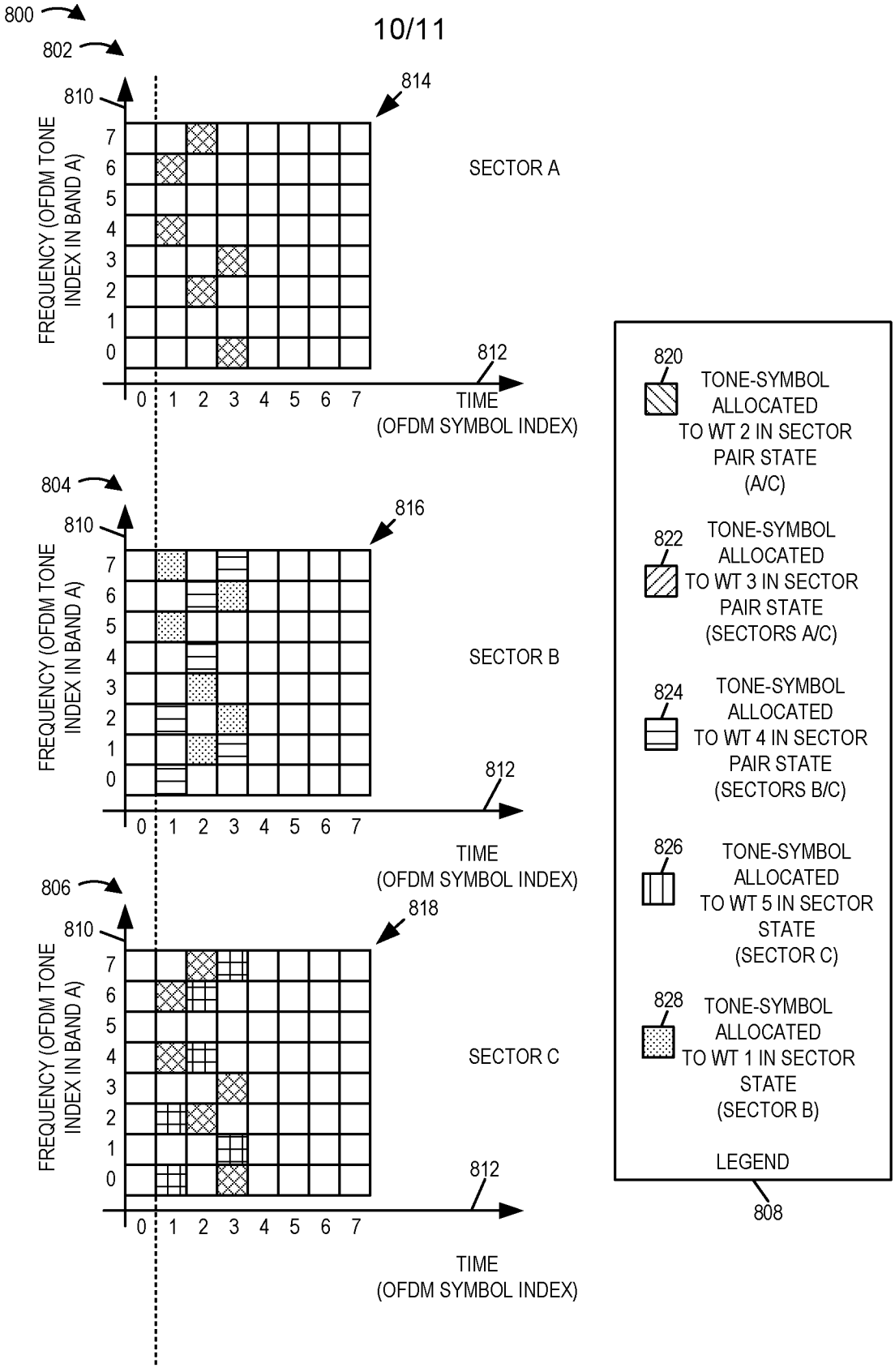

800
802
804
806
810
812
814
816
818
FREQUENCY (OFDM TONE INDEX IN BAND A)
TIME (OFDM SYMBOL INDEX)
SECTOR A
SECTOR B
SECTOR C
820
TONE-SYMBOL ALLOCATED TO WT 2 IN SECTOR PAIR STATE (A/C)
822
TONE-SYMBOL ALLOCATED TO WT 3 IN SECTOR PAIR STATE (SECTORS A/C)
824
TONE-SYMBOL ALLOCATED TO WT 4 IN SECTOR PAIR STATE (SECTORS B/C)
826
TONE-SYMBOL ALLOCATED TO WT 5 IN SECTOR STATE (SECTOR C)
828
TONE-SYMBOL ALLOCATED TO WT 1 IN SECTOR STATE (SECTOR B)
LEGEND
808

FIGURE 8

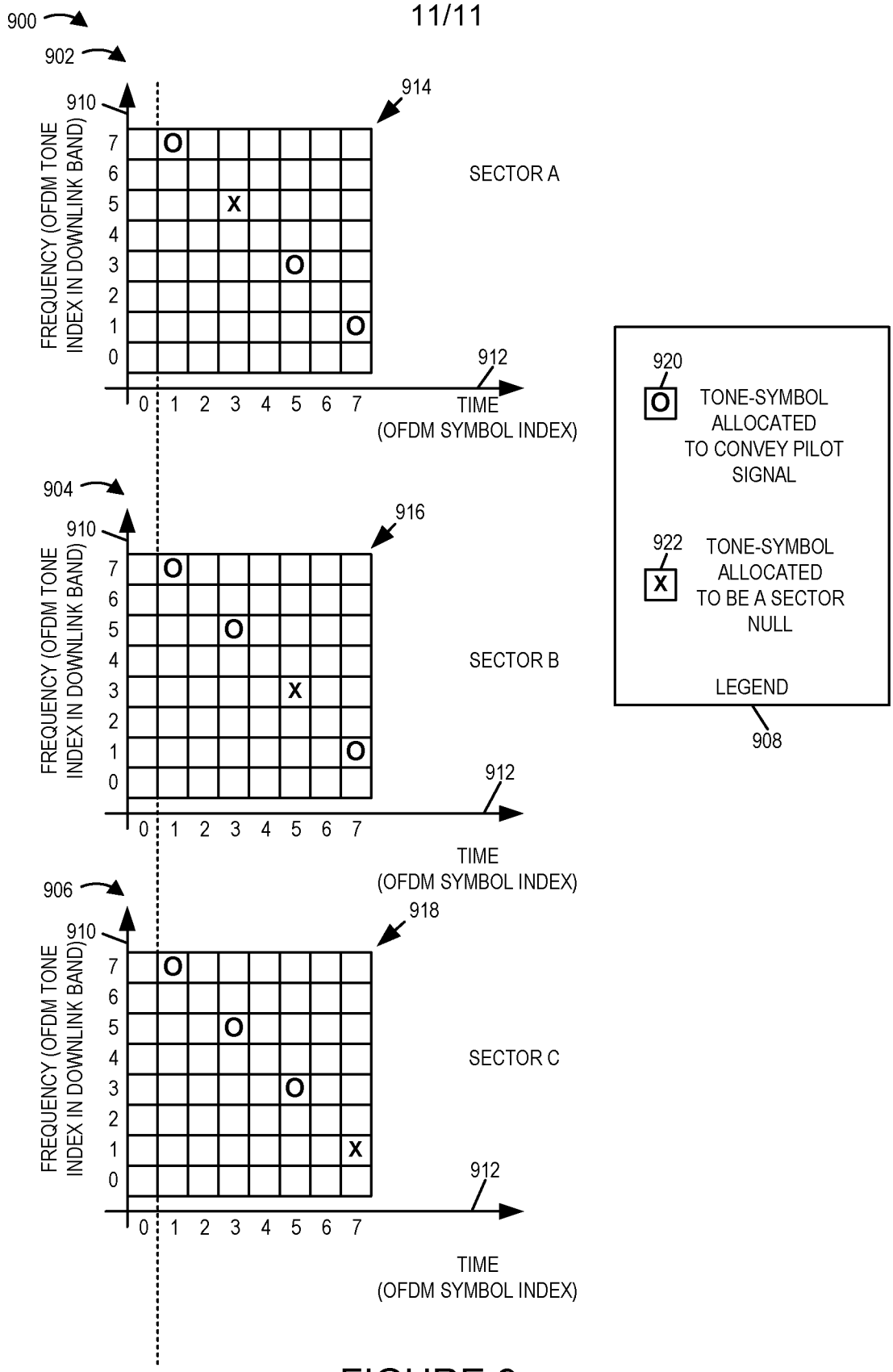

900
902
910
914
FREQUENCY (OFDM TONE INDEX IN DOWNLINK BAND)
SECTOR A
912
TIME (OFDM SYMBOL INDEX)
904
916
SECTOR B
906
918
SECTOR C
920
TONE-SYMBOL ALLOCATED TO CONVEY PILOT SIGNAL
922
TONE-SYMBOL ALLOCATED TO BE A SECTOR NULL
LEGEND
908

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/064842

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/272432 A1 (JI TINGFANG [US] ET AL) 8 December 2005 (2005-12-08)	1-7,10, 11, 14-18, 20-31, 34-39, 41-50
Y	abstract paragraphs [0006] - [0011], [0030] - [0050], [0058], [0078] - [0085] figures 3b,6-8,11,13	9,13

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 August 2008	02/09/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fernández Cuenca, B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/064842

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	abstract column 4, line 3 - column 9, line 13 column 10, line 39 - column 11, line 21	9,13
Y	JIANG M ET AL: "Multiuser MIMO-OFDM systems using subcarrier hopping" IEE PROCEEDINGS : COMMUNICATIONS, INSTITUTION OF ELECTRICAL ENGINEERS, GB, vol. 153, no. 6, 1 December 2006 (2006-12-01), pages 802-809, XP006027589 ISSN: 1350-2425 the whole document	9
Y	US 2004/166886 A1 (LAROIA RAJIV [US] ET AL) 26 August 2004 (2004-08-26) abstract paragraphs [0002], [0006] - [0009], [0012], [0018], [0020], [0022], [0042] - [0045]	13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2008/064842

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