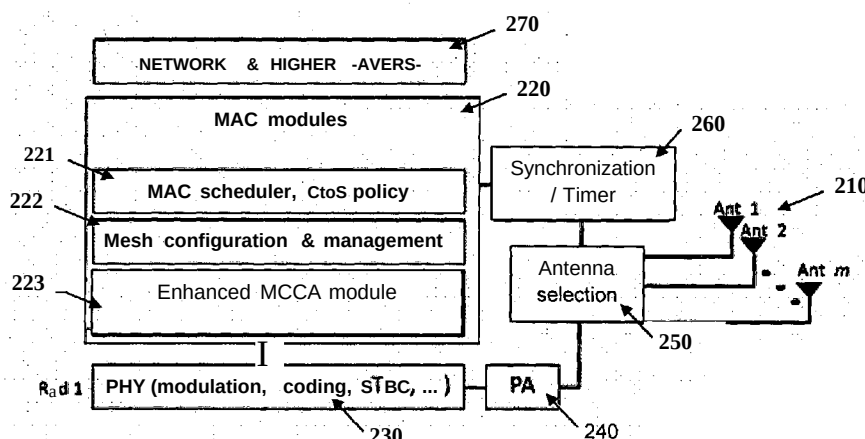




- (51) **International Patent Classification:**
H04W 88/00 (2009.01) *H04W 84/00* (2009.01)
- (21) **International Application Number:**
PCT/MY20 12/000 172
- (22) **International Filing Date:**
29 June 2012 (29.06.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
PI 201 1700208 29 December 2011 (29.12.2011) MY
- (71) **Applicant (for all designated States except US):** **MIMOS BERHAD** [MY/MY]; Technology Park Malaysia, 57000 Kuala Lumpur (MY).
- (72) **Inventors; and**
- (75) **Inventors/Applicants (for US only):** **YAACOB, Azmi** [MY/MY]; Mimos Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). **BIN MOHAMAD @ DIN, Hafizal** [MY/MY]; Mimos Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). **BIN RAMLI, Nor-din** [MY/MY]; Mimos Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). **BIN ABU BAKAR, Ahmad Zaki** [MY/MY]; Mimos Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). **HASHIM, Wahidah Binti** [MY/MY]; Mimos Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY).
- (74) **Agent:** **H.A. RASHID, Ahmad, Fadzlee;** Ipvolusi SDN BHD, A-6-6, Centrio Pantai Hill Park, No.1, Jalan Pantai Murni, Kuala Lumpur 59200 (MY).
- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States (unless otherwise indicated, for every kind of regional protection available):** ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Declarations under Rule 4.17:**
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))
 - of inventorship (Rule 4.17(iv))

[Continued on nextpage]

(54) **Title:** A WIRELESS COMMUNICATION SYSTEM

(57) **Abstract:** The present invention relates to a wireless communication system. The wireless communication system is equipped with multiple antennas (210, 310) to work with lower number of radio in a wireless mesh network. The wireless communication system includes an enhanced mesh coordinated channel access (MCCA) module (223, 323) to provide reservation of contention free time slots and to map the direction of source and destination nodes in the wireless mesh network. Moreover, the wireless communication system further includes an antenna selection module (250, 350) to select the appropriate antenna (210, 310) to be employed during transmission and reception of data in the wireless mesh network. In order to ensure synchronization between the MCCA module (223, 323) and the antenna selection module (250, 350), a synchronization module (260, 360) is provided in the wireless communication system.

Published:

— *with international search report (Art. 21(3))*

A WIRELESS COMMUNICATION SYSTEM

FIELD OF INVENTION

The present invention relates to a wireless communication system and more particularly to a wireless communication system having multiple antenna configuration for use in a wireless mesh network.

BACKGROUND OF THE INVENTION

IEEE 802.11 is a set of standards for implementing wireless local area network (WLAN) computer communication in frequency bands of 2.4 GHz, 3.6 GHz and 5 GHz. IEEE 802.11s extends those standards for wireless mesh networking by defining an extended service set (ESS) of a number of interconnected devices or nodes to enable automatic topology learning and dynamic path configuration.

Referring now to **FIG. 1**, a wireless mesh network (WMN) generally comprises of mesh routers (**10**), mesh clients (**20**) and a mesh portal (**30**). Each node is capable to operate both as a host and as a router that can provide packet forwarding on behalf of another node that is out of range of transmission with its destination. Moreover, each node supports mesh functions such as neighbour discovery, channel selection and association forming with its neighbouring nodes. The mesh routers (**10**) are interconnected through wireless connection. The mesh clients (**20**) are connected to the mesh routers (**10**) through either an Ethernet interface or the same radio technology as the mesh routers (**10**). The mesh portal (**30**) is connected to the mesh routers for connecting to other wired or wireless network. For instance, the mesh portal (**30**) is further connected to a gateway (**40**) for Internet connection.

However, the current routing and Media Access Control (MAC) protocols limit the capacity, quality of service and capabilities of WMN and thus, enhancements are made to the MAC protocol. Such MAC enhancements include Mesh Coordinated Channel Access (MCCA) which is a distributed reservation protocol that allows mesh routers to avoid frame collisions. MCCA is an optional protocol in the IEEE 802.11s standard.

In another effort to increase the network capacity of WMN, the mesh router is equipped with multiple antennas to support multiple 802.11 radios for deploying a multi-radio mesh network whereby a unique frequency is used for each wireless hop. FIG. 2 shows network architecture of the mesh router equipped with multiple
5 antennas (110). The mesh router includes a MAC layer (120) which comprises of MAC scheduler and QoS policy module (121), mesh topology and routing module (122), and a medium access coordination module (123). The MAC layer (120) is connected to multiple physical layers (130). Each physical layer (130) is further connected to a power amplifier (140) which is coupled to an antenna (110) dedicated
10 for a particular radio. Therefore, for N number of radio to be used in multi-radio mesh network, N number of physical layer (130), power amplifier (140) and antenna (110) are required for the mesh router.

However, the usage of multiple radios and power amplifiers of the mesh
15 router is a waste or inefficient for lightly loaded node or network. Moreover, such mesh router cannot be used for single-radio mesh network.

Therefore, there is a need to provide a wireless communication system that addresses the abovementioned drawbacks.

20

SUMMARY OF INVENTION

The present invention provides a wireless communication system for use in a wireless mesh network. The system comprises of at least three antennas (210, 310), a Media Access Control (MAC) layer (220, 320), at least one physical layer (230, 330), at least one power amplifier (240, 340), an antenna selection module (250, 350) and a synchronization module (260, 360). The MAC layer (220, 320) is connected to the at least one physical layer (230, 330) and the synchronization module (240, 340). The MAC layer (220, 320) includes a MAC scheduler and QoS policy module (221, 321), a mesh configuration and management module (222, 322),
25 and a Mesh Coordinated Channel Access (MCCA) module (223, 323). The at least one power amplifier (240, 340) is connected to the at least one physical layer (230, 330) and the antenna selection module (250, 350). The antenna selection module (250, 350) is further connected to the at least three antennas and the synchronization module (260, 360).

35

Preferably, the at least three antennas (210, 310) include at least one omni-directional antenna, and at least two directional antennas.

5

Preferably, the number of antennas (210, 310) used is based on $M \geq N + 2$, where M is a number of antennas (210, 310), and N is a number of radios.

The present invention also provides a method for operating a wireless communication system in a wireless mesh network. The method is characterised by the steps of determining number of radio and antenna within the wireless communication system by a mesh coordinated channel access (MCCA) module (223, 323); performing a coordinated channel access sub-process; creating and updating a resource allocation table based on the information from an antenna node assignment table by the MCCA module (223, 323); synchronizing the MCCA module (223, 323) and an antenna selection module (250, 350) by a synchronization module (260, 360); assigning each antenna (210, 310) for different neighbouring nodes by the antenna selection module (250, 350); and transmitting and receiving data from neighbouring nodes.

20

Preferably, the coordinated channel access sub-process comprising the steps of activating the antennas (210, 310) to receive beacon signal from neighbouring nodes; receiving beacon signal from a neighbouring node; locating a source node of the beacon signal; sending a peering request to the identified source node; establishing a mesh peering link with the identified source node; and storing location and direction information of the identified source node in an antenna node assignment table. Moreover, the step of establishing a mesh peering link suitably includes receiving an acknowledgement from the identified source node.

30

Preferably, synchronizing the MCCA module (223, 323) and the antenna selection module (250, 350) by the synchronization module (260, 360) comprises the steps of initializing a timing reference entity; reading and verifying validity of clock from the timing reference entity by the MCCA module (223, 323) and the antenna selection module (250, 350); synchronizing timer of the MCCA module (223, 323) and the antenna selection module (250, 350) with the timing reference entity; sending

35

4

test frames with timestamp from the MCCA module (223, 323) to the antenna selection module (250, 350); comparing the timestamp on the test frames with the time it received the test frames by the antenna selection module (250, 350); and instructing the MCCA module (223, 323) to speed up or slow down transmission rate
5 by the antenna selection module (250, 350) if the timestamp differs from the time the antenna selection module (250, 350) received the test frames.

Preferably, assigning each antenna (210, 310) for different neighbouring nodes by the antenna selection module (250, 350) includes the steps of sending the
10 resource allocation table from the MCCA module (223, 323) to the antenna selection module (250, 350); comparing the received resource allocation table with a stored resource allocation table by the antenna selection module (250, 350); discarding the received resource allocation table and utilizing the stored resource allocation table if there is no difference between the two resource allocation tables; updating the stored
15 resource allocation table with the received resource allocation table by the antenna selection module (250, 350) if there is a difference between the two resource allocation tables; and selecting an appropriate antenna (210, 310) towards the source nodes by the antenna selection module (250, 350).

20 Preferably, transmitting and receiving data from neighbouring nodes includes the steps of constructing and mapping the resource allocation table based on the antenna nodes assignment table; broadcasting the resource allocation table to neighbouring nodes; and sending the resource allocation table to the antenna selection module (250, 350).

25 Advantageously, the present invention improves transmission and reception efficiency of a wireless communication system used in a wireless mesh network.

30 Advantageously, the present invention increases network capacity of a wireless mesh network.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

5

FIG. 1 shows a network diagram of a wireless mesh network.

FIG. 2 shows a network architecture block diagram of a mesh router equipped with multiple antennas.

10

FIG. 3 shows an architecture diagram of a wireless mesh network.

FIG. 4 shows a network architecture of a wireless communication system in accordance with a first embodiment of the present invention.

15

FIG. 5 shows a network architecture of a wireless communication system in accordance with a second embodiment of the present invention.

FIGS. 6(a-e) show flowcharts of operating the wireless communication system in accordance with an embodiment of the present invention.

20

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

25

A wireless communication system is provided in the present invention. The wireless communication system is equipped with multiple antennas to work with lower number of radio in a wireless mesh network. More particularly, the wireless communication system uses M-number of antennas to work with N-number of radio based on $M \geq N + 2$. Moreover, the wireless communication system includes an enhanced mesh coordinated channel access (MCCA) module to provide reservation of contention free time slots and to map the direction of source and destination nodes in the wireless mesh network. In addition to that, the wireless communication system

30

35

includes an antenna selection module to select the appropriate antenna to be employed during transmission and reception of data in the wireless mesh network. In order to ensure the synchronization between MCCA module and antenna selection module, a synchronization module is provided in the wireless communication system.

5

FIG. 3 shows an architecture diagram of a wireless mesh network which comprises of a plurality of nodes. The wireless communication system is used as a node in the wireless mesh network, wherein each node is able to transmit and receive data signal from all different angles of its neighbouring nodes. Moreover, the wireless communication system is able to accommodate concurrent incoming and outgoing signals. For an example, if a first source node (**S1**) is transmitting data to a first destination node (**D1**) through several intermediate nodes as depicted by solid arrows, while a second source node (**S2**) is also transmitting data to a second destination node (**D2**) through several intermediate nodes as depicted by dashed arrows, an intermediate node (11) is able to efficiently organize and schedule the transmission and reception from its neighbouring nodes.

Referring now to **FIG. 4**, there is shown a wireless communication system according to a first embodiment of the present invention. The wireless communication system is used as a node in a single-radio wireless mesh network. The wireless communication system comprises of M-number of antennas (**210**), a Media Access Control (MAC) layer (**220**), a physical layer (**230**), a power amplifier (**240**), an antenna selection module (**250**) and a synchronization module (**260**). Moreover, the wireless communication system may include other higher layers (**270**) that may be apparent to a person skilled in the art. Such higher layers (**270**) include transport layer, session layer, presentation layer and application layer.

The number of antennas (**210**) used in the wireless communication system is based on $M \geq N + 2$, where M is a number of antennas (**210**), and N is a number of radios. Moreover, the multiple antennas (**210**) include at least one omni-directional antenna, and at least two directional antennas. The omni-directional antenna is used for receiving beacon from neighbouring nodes, while the directional antennas are used for locating a source beacon and for data transmission between nodes.

30

The MAC layer (220) is connected to the physical layer (230) and the synchronization module (240). The MAC layer (220) further includes a MAC scheduler and QoS policy module (221), a mesh configuration and management module (222), and a MCCA module (223). The MAC scheduler and QoS policy module (221) is used to schedule the transmission operation through the antennas and to select quality of service (QoS) based on the underlined policy such as, but not limited to, type of traffics and network capacity. Generally, the main purpose of the MAC scheduler and QoS policy module (221) is for supporting QoS, and increasing the network throughput which includes power management and selection of multi-channel. The mesh configuration and management module (222) is used for handling the mesh topology, layer two routing (path selection) and mesh security. The MCCA module (223) is used to enable the reservation of contention time slots in the wireless mesh network. Moreover, the MCCA module (223) is also used to map the antenna direction of a source node in an antenna node assignment table which is then used for determining the direction of the source node.

The physical layer (230) is connected to the MAC layer (220) and the power amplifier (240). The physical layer (230) is used to define the signal based on type of modulation, forward error correction, and channel coding. Moreover, the physical layer (230) includes a channel equalizer to mitigate the effect of multipath signals.

The power amplifier (240) is used to amplify the transmission and reception signals and it is connected to the physical layer (230) and the antenna selection module (250).

The antenna selection module (250) is connected to the multiple antennas and it selects the appropriate antenna (210) to be employed for transmission and reception in the wireless mesh network. The selection is based on the MCCA module (223). The antenna selection module (250) is also connected to the power amplifier (240) and the synchronization module (260).

The synchronization module (260) is used to provide the timing alignment between the MCCA module (223) and antenna selection module (250) and thus, ensuring timely interaction between the MCCA module (223) and the antenna

selection module (250). The synchronization module (260) is connected to the MAC layer (220) and the antenna selection module (250).

Referring now to FIG. 5, there is shown a wireless communication system according to a second embodiment of the present invention. The wireless communication system is used as a node in a multi-radio wireless mesh network. The wireless communication system comprises of M-number of antennas (310), a Media Access Control (MAC) layer (320), A-number of physical layers (330), N-number of power amplifiers (340), an antenna selection module (350) and a synchronization module (360). Moreover, the wireless communication system may include other higher layers (370) that may be apparent to a person skilled in the art. Such higher layers include transport layer, session layer, presentation layer and application layer.

The number of antennas (310) used in the wireless communication system is based on $M \geq N + 2$, where M is a number of antennas (310), and N is a number of radios. Moreover, the multiple antennas (310) include at least one omni-directional antenna, and at least two directional antennas. The omni-directional antenna is used for receiving beacon from neighbouring nodes, while the directional antennas are used for locating a source beacon and for data transmission between nodes.

The MAC layer (320) is connected to the physical layer (330) and the synchronization module (360). The MAC layer (320) further includes a MAC scheduler and QoS policy module (321), a mesh configuration and management module (322), and a MCCA module (323). The MAC scheduler and QoS policy module (321) is used to schedule the transmission operation through the antennas and to select quality of service (QoS) based on the underlined policy such as, but not limited to, type of traffics and network capacity. Generally, the main purpose of the MAC scheduler and QoS policy module (321) is for supporting QoS, and increasing the network throughput which includes power management and selection of multi-channel. The mesh configuration and management module (322) is used for handling the mesh topology, layer two routing (path selection) and mesh security. The MCCA module (323) is used to enable the reservation of contention time slots in the wireless mesh network. Moreover, the MCCA module (323) is also used to map the antenna

direction of a source node in an antenna node assignment table which is then used for determining the direction of the source node.

Each physical layer (330) is connected to the MAC layer (320) and a power amplifier (340). The physical layers (330) are used to define the signal based on type of modulation, forward error correction, and channel coding. Moreover, the physical layer (330) includes a channel equalizer to mitigate the effect of multipath signals. Moreover, each physical layer (330) includes a channel equalizer to mitigate the effect of multipath signals.

The power amplifiers (340) are used to amplify the transmission and reception signals. Each power amplifier (340) is connected to a physical layer (330) and the antenna selection module (350). Each power amplifier (340) connected to a physical layer (330) corresponds to a particular radio used.

The antenna selection module (350) is connected to the multiple antennas (310) and it selects the appropriate antenna (310) to be employed for transmission and reception in the wireless mesh network. The selection is based on the MCCA module (323). The antenna selection module (350) is also connected to the power amplifiers (340) and the synchronization module (360).

The synchronization module (360) is used to ensure timely interaction between the MCCA module (323) and the antenna selection module (350). The synchronization module (360) is connected to the MAC layer (320) and the antenna selection module (350).

The operation of the wireless communication system is shown in FIGS. 6. Referring now to FIG. 7a, the MCCA module determines the number of radio and antenna within the wireless communication system as in step 701. Thereon, the wireless communication system performs a coordinated channel access sub-process as in step 702. The coordinated channel access sub-process is to identify all active neighbouring nodes and store information relating to its neighbouring nodes in an antenna node assignment table. In step 703, a resource allocation table is created and updated based on the information from antenna node assignment table by the

MCCA module. This is to reserve the time slot for data transmission towards the source node. **Table 1** is an example of the resource allocation table.

Table 1

Source Node	Destination Node	Time Slot	Antenna
X	A	T1	Ant-1
X	B	T2	Ant-2
X	C	T3	Ant-3
X	D	T4	Ant-4

5

In step **704**, the wireless communication system performs a synchronization sub-process to synchronize the timing information provided in the resource allocation table with the antenna selection module. Thereon, in step **705**, the wireless communication system performs an antenna selection sub-process by assigning each of its directional antennas toward different neighbouring nodes. The antenna selection sub-process is based on the neighbour node request. In step **706**, the wireless communication system performs transmit and receive sub-process for data transmission to/from the wireless communication system from/to its neighbouring nodes. Thereon, the wireless communication system determines whether its neighbouring nodes have transmitted a new request as in decision **707**. If a new request exists, then the wireless communication system repeats steps **703** to **706**.

10

15

20

25

Referring now to **FIG. 6b**, there is shown a flowchart of the coordinated channel access sub-process. Initially, as in step **801**, the omni-directional antenna is activated and waiting to receive beacon from its neighbouring nodes. If there is a request to associate from the neighbouring nodes, the wireless communication system associates with the requested node by trying to locate the source of the beacon via its directional antennas (decision **802** and step **803**). Once the wireless communication system has found the source of the beacon, it sends a peering request to the identified source node as in step **804**. If source node acknowledges the peering request, then a mesh peering link is established and thereon, the location and direction information of the newly established node is added and updated in an antenna node assignment table (decision **805**, and steps **806** to **807**). **Table 2** is an example of the antenna node assignment table.

Table 2

Node	Antenna
A	Ant-1
B	Ant-2
C	Ant-3
D	Ant-4

If the source node does not acknowledge the peering request, then a mesh
 5 peering link is not established and the wireless communication system randomly tries
 to associate the failed-to-established source node with a different directional antenna
 (decision **805**, and steps **808** to **809**). Steps **803** to decision **805** are then repeated.

Referring now to **FIG. 6c**, there is shown a flowchart of the synchronization
 10 sub-process. A timing reference entity can be of any form of entity to provide a timing
 reference for the antenna selection module such as a global positioning system
 (GPS) module, a timer circuit, or a dedicated timing module. Initially, the timing
 reference entity is initialized and thereon, the MCCA module and antenna selection
 module read and verify the validity of the clock from the timing reference entity (steps
 15 **901** and **902**). If the clock value is invalid, the timing reference entity is restarted
 (decision **903** and step **904**) and thereon, steps **901** to **902** are repeated.

If the clock value is valid, then the MCCA module and antenna selection
 module adjust their own reference timer to be the same as the timing reference entity
 20 and thereon, the MCCA module sends test frames with its timestamp on it to the
 antenna selection module (decision **903** and step **905**). In steps **906** and **907**, the
 antenna selection module receives the test frames and compares the timestamp on
 the test frames with the time it received the test frames. If a clock drift exists, it
 means there is some delay in the communication line and then, the clock drift is
 25 compared with a threshold of clock drift (decision **908** and step **909**). If the clock drift
 is greater than the threshold, the antenna selection module instructs the MCCA
 module to speed up frame sending and steps **905** to **907** are repeated. If it is lower
 than the threshold, the antenna selection module instructs the MCCA module to slow

down the frame sending and steps **905** to **907** are repeated. However, if no clock drift exists, then the MCCA module and the antenna selection module are synchronized and ready (decision **908** and step **910**).

5 Referring now to **FIG. 6d**, there is shown the antenna selection sub-process of the wireless communication system. In step **1001**, the MCCA module sends the resource allocation table to the antenna selection module. Thereon, in step **1002**, the antenna selection module compares the received resource allocation table with a stored resource allocation table. If there is no difference between the two resource
10 allocation tables, then the antenna selection module discards the received resource allocation table and utilizes the stored resource allocation table (decision **1003** and step **1004**). If there is a difference between the two resource allocation tables such as but not limited to the source node, destination node, reservation time slot and antenna, then the antenna selection module updates its stored resource allocation
15 table with the received resource allocation table (decision **1003** and step **1005**). Thereon in step **1006**, the antenna selection module selects the appropriate antenna towards the source nodes by using round robin or fix assignment, or new algorithm that can improve the efficiency and throughput of transmission.

20 Referring now to **FIG. 6e**, there is shown a flowchart of transmit and receive sub-process of the wireless communication system. If there is any transmission requested from the destination node, the wireless communication system constructs the resource allocation table and maps the resource allocation table with the antenna nodes assignment table (decision **1101**, and steps **1102** to **1103**). Thereon, the
25 resource allocation table is broadcasted to its neighbouring nodes as in step **1104**. The resource allocation table is also sent to the antenna selection module to select the correct direction towards the requested nodes (**1105**).

30 While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrated and describe all possible forms of the invention. Rather, the words used in the specifications are words of description rather than limitation and various changes may be made without departing from the scope of the invention.

CLAIMS

1. A wireless communication system for use in a wireless mesh network comprising:

- 5 a) at least three antennas (210, 310),
 b) a Media Access Control (MAC) layer (220, 320),
 c) at least one physical layer (230, 330), and
 d) at least one power amplifier (240, 340);

wherein the wireless communication system is characterised in that:

- 10 the wireless communication system further includes an antenna
 selection module (250, 350) and a synchronization module (260, 360),
 wherein the MAC layer (220, 320) is connected to the at least one physical
 layer (230, 330) and the synchronization module (260, 360), the at least one
 power amplifier (240, 340) is connected to the at least one physical layer
 (230, 330) and the antenna selection module (250, 350), and the antenna
15 selection module (250, 350) is further connected to the at least three
 antennas (210, 310) and the synchronization module (260, 360);

- 20 the MAC layer (220, 320) includes a MAC scheduler and QoS policy
 module (221, 321), a mesh configuration and management module (222,
 322), and a Mesh Coordinated Channel Access (MCCA) module (223, 323).

2. The wireless communication system as claimed in claim 1, wherein the at
least three antennas (210, 310) include at least one omni-directional antenna,
and at least two directional antennas.

3. The wireless communication system as claimed in claim 1, wherein the
number of antennas (210, 310) used is based on $M \geq N + 2$, where M is a
number of antennas (210, 310), and N is a number of radios.

4. A method for operating a wireless communication system as claimed in
claims 1 to 3 in a wireless mesh network, is characterised by the steps of:

- 35 a) determining number of radio and antenna within the wireless
 communication system by a mesh coordinated channel access
 (MCCA) module (223, 323);
 b) performing a coordinated channel access sub-process;

- c) creating and updating a resource allocation table based on the information from an antenna node assignment table by the MCCA module (223, 323);
 - d) synchronizing the MCCA module (223, 323) and an antenna selection module (250, 350) by a synchronization module (260, 360);
 - e) assigning each antenna (210, 310) for different neighbouring nodes by the antenna selection module (250, 350); and
 - f) transmitting and receiving data from neighbouring nodes.
- 5
- 10 5. The method as claimed in claim 4, wherein the coordinated channel access sub-process comprising the steps of:
- a) activating the antennas (210, 310) to receive beacon signal from neighbouring nodes;
 - b) receiving beacon signal from a neighbouring node;
 - c) locating a source node of the beacon signal;
 - d) sending a peering request to the identified source node;
 - e) establishing a mesh peering link with the identified source node; and
 - f) storing location and direction information of the identified source node in an antenna node assignment table.
- 15
- 20
6. The method as claimed in claim 5, wherein establishing a mesh peering link includes receiving an acknowledgement from the identified source node.
- 25
7. The method as claimed in claim 4, wherein synchronizing the MCCA module (223, 323) and the antenna selection module (250, 350) by the synchronization module (260, 360) comprising the steps of:
- a) initializing a timing reference entity;
 - b) reading and verifying validity of clock from the timing reference entity by the MCCA module (223, 323) and the antenna selection module (250, 350);
 - c) synchronizing timer of the MCCA module (223, 323) and the antenna selection module (250, 350) with the timing reference entity;
 - d) sending test frames with timestamp from the MCCA module (223, 323) to the antenna selection module (250, 350);
- 30

- e) comparing the timestamp on the test frames with the time it received the test frames by the antenna selection module (250, 350); and
- f) instructing the MCCA module (223, 323) to speed up or slow down transmission rate by the antenna selection module (250, 350) if the timestamp differs from the time the antenna selection module (250, 350) received the test frames.
- 5
8. The method as claimed in claim 4, wherein assigning each antenna (210, 310) for different neighbouring nodes by the antenna selection module (250, 350) includes the steps of:
- 10
- a) sending the resource allocation table from the MCCA module (223, 323) to the antenna selection module (250, 350);
- b) comparing the received resource allocation table with a stored resource allocation table by the antenna selection module (250, 350);
- 15
- c) discarding the received resource allocation table and utilizing the stored resource allocation table if there is no difference between the two resource allocation tables;
- d) updating the stored resource allocation table with the received resource allocation table by the antenna selection module (250, 350) if there is a difference between the two resource allocation tables; and
- 20
- e) selecting an appropriate antenna (210, 310) towards the source nodes by the antenna selection module (250, 350).
9. The method as claimed in claim 4, wherein transmitting and receiving data from neighbouring nodes includes the steps of:
- 25
- a) constructing and mapping the resource allocation table based on the antenna nodes assignment table;
- b) broadcasting the resource allocation table to neighbouring nodes; and
- c) sending the resource allocation table to the antenna selection module (250, 350).
- 30

1/7

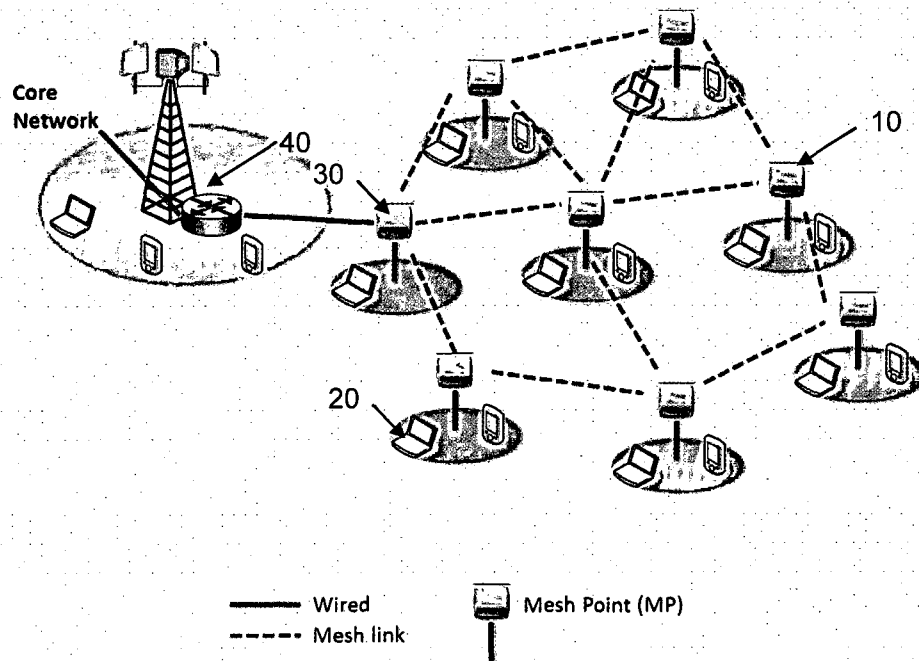


FIG. 1

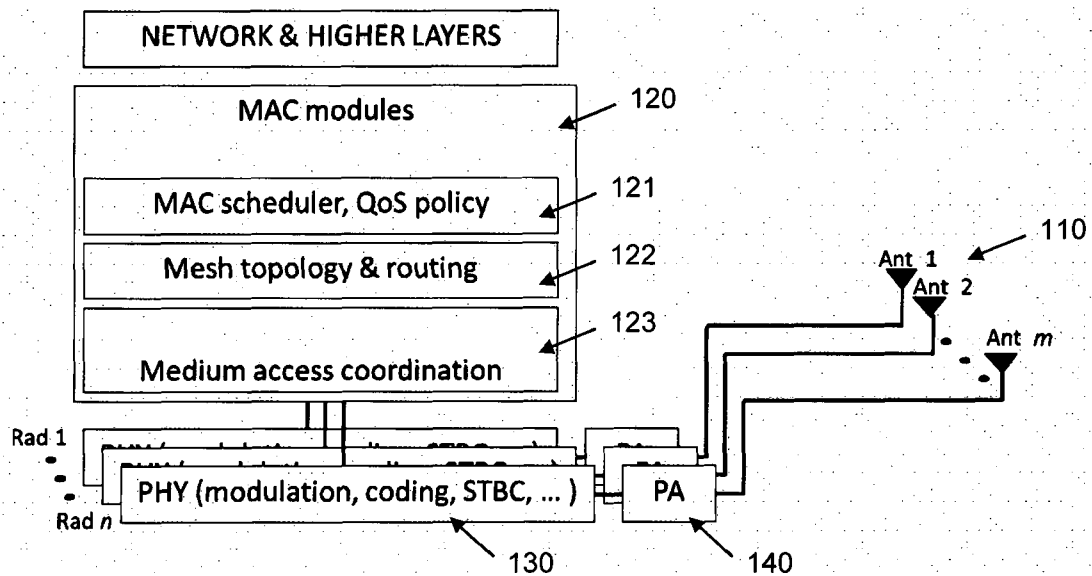


FIG. 2

2/7

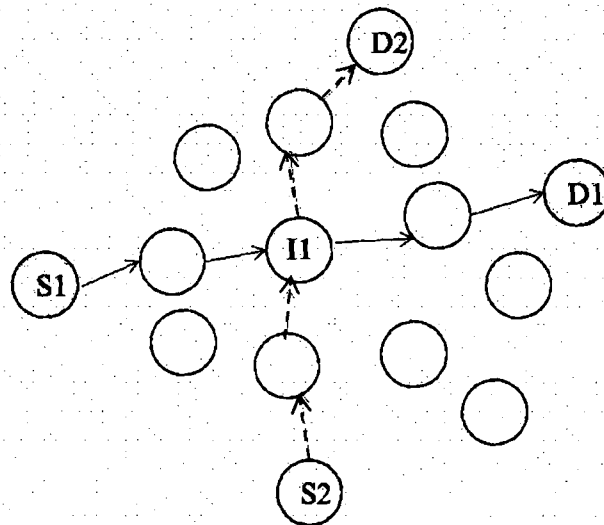


FIG. 3

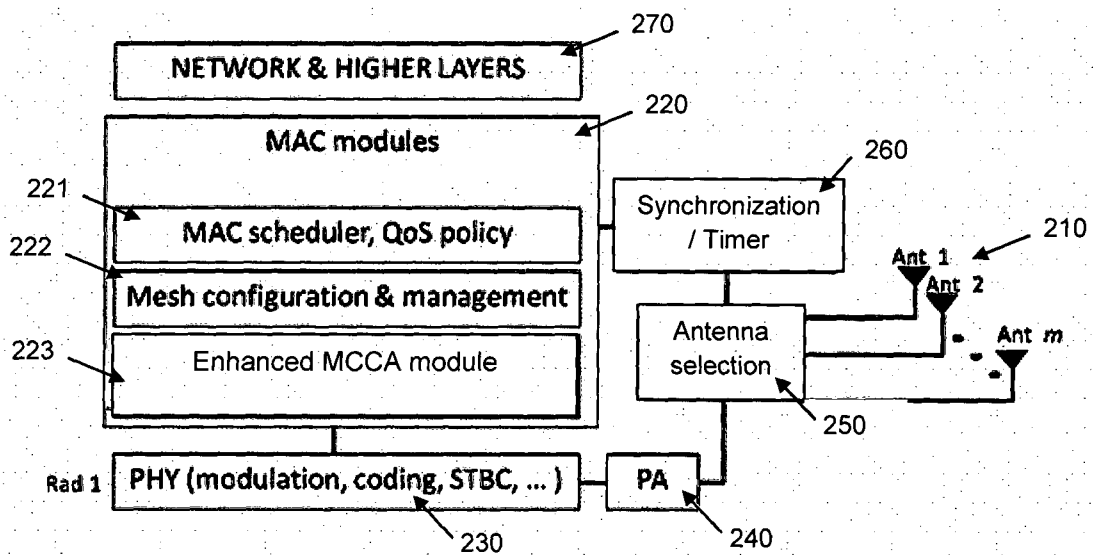


FIG. 4

3/7

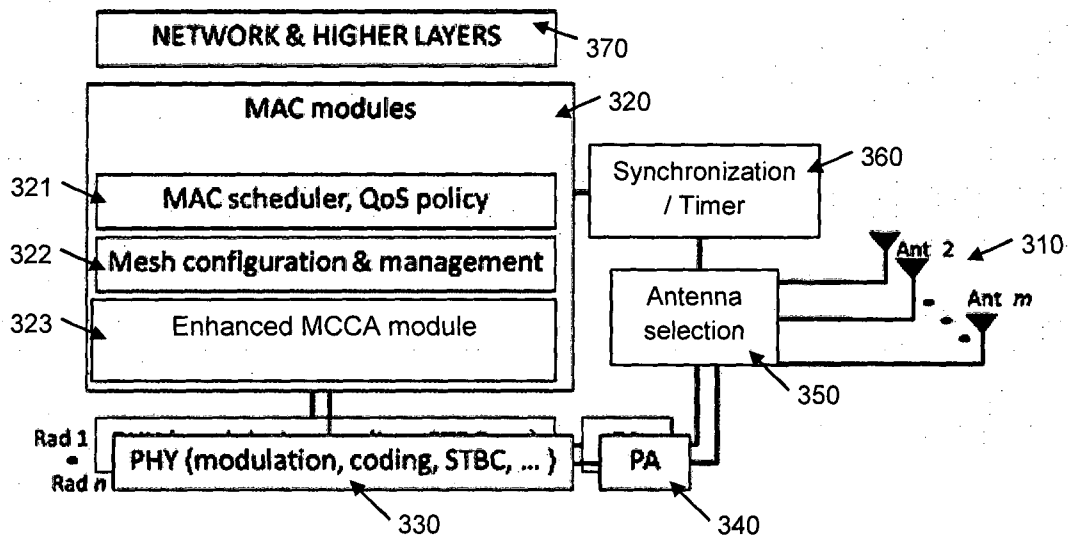


FIG. 5

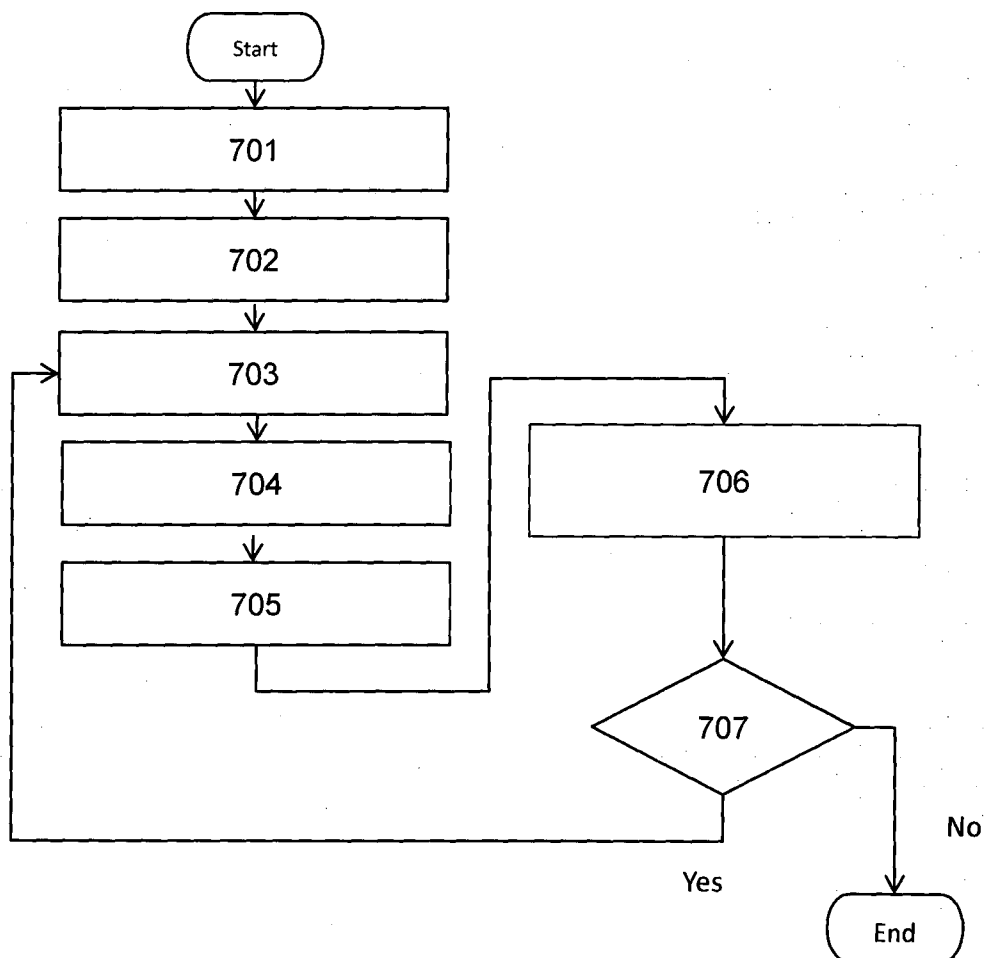


FIG. 6a

4/7

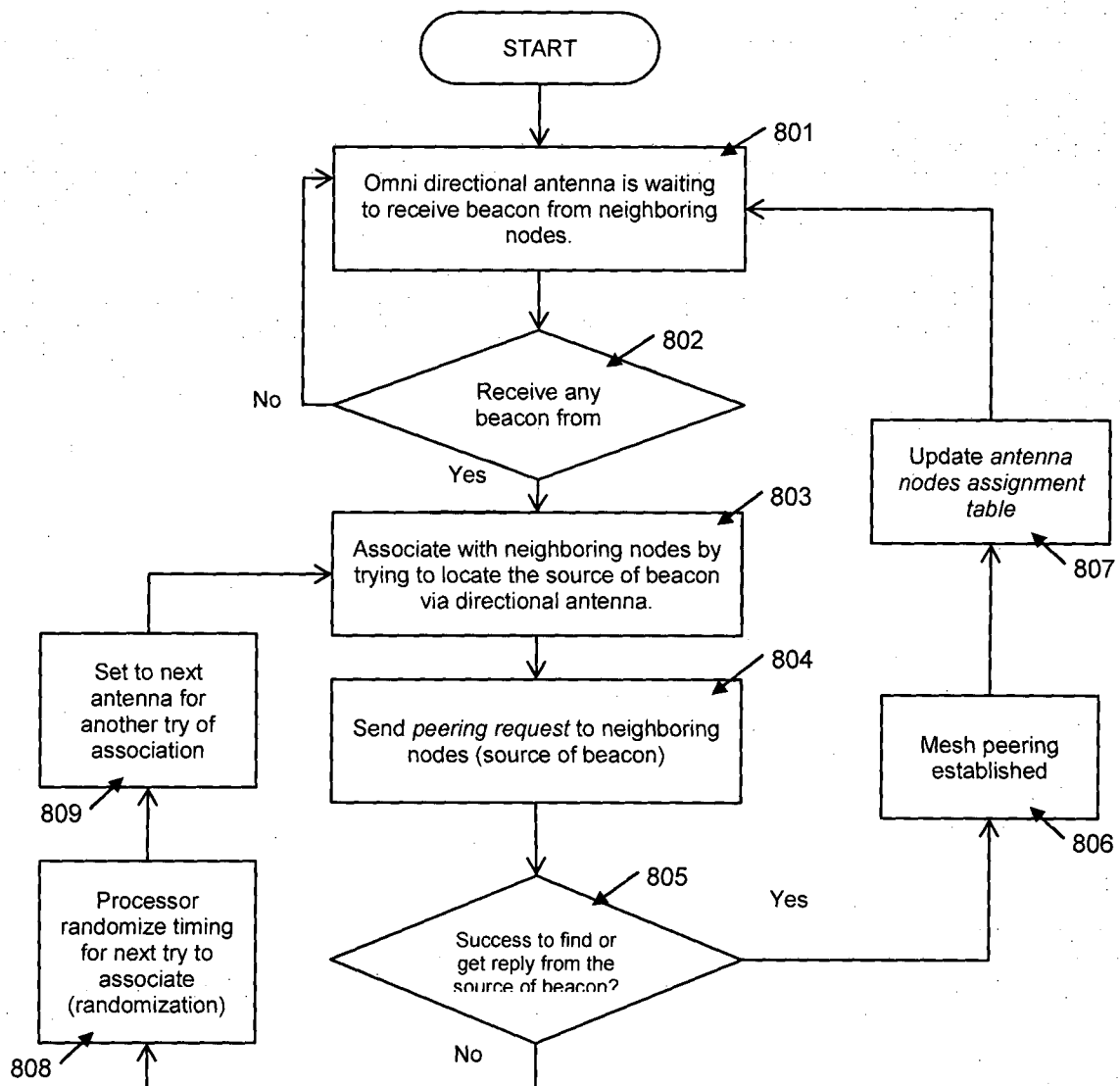


FIG. 6b

5/7

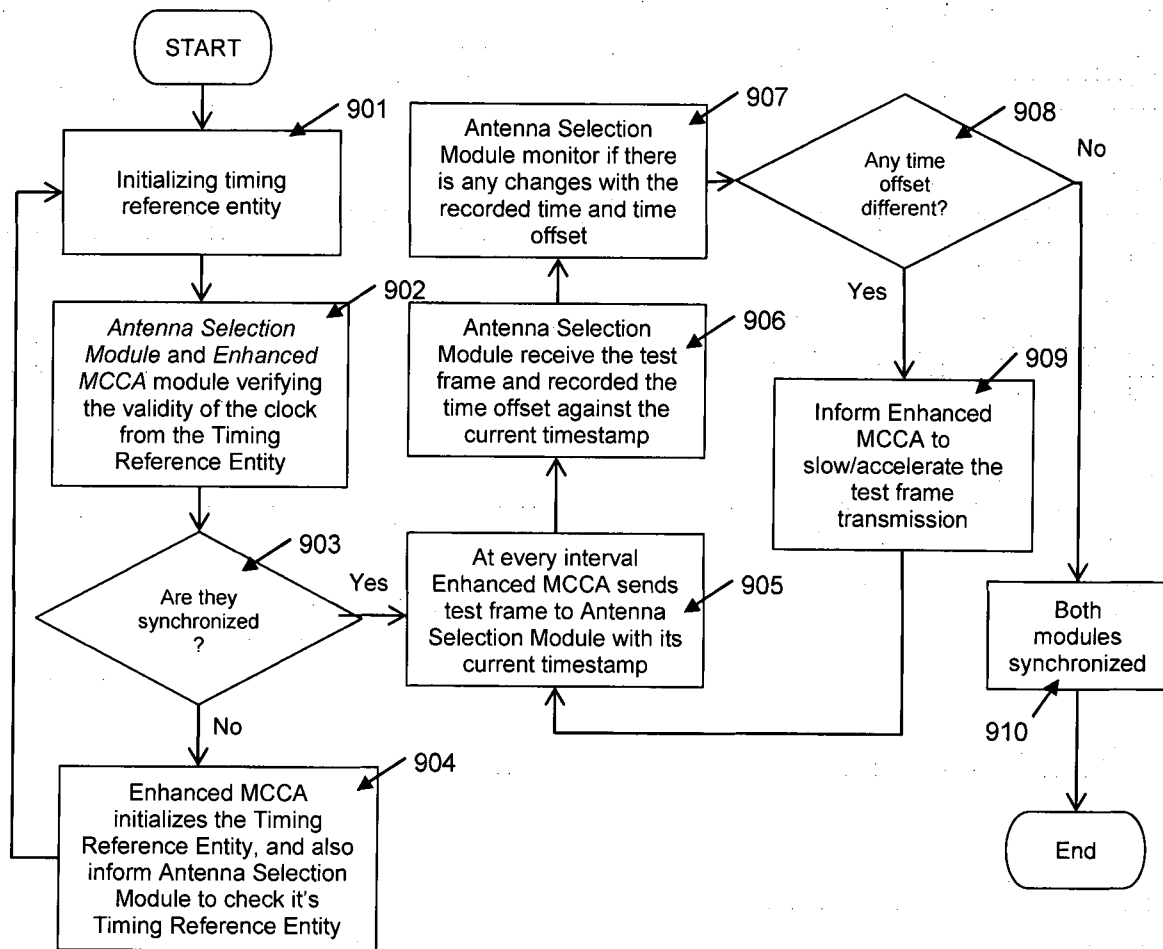


FIG. 6c

6/7

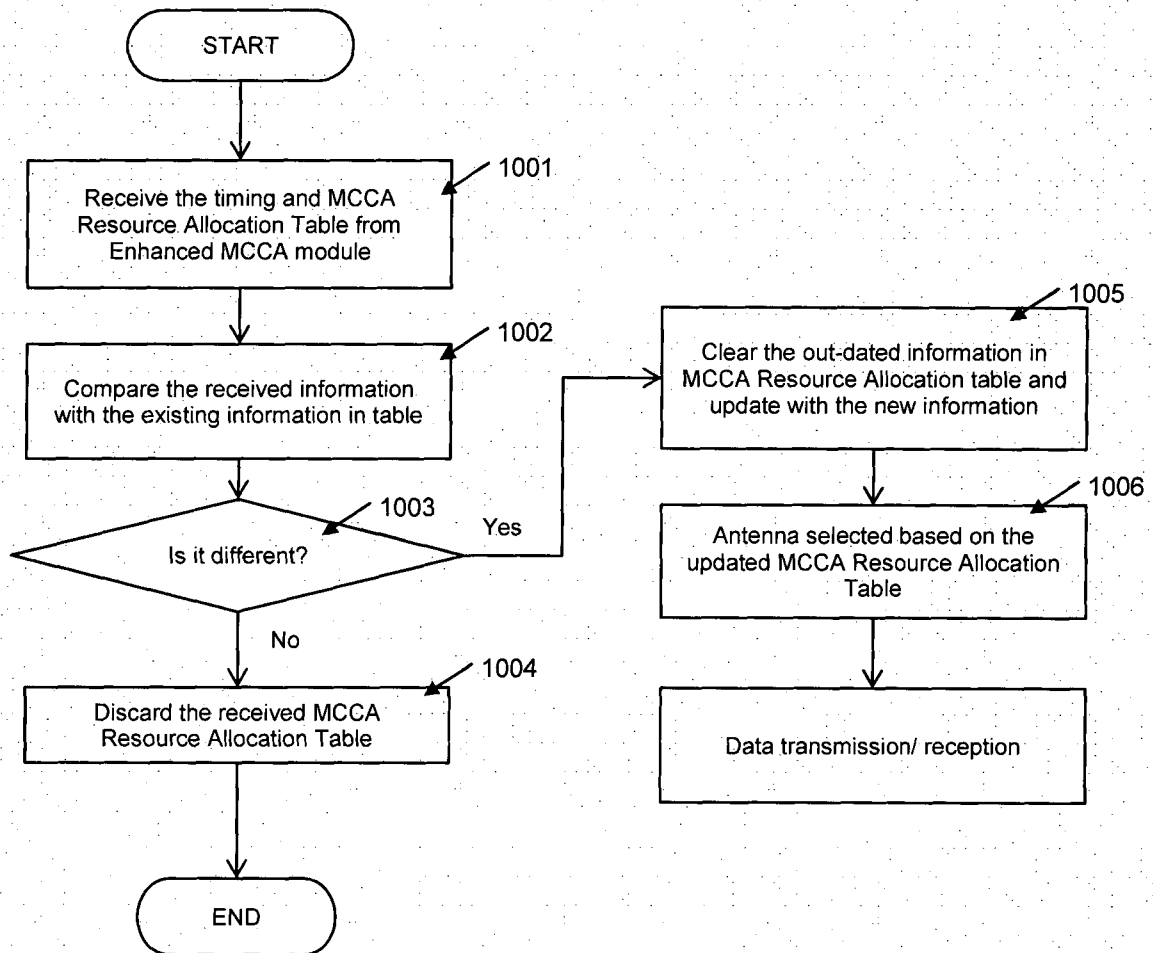


FIG. 6d

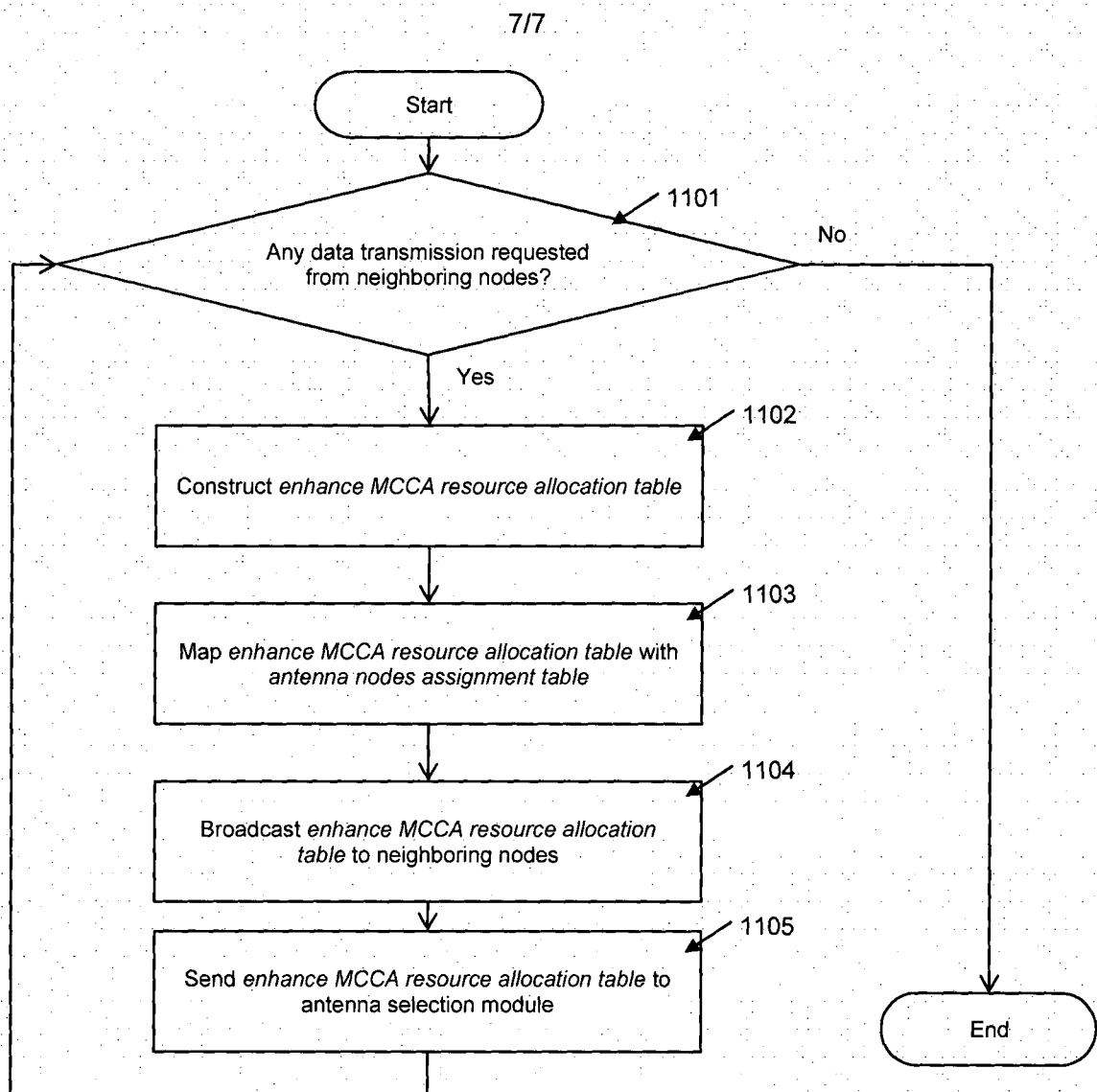


FIG. 6e

INTERNATIONAL SEARCH REPORT

International application No

PCT/MY2012/000172

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W88/00

ADD. H04W84/00

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)

H04W

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 practicable, 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.
Y	EP 1 225 723 A2 (NOKIA CORP [FI]) 24 July 2002 (2002-07-24)	1-3
A	paragraph [0001] - paragraph [0026] paragraph [0043] - paragraph [0044] paragraph [0049]	4
Y	----- US 2005/215262 AI (CHA INHYOK [US] ET AL) 29 September 2005 (2005-09-29)	1-3
A	paragraph [0002] - paragraph [0015] paragraph [0073] figure 2	4
A	----- US 2005/201340 AI (WANG XUDONG [CN] ET AL) 15 September 2005 (2005-09-15) the whole document	1,4
	----- -/- .	



Further documents are listed in the continuation of Box C.



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 application or patent 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

4 December 2012

Date of mailing of the international search report

12/12/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Vaskimo, Kimrno

INTERNATIONAL SEARCH REPORT

International application No

PCT/MY2012/000172

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/230403 AI (DOUGLAS BRETTON L [US] ET AL DOUGLAS BRETTON LEE [US] ET AL) 4 October 2007 (2007-10-04) the whole document -----	1, 4
A	US 2006/215583 AI (CASTAGNOLI NEAL D [US]) 28 September 2006 (2006-09-28) the whole document -----	1, 4
A	US 2010/177755 AI (CHU LI WEN [US] ET AL) 15 July 2010 (2010-07-15) the whole document -----	1, 4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/MY2012/000172

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1225723	A2	24-07-2002	EP 1225723 A2	24-07-2002
			US 2002097700 A1	25-07-2002
			US 2005083852 A1	21-04-2005

US 2005215262	A1	29-09-2005	AT 433231 T	15-06-2009
			EP 1730851 A2	13-12-2006
			JP 4663711 B2	06-04-2011
			JP 2008501254 A	17-01-2008
			KR 20060123655 A	01-12-2006
			TW 1262030 B	11-09-2006
			TW 1362141 B	11-04-2012
			US 2005215262 A1	29-09-2005
			WO 2005089362 A2	29-09-2005

US 2005201340	A1	15-09-2005	NONE	

US 2007230403	A1	04-10-2007	NONE	

US 2006215583	A1	28-09-2006	NONE	

US 2010177755	A1	15-07-2010	NONE	
